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Residential Development


25-27 Warriewood Road, Warriewood

Water Management Report
Issue 10

Prepared for Knowles Group/ArCare

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1 Executive Summary

This document is a water management report in support of the proposed residential development at 25-27 Warriewood Road, Warriewood (Stage 2). This report should be read in conjunction with the approved water management report (ref. 20160112-R01 revision 05) prepared by SGC for the aged care facility (Stage 1) at the same site address under DA N0611/16.

The Knowles Group are proposing a residential development which includes a residential flat building on the lower side facing Lorikeet Grove with one (1) basement level and eleven (11) split level dwelling /semi-detached dwellings on the upper end facing Warriewood Road. The proposed subdivision plan is illustrated in Figure 1-1 below. Lot 11 (yellow) has already been constructed with an aged care facility under Stage 1, Lorikeet Grove similarly is finished and this report addresses council's requirements for areas marked in green and orange (Lots 1 & 2).

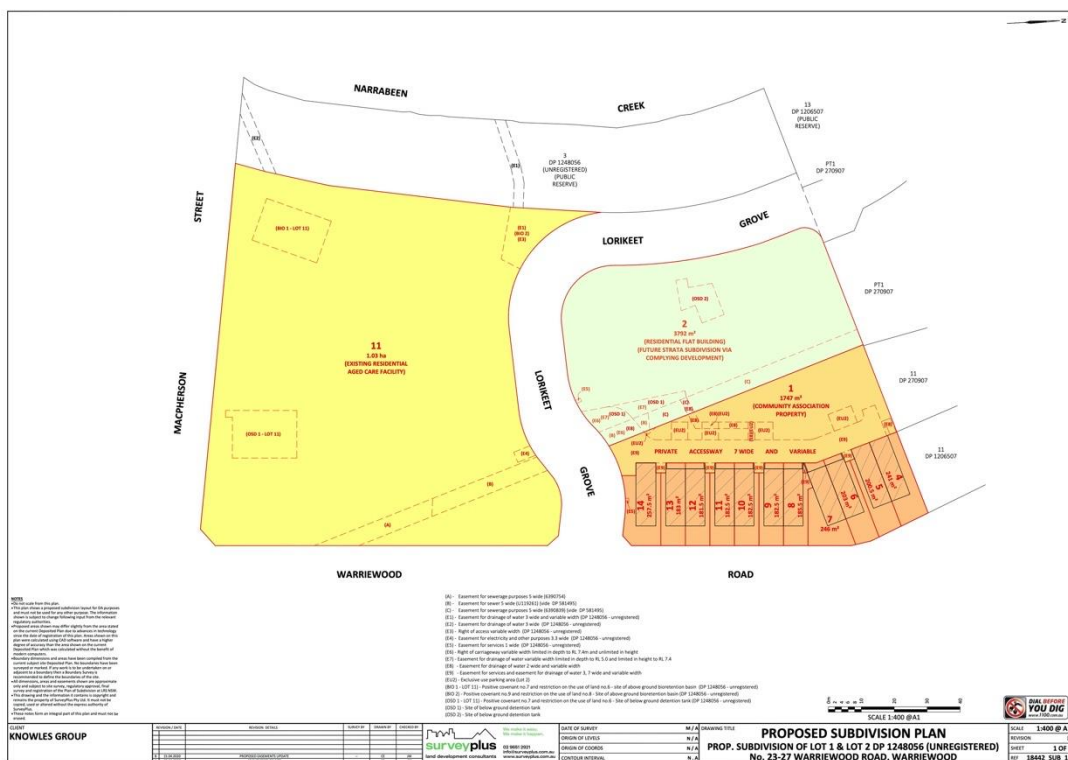


Figure 1-1 Subdivision plan

This water management report addresses the requirements of Council for the residential development only as the aged care is already approved by Council.

This water management report provides an assessment of the requirements of the Warriewood Valley Water Management Specification (WVWMS) with respect to water quantity, balance and quality.

The following have been addressed in Stage 1:

- An assessment of flooding from Narrabeen Creek;
- Assessment of any flood impact from the proposed development;
- Mitigation measures to negate the impact of the development including proposed creek corridor works (construction completed); and
- Addressing the requirements of the NSW Floodplain Development Manual (2005) in relation to flood hazard and flood risk from the creek.

The Flood Planning Level (FPL) adopted for the residential development is RL 4.29m AHD which achieves 0.5m above the 100-year ARI flood level inclusive of the Climate Change controls.

The creek has been widened to cater for the 50% AEP flows, while the 50m wide corridor is provided to convey the 1% AEP flows.

The following water management measures are proposed for the residential development site: -

- 159.3m³ (OSD 2) and 109.6m³ (OSD 3) tanks for the townhouses and the residential flat building catchments respectively; and
- 2.2KL rainwater tank for each dwelling /semi-detached dwelling and 20KL rainwater tank for the residential flat building;

A treatment train approach is proposed for the WSUD to achieve the water balance and to meet the pollutants reduction ratios which involves rainwater tanks for internal and external re-use, a gross pollutant trap to collect litter, leaves and other pollutants larger than 5mm and a bio-retention basin (already approved and constructed under council's consent N0611/16) to reduce the finer and suspended pollutants.

The proposed development achieves the water quantity and water quality requirements set out by Council in the WVWMS.

Reference is made to the referenced stormwater drawings for details.

SECTION A – GENERAL

2 Introduction

2.1 Brief

S&G Consultants Pty Ltd (SGC) have been engaged by The Knowles Group to prepare a water management report in support of the proposed residential development at 25-27 Warriewood Road, Warriewood identified as Stage 2 in reference to Stage 1 which is the approved aged care facility under DA N0611/16.

The Northern Beaches Council (previously Pittwater) requires the water management report because the site falls in the Warriewood Valley release area.

The following tasks were carried out: -

- Site visit was undertaken on the 10th of May 2016 to ascertain on-site conditions and familiarise with the catchment. Subsequent site visits were carried out during the roads and the aged care construction under Stage 1;
- Supplied documents and previous studies were reviewed;
- Liaison with Council Engineers;
- A flood impact assessment was carried out;
- Water quantity and water quality modelling and design was undertaken; and
- This report has been compiled.

2.2 Limitations

This report is intended solely for The Knowles Group as the Client of SGC and no liability will be accepted for use of the information contained in this report by other parties than this client.

This report is limited to visual observations and to the information including the referenced documents made available at the time when this report was written.

2.3 Reference Documents

The following documents have been referenced in this report: -

1. Site survey prepared by SDG ref. 6952 rev B dated 13/05/2016;
2. Additional site survey prepared by SurveyPlus ref.18442_DET_1A rev A dated 23/01/2019;
3. Architectural drawings prepared by V-Arc;
4. Water management report prepared for the aged care facility by SGC and approved by Council under Stage 1 (reference 20160112-R01 revision 05 dated 12/05/2017);

5. NSW Government The Floodplain Development Manual – The management of Flood Liable Land (2005);
6. Engineers Australia, *Australian Rainfall & Runoff* (AR&R 1999);
7. Narrabeen Lagoon Flood Study Tuflow Model received from Council;
8. Northern Beaches (Pittwater) Council DCP 21;
9. Warriewood Valley Land Release Water Management Specification by Northern Beaches Council; and
10. *Draft MUSIC Modelling Guidelines* by Sydney Metropolitan Catchment Authority ref. R.B17048.001.01 dated August 2010.

2.4 Author

This report has been prepared by Samer El Haddad from S&G Consultants Pty Ltd. Samer has more than 20 years' experience preparing flood studies and flood risk management reports.

Samer's qualifications are as follows: -

- B.E. Civil Engineering – 1997;
- Masters in Engineering Management – 2004;
- Chartered Member – Engineers Australia (MIEAust CPEng 2247040); and
- On the National Professional Engineering Register (NPER-3 Civil).

3 Natural & Built Environment

3.1 Local Catchment

The site is made out of three lots being Nos. 25 & 27 Warriewood Road (lots 28 & 29 of Sec 7 in DP 5464) in the suburb of Warriewood on the northern beaches of Sydney. The site falls in the Local Government Area of Northern Beaches Council (previously Pittwater).

The site is bounded by Narrabeen Creek to the West, Warriewood Road to the East, Macpherson Street to the South and adjoining properties to the North.

Narrabeen Creek flows in a southerly direction. It originates about 1.5km to the west of the site and discharges into Narrabeen Lagoon.

The land adjoining the creek is extensively vegetated and overgrown.

The site has a trapezoidal shape and is characterised by a natural gradient from Warriewood Road towards the creek. Figure 3-1 shows the location of the site.



Figure 3-1 Locality Plan

3.2 Proposed Development

As previously mentioned, the new Lot 11 is on the corner of Warriewood Road and MacPherson Street and has been developed with an aged care facility for ArCare under DA N0611/16. The water management specific to this development have been addressed by

SGC in report reference 2016.0112-R01 revision 05 that accompanied the DA documents. The approved DA included the extension to Lorikeet Grove from the northern boundary towards the proposed roundabout on Warriewood Road.

The new lots 1 & 2 identified as stage 2 will be a residential development which is the subject of this water management plan. Some of the water management measures for this stage 2 were previously addressed as part of the previous submission for DA N0611/16, however because the proposed development layout has been modified from the original layout and because Council did not include this lot in the consent, this report is prepared to demonstrate compliance with requirements of the WVWMS.

The residential development includes a residential flat building on the lower side facing Lorikeet Grove with one (1) basement level and eleven (11) split level dwelling /semi-detached dwellings facing Warriewood Road.

Reference should be made to the architectural drawings prepared by V-Arc for more details on the proposed development.

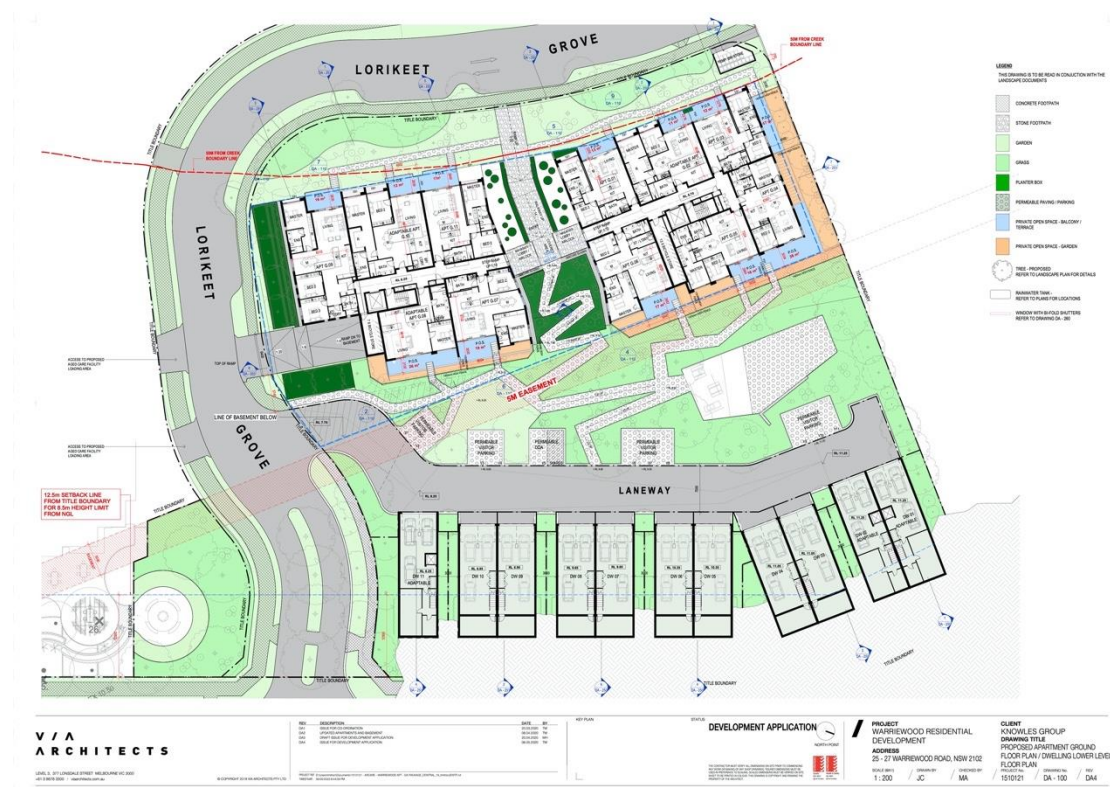


Figure 3-2 General Arrangement Plan – Residential Development

4 Glossary

Annual Exceedance Probability (AEP)

The chance of a flood of a given or a larger size occurring in any one year, usually expressed as a percentage.

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Recurrence Interval (ARI)

The long term average number of years between the occurrence of a flood as big as or larger than the selected event.

Catchment

The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

Flood

Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse.

Flood Liable Land or Flood Prone Land

Land susceptible to flooding by the PMF.

Flood Planning Levels (FPLs)

Are the combinations of flood levels and freeboards selected for floodplain risk management purposes.

Freeboard

Is a factor of safety typically used in relation to the setting of floor levels.

Habitable Room

In industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to damage in the event of a flood.

Peak Discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood

PMF is the largest flood that could conceivably occur at a location, usually estimated from probable maximum precipitation.

Probable Maximum Precipitation

PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year.

Runoff

The amount of rainfall which actually ends up as stream flow.

SECTION B – WATER QUALITY

5 Water Cycle Assessment

5.1 General

This section addresses the requirements of Section 4.1 of the Warriewood Valley Water Management Specification (WVWMS).

The site is located in Sector D of the Warriewood Valley release area.

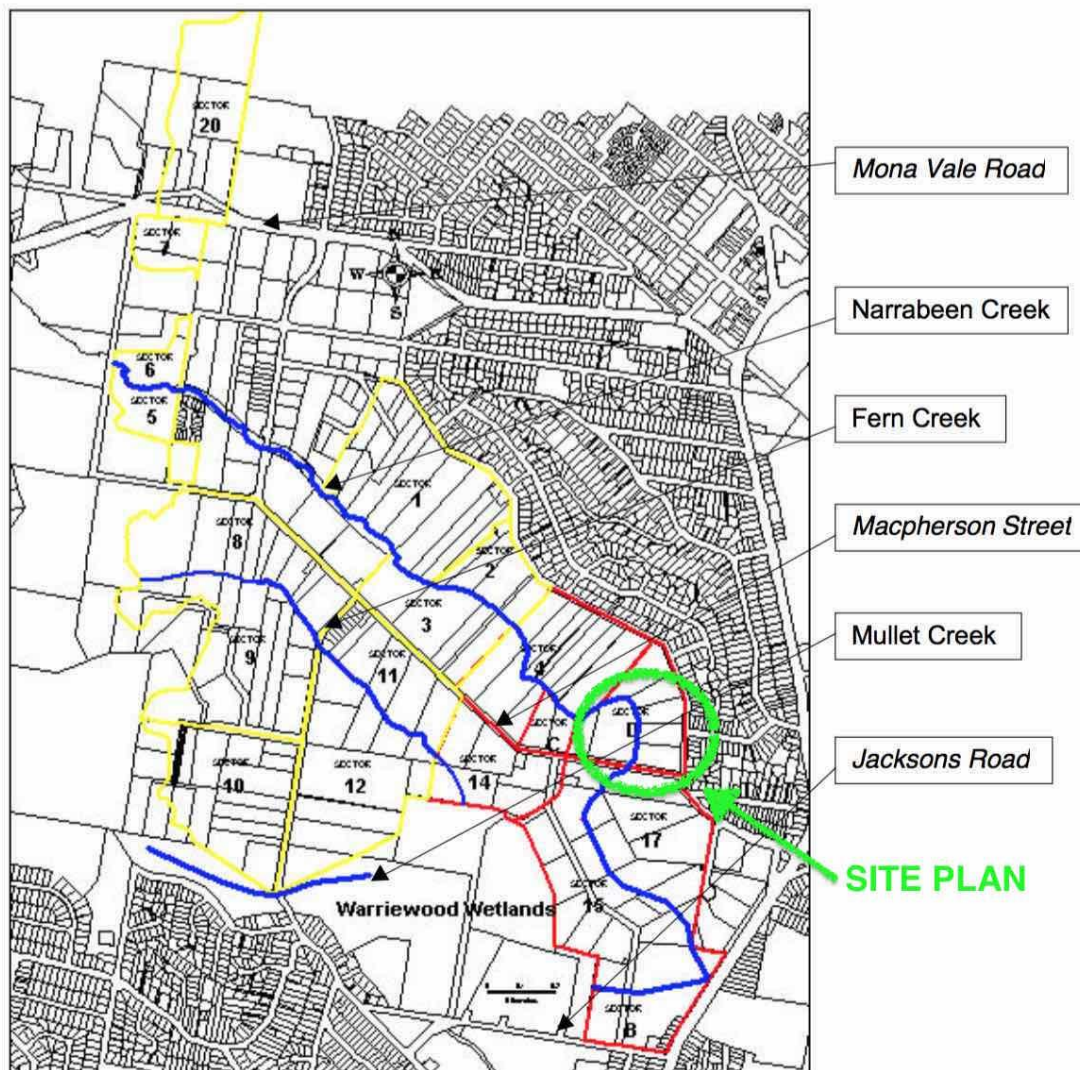


Figure 5-1 Sector Plan

5.2 Existing Geotechnical Conditions

This section of the report relates to existing subsurface conditions as identified by the geotechnical engineer for the site. A summary of the field works and results is included below. Reference is made to Geotechnique Pty Ltd Job No. 13787/1-AA (03/08/2016).

- ### 5.3 Existing Catchment and Topography

The total site area is 8177.9m². The natural gradient of the land falls towards Narrabeen Creek which outlines the western boundary of the site (average slope of 5.5%). Refer Figure 5-2 below which is a copy of the detailed survey plan by SDG.

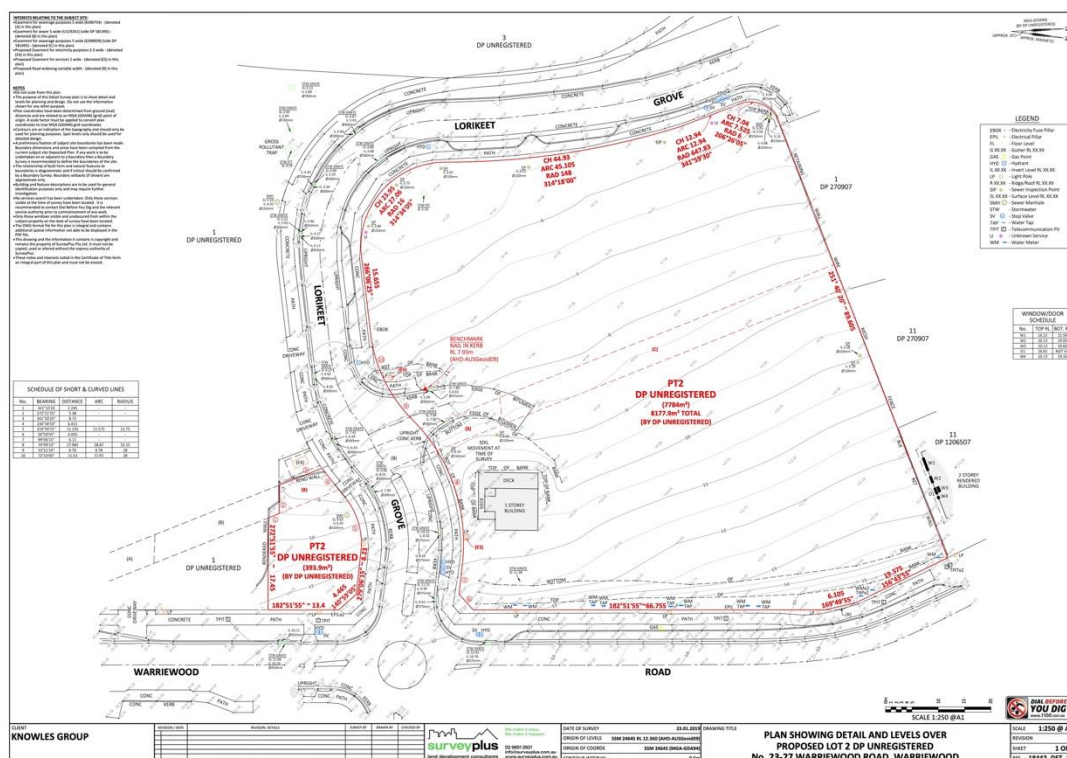


Figure 5-2 Site Topography

The site is traversed with a Sydney Water sewer easement as shown in the survey plan.

5.4 Assessment of Developed Conditions

The proposed site conditions are as per the general arrangement plans prepared by V-Arc (ref. 1510121). The site will be developed as follows: -

1. The first 25m setback from the creek will be the public setback which will include the riparian corridor which has been re-shaped to convey the 100-yr flows associated with the Narrabeen Creek under Stage 1;
2. The second 25m setback will for the private buffer that will not have any structures but provides the required areas for the proposed water quantity and quality measures to meet the requirements of the WVWMS; and
3. The northern part of the site will form the proposed lot that will be developed with the residential development subject of this water management report and strategy. This area will provide the new internal private road and new residential lots. Figure 5-3 below show the proposed land uses for the site.

A water balance model is prepared to assess the impact of the proposed conditions and to propose mitigation measures to ensure that the development will not have any adverse impacts on water quality. Reference is made to Section 6 “Water Quality Assessment” for details.

The proposed land-use of the site is shown in Figure 5-3 below. Reference is made to the stormwater concept plans for more details.

