Project:	*Flood Study for Lot 23 DP537919 – Blueys Beach Development*
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To:	*Cardno/Stantec, Fran Liao*
Subject:	***Flood Study for Lot 23 DP537919 – Blueys Beach Development***
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Executive Summary

Cardno engaged GRC Hydro to conduct a flood investigation for a proposed lot subdivision at Lot 23 DP537919, Blueys Beach, situated in the Midcoast Council Local Government Area.

Flood modelling was undertaken using a DRAINS / TUFLOW hydrologic/hydraulic modelling system utilising ARR2019 methods. Model parameters derived by nearby Council flood studies have been used where appropriate. A pre-development conditions flood model was developed using available survey and stormwater information. Five events were assessed; the 20% AEP, 1% AEP and PMF for current climate conditions, and the 5% AEP and 1% AEP with allowance for climate change projections for 2090 assuming RCP4.5 projections.

Pre-development conditions flood model results show an existing flood risk for a number of properties downstream of the site for events as frequent as the 20% AEP flood. Existing flood risk at these properties has also been identified by Council.

The pre-development conditions model was modified with incorporation of design information provided by Cardno to develop a post development conditions model. Concept flood mitigation strategies were developed to manage flood risk within the proposed development site and mitigate flood impacts affecting surrounding properties. The flood mitigation strategy includes flood storage areas, swales and trunk drainage.

Post development conditions flood model results show that proposed development lots within the Site are not flood affected for events up to and including the 1% AEP event with allowance for climate change. During the PMF, most lots are noted to be flood free, with a small number of lots experiencing flood depths of less than 0.3 m with an associated H1 hazard category (benign flood conditions). The flood impact assessment shows that site discharge to flow paths downstream of the Site are reduced relative to pre-development conditions and flood depths and levels are reduced for a range of flood events.

Assessment of the development in consideration of Council's flood planning policy (LEP, 2013 and DCP, 2014) shows that the proposed design complies with Council's flood related development controls.

Further development of the design should be undertaken at detailed design to:

- Develop scour mitigation measures within the site if required;
- Further optimise the sizing of the concept trunk stormwater system;
- Incorporate lateral drainage into the design where required;
- Appropriately size road inlet structures with allowance for blockage
- Confirm flood planning levels for flood affected lots (if any).

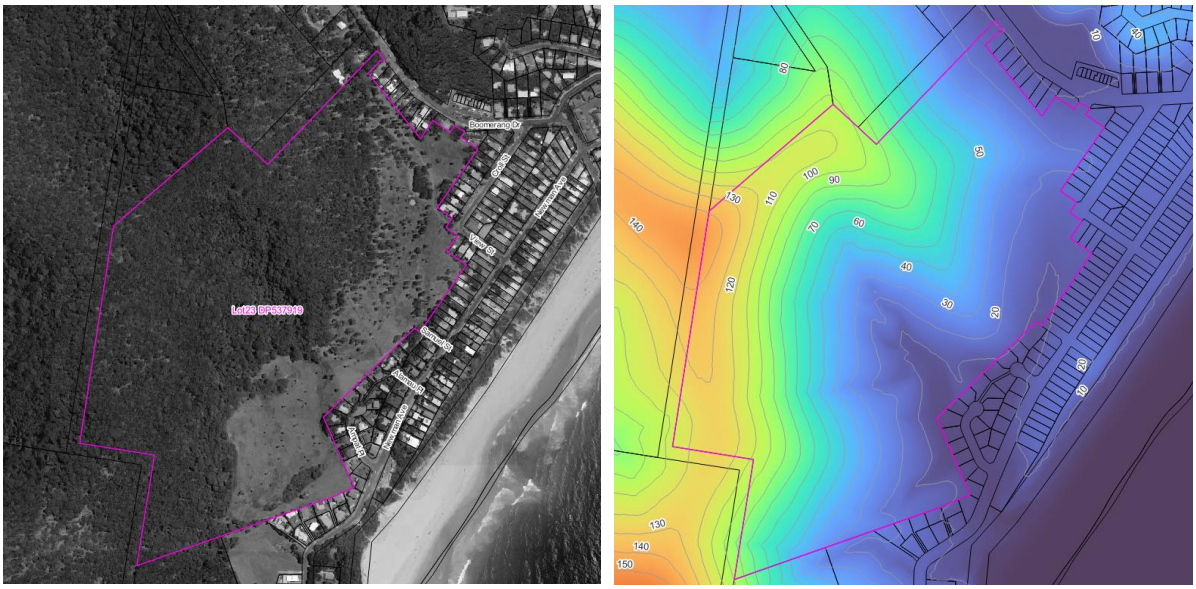
Introduction

The Blueys Beach Development is a residential development planned for Lot 23 DP537919 (the Site) at Blueys Beach in the Midcoast Council Local Government Area in NSW. The proposed development of the Site includes a subdivision to create 73 residential and two commercial lots, with accompanying roads and bulk earthworks for approximately 10 ha of the 35 ha lot. Cardno have engaged GRC Hydro to conduct a flood investigation to assess flooding characteristics for pre-development and post-development conditions at the Site.

As shown in Image 1, the Site is located to the west of Blueys Beach between Boomerang Drive in the north, and towards the southern end of Newman Avenue to the south. The subdivision is proposed for the eastern portion of the lot, on areas of lower elevation. Image 1 presents existing terrain contours based on 2013 LiDAR.

The Site is densely vegetated in the upper slopes, with the lower areas of the lot mostly cleared of trees. Several dams are present on the main existing flow paths which are ephemeral in nature. Existing residential development is location downstream of the Site, with runoff conveyed by existing stormwater infrastructure, the capacity of which is noted to be frequently exceeded based on reports from Council. Based on existing terrain, the majority of the Site drains towards the southern end of Blueys Beach, with about 4.3 ha of the Site draining north past Boomerang Drive, and into Wallis Lake.

Figure 1: Site Locality and Existing Terrain



Relevant Policy/Guidance Documents

The relevant studies and policy documents that have been considered as part of the assessment are:

- Great Lakes Local Environmental Plan (LEP, 2014)
- Great Lakes Development Control Plan (DCP, 2013)
- NSW Floodplain Development Manual (FDM, 2005)

Assessment of the development has been undertaken in consideration of these policies.

Previous Flood Related Studies

The Site is not covered by an existing Council flood study. The closest study is the Wallis Lake Floodplain Management Study (Manly Hydraulic Laboratory, 2001) and the Wallis Lake Foreshore (Floodplain) Risk

Management Study (WMA Water, 2014) which focus on the adjacent catchments draining into Wallis Lake. These studies have been used for reference where appropriate.

As no existing Council flood study was available, GRCHydro have developed a DRAINS / TUFLOW model system for the Site to define design flood behaviour.

Scope and Omissions

This assessment includes consideration of mainstream, overland flow and oceanic flooding at the Site, including trunk stormwater infrastructure. The following aspects of the development have not been considered as part of this assessment:

- Lot stormwater and drainage (other than its effect on downstream flooding)
- Assessment of water quality requirements;
- Scour protection requirements;
- Civil design aspects (earthworks, roads etc.).

Design Objectives

The proposed layout and mitigation strategy aims to meet requirements of the policy/guidance documents described previously and summarised below.

LEP (2009) – 5.21 Flood Planning (2)

> *Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—*
>
> *(a) is compatible with the flood function and behaviour on the land, and*
>
> *(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and*
>
> *(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and*
>
> *(d) incorporates appropriate measures to manage risk to life in the event of a flood, and*
>
> *(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.*

(2a to d) are addressed as part of this report. (2e) is outside the scope of this assessment and should be managed through future design.

DCP (2013) – 4.2 Flooding

Flood Studies

Applications to subdivide or develop within the Great Lakes LEP 2014 Flood Planning Area may be required to submit a flood study to establish:

- *Site specific flood planning levels including allowances for sea level rise;*
- *How any alterations in flood behaviour caused by the development may impact on surrounding properties;*
- *Appropriate habitable floor levels for development; and*
- *The impact of the development on flood conveyance and storage.*

Subdivision Controls

1. *New allotments are to be designed to ensure that all proposed building envelopes are located outside the 2100 flood planning area.*
2. *In circumstances where the location of a building envelope beyond the 2100 flood planning area is not possible a variation may be sought. If supported by Council, building envelopes are to be located at or above the 2100 1% AEP flood level.*
3. *All lots are to have a continuous and rising vehicle evacuation route.*
4. *The filling of land is to limit the impact on adjoining properties and visual amenity of the location.*
5. *Landscaping and vegetated buffers located in flood prone areas must be designed and located to reduce the impacts of flood waters on soil stability and adjoining buildings and structures.*
6. *Subdivisions in non-urban zones e.g. large lot residential, rural and environmental zones that create an additional dwelling entitlement, are to provide:*
    a. *Storage of vehicles, machinery and the installation of septic tanks within the building envelope; and*
    b. *An on-site sewage disposal area above the 2100 5% AEP flood level.*

Existing Conditions Flood Modelling

Hydrology

Hydrologic analysis has been prepared using DRAINS. Cardno (now Stantec) had developed a DRAINS model of the Site prior to engaging GRC Hydro to initialise their design. This model was adapted for use to perform a hydrologic analysis of the local catchment in line with ARR2019 procedures and recommendations. This was used to define critical storms for this analysis, as well as used to define the inflow hydrographs for the TUFLOW 2D hydraulic model.

The model schematisation was setup based on sub-catchments derived from the terrain and exiting stormwater infrastructure as shown in Appendix A along with the parameters for the nodes, links and catchments. The solution scheme utilised for the hydrology was the RAFTS approach, with implementation of an IL-CL (Initial Loss and Continual Loss) model. As per the hierarch of approaches presented in the 'Floodplain Risk Management Guide, Incorporating 2016 Australian Rainfall and Runoff in studies' (NSW OEH, 2019), IL-CL values were sourced from nearby catchments with a calibrated model. Two nearby studies, the Lower Myall River and Myall Lakes Flood Study (BMT, 2015) and Wallis Lake Foreshore (Floodplain) Risk Management Study (WMA Water, 2014) were available which used an IL-CL value of 15 mm and 0.5 mm/hr, and 21 mm and 2.5 mm/hr respectfully for pervious areas. 0 mm and 0 mm/hr were used where impervious areas were considered. The values from the Lower Myall River and Myall Lakes Flood Study were based on a best fit value calibrated to the 2011 event, whilst the Wallis Lake Foreshore FPRS were legacy values maintained from the 1989 study. As the Lower Myall River and Myall Lakes Flood Study were partially calibrated to a recent event, and also the more conservative of the two, these values were adopted for this study. Applied hydrologic parameters are in Table 1.

Table 1: Hydrologic model parameters

Parameter	Value
Impervious Area Intial Loss	0 mm
Impervious Area Continuing Loss	0 mm/hr
Pervious Area Initial Loss	15 mm*
Pervious Area Continuing Loss	0.5 mm/hr
BX	1

* The calibrated storm ILs were transformed into burst ILs using Equation 1 or the NSW OEH (2019) study.

The DRAINS model was run for the full suite of ARR2019 temporal patterns for five events, the 20% AEP, 1% AEP and PMF for present climate conditions, and the 5% AEP and 1% AEP with allowance for climate change projections for 2090 assuming RCP4.5 conditions. This resulted in an increase in rainfall intensity of 9.5% (with a 0.9 m increase in sea level rise assed in the TUFLOW model). Critical storms for the site were determined by reviewing the total outflows at the north and south outlets, as well as the six main flow paths exiting the Site. A conservative approach was utilised, choosing a final representative storm duration and temporal pattern that had a peak flow equal to or higher than one above the median for all eight inspection points. The final design storms applied to the flood model are detailed in Table 2.

Table 2: Design storm events selected for flood modelling

Event	Critical Duration (min)	Critical Storm Temporal Pattern #
20% AEP	45	9
5% AEP with Climate Change	60	10
1% AEP	20	10
1% AEP with Climate Change	20	10
PMF	15	GSDM*

* Generalised Short Duration Method

The Probable Maximum Precipitation (PMP) for the Site was calculated using the Generalised Short-Duration Method as detailed in '*The Estimation of Probable Maximum Precipitation in Australia Generalised Short-Duration Method (Bureau of Meteorology, 2003 Amendment)*'. This rainfall was run in the DRAINS model and critical storms selected following a similar approach to the other events. The final representative storm for the catchment was the 15 minute duration, as detailed in Table 2.

Hydraulics – TUFLOW Model

Flooding modelling was undertaken using a TUFLOW hydraulic model (version 'TUFLOW.2020-10-AD' with utilisation of the 'Classic' solver). The model was constructed to model mainstream, overland flow, oceanic and trunk stormwater drainage flooding for the Site. TUFLOW is a 2D numerical modelling package suitable for floodplains in urban catchments and widely used in Australia for the 1D-2D coupled hydraulic modelling required for flood studies and floodplain risk management plans.

The various data and parameters implemented in the TUFLOW model are discussed below, with Figure 2 detailing the model schematisation.