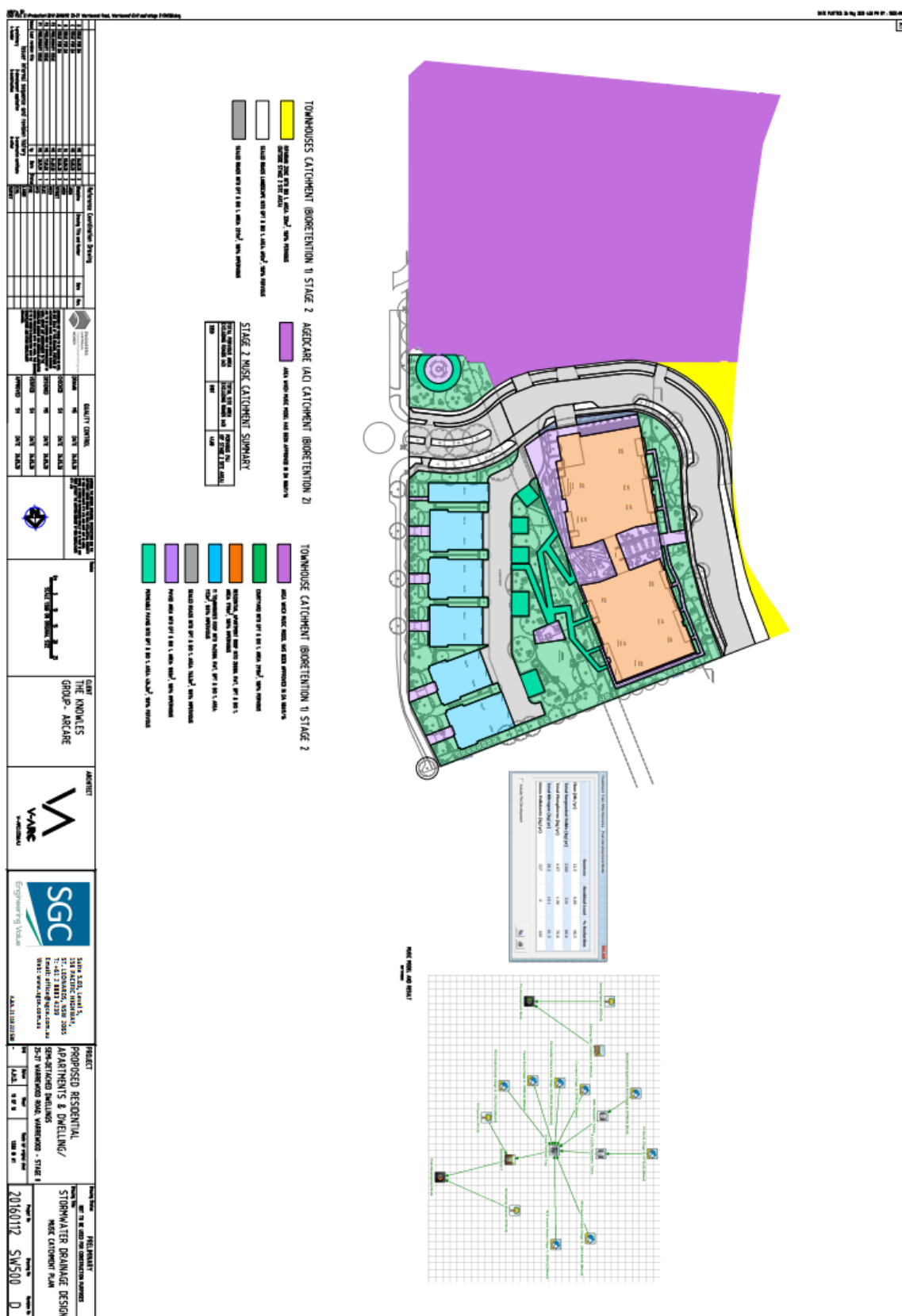


Figure 5-3 Proposed Land Use (full size copy in set of stormwater plans)

6 Water Quality Assessment

The water quality assessment is being carried out by another specialist consultant.

Reference is made to the report and the documents prepared by Marine Pollution Research Pty Ltd (March 2017) for details on water quality monitoring, sites chosen, methodology, monitoring regime, etc...

6.1 Water Balance

The proposed development will have rainwater reuse tanks to collect roof water for internal and external reuse as per the requirements of BASIX. At this stage, we have assumed that a 2,200 litres rainwater tank will be provided for each of the dwelling /semi-detached dwellings and a 20,000 litres rainwater tank for the residential flat building.

Based on the above, the provision of 11 dwelling /semi-detached dwellings will include a combined 44.2KL rainwater tanks volume in conjunction with the residential flat building. The tanks will supply daily demands, which will include laundry, toilet flushing and watering of landscaping.

The daily demands are calculated based on the following: -

- Internal non-potable demand based on 0.25KL/day per unit (refer SCA MUSIC Modelling Guidelines); and
- Watering of grassed areas based on 0.0011KL/day/m² (refer Blacktown Council WSUD Guidelines).

Based on the above, the daily demand is proposed to be at 3.96KL/day for the dwelling /semi-detached dwellings and 8.55KL/day for the units based on 100m² of irrigation area per dwelling /semi-detached dwelling and 500m² irrigation area for the units. This has been included in the MUSIC model as detailed below.

It is assumed that direct connection will be made to the kerb or to the in-ground drainage infrastructure in the streets from the overflows of the rainwater tanks, which will eventually drain through the proposed on-site detention basin and then through the approved bio-retention basin.

The internal drainage will be designed to cater for 20-yr ARI storm event. All roof drainage will pass through a first flush device prior to discharging into the rainwater tanks. All roof gutters draining into the rainwater tanks will be fitted with leaf guards.

It is also envisaged that the approved bio-retention basin will have infiltration capabilities into the ground to increase the groundwater recharge and reduce the volume of runoff into the creek.

The results of the MUSIC modelling indicate that the yearly volume of runoff from the proposed development will be less than the yearly volume of runoff under existing

conditions. This result meets the requirement of Section 4.6.4 of the specification as tabulated below. Reference is made to the MUSIC model file for details.

Table 6.1 Water Balance Results

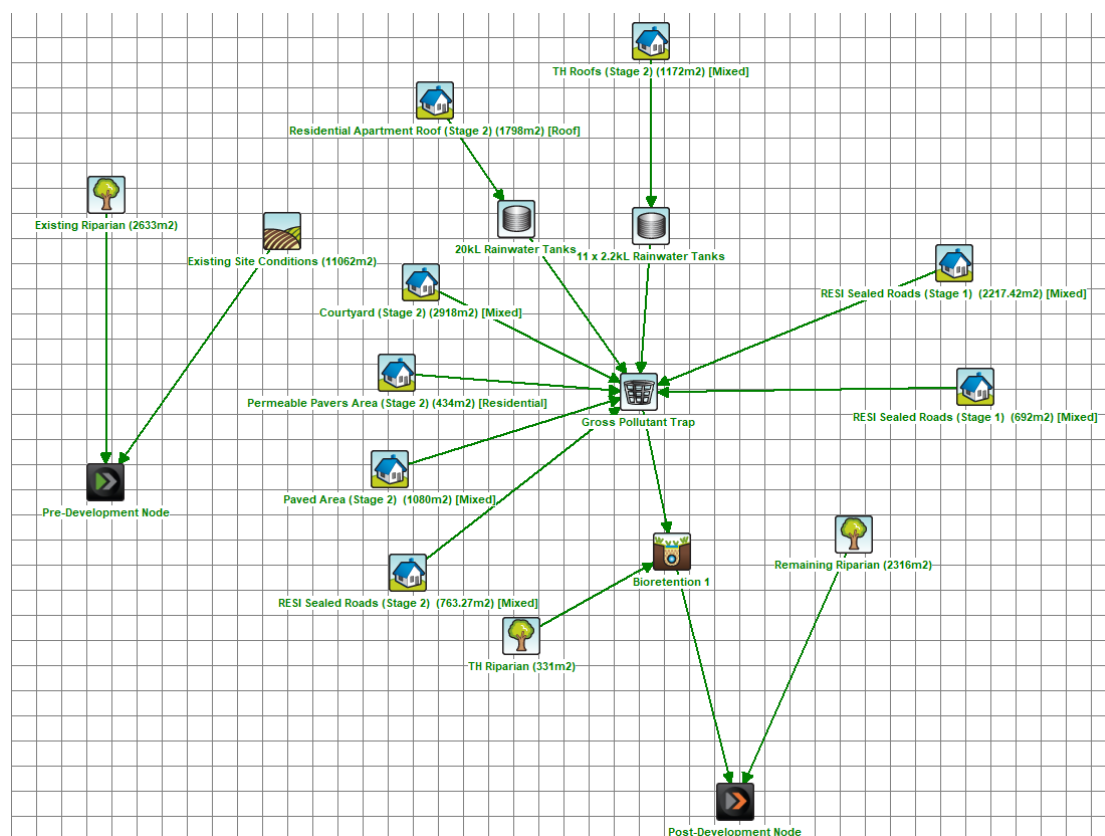
Site Condition	Site Runoff (ML/yr)	Residual Runoff (ML/yr)
Existing	7.08	7.08
Proposed	13.1	7.12

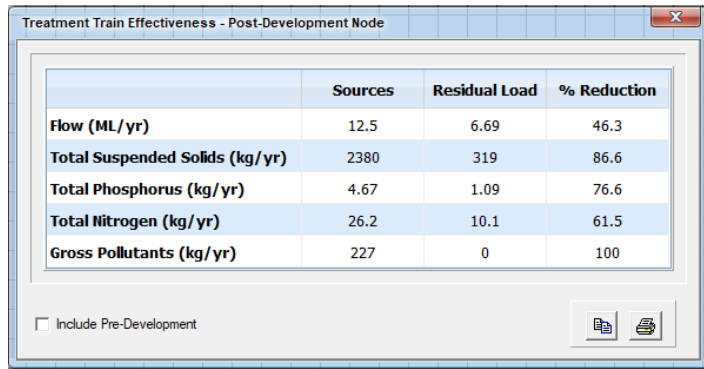
6.2 Assessment of Developed Conditions

A water balance model is prepared to assess the impacts of the proposed development on water quality downstream of the site. The model compares the post-developed site conditions to pre-development conditions based on soil conditions, land use, site coverage, etc....

A “MUSIC” model is assembled to assess the effectiveness of the proposed treatment measures.

The existing site is entered as a combination of “Agriculture” for the cleared area of the site and “Forest” for the riparian corridor in the base model and water quality discharges from the site are obtained to establish a benchmark.





	Sources	Residual Load	% Reduction
Flow (ML/yr)	12.5	6.69	46.3
Total Suspended Solids (kg/yr)	2380	319	86.6
Total Phosphorus (kg/yr)	4.67	1.09	76.6
Total Nitrogen (kg/yr)	26.2	10.1	61.5
Gross Pollutants (kg/yr)	227	0	100

☐ Include Pre-Development

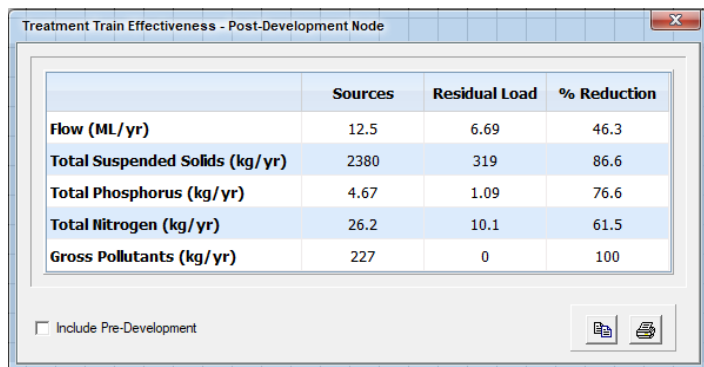
Figure 6-1 below shows the layout of the model.

The model is then modified to include all the proposed developed site conditions along with the treatment measures. The results of the water quality discharge are compared with the existing site discharges. A “no adverse impact” approach is adopted with respect to frequent flows.

The parameters adopted in the model are based on the recommendations included in the “Draft MUSIC Modelling Guidelines” by Sydney Metropolitan Catchment Authority.

Although not required in the WVWMS, we have adopted the current best practice of achieving the post-development pollutants’ load reduction as follows:-

- 85% reduction in Total Suspended Solids (TSS);
- 65% reduction in Total Phosphorus (TP); and
- 45% reduction in Total Nitrogen (TN).



	Sources	Residual Load	% Reduction
Flow (ML/yr)	12.5	6.69	46.3
Total Suspended Solids (kg/yr)	2380	319	86.6
Total Phosphorus (kg/yr)	4.67	1.09	76.6
Total Nitrogen (kg/yr)	26.2	10.1	61.5
Gross Pollutants (kg/yr)	227	0	100

☐ Include Pre-Development

Figure 6-1 MUSIC Model Layout

For the purpose of achieving a “No Adverse Impact” result, it is proposed to adopt a treatment train approach solution as follows:-

- Install a 2.2KL rainwater tank to every dwelling /semi-detached dwelling;
- Install a 20KL rainwater tank for the residential flat building;
- A Gross Pollutant Trap (GPT) on the upstream side of the bio-retention basin that drains the roads and the dwelling /semi-detached dwellings only to capture large

pollutants, litter and leaves type Vortcapture VC80 by Ocean Protect has already been installed under Stage 1 works; and

- A bio-retention basin as approved in council's consent N0611/16 to treat the stormwater runoff from the development is constructed under Stage 1 works. The basin is outside the 25m public riparian corridor (inside the 25m private corridor). The bio-retention basins has the following parameters:-

1. Bio Basin (Approved in N0611/16)
 - a. An overall surface area of 75m²;
 - b. A filter media area of 35m²;
 - c. A filter media depth of 0.5m;
 - d. Filter media to have a saturated hydraulic conductivity of 125mm/hr;
 - e. Exfiltration rate of 55mm/hr;
 - f. An extended water depth of 0.3m;
 - g. TN content of filter media no more than 400mg/kg;
 - h. Basin to be vegetated with effective nutrient removal plants; and
 - i. Basin to have underdrain subsoil lines.

The treatment measures above are detailed in the stormwater concept plans to be read in conjunction with this report. The approved bio-retention will also treat the runoff from Lorikeet Grove.

The results of the MUSIC simulations indicate that the proposed treatment train (including the approved bio-retention basin) approach adopted will reduce the pollutants load to less than pre-development conditions and meet the requirements of current industry best practice approach. Table 6.2 below summarises the results of the modelling.

Table 6.2 MUSIC Model Summary Results

Pollutant	Source Load (Existing)	Source Load (Proposed – no treatment)	Residual Load (after Treatment)	Effectiveness	Best Practice Objectives	Council Policy “No Adverse”
Flow (KL/yr)	7.08	12.5	6.69	46.3		Yes
TSS	604	2380	319	86.6	85	Yes
TP	2.51	4.67	1.09	76.6	65	Yes
TN	14.4	26.2	10.1	61.5	45	Yes
GP	30.8	227	0	100	90	Yes

6.3 WSUD Measures Operations and Maintenance

6.3.1 Gross Pollutant Trap (installed in Stage 1)

The gross pollutant trap is type VortCapture VC80 by Ocean Protect. The GPT has been installed under Stage 1 works.

The maintenance frequency of the gross pollutant trap is dependent on several variables, such as catchment area, surrounding land use, vegetation type, traffic loading and rainfall patterns. It is recommended that during the first year of operation the units should be monitored monthly, with maintenance as required.

Maintenance frequency should be adjusted to accommodate variable rainfall patterns. Regions east of the Great Dividing Range typically are dominated by greater rainfall during summer and Autumn Months, as such more maintenance is typically required during these periods. It is recommended that biannual inspections be carried out in November and April, while quarterly inspections should be conducted in February, April, July and November.

It is also recommended that additional monitoring should be conducted following moderate to extreme rainfall events, in particular when preceding months have had little to no rainfall. This monitoring is considered necessary to accommodate for higher volumes of runoff generated during major rainfall events, an anticipated greater accumulation of surface contamination during low rainfall periods and to ensure that the units have not been damaged due to high pipe velocities. Table 6.3 below indicates the recommended inspection and maintenance frequency.

Table 6.3 VortCapture Maintenance Frequency

Item	Period	Responsibility	Maintenance Procedure
Inspection – Minor Maintenance	3 monthly and after major storms	Maintenance Contractor	Follow recommended procedure set out in Stormwater 360 “Operation and Maintenance Guidelines”
Inspection – Major Maintenance	12 monthly except in case of spill	Maintenance Contractor	Follow recommended procedure set out in Stormwater 360 “Operation and Maintenance Guidelines”

Reference should be made to manufacturer’s specifications for inspection procedure, OHS, grates removal, cleaning methods, disposal of material and other procedures.

6.3.2 Bio-retention Basin (constructed in Stage 1)

As previously mentioned, there is one (1) basin approved in council’s consent N0611/16.

6.3.2.1 Elements of a Bio-retention basin

A bio-retention system includes the following components:-

- Vegetation: vegetation minimises surface clogging and assists in pollutant removal via biological processes;
- Extended detention (or ponding depth): it stores stormwater temporarily on the surface to buffer flows so that a greater volume can be treated;

- The filter media: it is the principal treatment zone. As stormwater passes through the filter media, pollutants are removed by filtration, adsorption and biological processes;
- A transition layer: it is a layer of clean well graded sand/coarse sand prevents the filter media from washing out of the system;
- The drainage layer: it is a layer of clean fine gravel which collects treated water at the base of the system and contains perforated pipes to convey treated water out of the system
- An impervious liner: required to prevent infiltration into surrounding soils, particularly if the treatment system is immediately adjacent to roads or buildings where infiltration may cause structural issues. Inlet and scour protection;
- An inlet for stormwater runoff. The inlet should be designed to protect the surface of the bio-retention system from scour and erosion;
- An overflow pit (or other controlled overflow point) to allow high flows, beyond the capacity of the treatment system, to escape to the stormwater drainage system in a controlled manner;
- A flushing point connected to the perforated pipes, so they can be cleaned in the event of blockage.
- Edge treatment (e.g. a raised kerb or series of bollards) may be required to protect the bio-retention system from traffic; and
- Pre-treatment is recommended when sediment loads are likely to be high, or if there is a risk of spills. The simplest option is to incorporate a pit with a sump immediately upstream of the bio-retention system.

6.3.2.2 Construction, Operation & Maintenance

During the construction phase, the approved bio-retention basins should be protected from high sediment loads associated with construction on site (erosion and sediment control measures should be in place to manage stormwater during this phase).

The commission of the bio-retention basins should not proceed or be brought on line until the civil works are completed and the catchment is stable (i.e. at least 80% of the housing construction is finished). Prior to this it should be used as a sedimentation device to manage the unstable upstream catchment.

Regular maintenance is important to ensure the ongoing performance of bio-retention systems. Maintenance requirements of bio-retention systems include:-

- Monitoring for scour and erosion, and sediment or litter build-up;
- Weed removal and plant re-establishment; and
- Monitoring overflow pits for structural integrity and blockage.

6.3.2.3 Inspection and Monitoring

Following construction, bio-retention basins should be inspected every 1 to 3 months (or after each major rainfall event) for the initial vegetation establishment period to determine

whether or not the bio-retention zone requires maintenance or the media requires replacement. The following critical items should be monitored: -

- Ponding, clogging and blockage of the filter media;
- Establishment of desired vegetation/plants and density; and
- Blockage of the outlet from the bio-retention system.
- After the initial establishment period (typically 1 to 2 years), inspections may be extended to the frequencies shown in Maintenance and Inspection Checklist for Bio-retention Systems.

6.3.2.4 Maintenance

If the bio-retention system is not maintained frequently, the entire filter media may need to be replaced due to clogging of the media material with fine particles. This can result in frequent maintenance being more cost effective in the long-term.

The following maintenance activities will be required with inspection frequencies shown in the Maintenance and Inspection Checklist: -

- Maintenance of flow to and through the system;
- Maintaining the surface vegetation;
- Preventing undesired overgrowth vegetation/weeds from taking over the area;
- Removal of accumulated sediments; and
- Debris removal.

The recommended maintenance frequency for the Bio-retention basins is included in Table 6.4 below.

Table 6.4 Bio-retention System Maintenance Frequency

Item	Period	Responsibility
Debris Cleanout	6 monthly	Maintenance Contractor
Trench Surface Vegetation	6 monthly	Maintenance Contractor
Dewatering	6 monthly	Maintenance Contractor
Outlet/Overflow pit	yearly	Maintenance Contractor

6.4 Maintenance Responsibilities

This section of the report outlines the responsibilities of the separate lots to maintain the respective OSD systems, the gross pollutants traps and bio-retention basins based on which measure services which respective lot.

For the purpose of this section, Lot 1 is identified as the aged care facility while Lot 2 is the residential development site. The following table identifies the responsibilities of each lot. It should be read in conjunction with the plan provided showing the location of the stormwater measures proposed for both lots.

Table 6.5 Maintenance responsibilities

Item	Location
GPT	In landscaped area at Lorikeet Grove bend – Stage 1 approved and installed
BIO- BASIN	In landscaped area at Lorikeet Grove bend – Stage 1 approved and constructed
RWT	In landscaped area of RFB fronting Lorikeet Grove – Stage 2
OSD2	Under ground floor deck of RFB fronting Lorikeet Grove – Stage 2
OSD3	Under private lane between RFB and townhouses – Stage 2

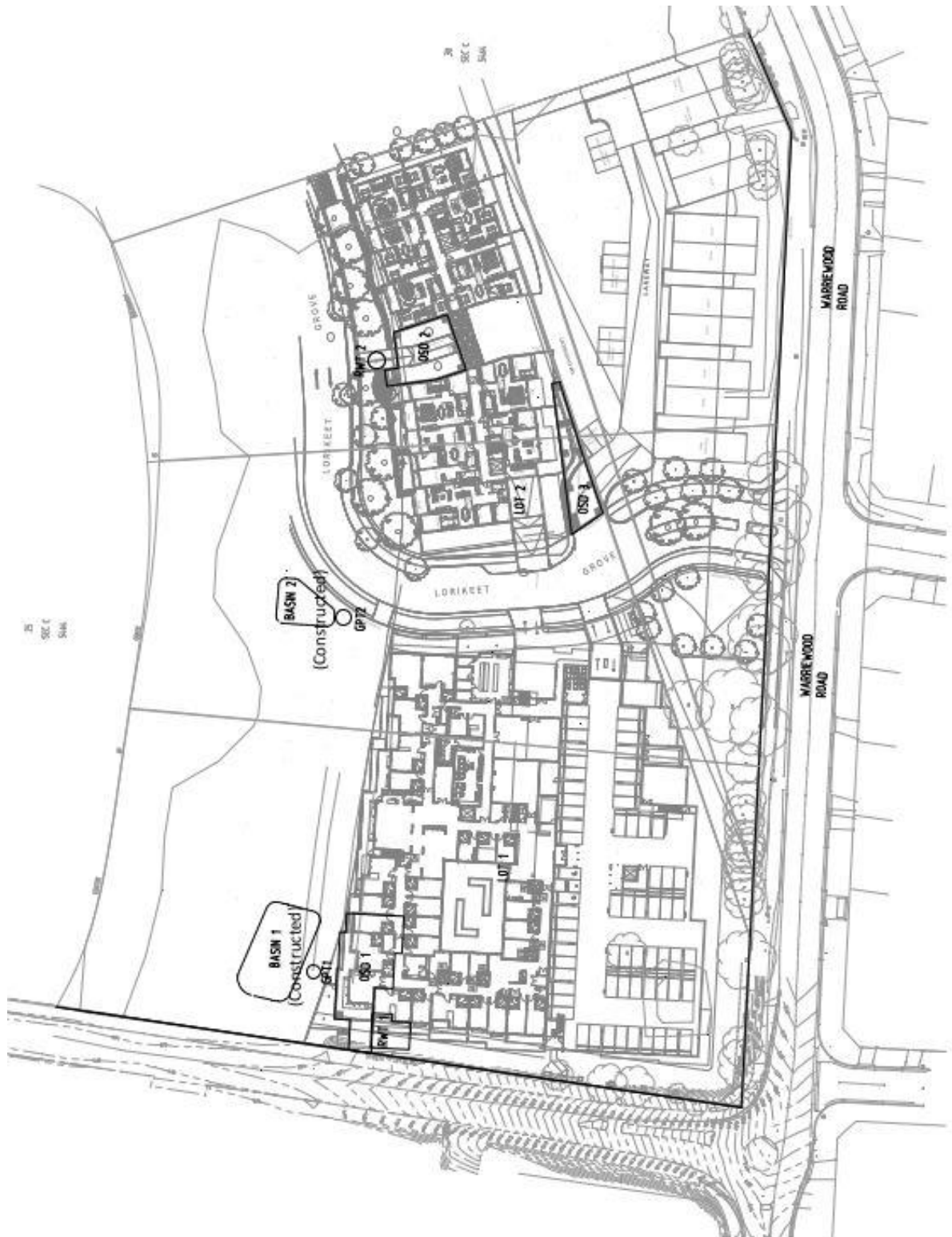


Figure 6-2 Location of stormwater measures

6.5 Construction Phase

A Soil and Water Management Plan (also known as an Erosion and Sediment Control Plan) is prepared to control the water quality discharge from the site during construction in accordance with Landcom's publication "Managing Urban Stormwater: Soils and Construction" (known as The Blue Book).

The objective of the plan is to provide temporary measures to be adopted by the contractor during construction. The measures will be monitored and controlled during the construction period. The maintenance and the operation of the measures will be the responsibility of the main contractor.

The effectiveness of the measures will be monitored during the construction period and reported on a monthly basis and after every noticeable rainfall event. Any incident of failure will also be reported and corrective action will be implemented where required.

The treatment measures proposed are detailed in drawing SW700. In summary, the following has been provided: -

- A silt fence is provided at the lower end of the site;
- A temporary all weather construction entry/exit point is provided off the end of Lorikeet Grove;
- Catch drains are provided to convey the "dirty" water to the sediment basin; and
- A sediment basin is proposed at the downstream side of the disturbed areas to collect and treat "dirty" water from the construction zone. The calculations of the storage capacity of the basin is done in accordance with the Blue Book and is shown below.

Project Name	ArCare-Warriewood				
Project Number	2016.0112				
(after DepHousing Blue Book)					
Sedimentation Basin	"Informal Area"				
5-day Rainfall Events (Table 6.5, Page 6-21)					
Station	Mona Vale	70th	75th	80th	90th
Rainfall Depth (mm)		0.0	29.0	0.0	0.0
Settling Zone					
Volumetric Runoff Coeff:	0.5 <<chosen, because a portion of site is stockpile				
Area	0.78 ha				
	Assuming Rainfall	70th	75th	80th	90th
Settling Zone (m ³)		0	113	0	0
TOTAL VOLUME					
Method 2:					
Assume Sedment Zone is	50% of Settling Zone (note minimum is 30% !!)				
	Assuming Rainfall	70th	75th	80th	90th
Settling + Sediment Zone		0	170	0	0 m ³
	RECOMMENDED	0	170	0	0 m ³

Figure 6-3 Sediment Basin Calculations

6.6 Preliminary Mosquito Risk Management

No permanent waterbodies have been proposed for this development therefore the risk of increasing mosquito activity is low. However, as part of the water quality management system that will be implemented consideration should be given to the potential for measures acting as pest mosquito breeding areas.

The approved bio-retention basin is not expected to contain storage for extended lengths of time. The pond is underlain with subsoil drains that will drain any water on the surface of the pond.

If the pond is properly constructed and maintained, there is a low risk that the pond will act as a mosquito habitat.

The flood storage pond is designed as a dry pond and will not hold any water permanently. The pond is also underlain with subsoil drainage that will ensure no ponding occurs after the floodwaters have receded below the invert of the pond.

At this stage, it is expected that the low risk of providing habitat for pest mosquitoes shall remain the same before and after the proposed works.

During the construction certificate stage, it is recommended that a specialist in this field undertake a further detailed mosquito risk assessment.

SECTION C – FLOOD PROTECTION

7 Watercourse & Creekline Corridor

7.1 Overview & Objectives

This section of the report addresses the requirements of Section 4.4 of the WVWMS. Because a large portion of the creek corridor is degraded, Council is seeking the upgrade of the creek corridor to, among other things, retain the pervious areas, preserve a water balance, provide a landscaping buffer, provide effective flood conveyance (1% AEP), provide a habitat and wildlife corridor and provide common link between open spaces.

For the purpose of this report, the creek line works are associated with the flood conveyance to ensure that the 50m wide public corridor is able to convey the flows generated from a 1% AEP storm event. Reference should be made to the landscaping reports and drawings for other corridor design aspects.

This report addresses the requirements of the creek widening works along the rear frontage of the site. The works are limited to the 25m public corridor on the side of the site only. No works are proposed within the opposing 25m corridor.

These works have been completed under Stage 1 works as per the requirements of the Office of Water and Northern Beaches Council.

7.2 Existing & Design Conditions

The existing creek line has been surveyed by SDG (ref. 6952/B dated 13/05/2016). From the above documents, cross sections at 20m intervals have been prepared (refer SGC civil drawings for details).

7.3 Design Flow Conditions

The WVWMS provides the peak design flows for the 100-yr in 2-hr storm duration which were derived using RAFTS model (XP Solutions).

As previously advised the site is located in Sector D. The peak design flow rates provided in Appendix B of the WVWMS are tabulated below.

Table 7.1 Peak Design Flows – WVWMS

Sector	PMF		1% AEP		2% AEP		5% AEP		20% AEP		50% AEP	
	u/s m3/s	d/s m3/s	u/s m3/s	d/s m3/s	u/s m3/s	d/s m3/s	u/s m3/s	d/s m3/s	u/s m3/s	d/s m3/s	u/s m3/s	d/s m3/s
D	180.5	193.5	39.6	42.2	32.3	34.5	24.1	25.6	12.8	13.5	5.7	6.2

The narrow creek line is upgraded to convey the 50% AEP up to the top of the batters, while the 50m wide corridor is sized to cater for the 1% AEP flows.

Because the site falls towards the upstream end of the sector, a peak design flow of 6.2m³/s is adopted to size the bank full section of the creek. A design peak flow of 42.2m³/s is required to be carried in the creek corridor. Refer to Section 8 for flood conveyance and protection details.

7.4 Creek Design (Construction Completed in Stage 1)

The works associated with the widening of the creek corridor have been completed in Stage 1 works and approved by Council. The information relating to the design are included for reference only and as such marked with a green text.

An average overall creek corridor width of 50m is adopted across the length of the site frontage. The widening and the trimming of the creek line corridor are shown in the civil drawings, which provide for a long section and cross sections at 20m intervals.

On average, the width of the narrow creek has been widened by 10m towards the site. Sections at 20m intervals have been provided showing the proposed changes between the existing and the proposed levels.

The following batters have been adopted in the design of the creek corridor: -

- 1V:3H maximum for the batters of the narrow creek carrying the 50% AEP flows (bank full section);
- 1V:6H maximum for the remaining width of the public corridor; and
- 1V:8H batters are proposed beyond to raise the site area above the FPL and provide flood free development site.

Reference should be made to the civil drawings for more details and to the landscaping design for all other requirements such as vegetation, cycleways, footpaths and pedestrian links.

7.5 Discharge Point (Construction Completed in Stage 1)

The works associated with the discharge of stormwater into the creek have been completed in Stage 1 works and approved by Council. The information relating to the design are included for reference only and as such marked with a green text.

The stormwater discharge point from the site is into the creek corridor. Reference is made to the WAE stormwater drawings for details.

An all-weather stabilised discharge point has been constructed. The location of the discharge arrangement is within the 25m public corridor and is separated to the existing discharge point for the constructed aged care building.

The discharge is stabilised through a natural rock mattress made of rock boulders sunk 200mm into the ground similar to outlet control structure by the Office of Water.

8 Flood Study (Stage 1)

8.1 Narrabeen Creek

The flood study has been already approved by Council under Stage 1 works and DA N0611/16. The inclusion of this section is only for completeness in accordance with the water management specification and as such has been marked with a green text.

Narrabeen Creek is a natural watercourse draining a catchment area of 354ha approximately upstream of the study area.

The creek originates approximately 1.5km to the West and flows in a northerly direction to the confluence of Mullet Creek and then discharges in Narrabeen Lagoon.

Narrabeen Creek forms part of the Warriewood Valley creek system which also includes Fern Creek and Mullet Creek.

8.2 Objectives

The purpose of this flood study is to determine if the proposed subdivision and development platform will impact the flood levels and will propose the mitigation measures to negate the impact.

In summary, the objectives are as follows: -

- Use the existing TUFLOW model obtained from Council to develop a post-development model that can be used to predict the magnitude and extent of future flood events;
- Define design flood levels, velocities and depths for the catchment;
- Define the extent of flooding for the 100-year and the PMF for the catchment to establish a benchmark;
- Determine if the proposed development has any impact on the flooding; and
- Propose mitigation measures (i.e. creek widening works) to negate the impacts and provide post-development modelling to verify the mitigation measures.

8.3 Authorities' Requirements

Northern Beaches Council (Pittwater) requirements for development on flood prone land are detailed in DCP 21 Section B. Any development in the Warriewood Valley is also affected by additional requirements included in the "Warriewood Valley Urban Land Release Water Management Specification".

Council's Floodplain Management Engineer has provided Council's specific requirements for subdividing and developing the site as outlined below.

8.3.1 Flood Assessment Analysis

A typical Flood Assessment Analysis should include (but not limited to) the following details:

- Determine and detail whether the development is located either wholly or partially on land being within an area classified as a flood prone in a 1% AEP flood event;
- Determine and detail whether the development (as a whole or partially) is located on land that can conceivably be affected by a probable maximum flood (PMF) level;
- Detail the flood characteristics of the site; hazard, hydraulic classification, depth, velocity, direction and the impact this may have on the proposed development;
- For non-residential development - detail the main use and number of occupants in the building/development, hours of operation and proposed traffic usage/movement; and
- For Major Overland Flow Paths, the Flood Assessment is to outline/map the 5m horizontal buffer (placed horizontally on the 1% AEP Major Overland Flow extent).

8.3.2 Assessment of Impacts

This section must state compliance with Part B3 (Hazard Controls) of the Pittwater 21 DCP and should include (but not limited) to the following: -

- Detail on how the flood affected land is to be sited and designed to minimise the impacts of flooding on the property with regards to the existing flood regime up to the PMF;
- There is no additional adverse flood impact on the surrounding properties or flooding processes for any flood event up to the Probable Maximum Flood event;
- There is no net decrease in the floodplain volume of a floodway or flood storage area within the property for any flood event up to the 1% AEP flood event;
- The impact that that development has to surrounding properties (with regard to flooding) needs to be detailed up to the PMF;
- Explain how the work will not reduce flood storage area or impact upon the existing flood regime (including calculations);
- Ensure and explain that the habitable storeys (floor level) of the building are set at or above the Flood Planning Level (shown in written form and diagrammatically);
- Determine if fences are included in the plans for the development and identify any impacts this will have on the existing flood regime;
- Detail how buildings or works are to be affected by flooding and how this can be mitigated through the use of flood compatible building materials;
- If there are any adverse impacts on surrounding sites, upstream or downstream, this must be detailed;
- On occasion, high flood volume and flow may cause movement of vehicles or other large objects. Devices such as bollards and gates can be installed to activate in the

event of such a flood and if these are required, they need to be detailed;

- If any hazardous materials are to be stored on-site, details must be made as to their location and the affect they may have if a flood occurs; and
- Ensure consistency with Australian Standards and the New South Wales Floodplain Development Manual.

8.3.3 Evacuation Procedures

This section of the Flood Management Report should contain the following information at the very least: -

- Evidence must be provided that the development provides an evacuation route that is flood free up to the PMF or an area to shelter in the event of a flood. If shelter-in-place is the only alternative, details must be provided that show the structural integrity of the building up to the level of the PMF (i.e./ show that the shelter can withstand the hydraulic forces of the PMF flood event); and
- If an evaluation plan is reposed a Draft Evacuation Plan containing the following is required: -
 - a. Route of evacuation to higher ground/shelter;
 - b. Depth of water for a PMF surrounding the building;
 - c. Details of the 'last chance' evacuation water levels/times for evacuation prior to floodwaters surrounding the building;
 - d. Details of flood warning systems and protocols; and
 - e. Details of how this information will be disseminated amongst users of the property.

8.3.4 Mitigation Measures

This section is used to outline and detail all the preventative measures used to assist the site and users of the site in the event of a flood. This includes flood compatible materials and is at the discretion of the applicant.

If flood mitigation works that modify a major drainage system, stormwater system, natural water course, floodway or flood behaviour within the development site the flood risk report needs to demonstrate the following: -

- The flood mitigation works do not have an adverse impact on any surrounding property or flooding processes for any flood event up to the Probable Maximum Flood event;
- The flood mitigation works result in no net decrease in the floodplain volume of a floodway or flood storage area within the property for any flood event up to the 1% AEP flood event;
- The flood mitigation works result in the protection of the existing and proposed development from a flood event to the minimum floor level requirement as defined in this control; and
- The works do not have an adverse impact on the environment. (This includes but is not limited to the altering of natural flow regimes, the clearing of riparian

vegetation, artificial modification of the natural stream, such as by relocation, piping etc.).

8.4 Design Flood Modelling

8.4.1 Introduction

A copy of the TUFLOW model was purchased from Council which formed the base for our flood modelling. The runs in the model were used as the base models for additional runs carried out to include the proposed development (i.e. fill platforms on site, creek works, etc...).

Two scenarios were prepared as part of this flood impact assessment. The scenarios are as follows: -

- Scenario 0: Existing Site Conditions. This scenario is basically the flood modelling that Council has undertaken and establishes the base case scenario and a benchmark for any development on site; and
- Scenario 1: Proposed Site Conditions. This scenario is based on the fully developed site conditions inclusive of the creek corridor works.

The modelling includes the upgrade of McPherson Street as provided by Council. The modelling takes into account the raising of the road levels, the upgrade of the existing 3x1200mm pipes crossing under the road and the new 9x3.6x1.2m culverts.

8.4.2 Design Flood Modelling Results

Design flood modelling was undertaken for the 5, 10, 20, 50 & 100-year ARI standard design flood event and the PMF. Modelling was also carried out for the 20-year and the 100-year ARI inclusive of Climate Change considerations which involves the increase in rainfall by 30% and rise in sea level by 0.9m by year 2100 due to the proposed intensification of the site.

The modelling was undertaken for the critical durations of 120min and 9hr as per the flood modelling report by BMT WBM, which identified the 2-hr storm as the critical duration for all the storms up to the 10% AEP and the 2% AEP and the 9hr storm as the critical duration for the 5% AEP and the 1% AEP inclusive of Climate Change and the PMF events.

The results for the 100-year ARI event including climate change and the PMF are presented in Appendix 4 of this report.

8.5 Flood Mitigation

The modelling results indicate that the proposed development and the completed creek widening works do not have any adverse impact on the flooding in the Narrabeen Creek.

The creek corridor has been modified in accordance with the requirements of Section 4.4 of the WVWMS. The narrow creek section has been widened to convey the 50% AEP flows with side banks with maximum batters at 1V:3H. The 1% AEP flows are contained within the 50m

wide corridor which is capable of conveying the flows without having an impact on downstream and upstream flood levels.

The mitigated post-development site conditions is modelled and the results are included in Appendix 4. Flood impact maps are produced for the 100-yr +CC and the PMF events to verify that the flood levels and the flood conveyance in the creek is generally unchanged after the works have been completed with the exception of a small and localised rise in flood levels confined to the creek corridor.

8.6 Discussion

8.6.1 Flooding Assessment Analysis

Mainstream flooding occurs within the site when the capacity of Narrabeen Creek is exceeded. The 1% AEP flood level for the site is RL 3.79m AHD and the PMF flood level is RL 4.88m AHD. The flooding is classified as Category – High Hazard.

This flood level is mainly due to the increase in rainfall volume by 30% across the upstream catchment because of the Climate Change considerations.

The Flood Planning Level (FPL) adopted for the dwellings /semi-detached dwellings is **RL 4.29m AHD**, which achieves 0.5m above the 100-year ARI flood level inclusive of Climate Change considerations.

Determine and detail whether the development is located either wholly or partially on land being within an area classified as a flood prone in a 1% AEP flood event;

The proposed development is separated from the creek by Lorikeet Grove extension and is wholly outside the 1% AEP flood extent.

Determine and detail whether the development (as a whole or partially) is located on land that can conceivably be affected by a probable maximum flood (PMF) level;

The proposed development is wholly outside the PMF flood extent because the proposed levels on Lorikeet Grove are at or above the PMF flood level.

Detail the flood characteristics of the site; hazard, hydraulic classification, depth, velocity, direction and the impact this may have on the proposed development;

The flood characteristic details of the site area have been determined and mapped in Appendix 4. As the proposed development is outside the flooding extents, there is no impact on the flooding behaviour.

For Major Overland Flow Paths, the Flood Assessment is to outline/map the 5m horizontal buffer (placed horizontally on the 1% AEP Major Overland Flow extent).

This requirement is not applicable for this site.

8.6.2 Assessment of Impacts

The site finished levels are raised above the PMF and the 100-yr flood level with 500mm freeboard for the residences as required in Part B3 (Hazard Controls) of the Pittwater 21 DCP. The residences levels including the ground floor units in the RFB vary across the site with the lowest being at RL 6.20m AHD.

The comparison of the modelling results between existing and post-development scenarios indicate that there are no flooding impacts within the creek corridor and no adverse impacts on surrounding properties. The flood impact maps demonstrate that the flooding is reduced approximately everywhere in the surrounding areas.

In the 100-yr event + CC, the adverse impacts are nil as can be shown in the flood maps (refer Figure A 4.14). There are no adverse impacts on any developable land in the floodplain.

In the PMF event, there are no adverse impacts as well. Due to the large coverage of the flooding in this event, the impacts of the proposed changes are absorbed in the floodplain and the impact maps do not show any rise in flood levels across the floodplain (refer Figure A 4.15).

Reference is made to the flood impact map in Appendix 4. The results indicate that the proposed development does not cause a decrease in the flood storage in the 1% AEP flood event. As such, the proposed development should not increase the flood hazard or risk to other properties. There is no upstream afflux created by this development indicating that the loss of flood storage due to the development of the site is negligible.

Based on the above, we believe that these results should be acceptable to Council as the proposed development does not adversely impact on the adjoining properties.

Detail on how the flood affected land is to be sited and designed to minimise the impacts of flooding on the property with regards to the existing flood regime up to the PMF;

The flood affected land is re-graded as required in the WVWMS so that the flood extents up to the PMF event are contained within the creek corridor and do not impact on the proposed development.

There is no additional adverse flood impact on the surrounding properties or flooding processes for any flood event up to the Probable Maximum Flood event;

The modelling has been undertaken for the pre- and the post-developed scenarios. The flood impact maps are included in Appendix 4 for reference. There are no adverse impacts.

There is no net decrease in the floodplain volume of a floodway or flood storage area within the property for any flood event up to the 1% AEP flood event;

The flood impact map for the 1% AEP (Figure A 4.14) demonstrates that there is no net decrease in floodplain volume because there is no increase in flood levels.

The impact that that development has to surrounding properties (with regard to flooding) needs to be detailed up to the PMF;

The flood impact map for the PMF (Figure A 4.15) demonstrates that there is no net decrease in floodplain volume because there is no increase in flood levels.

Explain how the work will not reduce flood storage area or impact upon the existing flood regime (including calculations);

The flood extent does not encroach substantially into the site, specifically where the development is proposed. The completed creek works provide additional flood conveyance and storage volumes such that the flood levels are not impacted elsewhere in the floodplain. This has been modelled in the TUFLOW model supplied by Council and pre- vs post- site conditions maps have been provided to substantiate these changes.

Ensure and explain that the habitable storeys (floor level) of the building are set at or above the Flood Planning Level (shown in written form and diagrammatically);

The proposed development is set at RL 6.20m AHD. This level is above the PMF flood level of the site (4.88m AHD). Reference is made to the architectural plans and the civil plans for level details.

Determine if fences are included in the plans for the development and identify any impacts this will have on the existing flood regime;

The fences around the perimeter of the site are above the PMF flood level and have no impact on the flooding regime.

Detail how buildings or works are to be affected by flooding and how this can be mitigated through the use of flood compatible building materials;

This requirement is not applicable as the proposed development is above the PMF flood level.

If there is any adverse impacts on surrounding sites, upstream or downstream, this must be detailed;

This requirement does not apply because there are no adverse impacts.

On occasion, high flood volume and flow may cause movement of vehicles or other large objects. Devices such as bollards and gates can be installed to activate in the event of such a flood and if these are required, they need to be detailed;

This requirement does not apply because the roads and the development are above the predicted flood levels even in extreme storm events.

If any hazardous materials are to be stored on-site, details must be made as to their location and the affect they may have if a flood occurs; and

This requirement does not apply because there is no storage of hazardous material proposed on this site.

Ensure consistency with Australian Standards and the New South Wales Floodplain Development Manual.

This requirement has been addressed in the flood modelling.

8.6.3 Evacuation Procedures

This section of the report contains information relating to the proposed off-site evacuation.

Evidence must be provided that the development provides an evacuation route that is flood free up to the PMF or an area to shelter in the event of a flood. If shelter-in-place is the only alternative, details must be provided that show the structural integrity of the building up to the level of the PMF (i.e./ show that the shelter can withstand the hydraulic forces of the PMF flood event); and

Because the site is set above the PMF flood level, then the proposed development is not subject to flooding in any event. This indicates that evacuation will not be required for this development.

The proposed residential development is above the PMF flood level so there is no need for evacuation as dwelling /semi-detached dwellings are considered flood free.

The constructed extension to Lorikeet Grove provides levels above the PMF flood level and can be used for evacuation during extreme flood events such as the PMF. Lorikeet Grove connects to Warriewood Road which is raised even further above the flood levels. The site can be classified as “Areas with Rising Road Access (RRA)” as labelled under the “Flood Emergency Response Planning – Classification of Communities”.

If an evaluation plan is reposed a Draft Evacuation Plan containing the following is required: -

Route of evacuation to higher ground/shelter;

Depth of water for a PMF surrounding the building;

Details of the ‘last chance’ evacuation water levels/times for evacuation prior to floodwaters surrounding the building;

Details of flood warning systems and protocols; and

Details of how this information will be disseminated amongst users of the property.

As stated above, the above requirements do not apply.

Pittwater Council’s DCP 21 sets some controls for land uses on flood prone land as follows:-

- A site emergency response flood plan must be prepared in case of a PMF flood;
- Adequate flood warning systems, signage and exists must be available to allow safe

and orderly evacuation without increased reliance upon the State Emergency Services (SES) or other authorized emergency personnel; and

- Reliable access for pedestrians or vehicles must be provided from the building, commencing at a level equal to the lowest habitable floor level to an area of refuge above the PMF.

8.6.4 Mitigation Measures

The flood mitigation works do not have an adverse impact on any surrounding property or flooding processes for any flood event up to the Probable Maximum Flood event;

The mitigation measures involve creek works to increase the conveyance and the storage of flood in the creek corridor along the rear of the site which have been completed under Stage 1 works. The works have been coordinated with the completed upgrade of McPherson Street and the new culverts/bridges. The creek design is also sympathetic with the proposed design for 29-31 Warriewood Road upstream of the site. These works have been taken in the modelling of the post-development scenario and the water level change has been mapped. The results indicate that there are no adverse impacts elsewhere in the floodplain.

The flood mitigation works result in no net decrease in the floodplain volume of a floodway or flood storage area within the property for any flood event up to the 1% AEP flood event;

This has been assessed and the flood impact maps demonstrate that this requirement has been met. We have addressed this requirement in previous sections of this report.