Figure 2: TUFLOW model schematisation

- Model Domain and Grid Size – The hydraulic model domain covers an area of approximately 23 ha as shown in Image 3. A 1-metre grid resolution has been implemented which allows representation of key features to sufficient detail for this assessment.
- Building profiles – Building profiles were removed from the model to generate flow obstructions following recommendations in ARR2019. Building extents were informed based on available aerial imagery.
- Upstream Boundary Conditions – Hydrology inflows defined by the DRAINS model detailed above were applied using the Source Area approach. The Source Area approach uses the sub catchments previously defined in DRAINS and applies the hydrograph from DRAINS to the TUFLOW model in that sub-catchment. In sub-catchments with pits, the flow is applied directly to the pits, otherwise applies it to the lowest point in the subcatchment.
- Downstream Boundary Conditions – Two downstream model boundaries were used – One draining north and one draining east into the ocean as shown in Image 3. The north boundary was applied as a stage-discharge (H/Q) boundary whereby the hydraulic model generates a stage-discharge curve based on the terrain slope. The ocean boundary was applied as a static level vs time boundary set to the ocean water level.
- Ocean Water Level –For the 1% AEP and PMF events, ocean water level boundaries consistent with the values used in the Wallis Lake Foreshore (Floodplain) Risk Management Study (WMA Water, 2014) were applied (see Table 3). These values are highly conservative as sea level and short duration storm events are only weakly correlated. Notwithstanding, flooding at the Site is not particularly sensitive to elevated sea levels at ground elevations are typically above 5 mAHD. For the 20% and 5% AEP events, a Mean High Water Springs (MHWS) water level of 0.675 mAHD was applied.

Table 3: Adopted ocean boundary levels

Event	Ocean Level (mAHD)	Climate Change Allowance (m)
20% AEP	0.675	-
5% AEP with Climate Change	1.575	0.9
1% AEP	1.73	-
1% AEP with Climate Change	2.63	0.9
PMF	1.85	-

- Initial Water Level – Initial water levels were applied at the Blueys Beach outlet as defined by the Ocean Water Level. Locations of storage in the terrain, such as dams, were filled to their outlet invert.
- Digital Elevation Model (DEM) - NSW Government Spatial Services LiDAR survey 1m grid DEM from 2013 was used to inform the topography of the 2D hydraulic model outside of the Site. Survey information provided by Cardno was used to inform the topography within the Site. A comparison between the two suggest a difference between survey and LiDAR of ±0.20 m in the flatter, less vegetated areas. The survey provided improved information in the channels and near downstream property boundaries that was hidden by vegetation in the LiDAR The survey has been used in preference to the LiDAR information where available.
- Mannings Roughness – Manning's values were selected based on inspection of street view images and images from the Cardno site inspection with consideration of ARR2019 guidelines. Applied values for each material type is presented in Table 4. Schematisation of material types in the 2D domain were informed by aerial imagery from 2020.

Table 4: Mannings 'n' values for each material type

Material Type	Mannings 'n' Value
Road	0.013
Verge	0.04
Residential	0.07
Open Water	0.02
Grassed	0.05
Trees/Heavy Vegetation	0.1
Dunes	0.02

- Climate Change – Implementation of climate change was done using the ARR2019 climate change factors for RCP4.5 in 2090 which resulted in a rainfall increase of 9.5%. An increase in sea level of 0.90 m was applied based on *'Department of Environment & Climate Change (DECC) Floodplain Risk Management Guideline – Practical Consideration of Climate Change (2007)'* guidelines.
- Stormwater Information – There are no existing stormwater infrastructure within the Site. Existing culverts, pits and pipes for the area downstream of the site between Samuel Street and Ampat Place were informed from survey conducted by Cardno of the culvert inlets on Site and existing plans from the residential development of the area in 1972. New infrastructure since that time was implemented with assumed values of a 1% grade and pipe sizes informed by the existing infrastructure. Pipe sizes and orientations for the area north of the Site along Boomerang Drive was provided by Council. Pit inlet types were then informed from street

imagery and inverts were assumed based on a minimum cover from surface to top of pipe of 750 mm under road or 600 mm under verge.

- Blockage – ARR2019 blockage calculations were done for the major culverts in the Site. The resultant blockages are detailed in Table 5. Pits were assumed to have 50% blockage in sag, or 20% blockage if on-grade. The calculations are presented in Appendix B.

Table 5: ARR2019 Blockage Values

Culvert Size	< 5% AEP Event	5% AEP to 1% AEP	> 1% AEP Event
375 mm	0	10	20
450 mm	0	10	20
600 mm	0	10	20
1050 mm	0	0	10

- Pit Inlet Curves – Pit inlet curves were derived for each pit inlet type in the catchment. Pit inlet types were determined from street view or site inspection. The resultant curves are presented in Appendix C.

Existing Conditions Flood Model Results

The TUFLOW model was run for pre-development conditions to determine the 20% AEP, 1% AEP and PMF for current conditions, as well as the 5% AEP and 1% AEP for climate change conditions.

Pre-development peak flood depth and level maps are presented in:

- Current Conditions: Figures 1 to 3
- Climate Change Conditions: Figures 4 and 5

Peak flood velocities with peak flows exiting the Site at key locations are presented in:

- Current Conditions: Figures 6 to 8
- Climate Change Conditions: Figures 9 and 10

Depths less than 0.05 m are considered minor drainage and have been omitted from the map results.

Locations 2 and 4, at approximately 13 Ampat Place and at the end of Samuel Street respectively, represent the majority of the overland flow exiting the Site. Other than sheet flow from the upper catchments, the only significant floodwater entering the Site is between Samuel Street and View Street which joins the main flow path through the Site.

Proposed Design Flood Modelling

The proposed design for the Site includes four new roads, bulk earthworks, and a lot subdivision to create 73 new residential and 2 commercial lots. The proposed hydraulic design includes bulk earthworks for the Site and flood mitigation strategies including basins, swales and an internal trunk stormwater network.

The proposed site layout is detailed conceptually in Figure 3, but refer to the DA Site Layout by Cardno (now Stantec) for full details. Of note are the following features:

- Drainage Reserve Y1 located near the existing flow path exiting the Site near 13 Ampat Place.
- Drainage Reserve Y2 located near the existing flow path exiting the Site near Samuel Street.
- Drainage Reserve Y3 created by the raised road proposed through the site and located upstream of the Y1 drainage reserve.

- Swale to convey flow near the south of the site, located near the existing flow path exiting the Site near 7 Ampat Place.
- Underground storage tank located near the northern outlet of the site, close to where the proposed road joins with Boomerang Drive.
- Stormwater and swales to convey water towards the proposed drainage reserves.

Figure 3: Conceptual Site Plan

Post Development DRAINS Model

The pre-development DRAINS model was updated with the proposed design. Sub-catchments within the Site were modified to reflect the new terrain, future development (and associated increase in imperviousness), and site drainage. The layout and parameters for the new catchments are presented in Appendix D.

The selected design storms used for the pre-development conditions were reviewed with the updated using the post development DRAINS model. The previous critical durations and temporal patterns were deemed appropriate for the proposed design as they retained the conservative approach with peak flow at or above the critical flows for the eight inspection points mentioned previously.

Post Development TUFLOW Model

The pre-development TUFLOW model was updated for post development conditions with the following changes:

- Terrain was updated with a TIN of the proposed surface provided by Cardno (now Stantec), which reflected the bulk earthworks as well as proposed roads, swales and drainage reserves.
- Updates were made to the terrain to implement concept flood mitigation measures to manage site flood characteristics and of site flood impacts. Specifically, the following was implemented:
    - Y2 Drainage Reserve

        - 6 metre wide, rectangular grass swale starting at 0.5 m below existing terrain levels and sloping at a constant 1% grade towards the Y2 drainage reserve to convey inflow from between Samuel Street and View Street.
        - Drainage reserve converted to a basin with a capacity of 1,140 m³ to hold the 1% AEP event + climate change
        - 1800 mm wide by 600 mm high box culvert to convey low flow out of the basin along with the existing culvert.
        - Weir at 9.25 m AHD for a controlled overtopping of the basin in larger events
    - Y3 Drainage Reserve
        - Proposed road between Y1 and Y3 forms a flood storage upstream of the embankment;
        - Mostly natural terrain with some cut to achieve a final capacity of ~5,020 m³ to hold the 1% AEP event + climate change volume whilst maintaining a 500 mm freeboard;
        - New 4 x 450 mm diameter circular culverts draining through the proposed road embankment;
    - 5 m wide swale to convey flow around the proposed development into the existing culvert running between 5 and 7 Ampat Place.
- A trunk stormwater concept was implemented into the design. The system was modelled as pipe limited and further optimisation of the design is envisaged during detailed design;
- Underground storage tank at the north of the catchment with a storage capacity of ~460 m³, sized to hold the 1% AEP + climate change to be utilised when the capacity of the downstream stormwater system is exceeded.

The proposed concept flood mitigation strategy works are presented in Figure 3.

Proposed Conditions Flood Model Results

Consistent with pre-development, the 20% AEP, 1% AEP and PMF for present climate conditions, and the 5% AEP and 1% AEP with climate change, were assessed.

Proposed conditions peak flood depths are presented in:

- Current Conditions: Figures 11 to 13
- Climate Change Conditions: Figures 14 and 15

Peak flood velocities with peak flows exiting the Site at key locations are presented in:

- Current Conditions: Figures 16 to 18
- Climate Change Conditions: Figures 19 and 20

Hazard maps are presented for the PMF and 1% AEP with climate change in Figures 26 and 27.

Depths less than 0.05 m are considered minor drainage and have been omitted from the mapping results.

Proposed lots are noted to be flood free in events up to and including the 1% AEP event climate change. Some shallow lot and road flooding is noted during the PMF, with lots affected by flood depths of less than 0.3 m with an associated H1 hazard category. Flood depths on the road are again generally less than 0.3 m, however, due to velocities exceeding 2 m/s, a flood hazard category of H5 is noted for some internal road, noting that the road verge is generally H1 hazard.

Flood Impact Analysis

Flood impact maps that compare pre and post development conditions are presented in:

- Current Conditions: Figures 21 to 23
- Climate Change Conditions: Figures 24 and 25

Flows for pre-development and under the proposed design are summarised in Table 6 and Table 7 for the locations presented in the above maps.

Table 6: Flows exiting the site for current climate conditions

Loc #	Location Description	20% AEP Flow (m^3/s)			1% AEP Flow (m^3/s)		
		Pre-Dev	Option 1	Reduction	Pre-Dev	Option 1	Reduction
1	Exiting near 7 Ampat Pl	0.98	0.23	77%	2.66	1.42	47%
2	Exiting Y1 Basin Location	1.14	0.22	81%	4.3	1.02	76%
3	Exiting near 3 Alamau Pl	0.00	0.00	NA	0.17	0.00	100%
4	Exiting Y2 Basin Location	0.93	0.86	8%	3.16	2.59	18%
5	Exiting near 188 Boomerang Dr	0.42	0.05	88%	0.97	0.34	65%
6	Exiting near 194 Boomerang Dr	0.25	0.00	100%	0.43	0.32	26%

Table 7: Flows exiting the site for climate change conditions

Loc #	Location Description	20% AEP Flow (m^3/s)			1% AEP Flow (m^3/s)		
		Pre-Dev	Option 1	Reduction	Pre-Dev	Option 1	Reduction
1	Exiting near 7 Ampat Pl	2.22	1.19	46%	3.01	1.66	45%
2	Exiting Y1 Basin Location	3.3	1.03	69%	5.18	1.29	75%
3	Exiting near 3 Alamau Pl	0.07	0.00	100%	0.22	0.00	100%
4	Exiting Y2 Basin Location	2.34	2.02	14%	3.64	3.40	7%
5	Exiting near 188 Boomerang Dr	0.72	0.19	74%	1.07	0.36	66%
6	Exiting near 194 Boomerang Dr	0.31	0.00	100%	0.5	0.42	16%

The analysis shows that the concept flood mitigation strategies result in reduced flows and flood levels for surrounding areas for events up to and including the 1% AEP event with allowance for climate change. Localised minor increases in flood level with the road corridor on Boomerang Drive are noted, however, these do not impact on existing development. Localised areas of minor impact are noted during the PMF, however, these do not alter existing flood risk for the area.

Assessment of Compliance with Policies and Guidelines

The LEP (2013) 'Clause 5.21 Flood Planning' requirements are detailed in Table 8 along with how the proposed development concept addresses these requirements.

Table 8: Summary of the proposed development meeting relevant LEP policies

Subclause	Description	Compliant?	Result
2a	Is compatible with the flood function and behaviour on the land	Yes	The site is predominantly flood free during the 1% AEP event + climate change. Development within flow conveyances areas is not proposed (as all lots are flood free). Lost flood storage will be replaced with implementation of the drainage reserves and storage tank which result in a reduced flows discharging from the Site.
2b	Will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties	Yes	A flood impact assessment shows generally reduced flood affection for existing properties downstream of the site for events up to the 1% AEP event with allowance for climate change. Impacts during the PMF are minor and are not expected to change existing flood risk in the area.
2c	Will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood	Yes	The proposed lots are flood free during events up to the 1% AEP event with climate change and experience only shallow low hazard (H1) flooding during the PMF. Evacuation from properties, or the site in general, due to flood risk is not required for any flood event. Therefore, the development will not *'adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes'.*
2d	Incorporates appropriate measures to manage risk to life in the event of a flood	Yes	See (2c) above.
2e	Will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses		This has not been assessed as part of the current study and can be managed through design development at the detailed design stage.

Relevant controls from the DCP (2014) for a flood study to address as well as specifics for a subdivision are detailed in Table 8 along with how the proposed development addresses them.