The flood mitigation works result in the protection of the existing and proposed development from a flood event to the minimum floor level requirement as defined in this control; and

This requirement has been complied with in full. The habitable levels across the development have been raised above the PMF flood levels.

The works do not have an adverse impact on the environment. (This includes but is not limited to the altering of natural flow regimes, the clearing of riparian vegetation, artificial modification of the natural stream, such as by relocation, piping etc.).

The requirements of the WVWMS have been implemented with regards to creek corridor design. There are no alterations to the natural regime or any modification proposed that is in contradiction to the WVWMS.

8.7 Conclusions

A detailed investigation on the flooding behaviour has been undertaken in the vicinity of 25-27 Warriewood Road, Warriewood.

A detailed 1D/2D hydraulic model was established based on the TUFLOW model prepared by Council.

Using the established model, the study has determined the flood behaviour for the 1% AEP design flood including Climate Change. The primary flood characteristics reported for the

design events considered include depths, levels and velocities. The study has also defined the Provisional Flood Hazard for flood-affected areas.

The study looked into the impact of the proposed development on the flooding behaviour in the creek and its impact on the flood levels both upstream and downstream.

Mitigation measures have been completed under Stage 1 to eliminate the adverse impact of the proposed residential development on flood characteristics. These are detailed in the engineering plans and in Section 7.4 of this report.

The flood maps are included under Appendix 4.

SECTION D – WATER QUANTITY

9 Water Quantity Management

9.1 General

The water quantity criteria is expressed as follows in the WVWMS: -

“Post-development peak flows both from the sector and in the channel at the downstream boundary of each sector are not to exceed the pre-development flows for the full range of duration's and frequencies up to the 1% AEP level.”

The design of the water quantity measures will cater for all rainfall events including the climate change requirements, which require the increase in average rainfall depth of 30% as required by Council.

9.2 Piped Drainage

The internal drainage design adopts the minor/major design approach. The piped drainage infrastructure is designed to cater for 5% AEP storm event inclusive of the 30% increase in rainfall to comply with the Climate Change requirements. The road network carries the flows from the storms in excess of the piped drainage capacity to the OSD.

Reference is made to the stormwater drawings for details.

9.3 On-Site Detention

The details of the proposed On-Site Detention (OSD) are as follows: -

- The reduction of post development discharge flows to the flows nominated in the WVWMS for the 1% AEP 30, 60, 120, 180 & 360 minutes durations. In order to achieve this outcome, it is proposed to provide On-Site Detention (OSD) systems;
- The site is split into two (2) separate catchment areas. The proposed apartments area of the development is identified as catchment 3 and the dwelling/semi-detached dwellings area is catchment 2. Catchment 2 drains into OSD 2 and catchment 3 into OSD 3;
- The catchment areas for OSD 2 & OSD 3 are 0.437ha and 0.2098ha respectively; and
- The catchments have been modelled as follows: -
 - a. No seepage allowed from the OSD tanks;
 - b. 100% Pervious for the existing site conditions;
 - c. 60% (averaged) impervious for the dwelling /semi-detached dwellings site; and
 - d. Manning's roughness adopted 0.08 for pervious and 0.02 for impervious.

Table 9.1 Site Catchment Area

Catchment	Area (ha)	Impervious Fraction (%)	Slope (%)
2	0.437	46.6	4.9
3	0.2098	73.4	4.9

9.4 Council requirements

Council has determined the detention requirements on a sector-by-sector basis using a RAFTS model. The model outlines the minimum storage requirements, the permissible site discharge, the maintenance of the base case hydrograph and use of the Australian Rainfall & Runoff.

Based on the site area, the specific council requirements for the development are reported in the table below.

Table 9.2 Detention Requirements – WVVMS

Sector	SSR (m3/ha)	1%-30min PSD (L/s/ha)	1%-1hr PSD (L/s/ha)	1%-2hr PSD (L/s/ha)	1%-3hr PSD (L/s/ha)	1%-6hr PSD (L/s/ha)
D	368	138	226	230	187	205

Based on Table 9.2 above, the site specific detention requirements are calculated for each catchment and reported in Table 9.3.

Table 9.3 Detention Requirements – Site Specific

Catchment	Site Area (ha)	SSR (m3/ha)	1%-30min PSD (L/s)	1%-1hr PSD (L/s)	1%-2hr PSD (L/s)	1%-3hr PSD (L/s)	1%-6hr PSD (L/s)
2	0.437	160.82	60.31	98.762	100.51	81.719	89.585
3	0.2098	77.20	28.9	47.4	48.3	39.2	43

9.5 Modelling

An XP-STORM Model has been prepared to simulate the site stormwater discharge and to size the OSD system that is suitable for the development and at the same time respond to Council requirements as per the above tables.

XP-STORM is a hydrology and a hydraulic software package by XP Solutions the providers of XP-RAFTS. Both softwares use the same hydrology method (Laurenson) and would ultimately provide similar peak discharge results. We note that XP-STORM is more suited for sizing OSD basins because it incorporates a hydraulic component which RAFTS does not. From our discussions with engineers from XP Solutions is that RAFTS should not be used for modelling

OSD basins in their opinion and they have been advising engineers not to use the software for any hydraulic modelling.

The difference between the STORM model by SGC and the RAFTS model prepared by Council is that the STORM model considers the increase in rainfall of 30% due to Climate Change. Hence the results of the STORM simulations may produce slightly different results to those proposed in the WVVMS by Council and more OSD volume is potentially provided.

The modelling results are tabulated below. The results are for the 1% AEP event for a range of storm durations as per the WVVMS.

Table 9.4 XP-STORM Model Results – Summary

Catchment	Volume (m3)	1%-30min Q (L/s)	1%-1hr Q (L/s)	1%-2hr Q (L/s)	1%-3hr Q (L/s)	1%-6hr Q (L/s)
2	157.442	48	55	58	57	56
3	97.74	24	36	42	39	40

Council requires that the pre-development hydrograph and the post development hydrograph be shown. The figures in Appendix 3 show the post-development site discharge hydrographs in comparison with the pre-development discharge flows.

The results indicate that the proposed on-site detentions achieve the requirements of the WVVMS as follows:-

- The OSD volumes are achieved; and
- The permissible site discharges are met.

A1 Appendix 1

Checklist

Figure A 1.1 Completed DA Checklist

Pittwater Council

Lawson & Treloar Pty Ltd

DOCUMENTATION CHECKLIST - DEVELOPMENT APPLICATION

(Detach and include with submissions)

Section	Item	Requirement	Check (✓)
4.1	Water Cycle Assessment - Water Balance Modelling Pre & Post Development	+++++++	✓
4.1.1	Stream Gauging, infiltration testing and use of local rainfall data for modelling	*****	✓
4.2.1	Water Quality Monitoring Plan	*****	✓
4.2.1	Water Quality Monitoring Sites Shown on Plan (at least three)	*****	✓
4.2.1, 2, C	Water Quality Monitoring Data	*****	✓
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data	*****	✓
4.2.1, 2, C	Assessment and interpretation of water quality monitoring data from SQID's		
4.3	Water Quality Management Assessment - Load Modelling Pre and Post Development	+++++++	✓
4.3.1, 3	Justification of assumptions for Event Mean Concentrations	*****	✓
4.3.2	Identification of and details for Stormwater quality facilities	*****	✓
4.3.2, 4.4.5	Mosquito Risk Assessment for both Watercourse and Water Quality/Quantity features	*****	✓
4.3.6, 4.6.5	Inspection and Cleaning Reports for SQID's and OSD		
4.3.6	Management Plan for Stormwater Quality Improvement Devices	*****	✓
4.3.5	Environmental Management Plan (Soil and Water Aspects)		
4.3.4	Erosion and Sediment Control Plan		
4.4.3, 4.5	Existing and Proposed Creek Corridor in plan with cross/long sections with flood levels	**Note 1**	✓
4.4.4	Proposed Creek Corridor Planting Schedule	***Note 1***	✓
4.4.5	Creek Corridor Vegetation Monitoring and Management Plan	Note 1	✓
4.4.5	Vegetation and Creek Maintenance and Monitoring Reports		
4.5	Flood Analysis – existing and design conditions		✓
4.5.2	Compliance of structures and creek corridor with flood planning levels	*****	✓
4.5.4	Details of Interim Flood Protection Works	*****	✓
4.6.3	Design Storm Hydrological Modelling of Site - Pre and Post Development	+++++++	✓
4.6.3	On-Site Detention Facilities	*****	✓
4.6.4	Stormwater Retention Facilities	*****	✓
4.7	Stormwater Concept Drainage Plan	*****	✓

KEY:

*****	Preliminary Calculations/Assessment Required	*****	Work as Executed Plans
*****	Concept Design Required	*****	Required/Reviewed/Updated
*****	Detailed Assessment/Calculations/Design	*****	Not required

Note 1 Even if the works are not to be constructed by the Applicant on the land to be transferred to Council under the Material Public Benefit Option in the Section 94 Plan, preliminary investigation for Rezoning and concept design at DA stage is required

Completed by Principal Certifier:

Name: SAM HADDAD
 Title: DIRECTOR - CIVIL
 Organisation: SGC CONSULTANTS P/L
 Signature: [Signature]
 Date: 01/05/2020

Figure A 1.1 Completed DA Checklist

A2 Appendix 2

Rainfall Data

Figure A 2.1 IFD Chart (Northern Beaches Council – Pittwater)

Figure A 2.2 IFD Table (Northern Beaches Council – Pittwater)

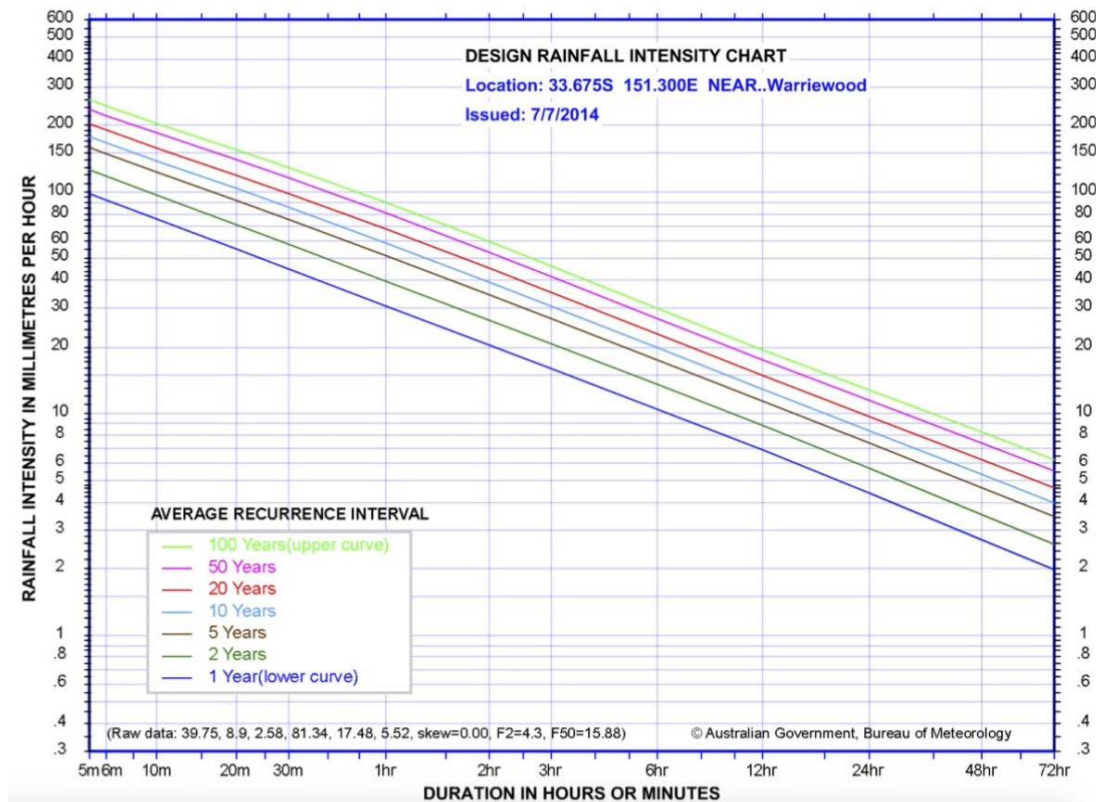


Figure A 2.1 IFD Chart (Northern Beaches Council – Pittwater)

Intensity-Frequency-Duration Table

Location: 33.675S 151.300E NEAR.. Warriewood Issued: 7/7/2014

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval							
Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	98.5	126	159	178	203	236	261
6Mins	92.2	118	149	167	191	221	245
10Mins	75.6	96.9	123	138	158	185	204
20Mins	55.3	71.2	91.6	104	119	140	155
30Mins	44.9	58.1	75.2	85.3	98.4	116	129
1Hr	30.6	39.6	51.7	58.9	68.2	80.5	89.8
2Hrs	20.4	26.4	34.4	39.2	45.4	53.5	59.8
3Hrs	16.0	20.7	26.9	30.6	35.3	41.6	46.4
6Hrs	10.5	13.6	17.5	19.9	22.9	26.9	29.9
12Hrs	6.87	8.86	11.4	12.9	14.9	17.5	19.4
24Hrs	4.39	5.68	7.39	8.40	9.72	11.5	12.8
48Hrs	2.70	3.51	4.64	5.33	6.21	7.38	8.28
72Hrs	1.98	2.58	3.44	3.96	4.63	5.52	6.20

(Raw data: 39.75, 8.9, 2.58, 81.34, 17.48, 5.52, skew=0.00, F2=4.3, F50=15.88)

© Australian Government, Bureau of Meteorology

Figure A 2.2 IFD Table (Northern Beaches Council – Pittwater)

A3 Appendix 3

Pre vs Post Outflow Hydrographs

Figure A 3.1 Catchment 2 – 1% AEP-30mins

Figure A 3.2 Catchment 2 – 1% AEP-60mins

Figure A 3.3 Catchment 2 – 1% AEP-120mins

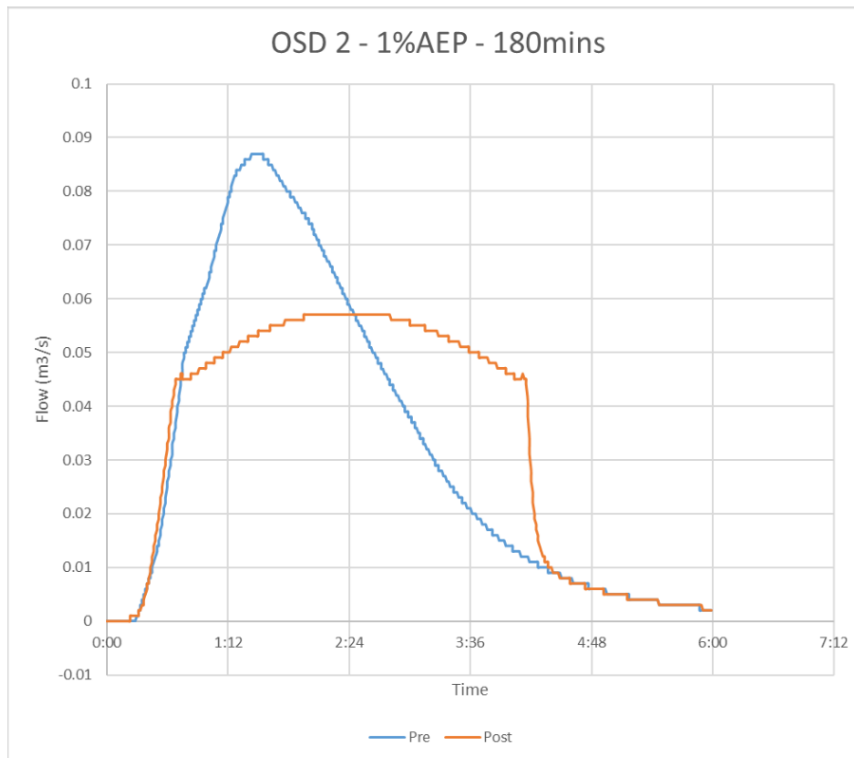


Figure A 3.4 Catchment 2 – 1% AEP-180mins

Figure A 3.5 Catchment 2 – 1% AEP-360mins

Figure A 3.6 Catchment 3 – 1% AEP-30mins

Figure A 3.7 Catchment 3 – 1% AEP-60mins

Figure A 3.8 Catchment 3 – 1% AEP-120mins

Figure A 3.9 Catchment 3 – 1% AEP-180mins

Figure A 3.10 Catchment 3 – 1% AEP-360mins

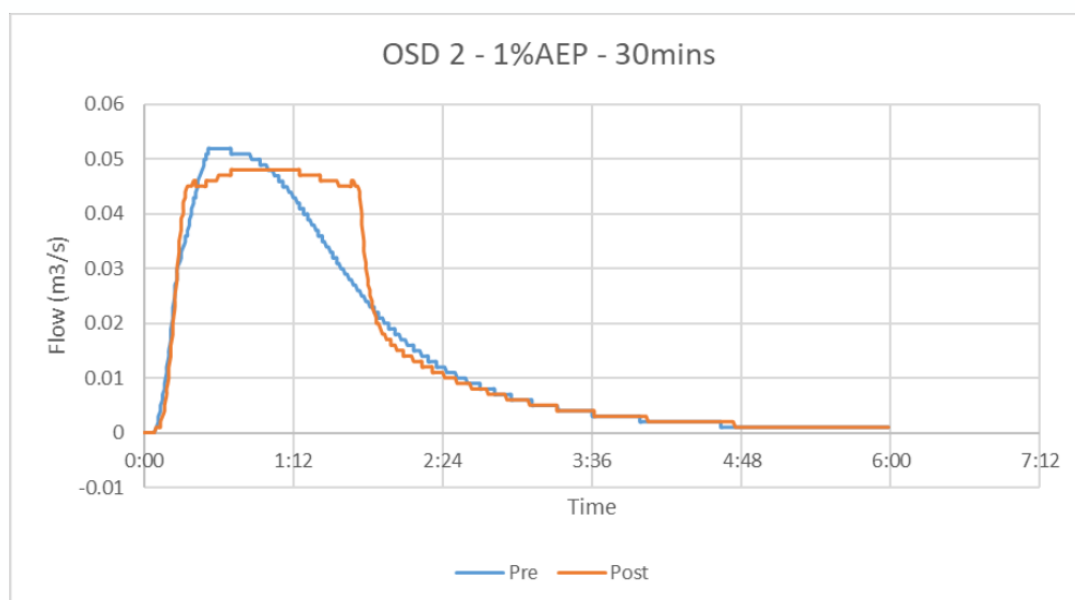


Figure A 3.1 Catchment 2 – 1% AEP-30mins

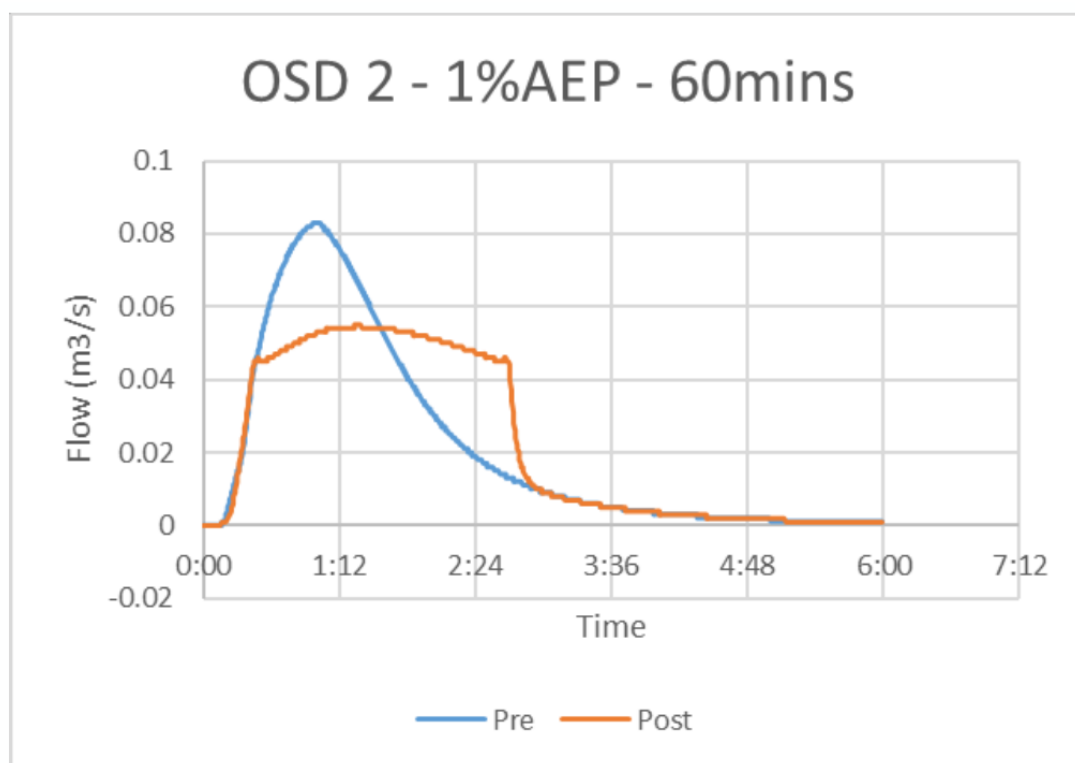


Figure A 3.2 Catchment 2 – 1% AEP-60mins

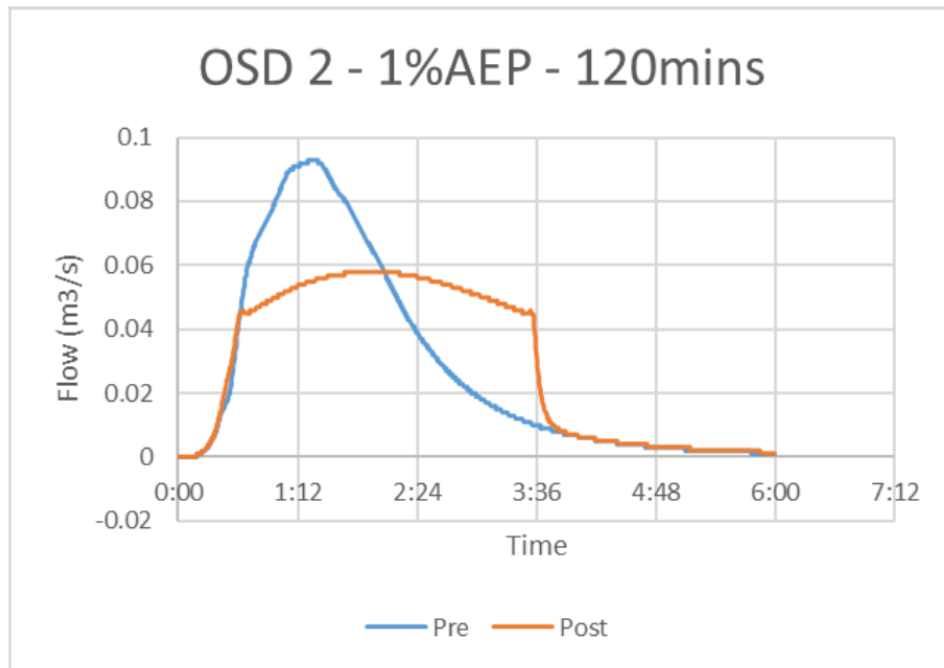


Figure A 3.3 Catchment 2 – 1% AEP-120mins

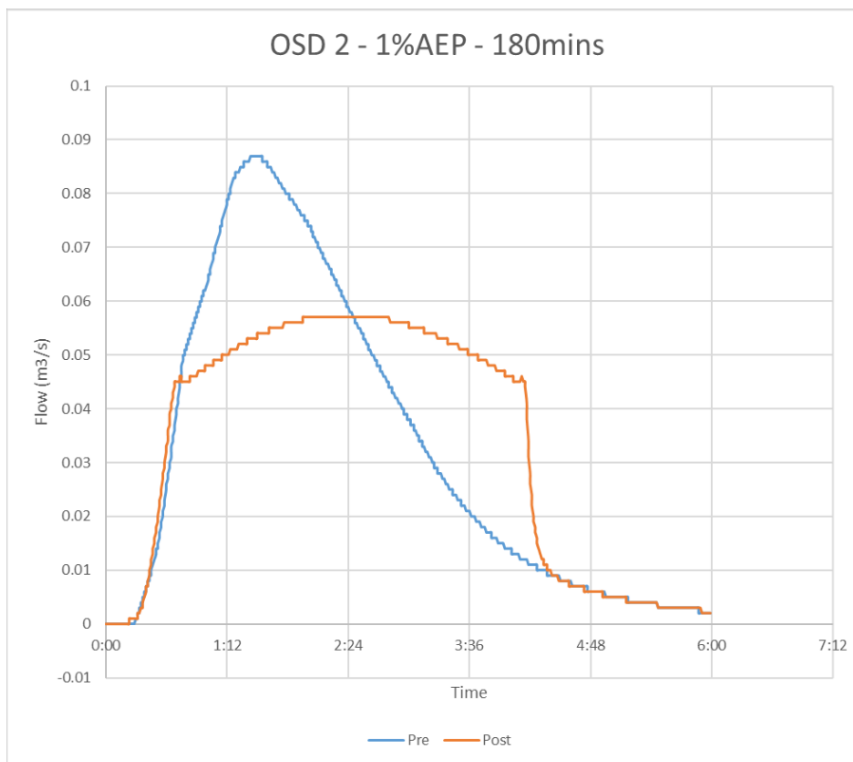


Figure A 3.4 Catchment 2 – 1% AEP-180mins

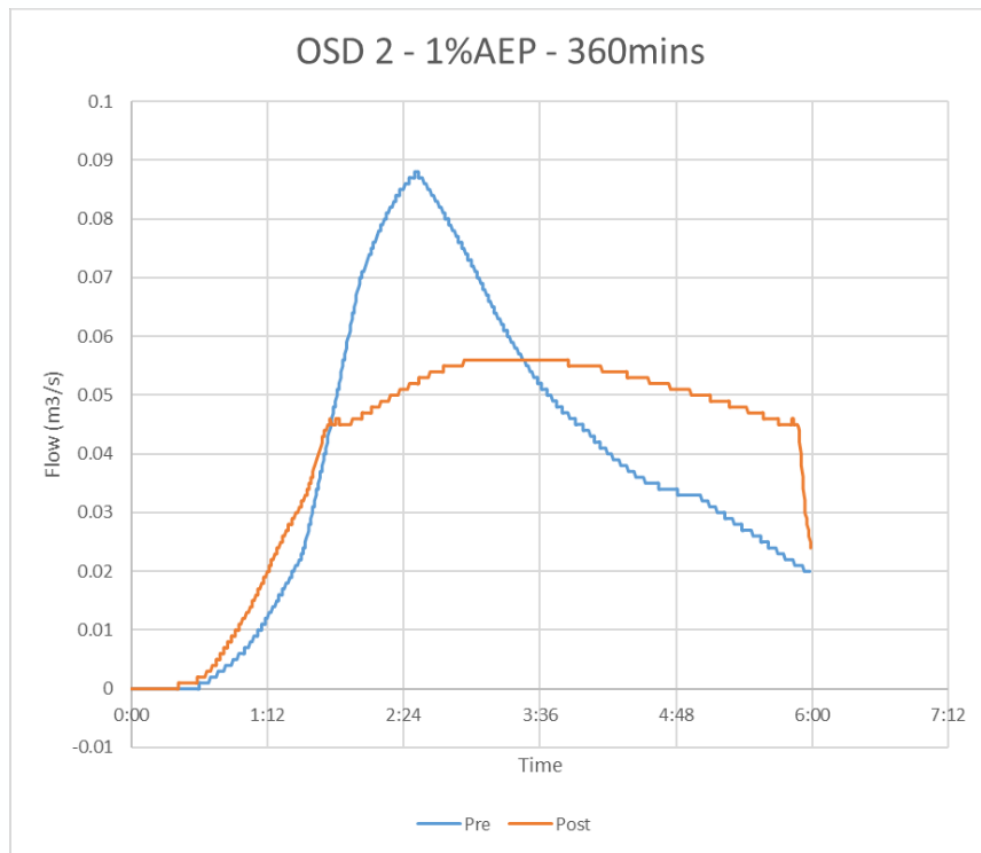


Figure A 3.5 Catchment 2 – 1% AEP-360mins

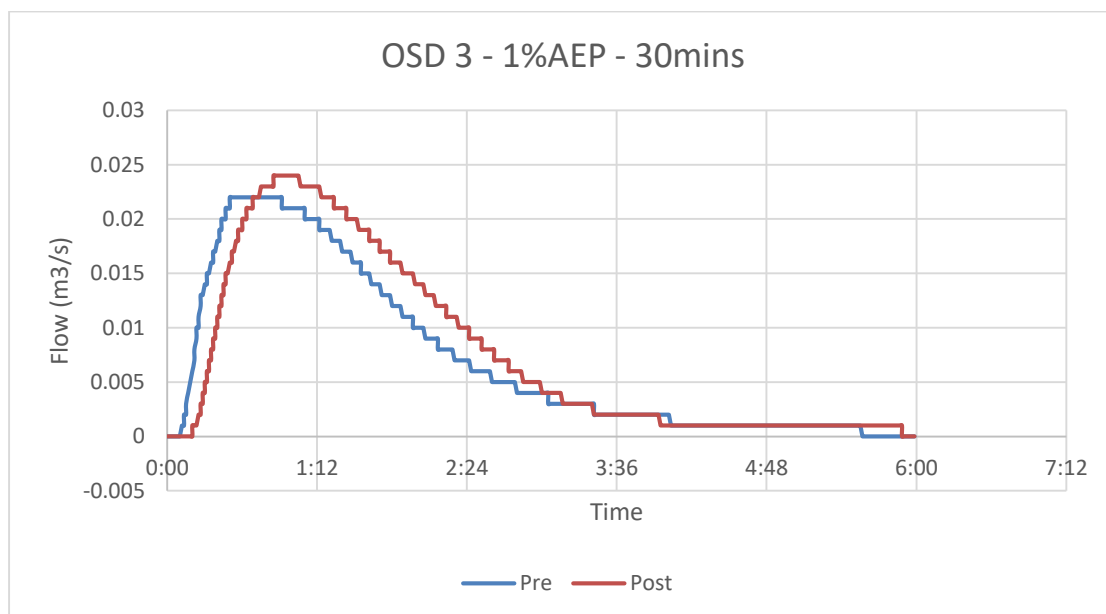


Figure A 3.6 Catchment 3 – 1% AEP-30mins

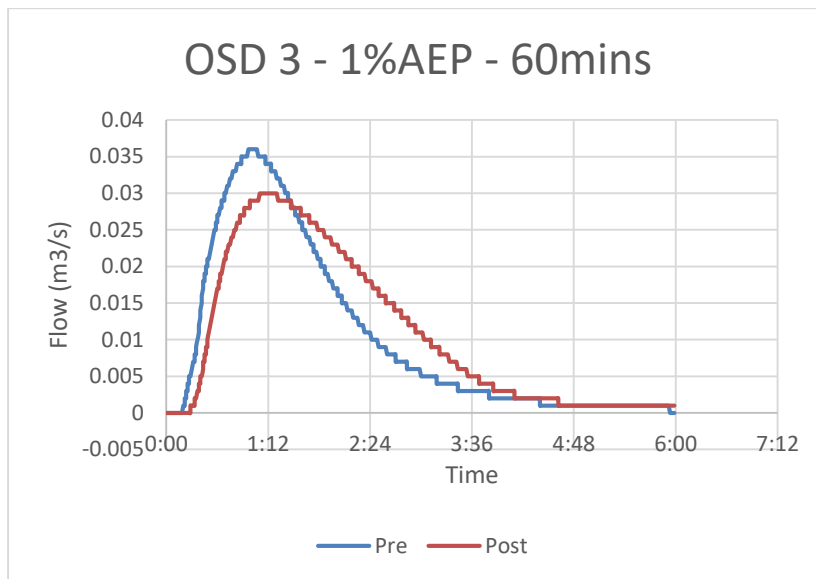


Figure A 3.7 Catchment 3 – 1% AEP-60mins

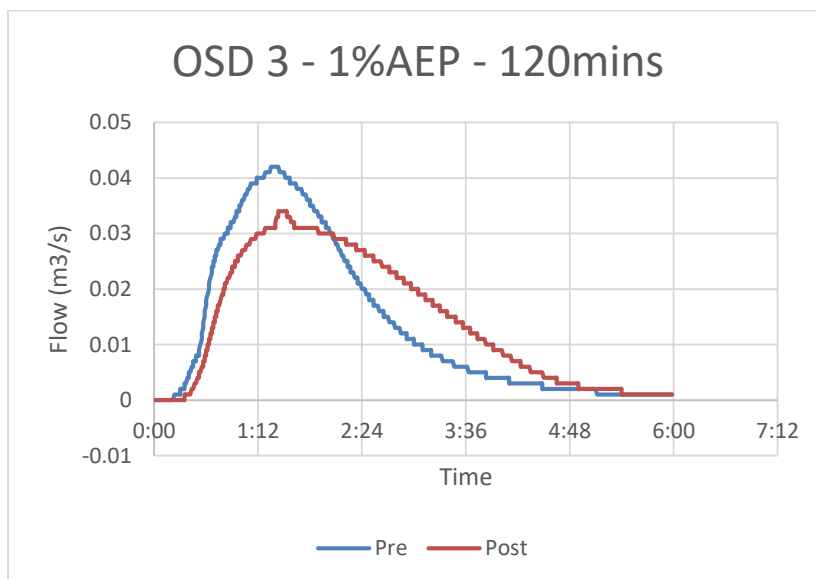


Figure A 3.8 Catchment 3 – 1% AEP-120mins

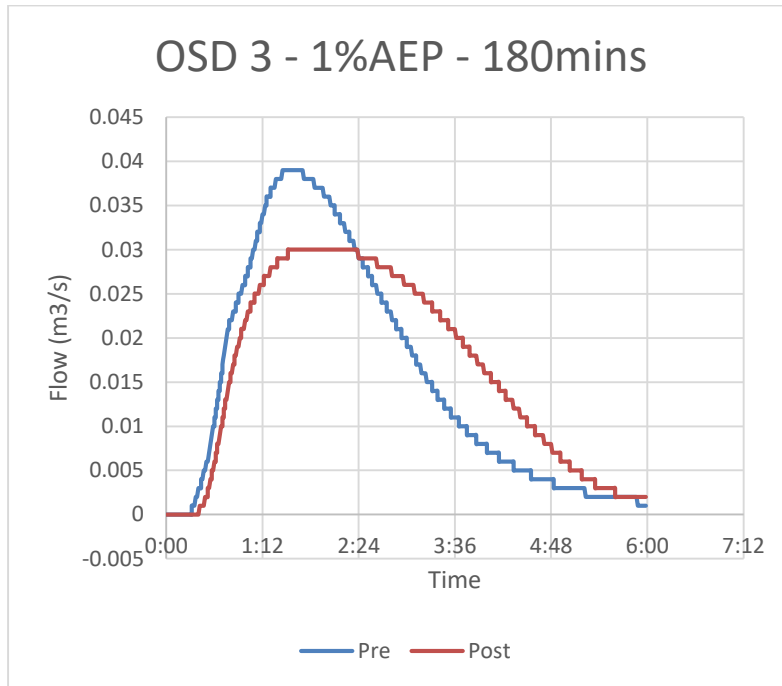


Figure A 3.9 Catchment 3 – 1% AEP-180mins

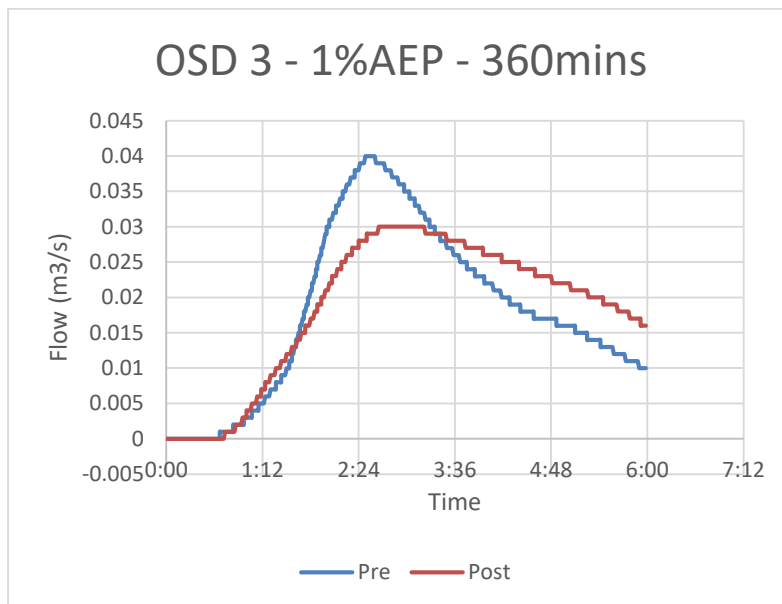


Figure A 3.10 Catchment 3 – 1% AEP-360mins

A4 Appendix 4

Flood Mapping

Figure A 4.1 Study Area

Figure A 4.2 2-yr ARI Depth & Level – Existing Site Conditions

Figure A 4.3 5-yr ARI Depth & Level – Existing Site Conditions

Figure A 4.4 10-yr ARI Depth & Level – Existing Site Conditions

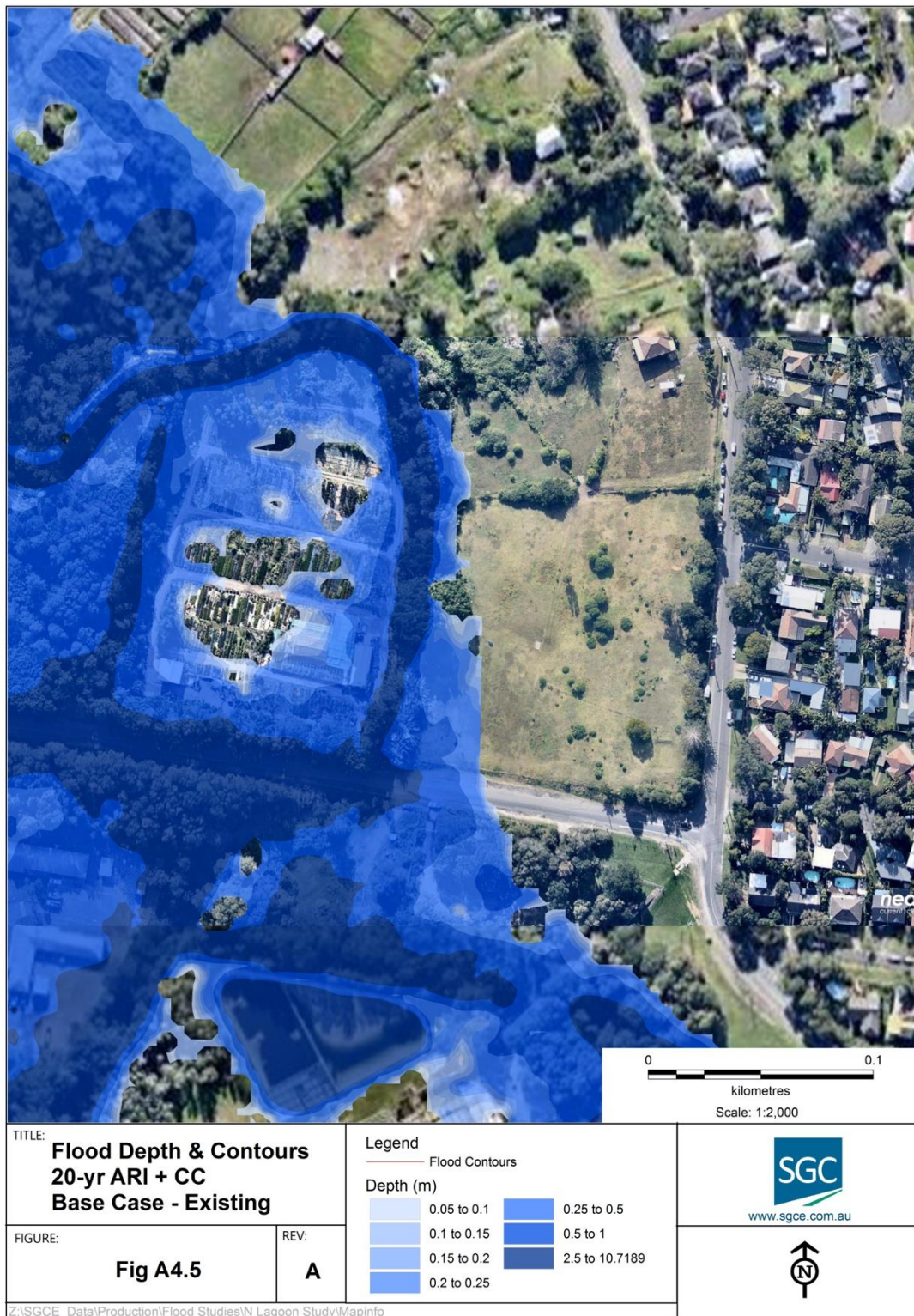


Figure A 4.5 20-yr ARI + CC Depth & Level – Existing Site Conditions

Figure A 4.6 50-yr ARI Depth & Level – Existing Site Conditions

Figure A 4.7 100-yr ARI + CC Depth & Level – Existing Site Conditions

Figure A 4.8 PMF Depth & Level – Existing Site Conditions

Figure A 4.9	100-yr ARI + CC Hazard – Existing Site Conditions
Figure A 4.10	20-yr ARI + CC Depth & Level – Proposed Site Conditions
Figure A 4.11	100-yr ARI + CC Depth & Level – Proposed Site Conditions
Figure A 4.12	PMF Depth & Level – Proposed Site Conditions
Figure A 4.13	100-yr ARI + CC Hazard – Proposed Site Conditions
Figure A 4.14	100-yr ARI + CC Flood Impact Map
Figure A 4.15	PMF Flood Impact Map – Levels
Figure A 4.16	PMF Flood Impact Map – Velocity