Table 9: Summary of the proposed development compliance with the DCP (2014)

Control	Description	Compliant?	Result
Flood Studies			
	Site specific flood planning levels including allowances for sea level rise	Yes	Results are presented for the 1% AEP event + climate change with allowance for 0.9 m sea level rise. The site is flood free during events up to and including this event. Site specific flood planning levels are not required. This assumption should be reviewed at the detailed design stage.
	How any alterations in flood behaviour caused by the development may	Yes	Impacts and changes to the peak flow due to alterations in flood behaviour from the proposed development have been presented and shown to have no impacts on any downstream properties, as

	impact on surrounding properties		well as reduce peak flow to below pre-development peak flows for a range for flood events.
	Appropriate habitable floor levels for development		The proposed lots are flood free during events up to the 1% AEP event with climate change. Site specific flood planning levels are not envisaged to be required. This should be reviewed at the detailed design stage.
	The impact of the development on flood conveyance and storage		Development areas are not flood affected (and are thus not affected by flow conveyance or flood storage areas). Flood storage is envisaged to be increased with the construction of proposed drainage reserves. Peak flow results have shown decreases in all the major outflow locations for the Site for events up to and including the 1% AEP + climate change.
Subdivision Controls			
	New allotments are to be designed to ensure that all proposed building envelopes are located outside the 2100 flood planning area		The proposed lots are flood free during events up to the 1% AEP event with climate change.
	In circumstances where the location of a building envelope beyond the 2100 flood planning area is not possible a variation may be sought. If supported by Council, building envelopes are to be located at or above the 2100 1% AEP flood level		NA – see above
	All lots are to have a continuous and rising vehicle evacuation route		Proposed lots are typically flood free during the PMF with a small number of lots experiencing H1 flood hazard characteristics (no vulnerability constraints). Flood evacuation is not required during any flood event. Rising road access is available from all proposed lots.
	The filling of land is to limit the impact on adjoining properties and visual amenity of the location		Not assessed as part of this study.
	Landscaping and vegetated buffers located in flood prone areas must be designed and located to reduce the impacts of flood		Not assessed as part of this study. For consideration during detailed design.

	waters on soil stability and adjoining buildings and structures		
	Subdivisions in non-urban zones e.g. large lot residential, rural and environmental zones that create an additional dwelling entitlement, are to provide: -Storage of vehicles, machinery and the installation of septic tanks within the building envelope; and -An on-site sewage disposal area above the 2100 5% AEP flood level		Not applicable.

Conclusions and Recommendations

Cardno engaged GRC Hydro to conduct a flood investigation for a proposed lot subdivision at Lot 23 DP537919, Blueys Beach, situated in the Midcoast Council Local Government Area.

Flood modelling was undertaken using a DRAINS / TUFLOW hydrologic/hydraulic modelling system utilising ARR2019 methods. Model parameters derived by nearby Council flood studies have been used where appropriate. A pre-development conditions flood model was developed using available survey and stormwater information. Five events were assessed; the 20% AEP, 1% AEP and PMF for current climate conditions, and the 5% AEP and 1% AEP with allowance for climate change projections for 2090 assuming RCP4.5 projections.

Pre-development conditions flood model results show an existing flood risk for a number of properties downstream of the site for events as frequent as the 20% AEP flood. Existing flood risk at these properties has also been identified by Council.

The pre-development conditions model was modified with incorporation of design information provided by Cardno to develop a post development conditions model. Concept flood mitigation strategies were developed to manage flood risk within the proposed development site and mitigate flood impacts affecting surrounding properties. The flood mitigation strategy includes flood storage areas, swales and trunk drainage.

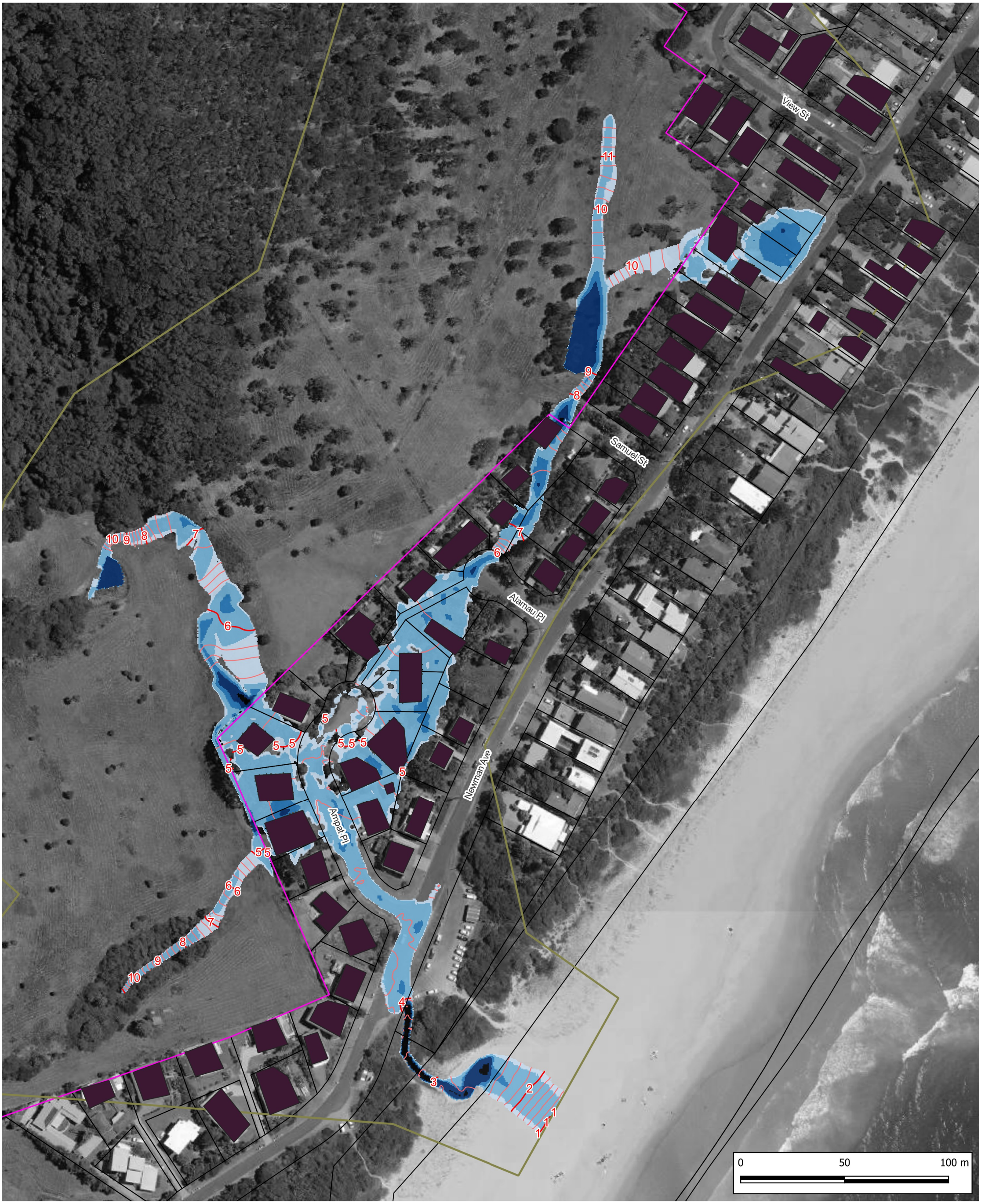
Post development conditions flood model results show that proposed development lots within the Site are not flood affected for events up to and including the 1% AEP event with allowance for climate change. During the PMF, most lots are noted to be flood free, with a small number of lots experiencing flood depths of less than 0.3 m with an associated H1 hazard category (benign flood conditions). The flood impact assessment shows that site discharge to flow paths downstream of the Site are reduced relative to pre-development conditions and flood depths and levels are reduced for a range of flood events.

Assessment of the development in consideration of Council's flood planning policy (LEP, 2013 and DCP, 2014) shows that the proposed design complies with Council's flood related development controls.

Further development of the design should be undertaken at detailed design to:

- Develop scour mitigation measures within the site if required;
- Further optimise the sizing of the concept trunk stormwater system;
- Incorporate lateral drainage into the design where required;
- Appropriately size road inlet structures with allowance for blockage
- Confirm flood planning levels for flood affected lots (if any).

Figures



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 20% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**1-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

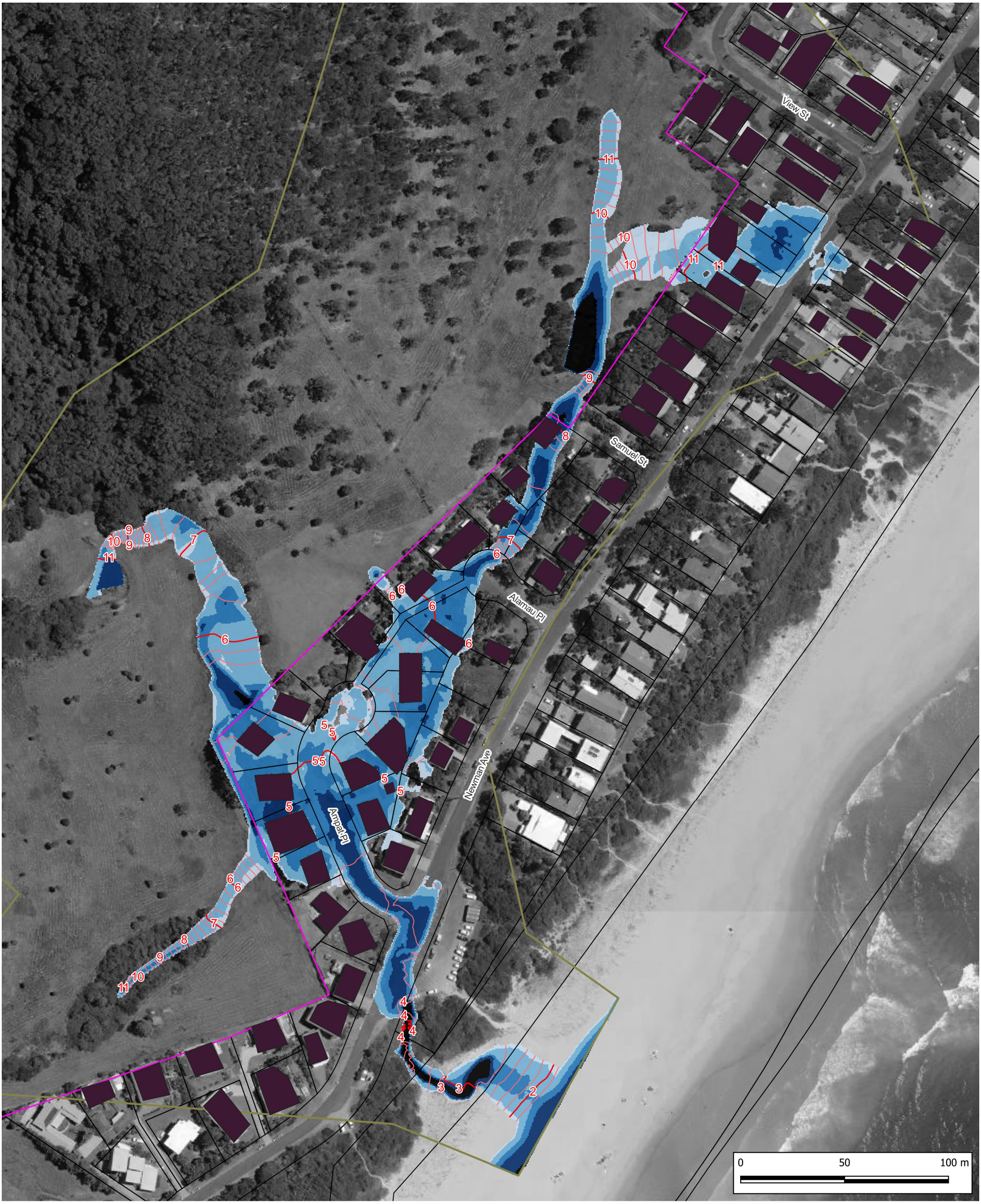
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 20% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **1-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

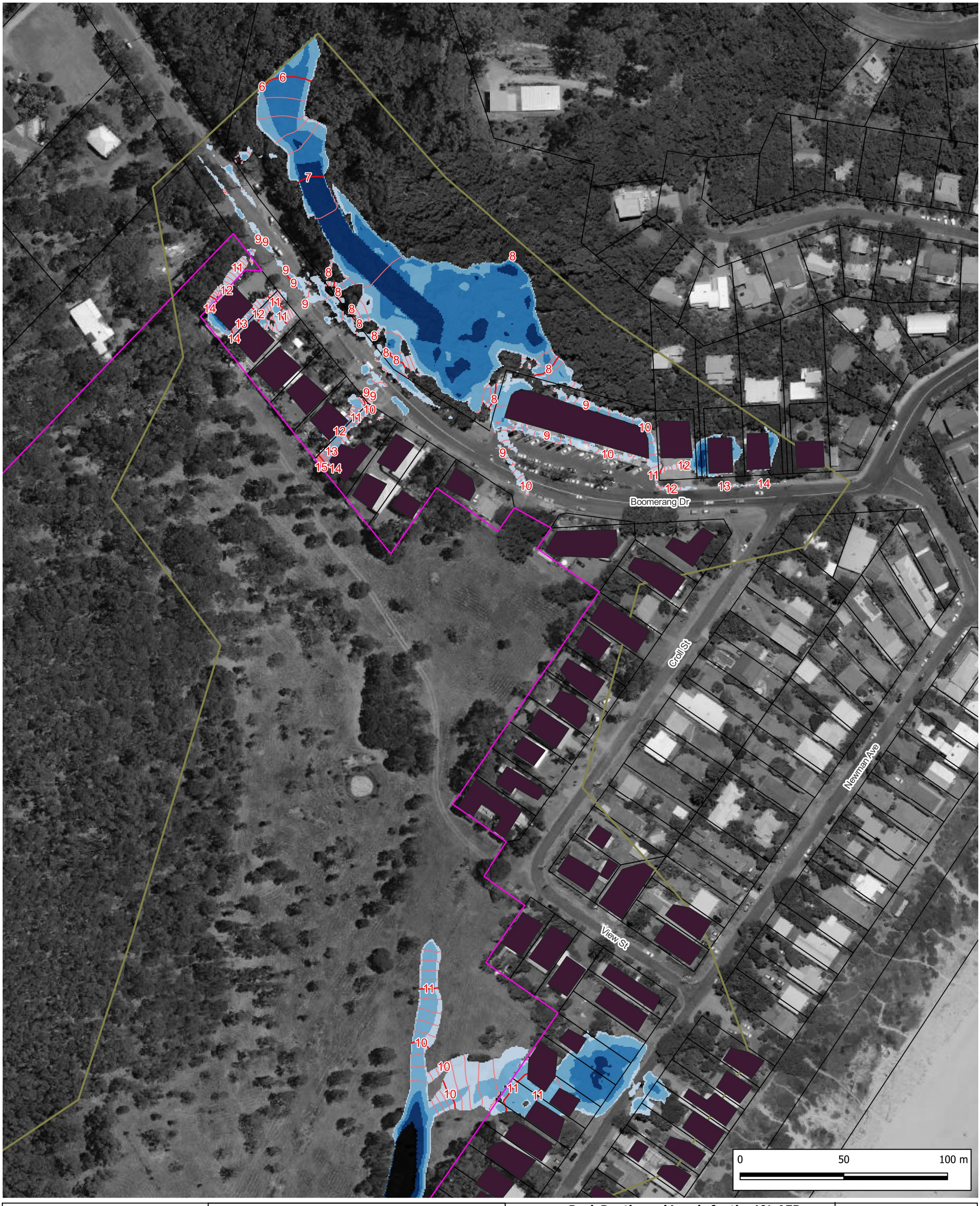
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **2-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