Figure A 4.1 Study Area

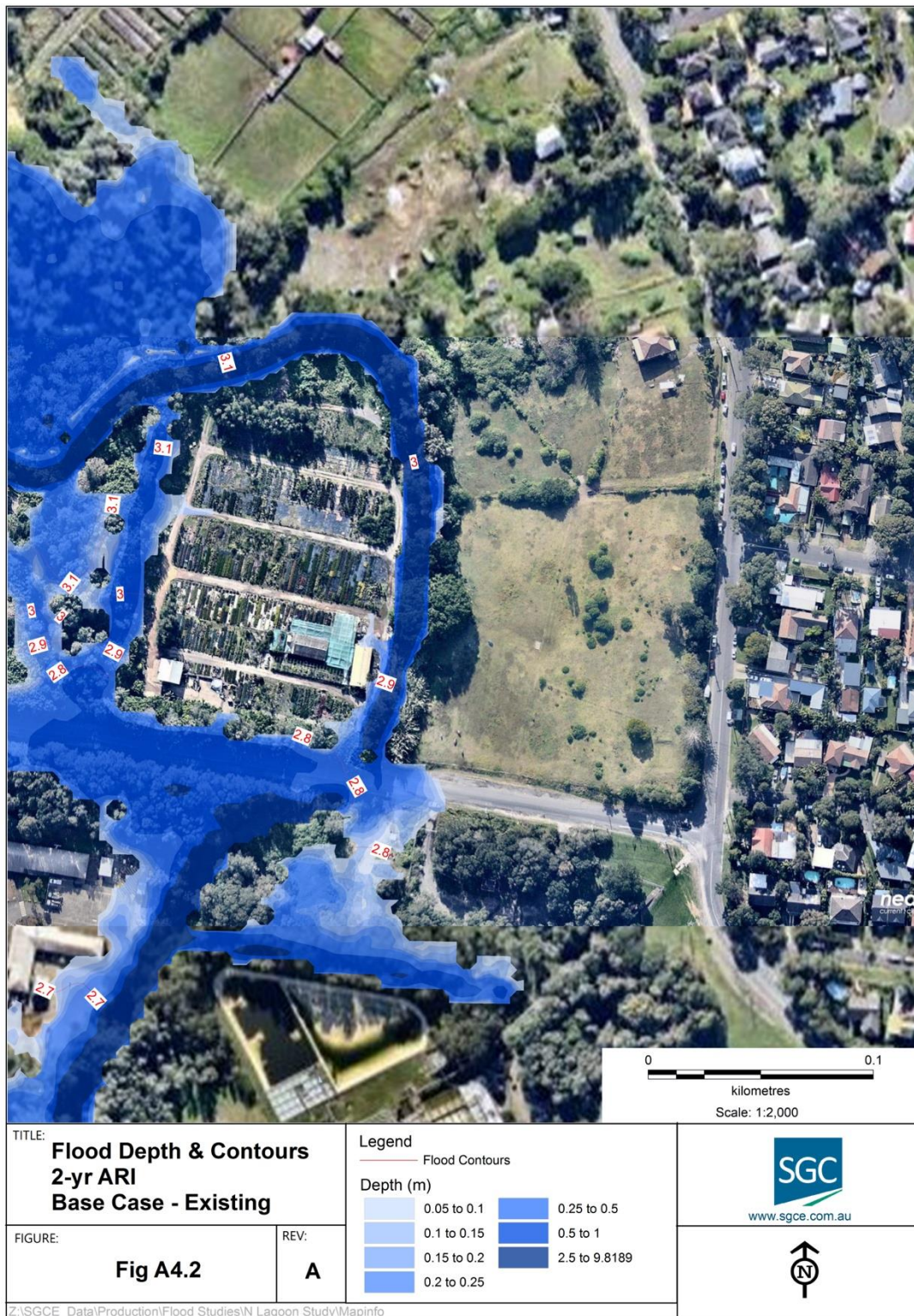


Figure A 4.2 2-yr ARI Depth & Level – Existing Site Conditions

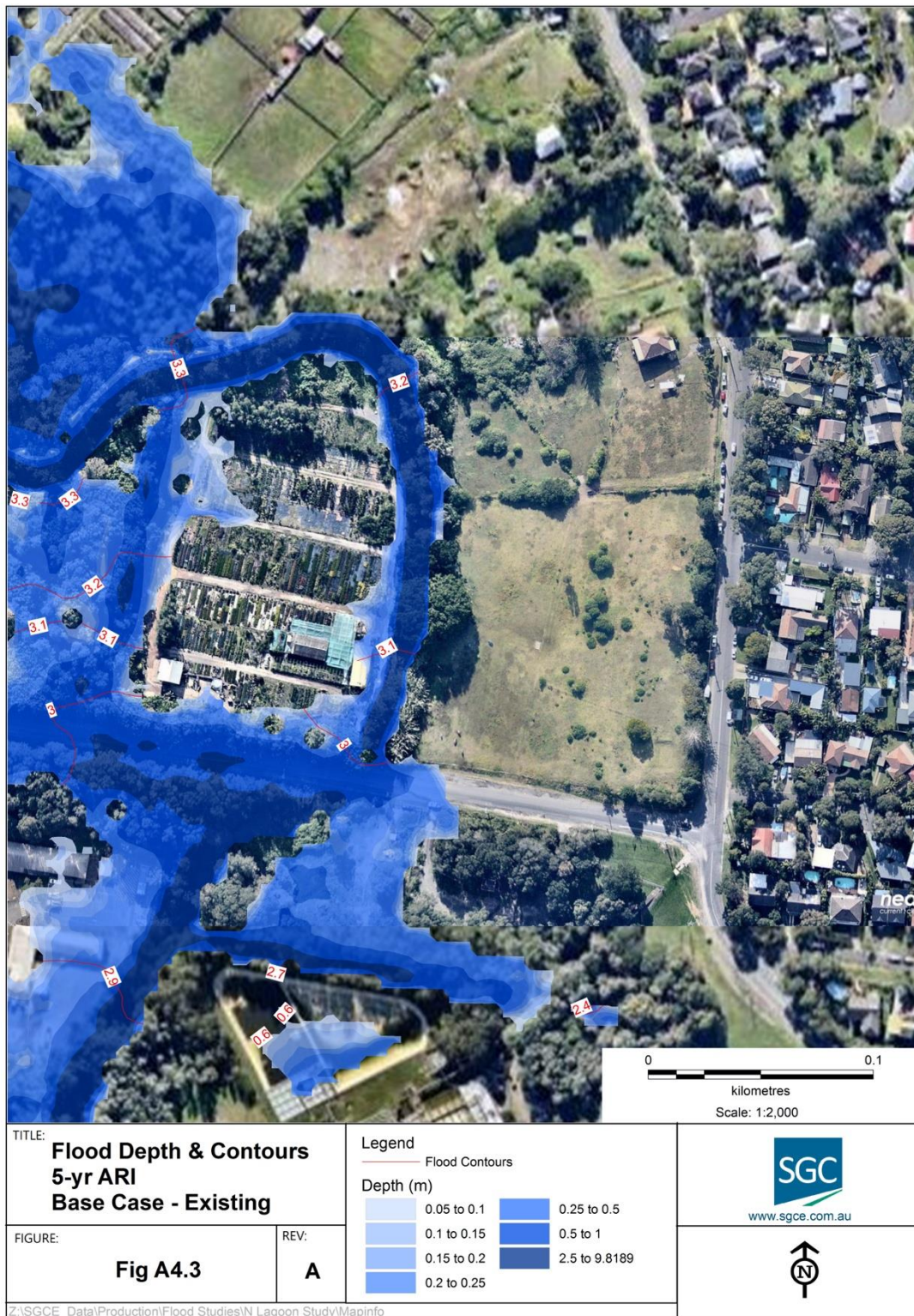


Figure A 4.3 5-yr ARI Depth & Level – Existing Site Conditions

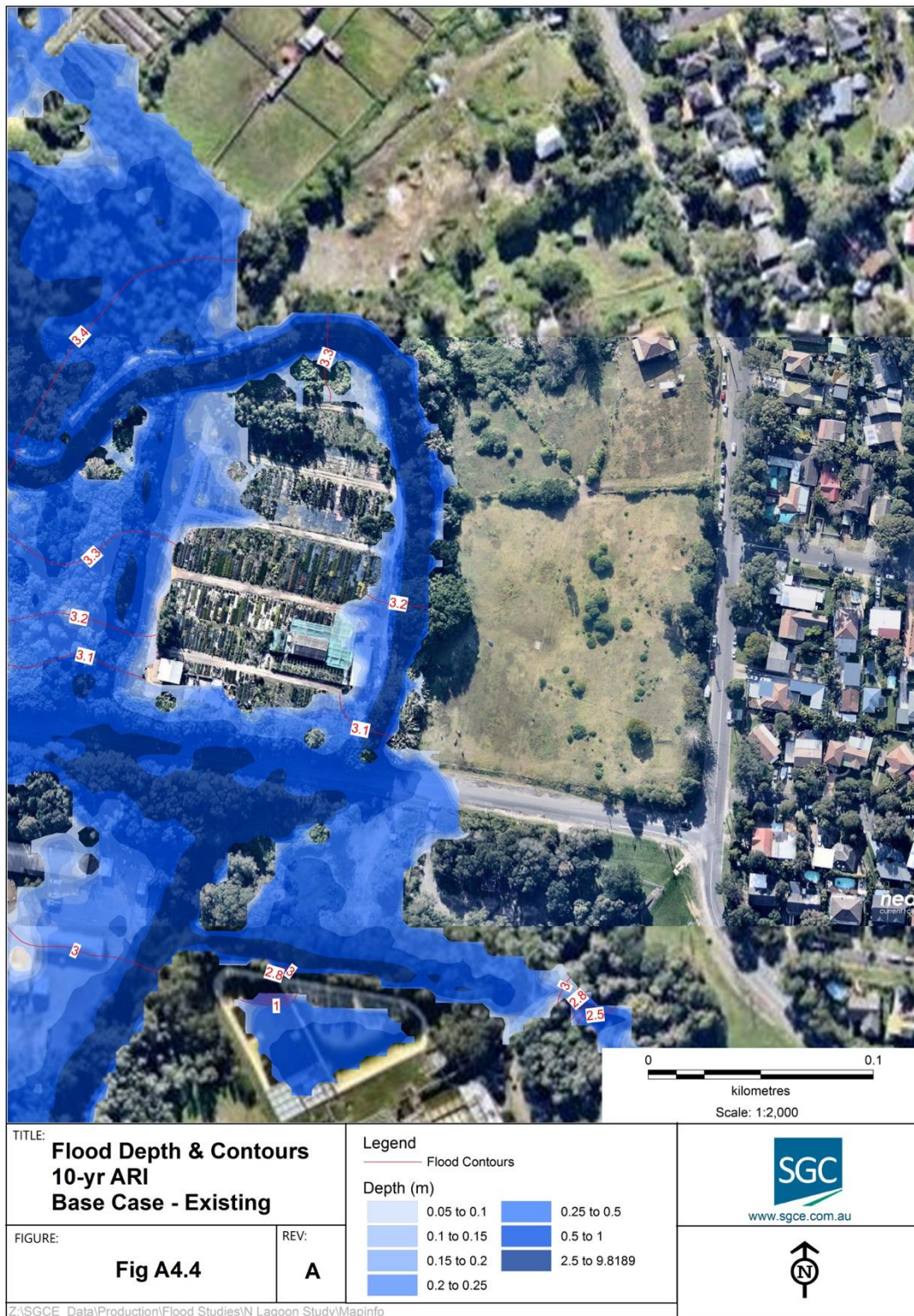


Figure A 4.4 10-yr ARI Depth & Level – Existing Site Conditions

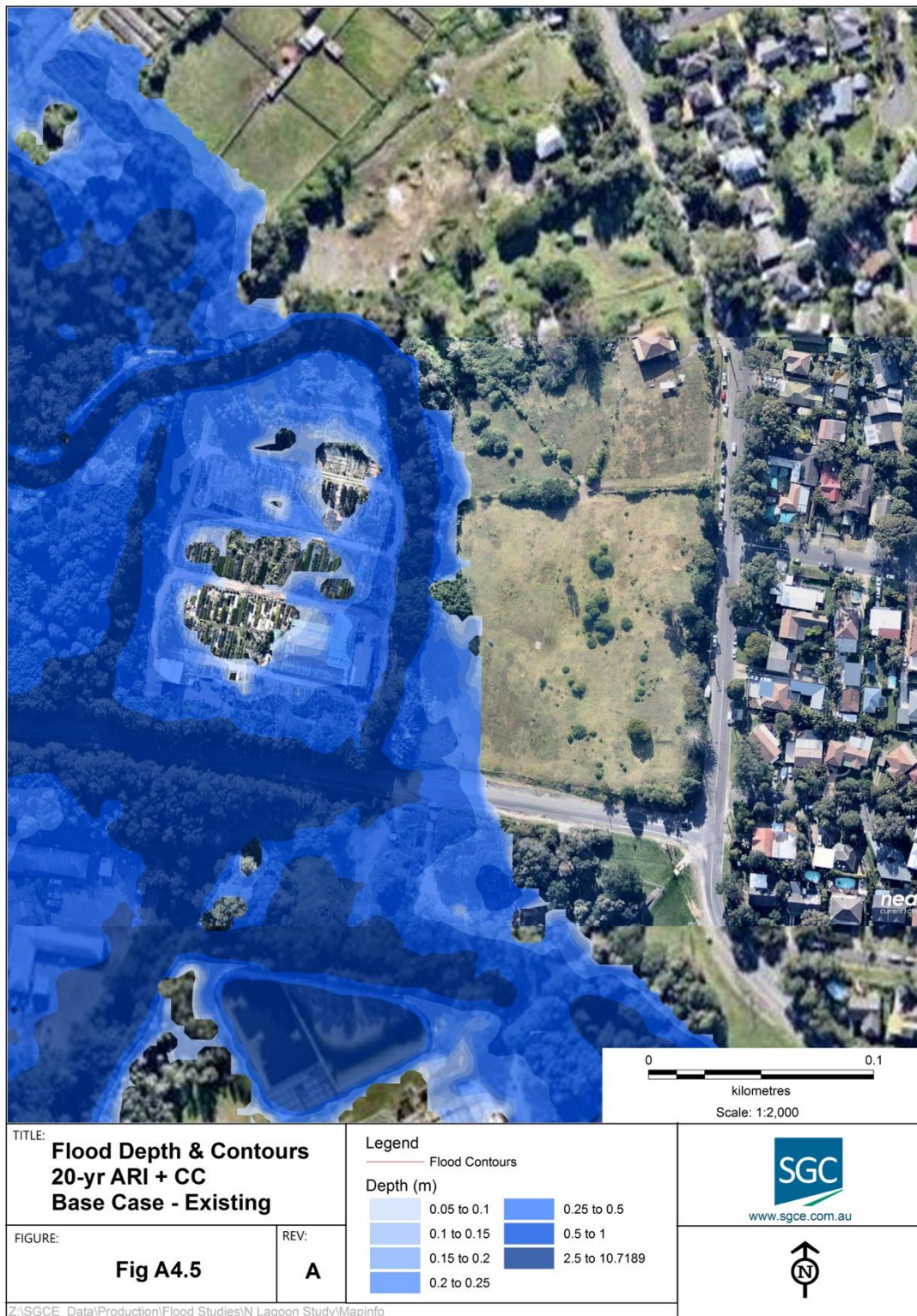


Figure A 4.5 20-yr ARI + CC Depth & Level – Existing Site Conditions

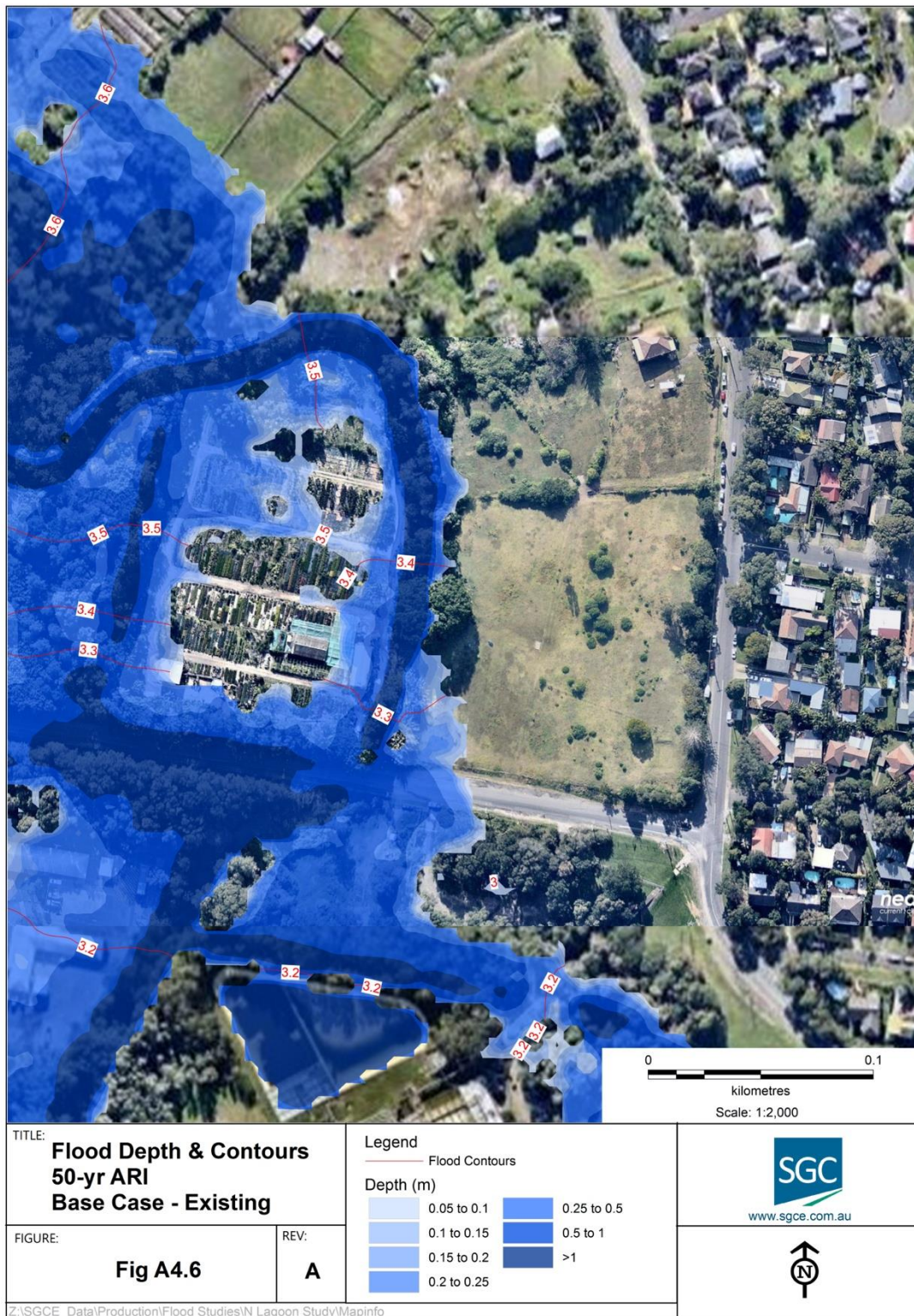


Figure A 4.6 50-yr ARI Depth & Level – Existing Site Conditions

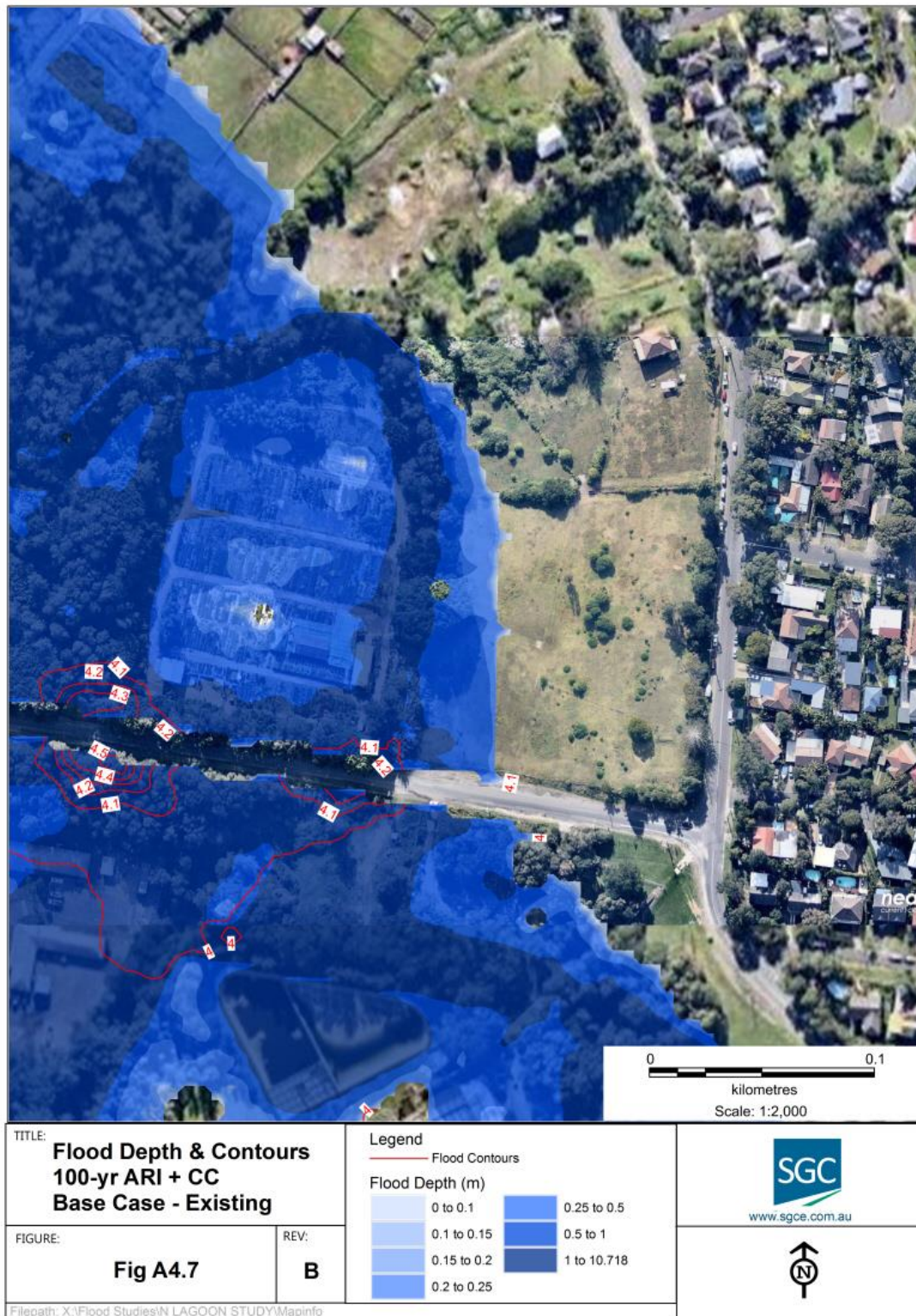


Figure A 4.7 100-yr ARI + CC Depth & Level – Existing Site Conditions



Figure A 4.8 PMF Depth & Level – Existing Site Conditions

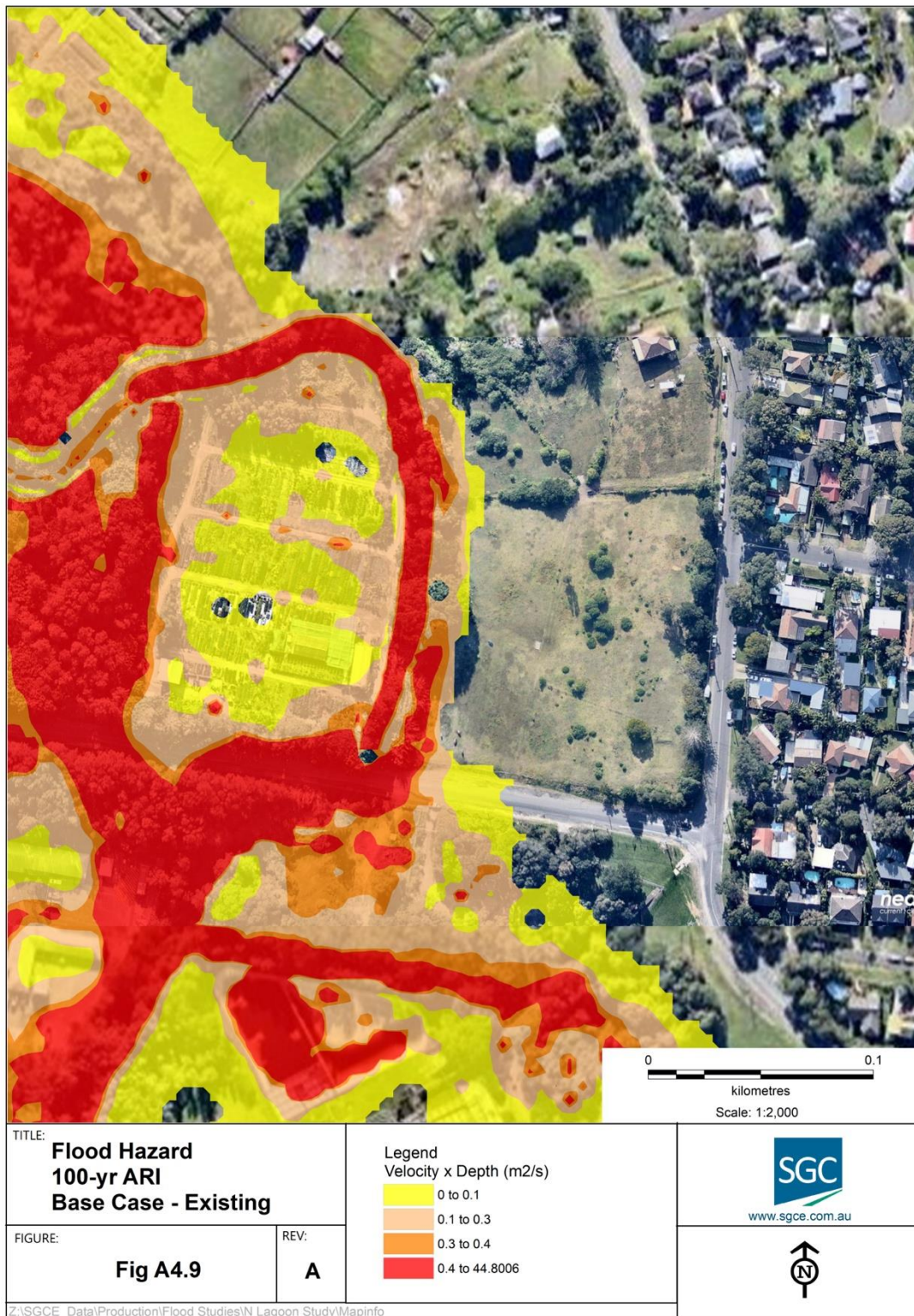


Figure A 4.9 100-yr ARI + CC Hazard – Existing Site Conditions

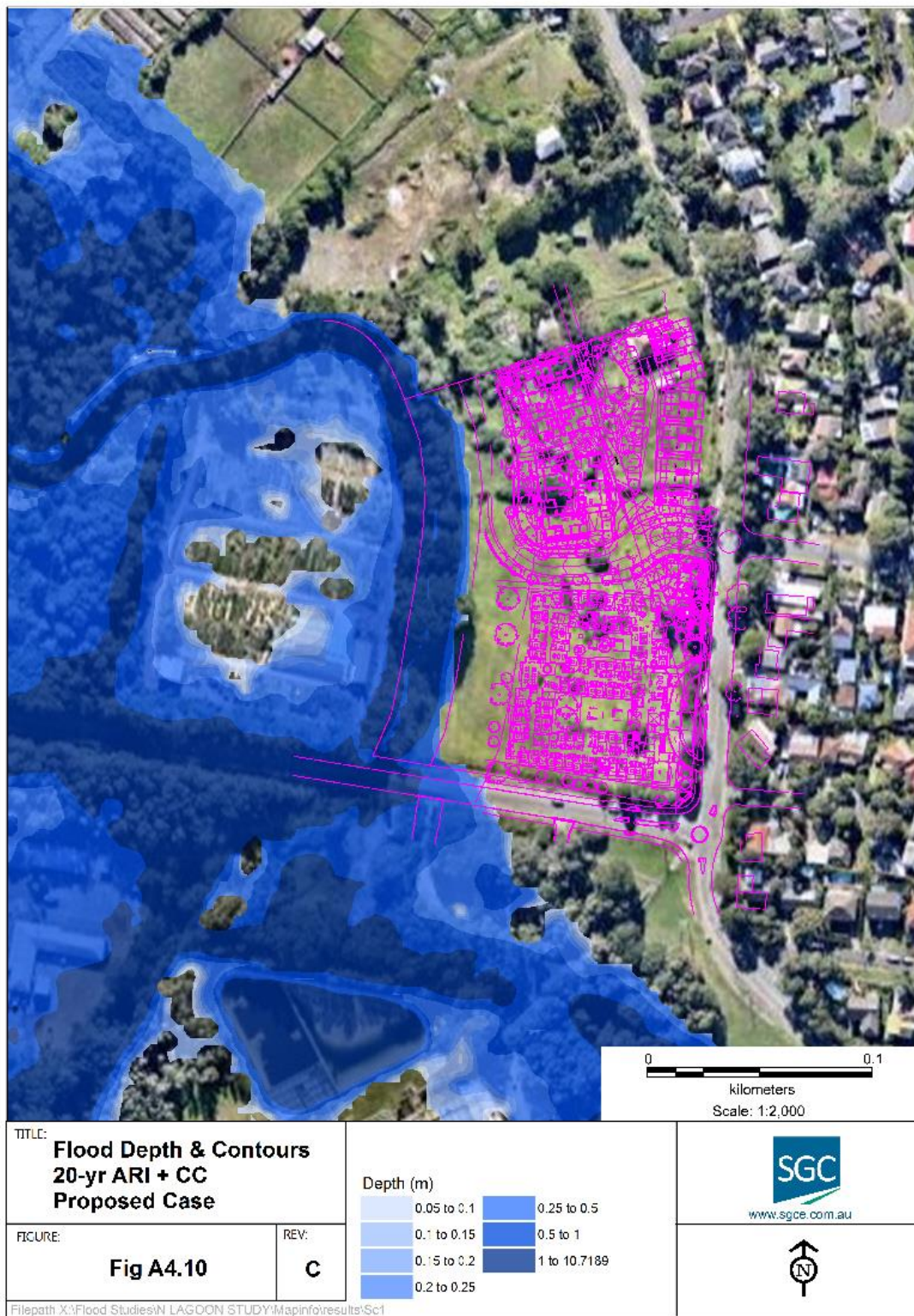


Figure A 4.10 20-yr ARI + CC Depth & Level – Proposed Site Conditions

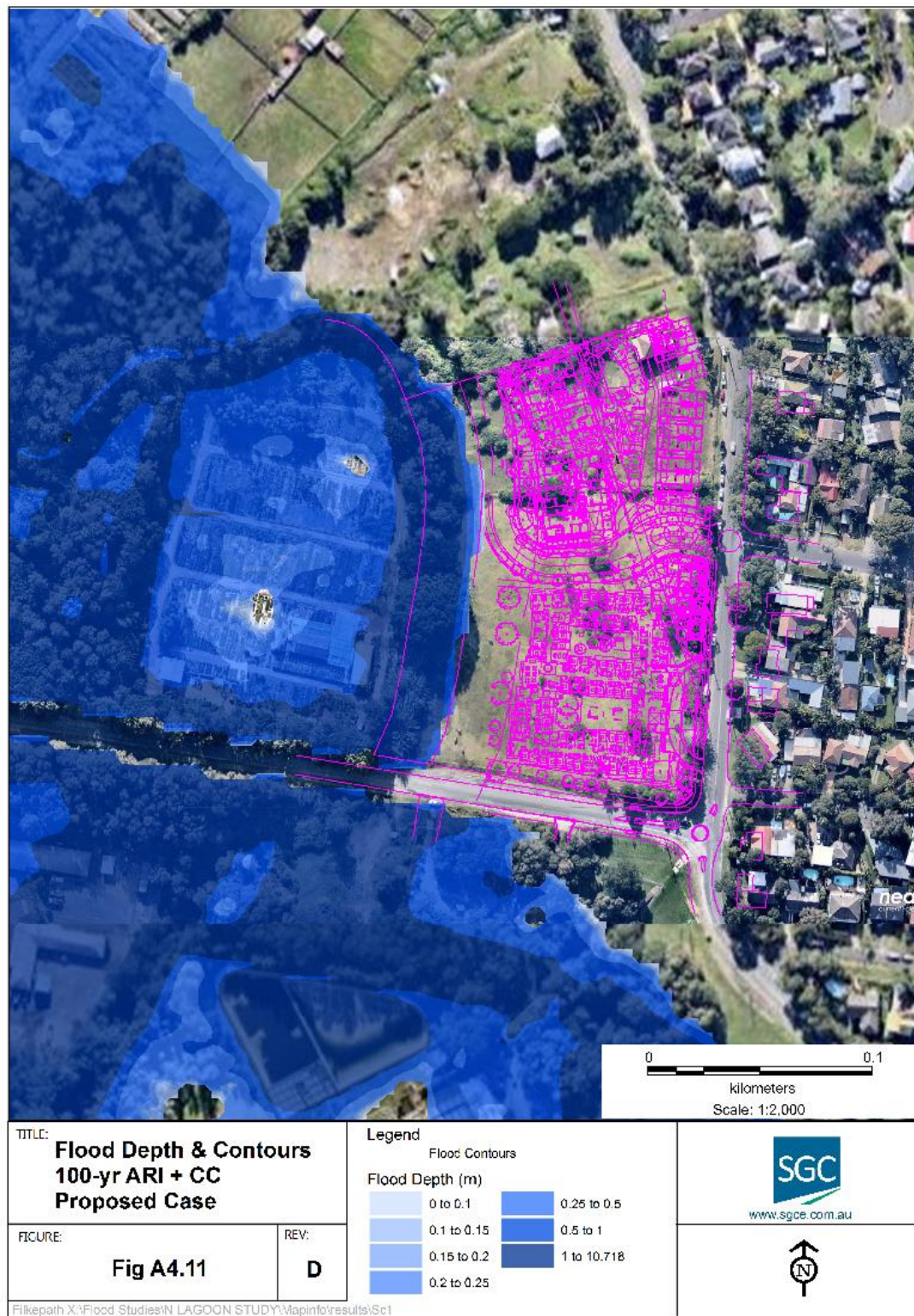


Figure A 4.11 100-yr ARI + CC Depth & Level – Proposed Site Conditions

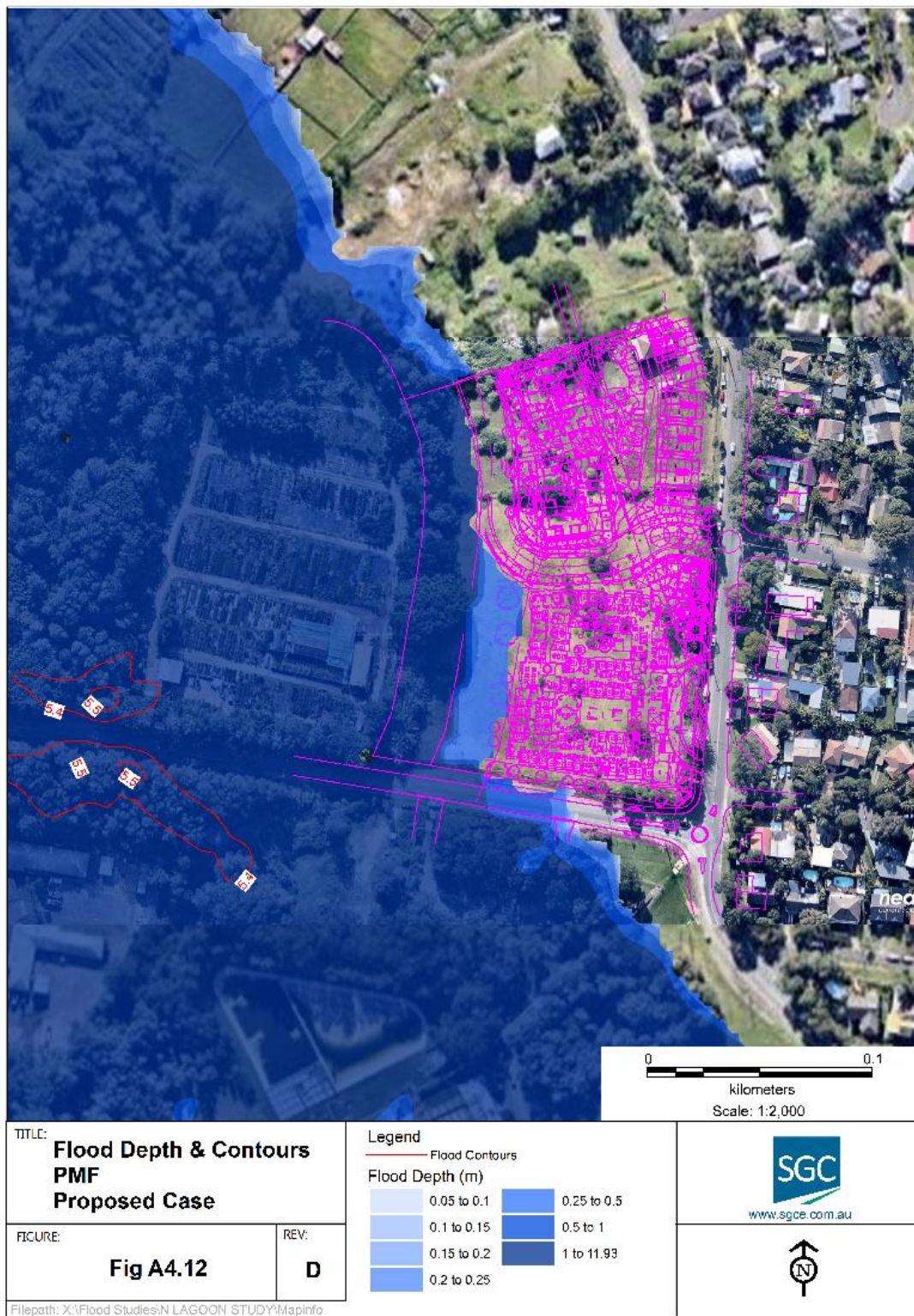


Figure A 4.12 PMF Depth & Level – Proposed Site Conditions

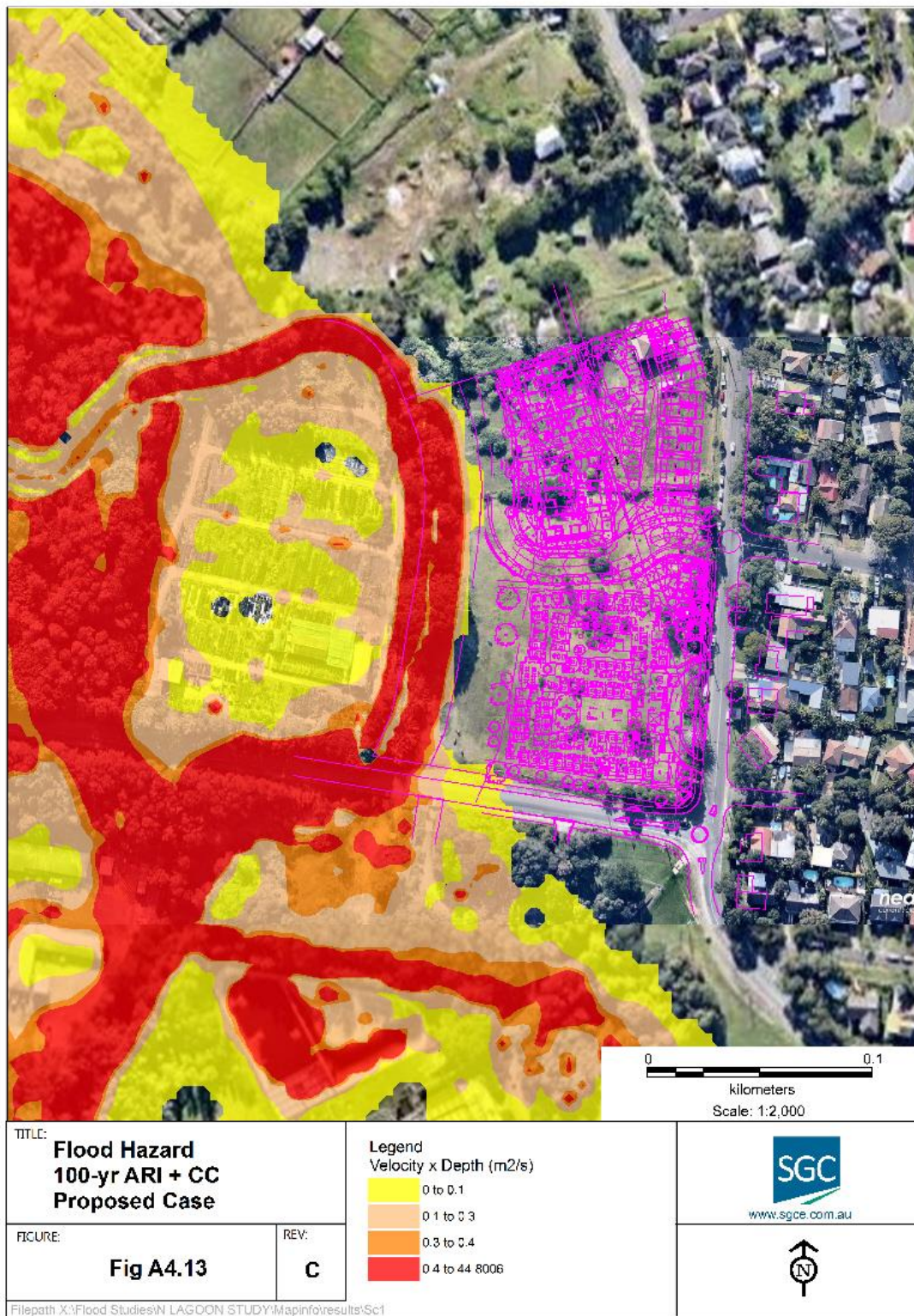


Figure A 4.13 100-yr ARI + CC Hazard – Proposed Site Conditions



Figure A 4.14 100-yr ARI + CC Flood Impact Map – Levels

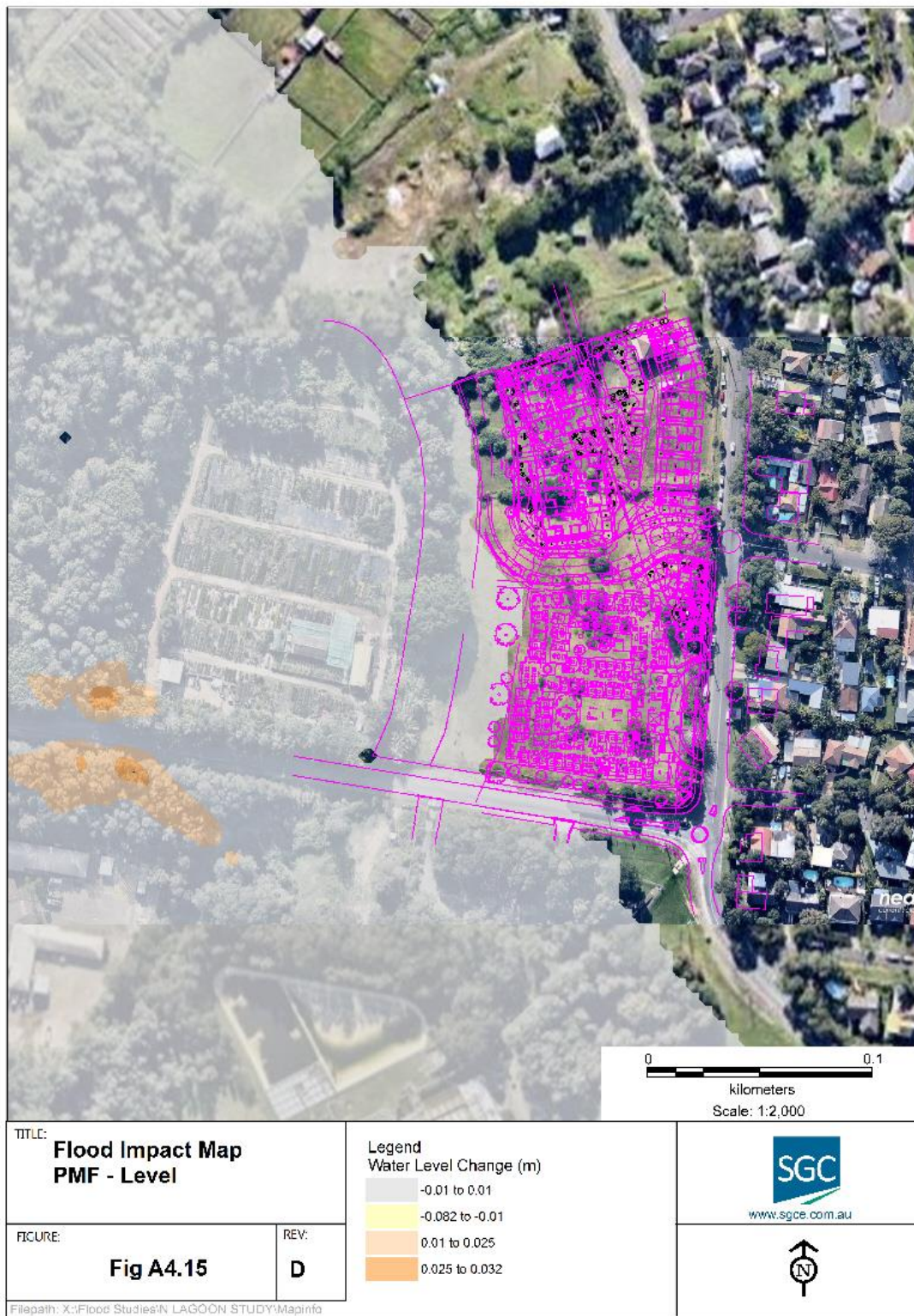


Figure A 4.15 PMF Flood Impact Map – Levels

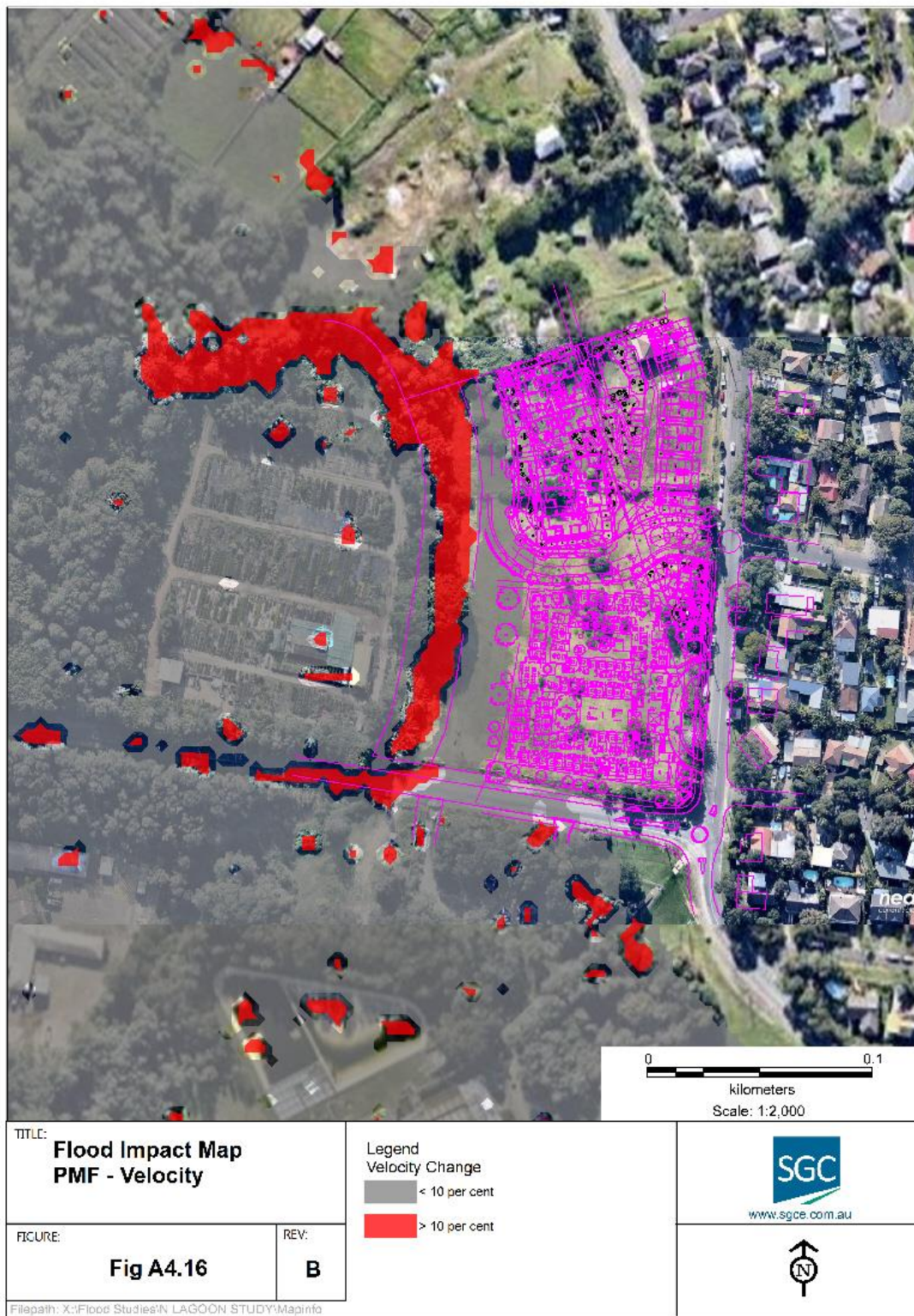