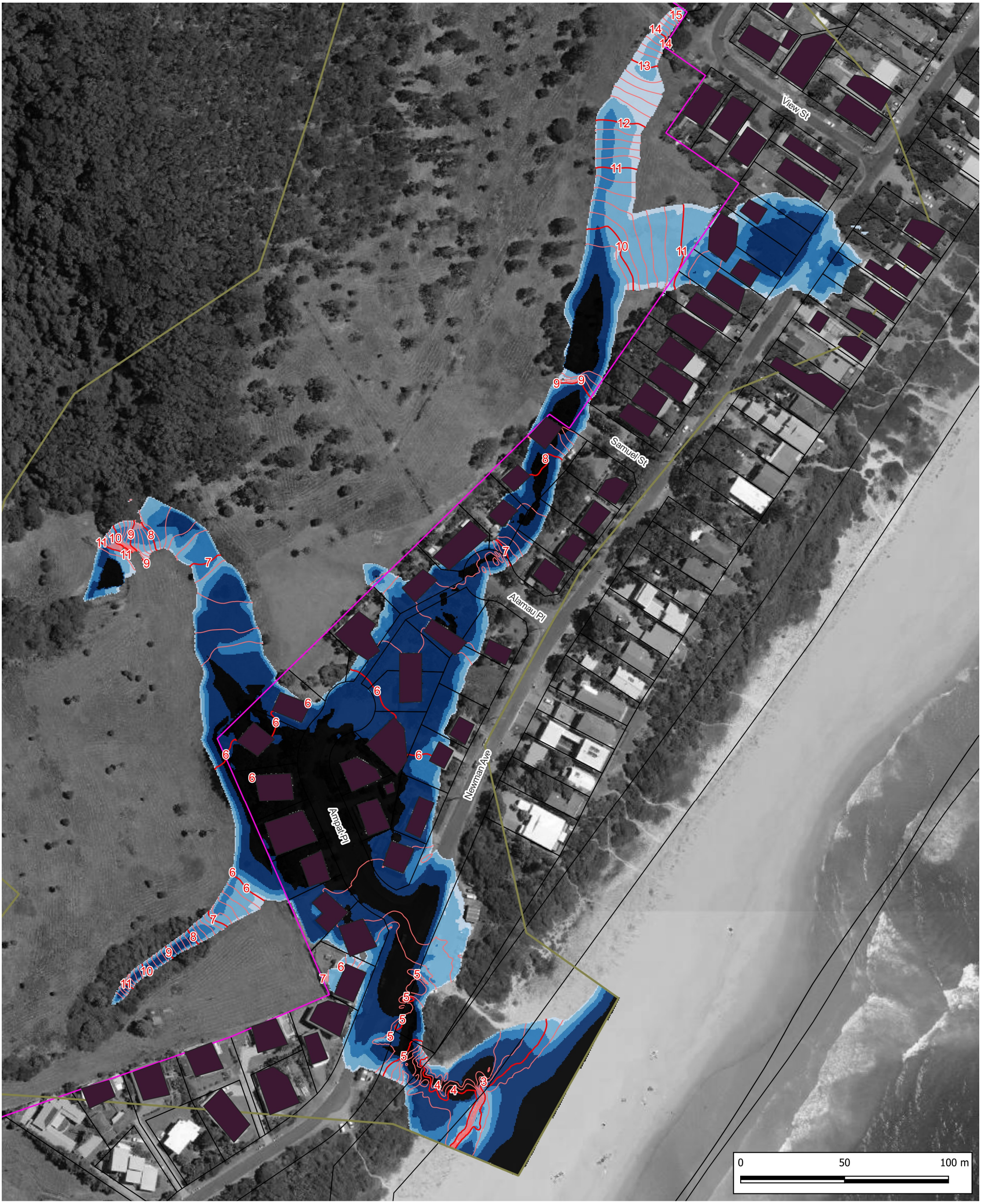
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**2-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the PMF Design Event- Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **3-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

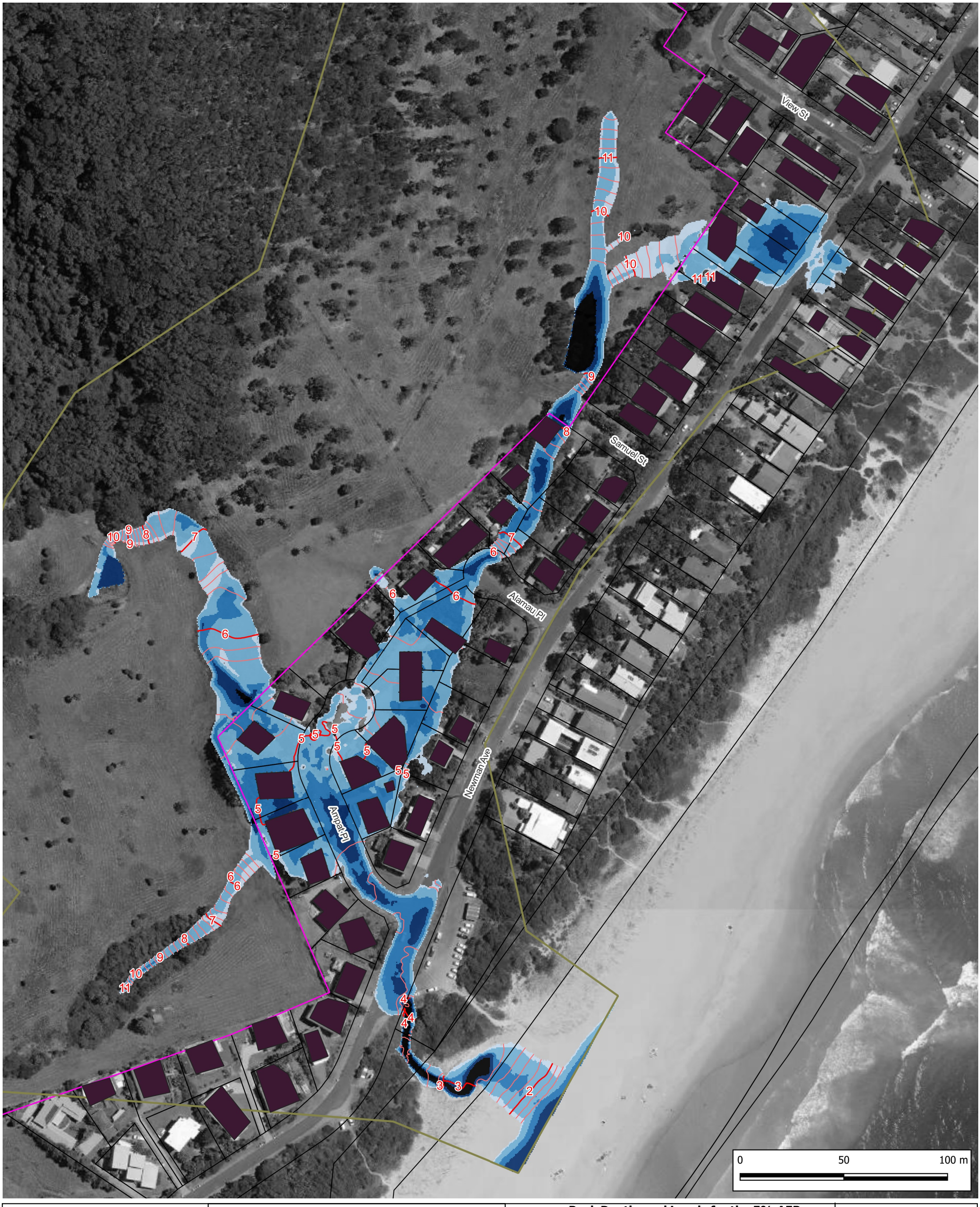
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the PMF Design Event- Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **3-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 5% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **4-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

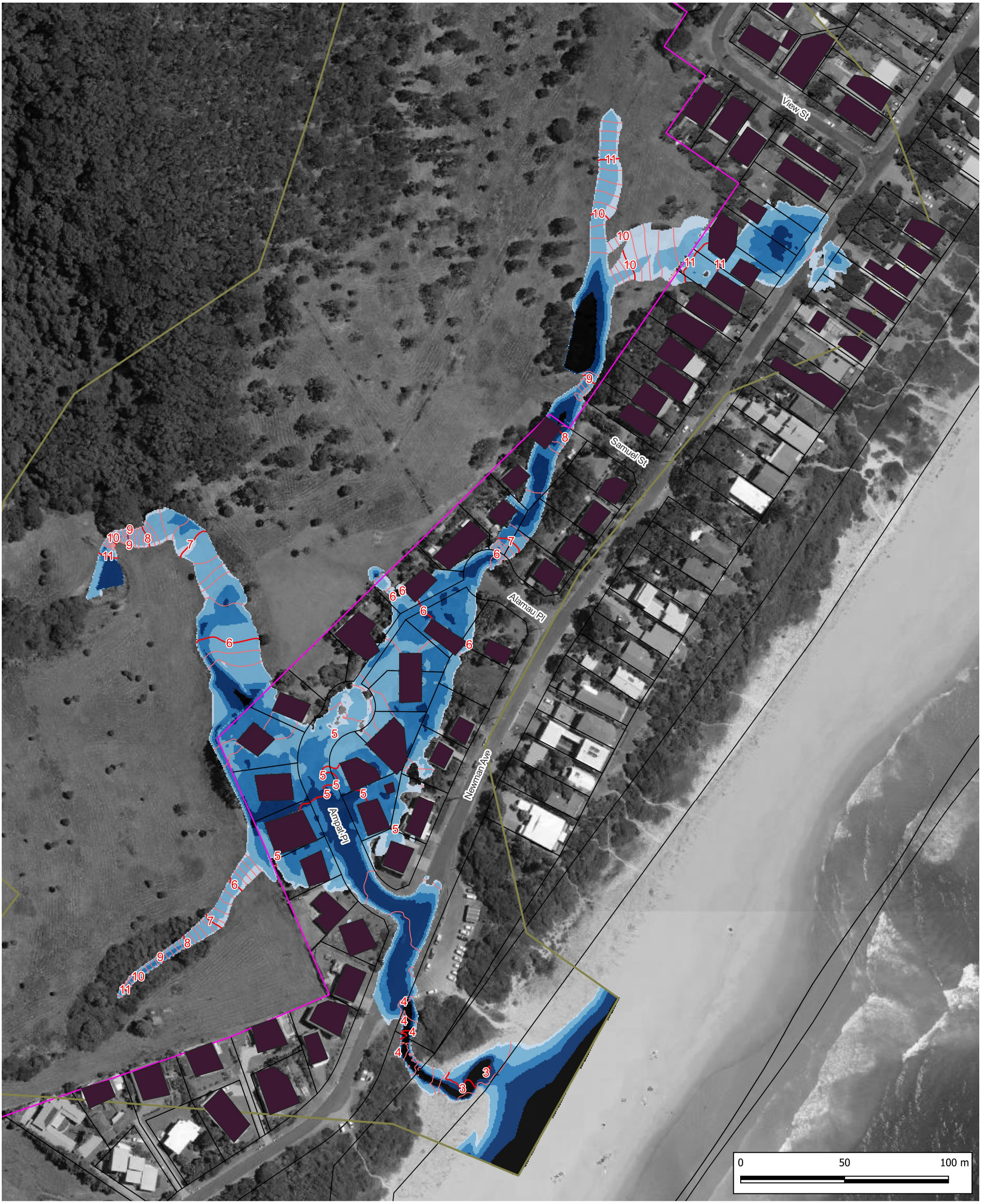
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 5% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **4-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

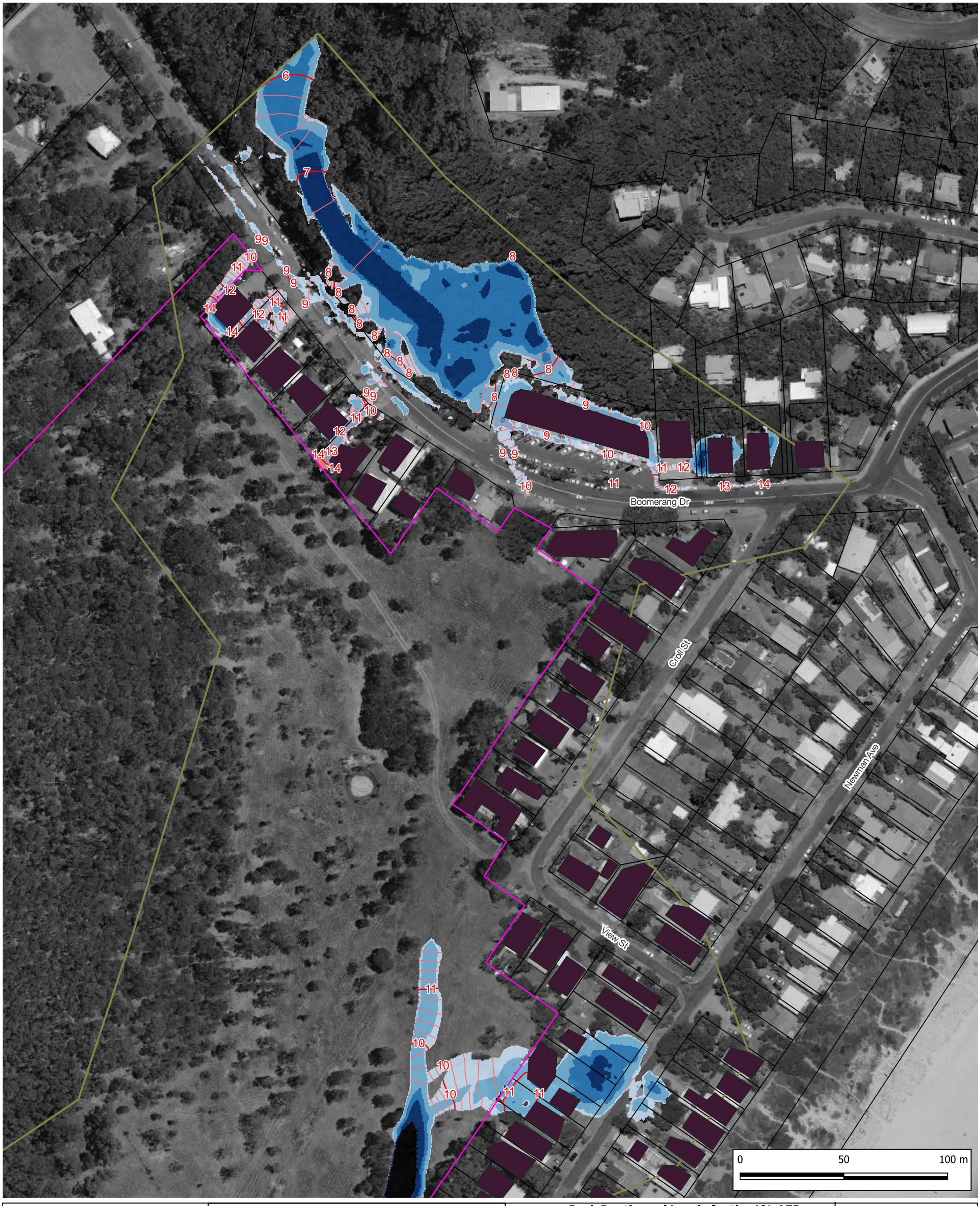
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **5-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **5-2**

grc HYDRO

Legend

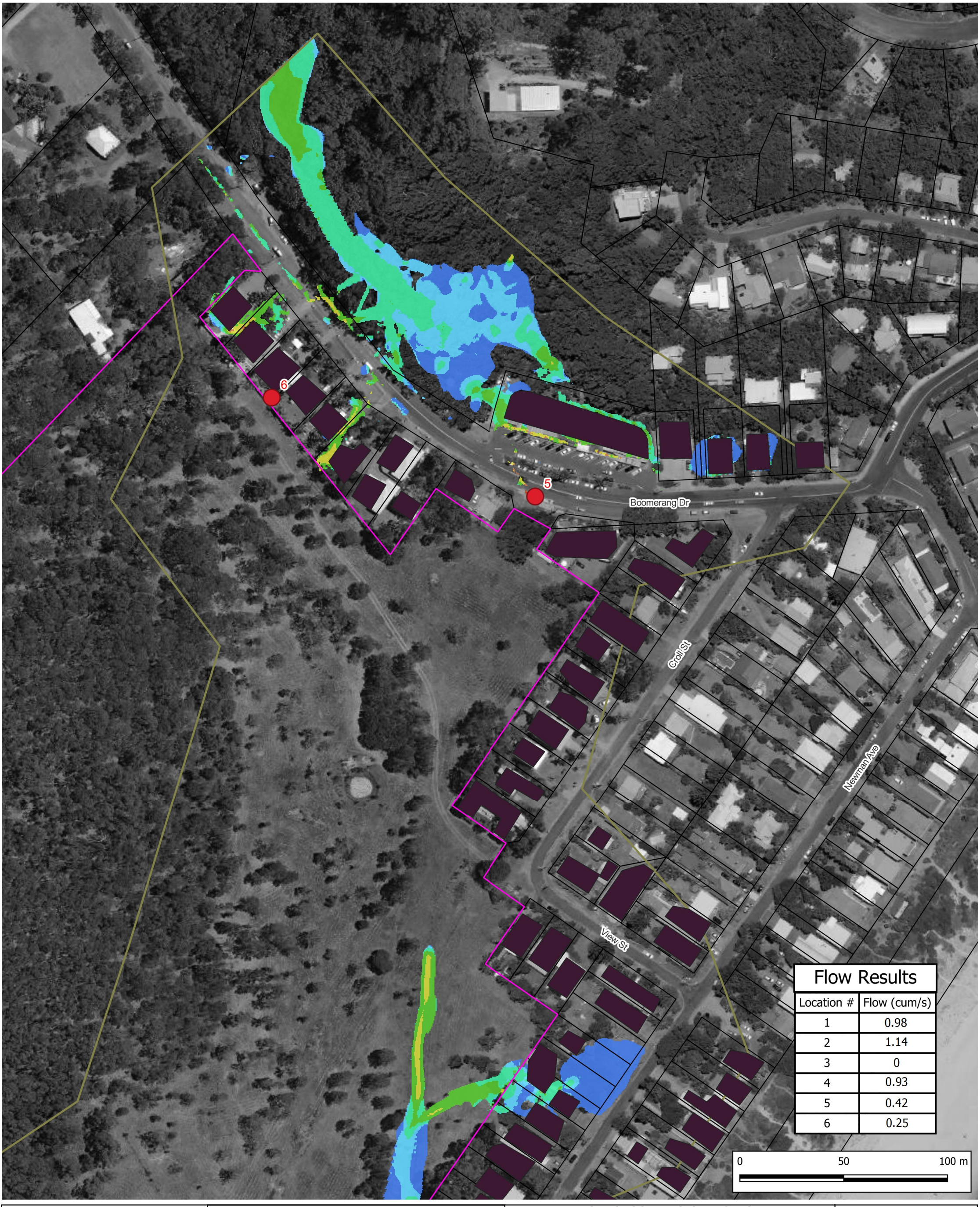
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 20% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **6-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 20% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **6-2**

grc HYDRO

Legend

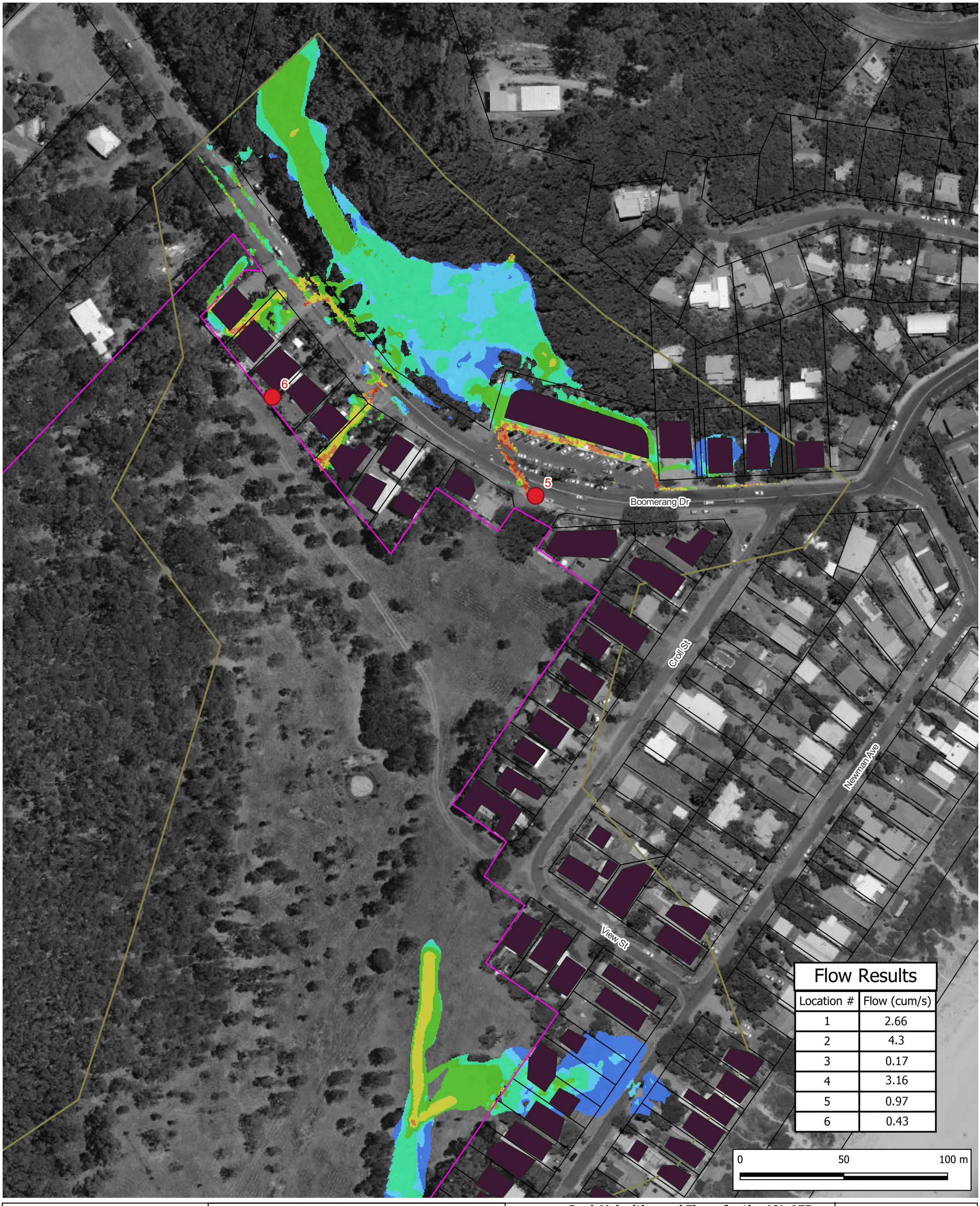
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **7-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

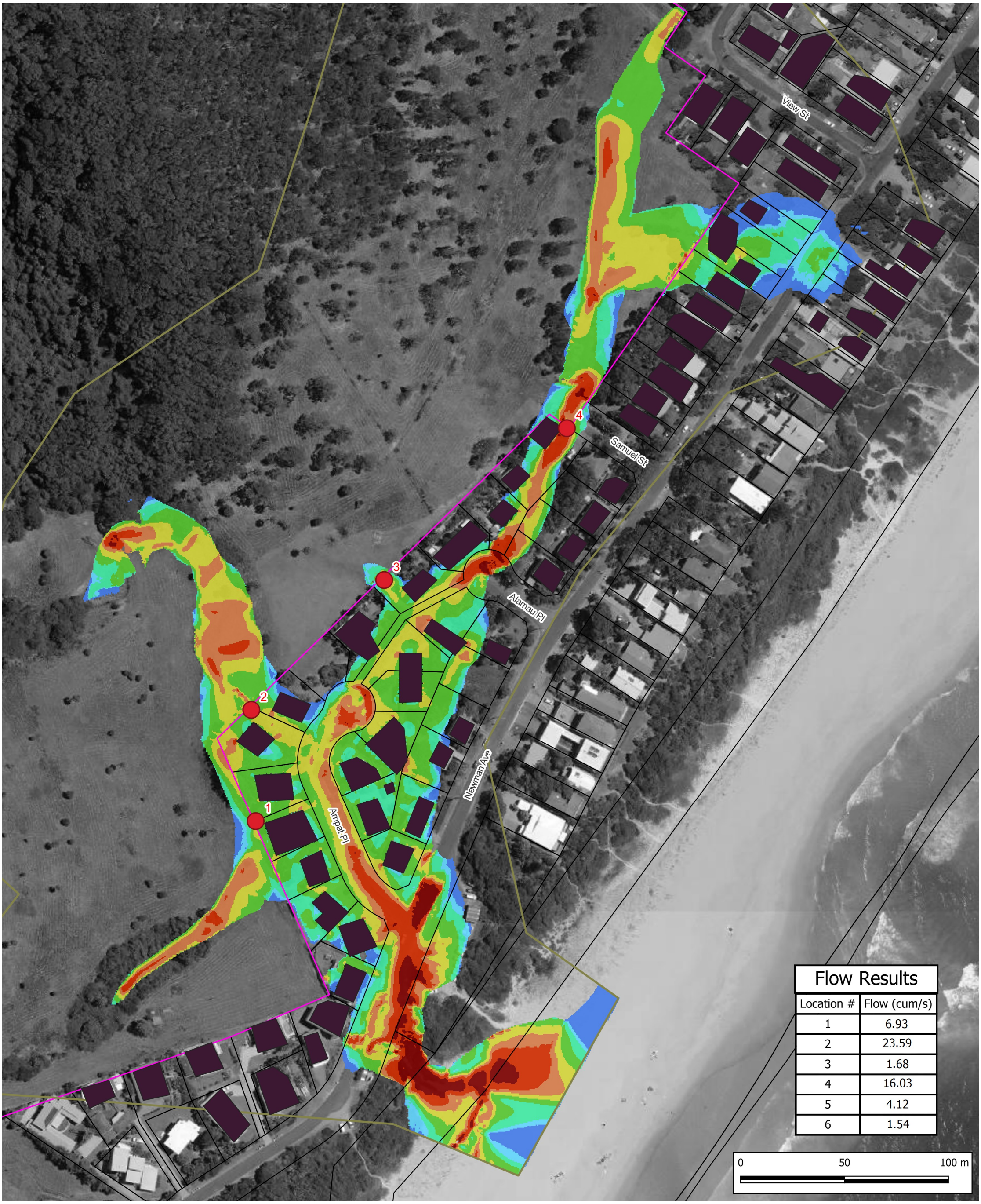
Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**