Figure A 4.16 PMF Flood Impact Map – Velocity

A5 Appendix 5

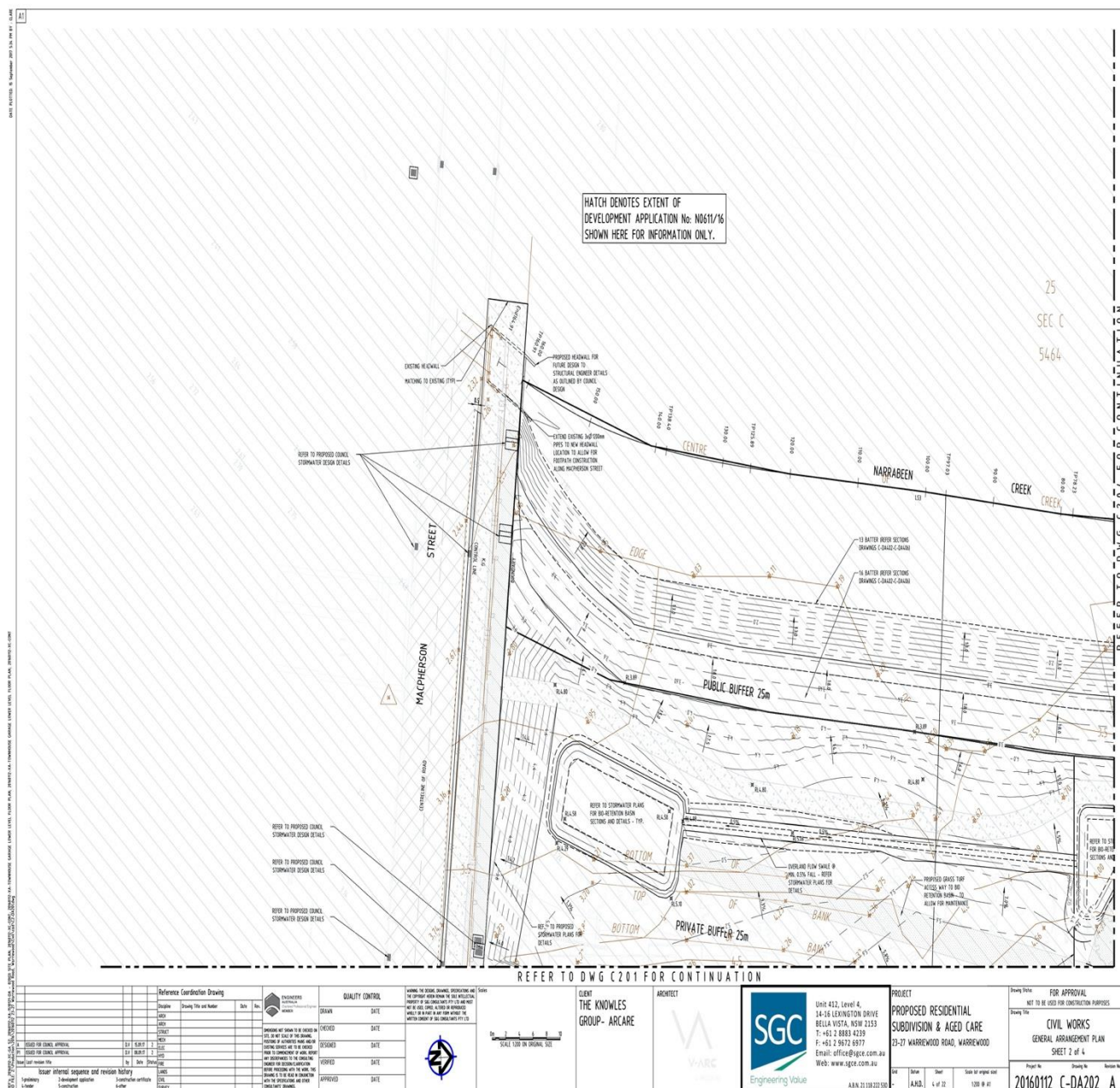
References

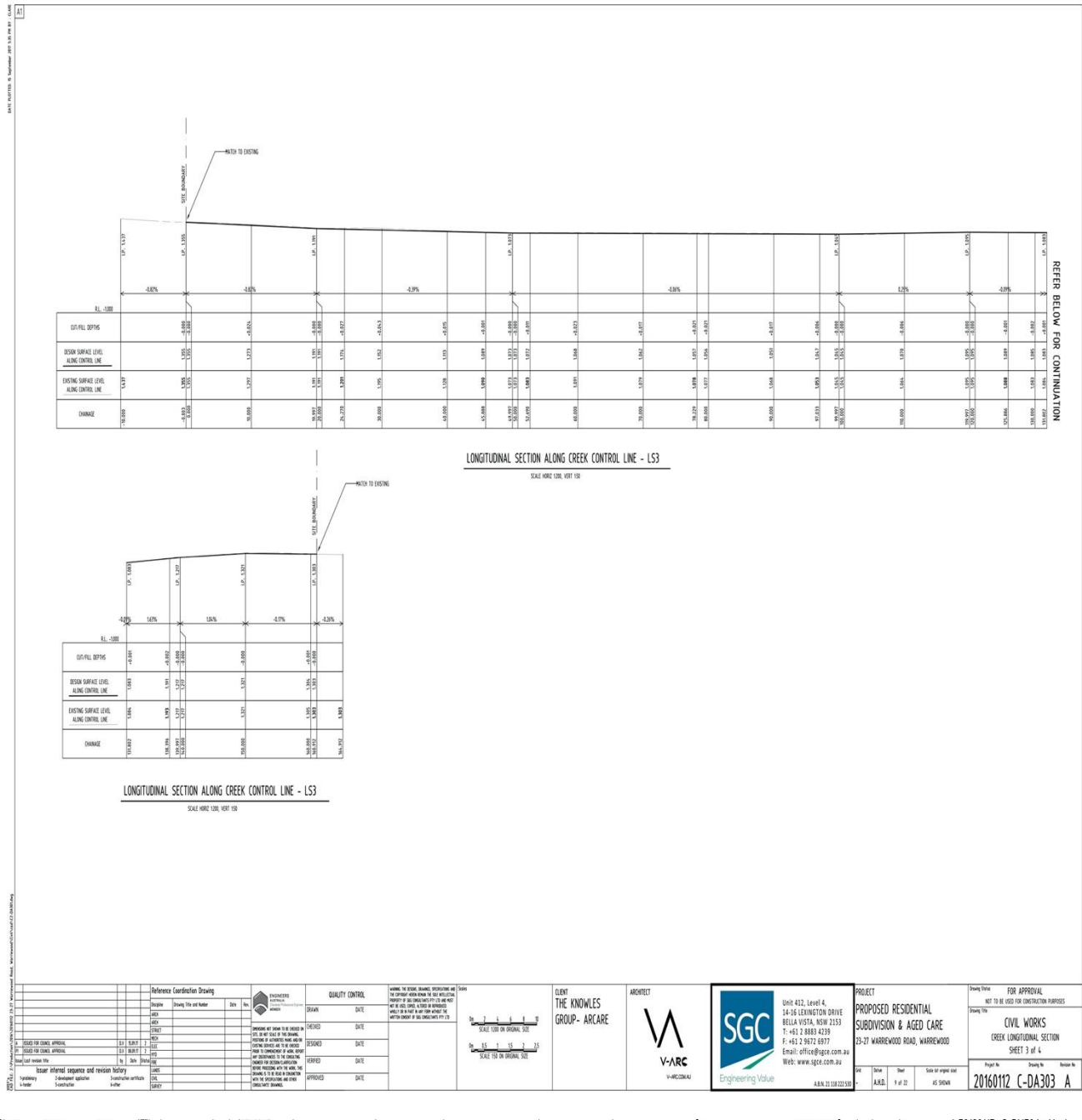
Reference reports by other consultants

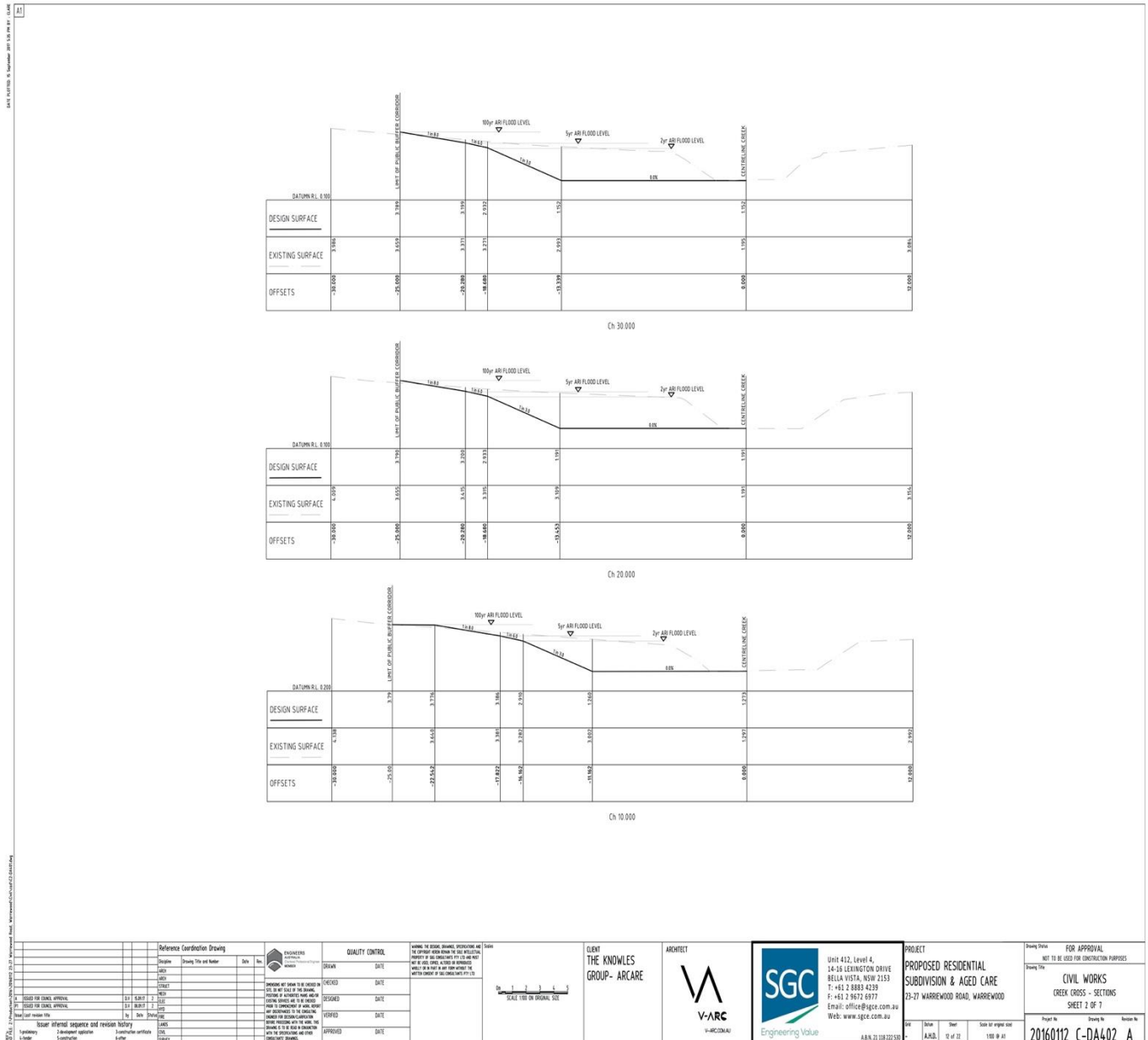
1. Vegetation Management Plan by Eco Logical Australia ref. 16SYD:5292; and
2. Water Quality Monitoring Plan/Sites Shown/Data/Assessment & interpretation of water quality monitoring data from SQID's by Marine Pollution Research Pty Ltd.

A6 Appendix 6

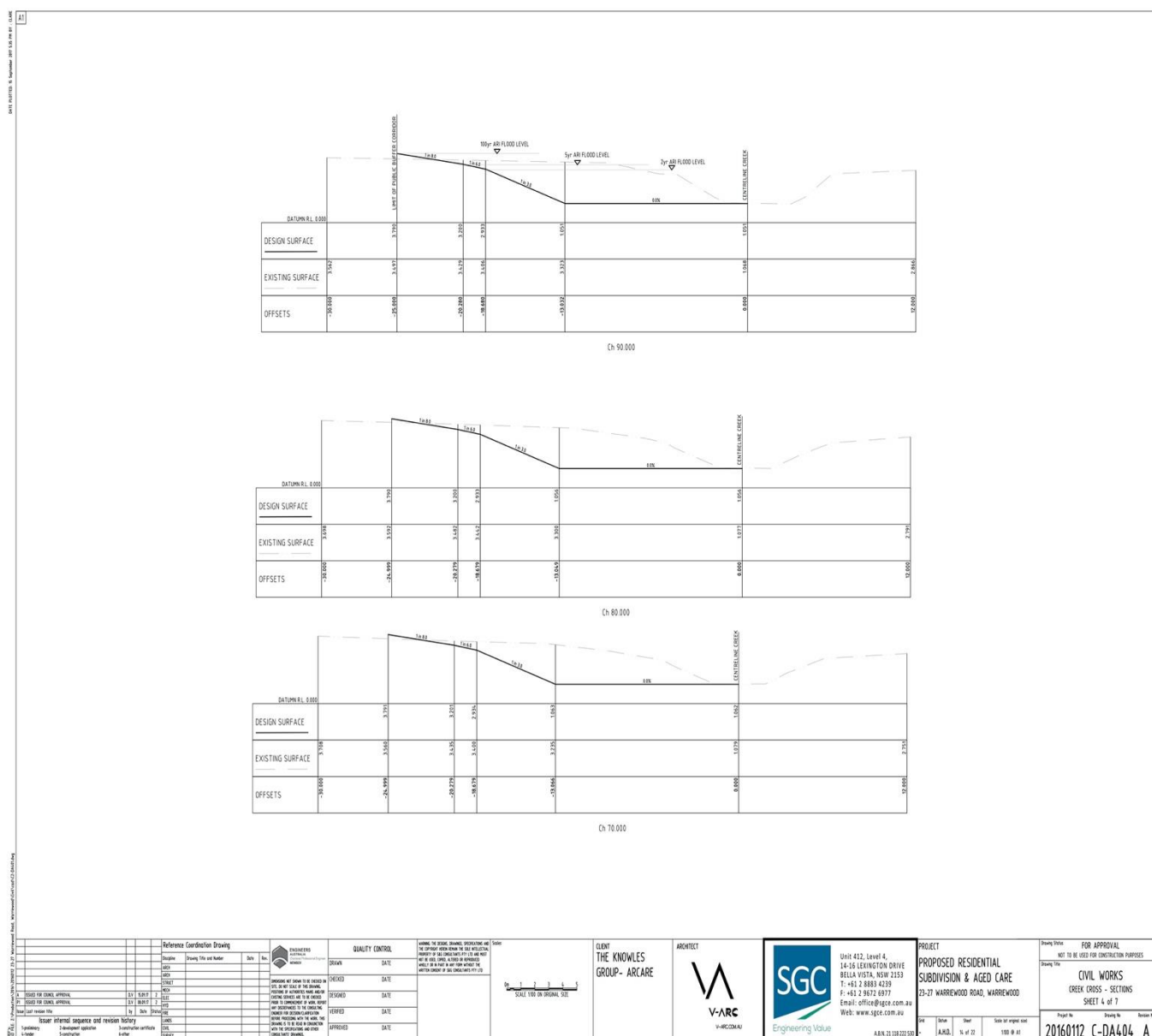
Creek Design Drawings (already constructed)

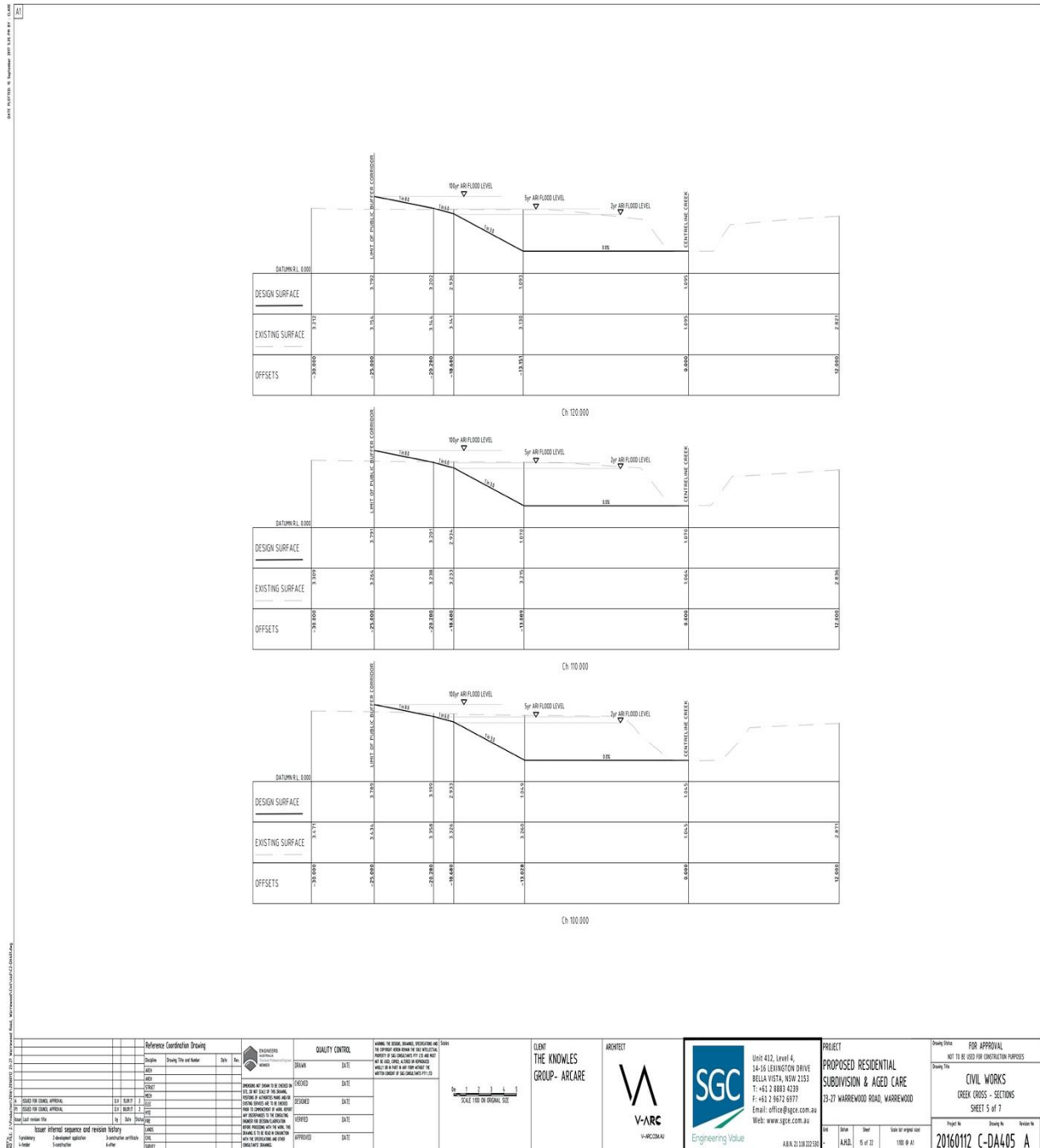


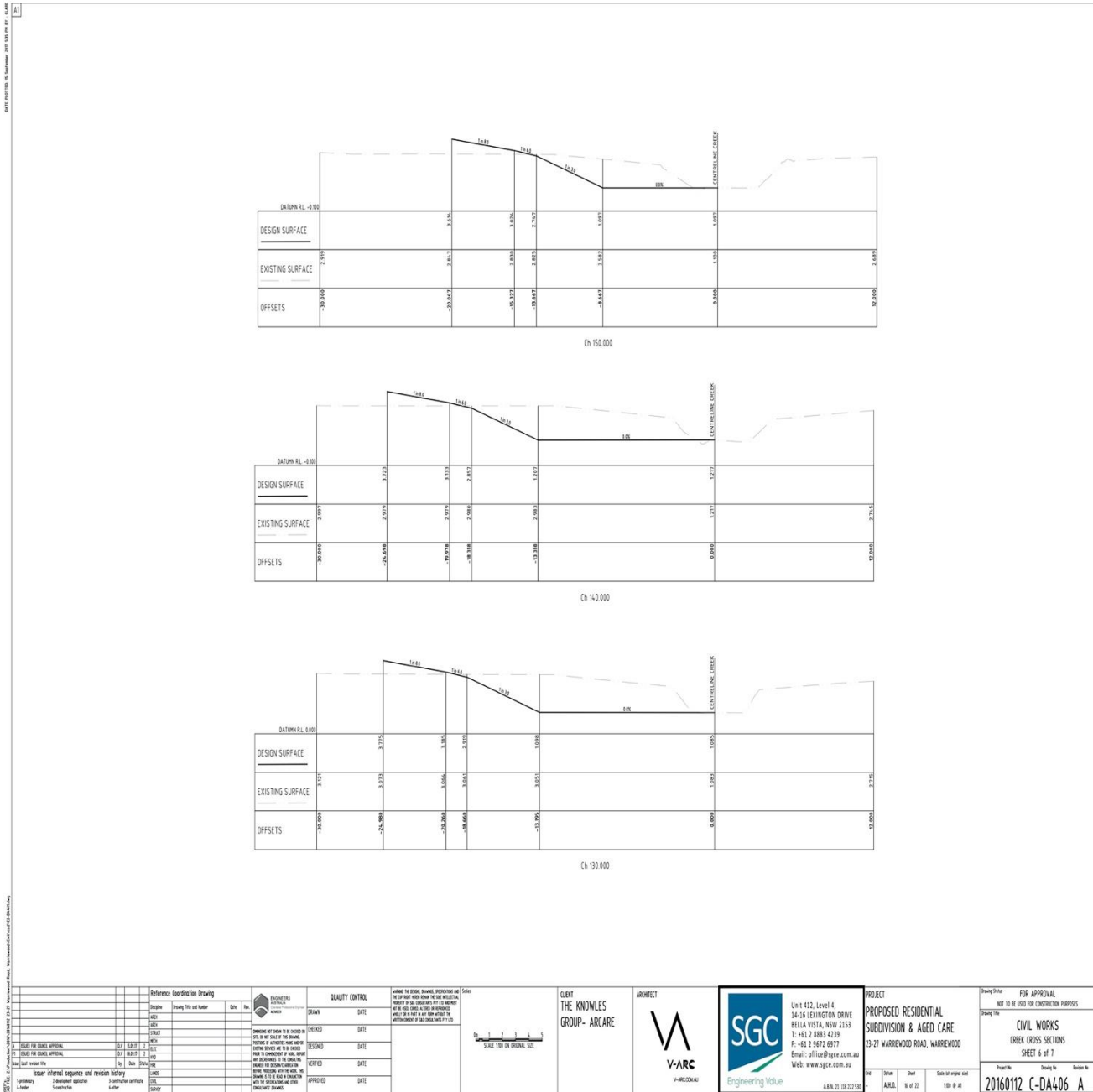














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