DATE: **08-2022** | SCALE: **1:1,600** | FIGURE No. **7-2**

grc HYDRO



Legend

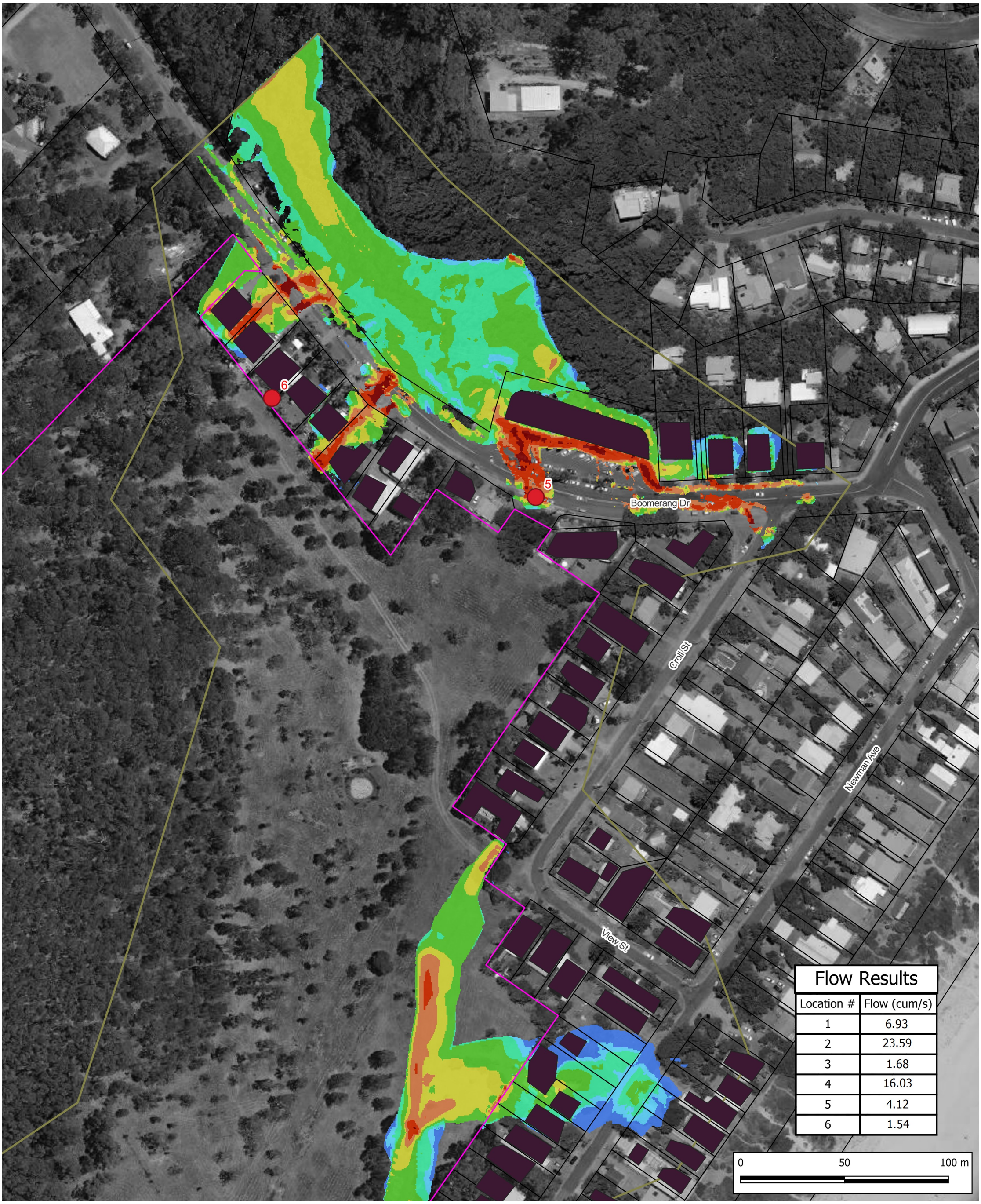
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the PMF Design Event- Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **8-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the PMF Design Event- Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **8-2**

grc HYDRO

Legend

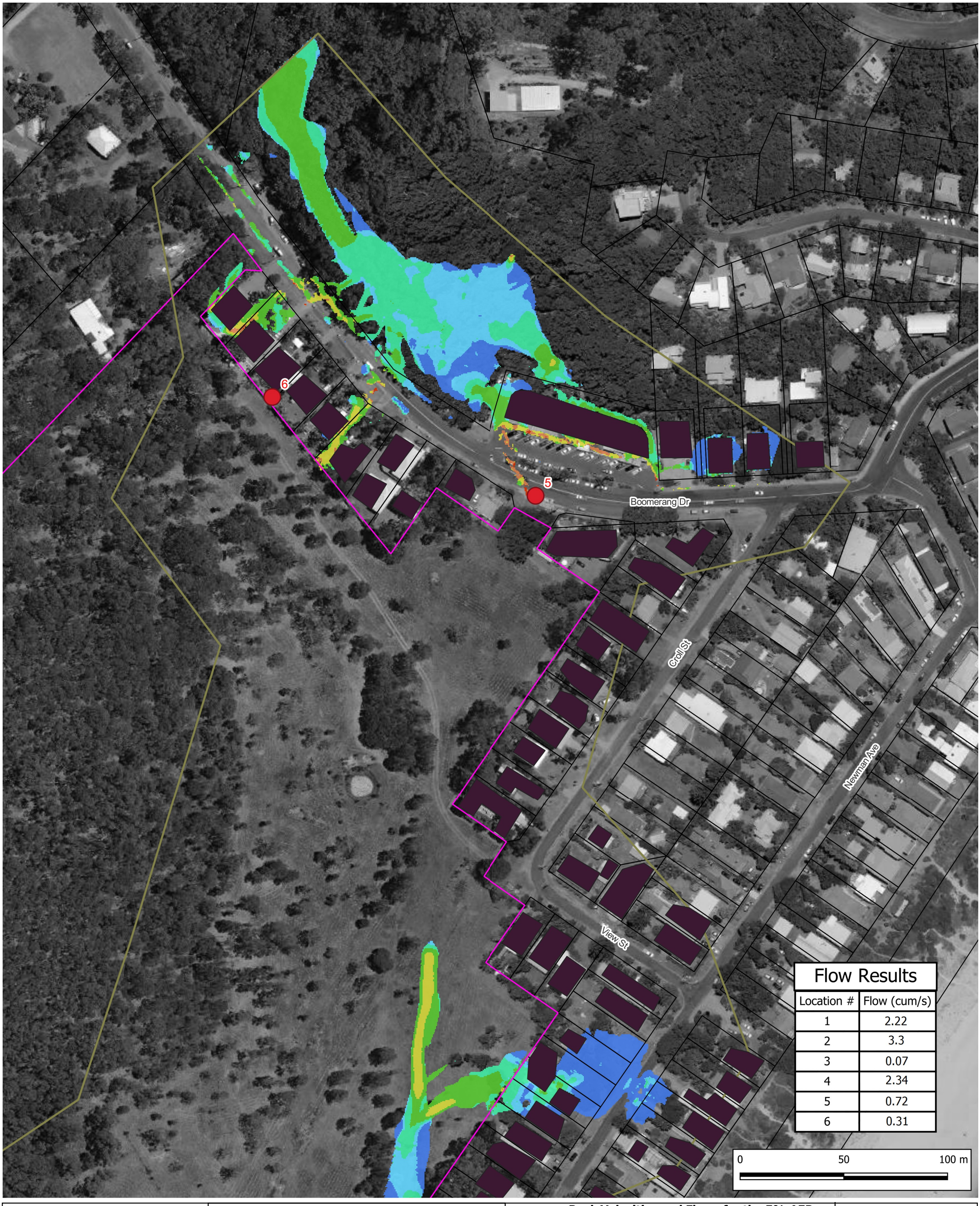
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 5% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **9-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 5% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**9-2**

grc HYDRO

Legend

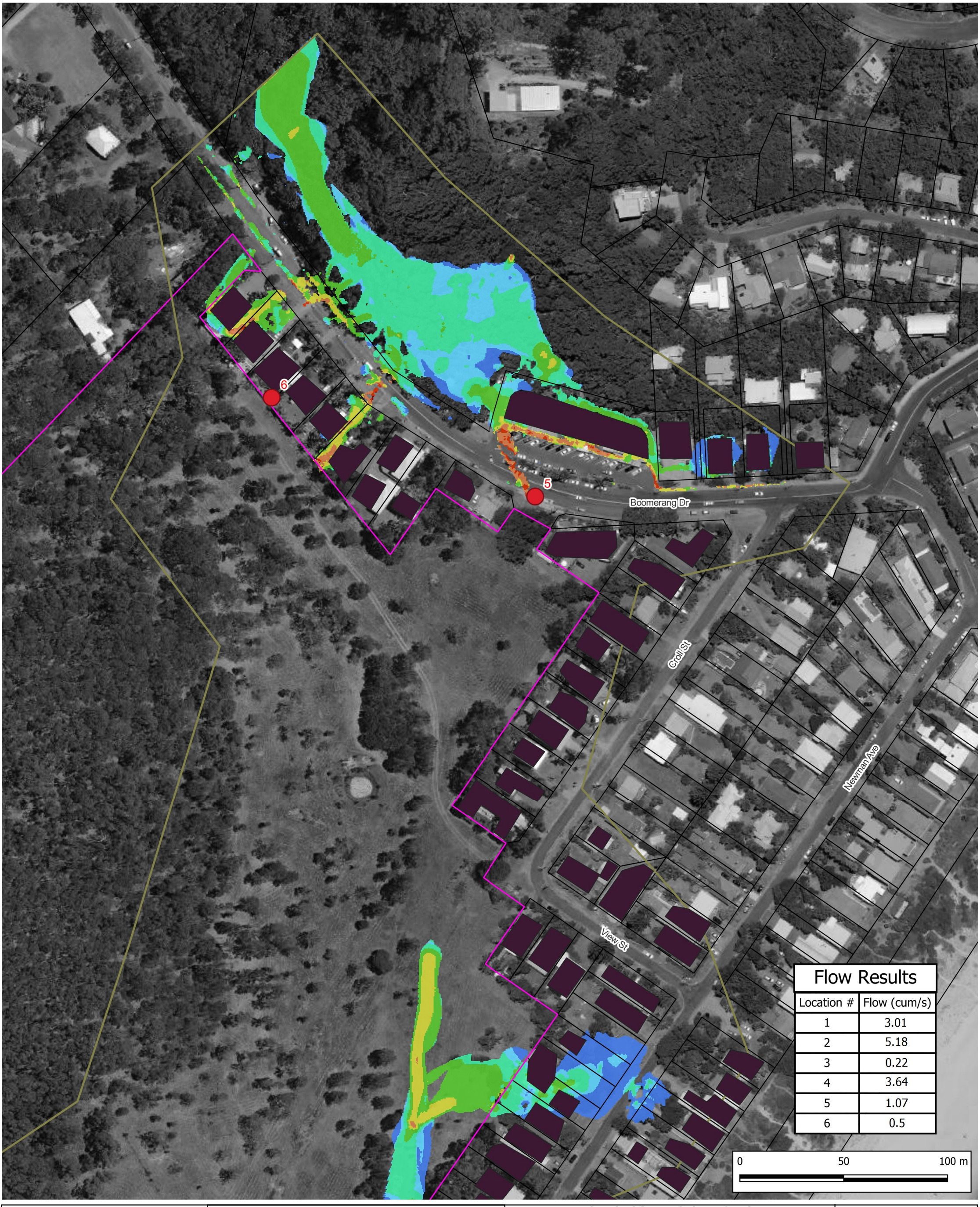
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **10-1**

grc HYDRO



Legend

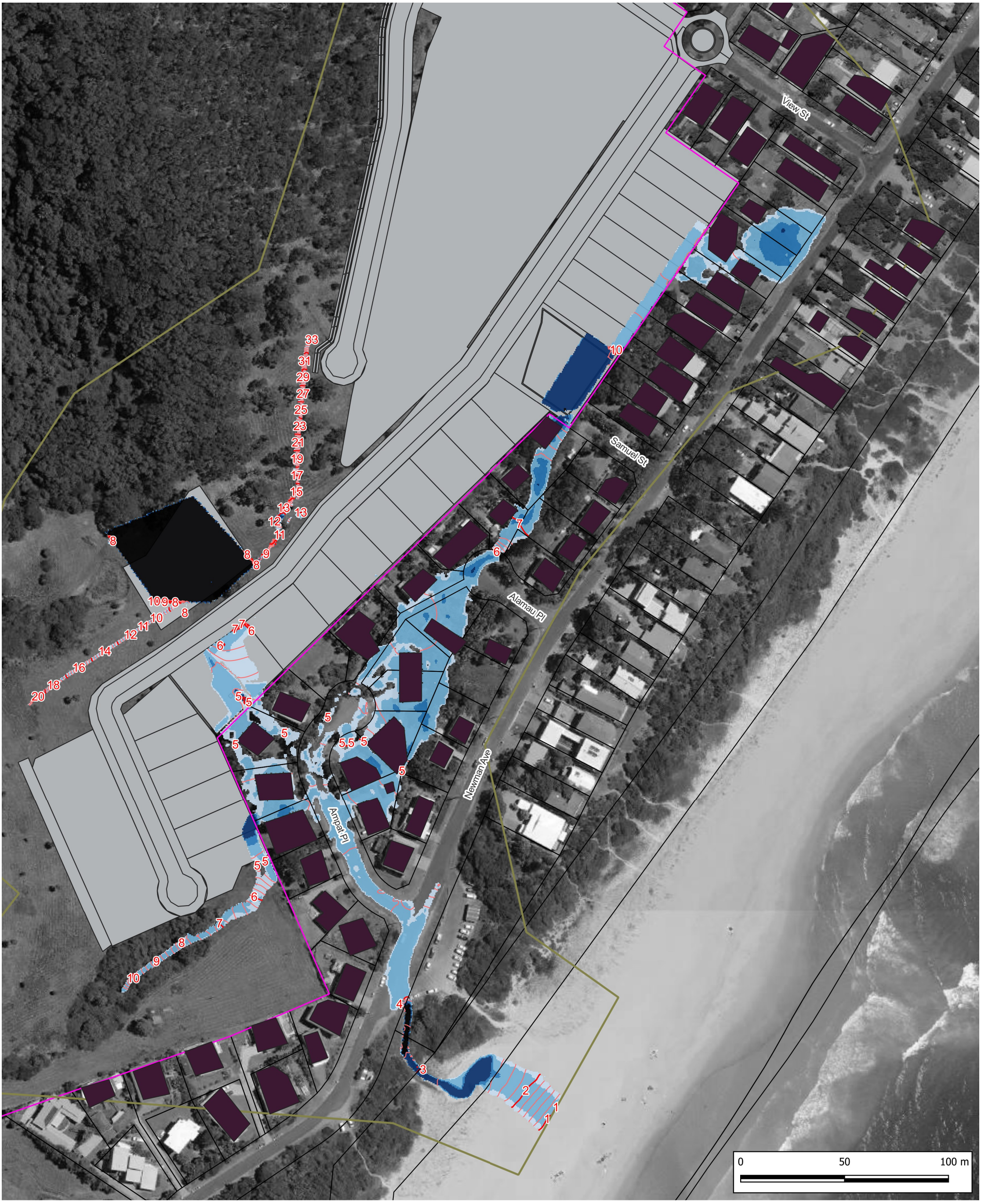
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event in 2100 - Pre-Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **10-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 20% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **11-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 20% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**11-2**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **12-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

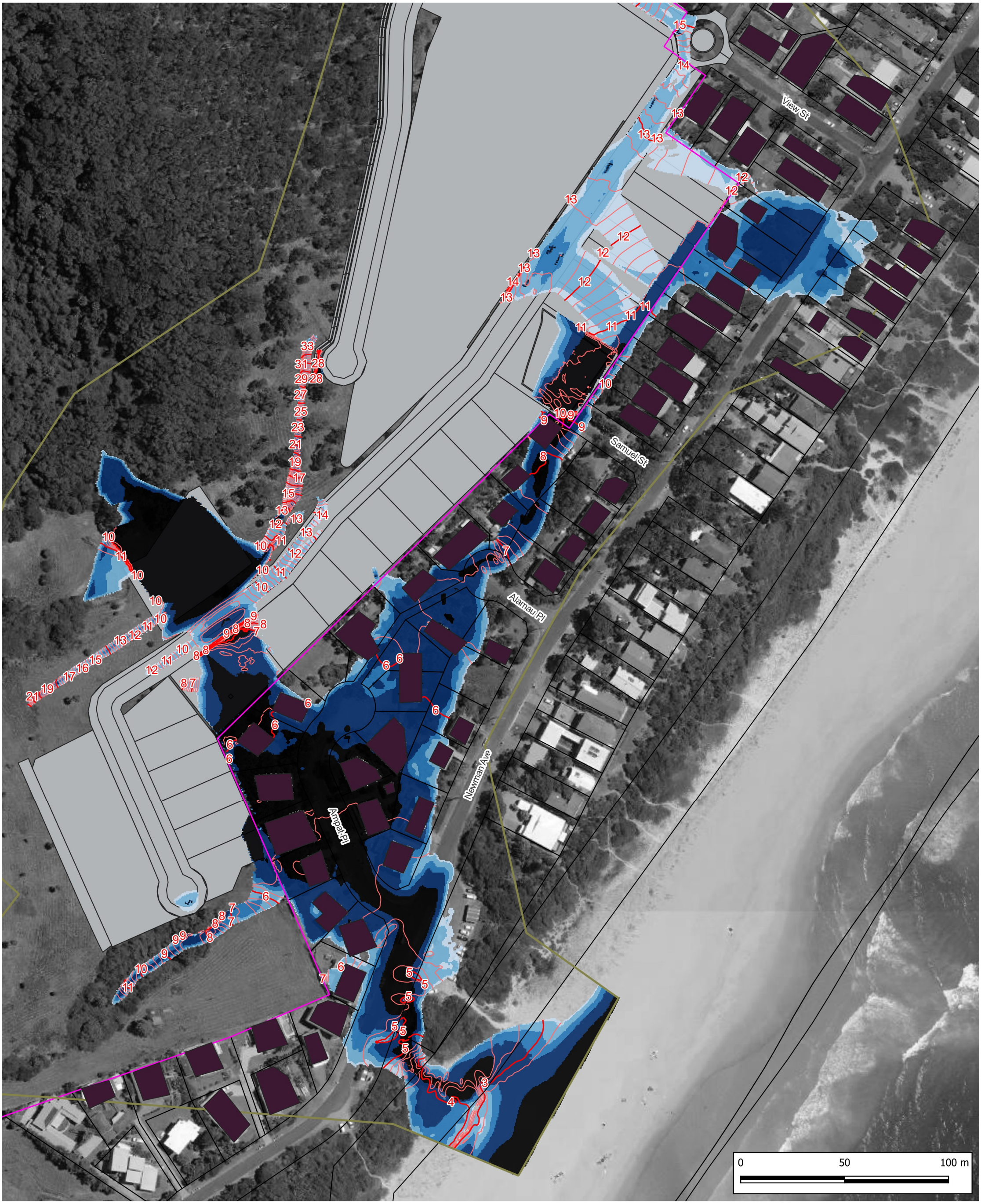
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**12-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the PMF Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **13-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

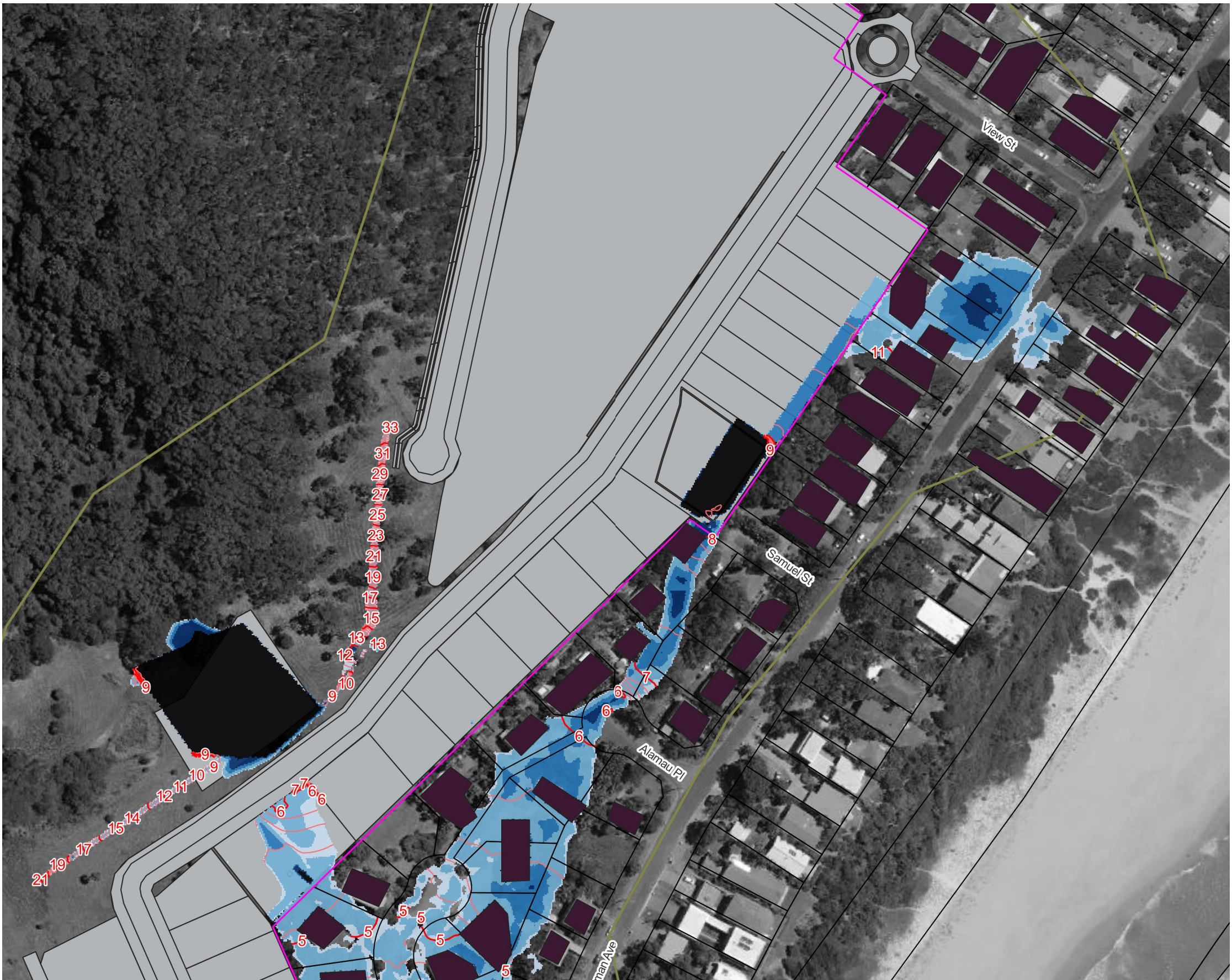
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the PMF Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **13-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 5% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **14-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

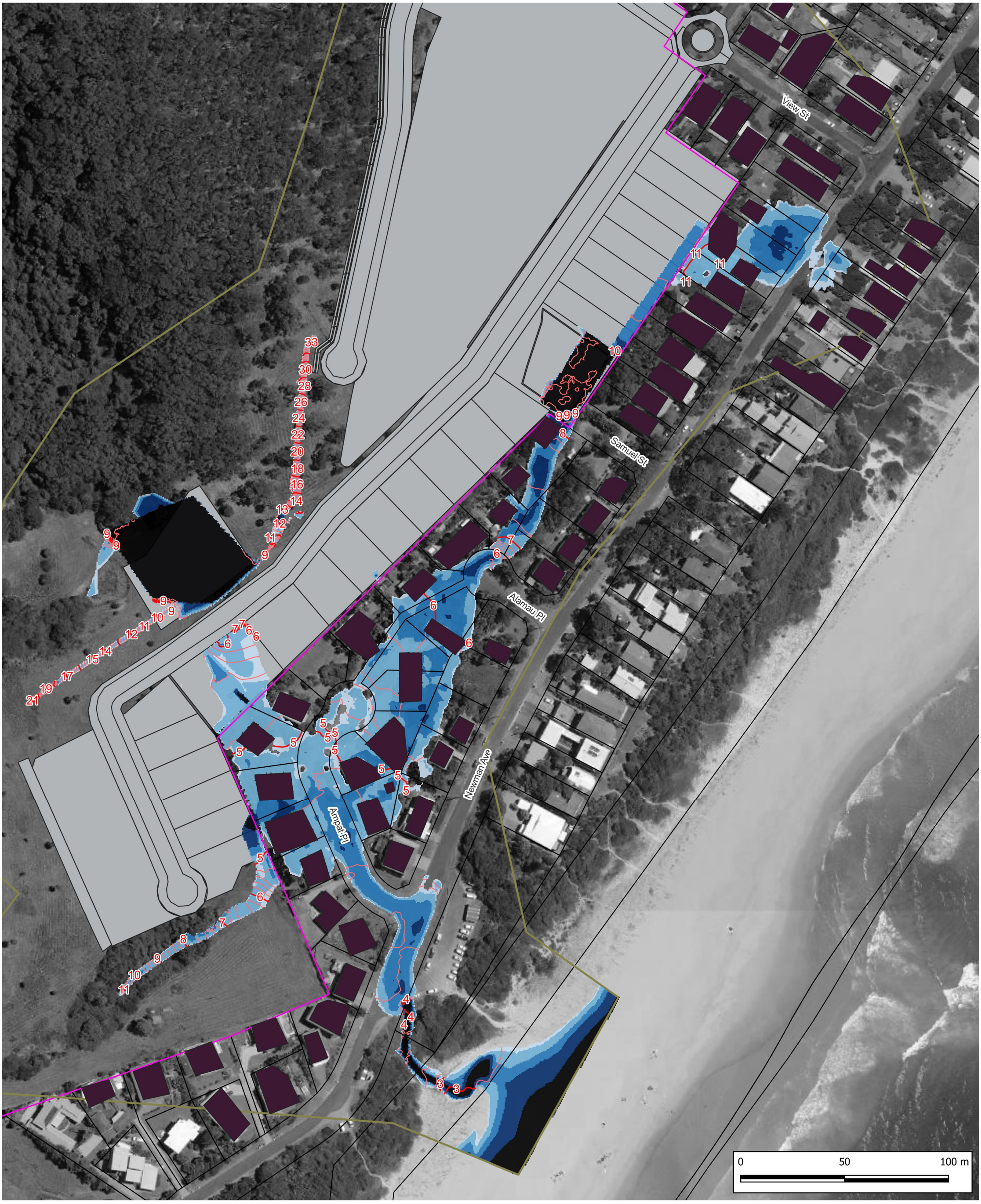
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 5% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**14-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

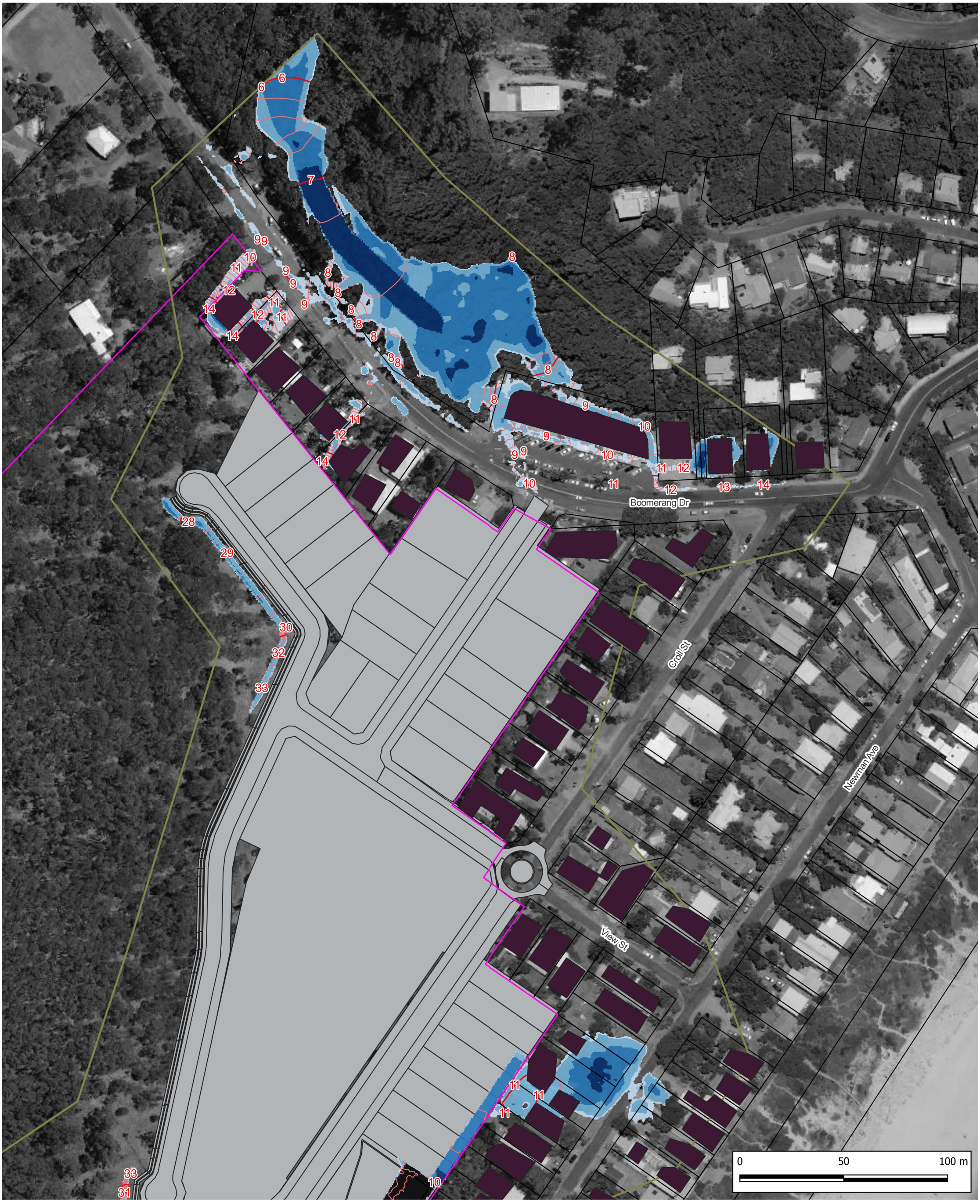
- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**15-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Level Contour (mAHD)

- Major Contour (1.0m interval)
- Minor Contour (0.2m interval)

Depth (m)

- 0.05 - 0.10
- 0.10 - 0.30
- 0.30 - 0.50
- 0.50 - 1.00
- > 1.00

TITLE:	**Peak Depths and Levels for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **15-2**

grc HYDRO

View St
Samuel St
Alamau Pl
Newman Ave
Ampat Pl
1
2
3
4

Flow Results	
Location #	Flow (cum/s)
1	0.23
2	0.22
3	0
4	0.86
5	0.05
6	0

0 50 100 m

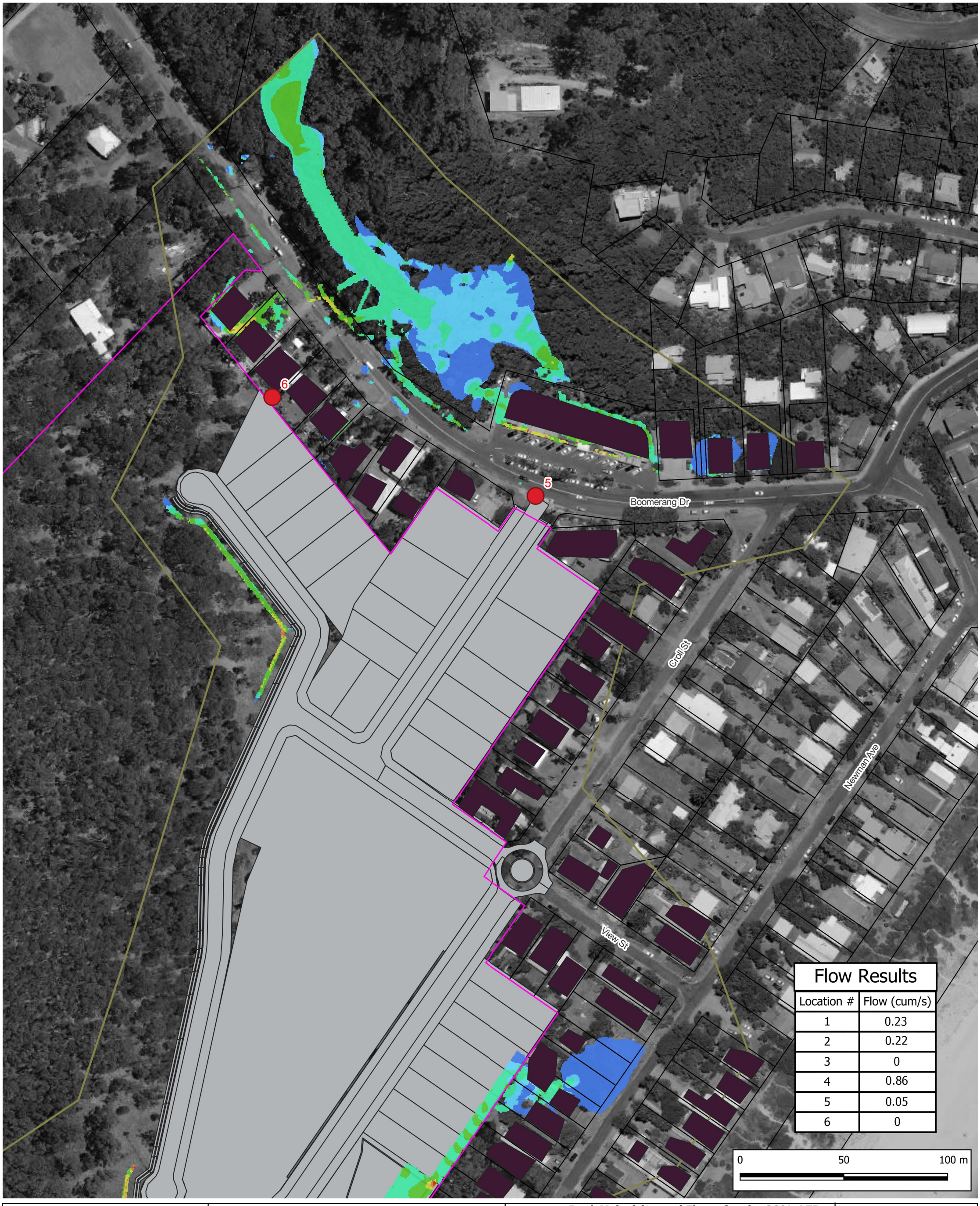
Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)
- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 20% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **16-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

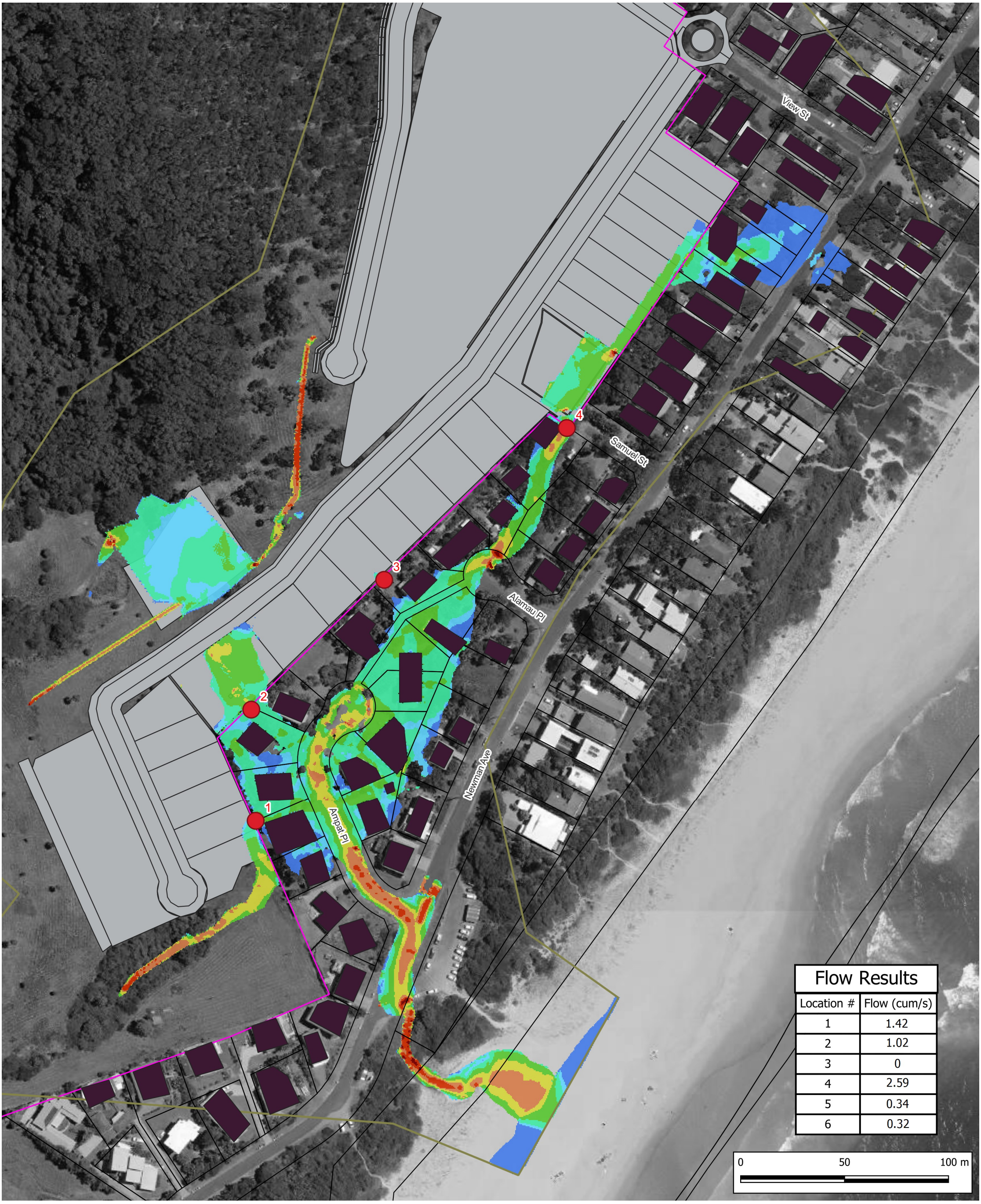
Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 20% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**

DATE: **08-2022** | SCALE: **1:1,600** | FIGURE No. **16-2**

grc HYDRO



Legend

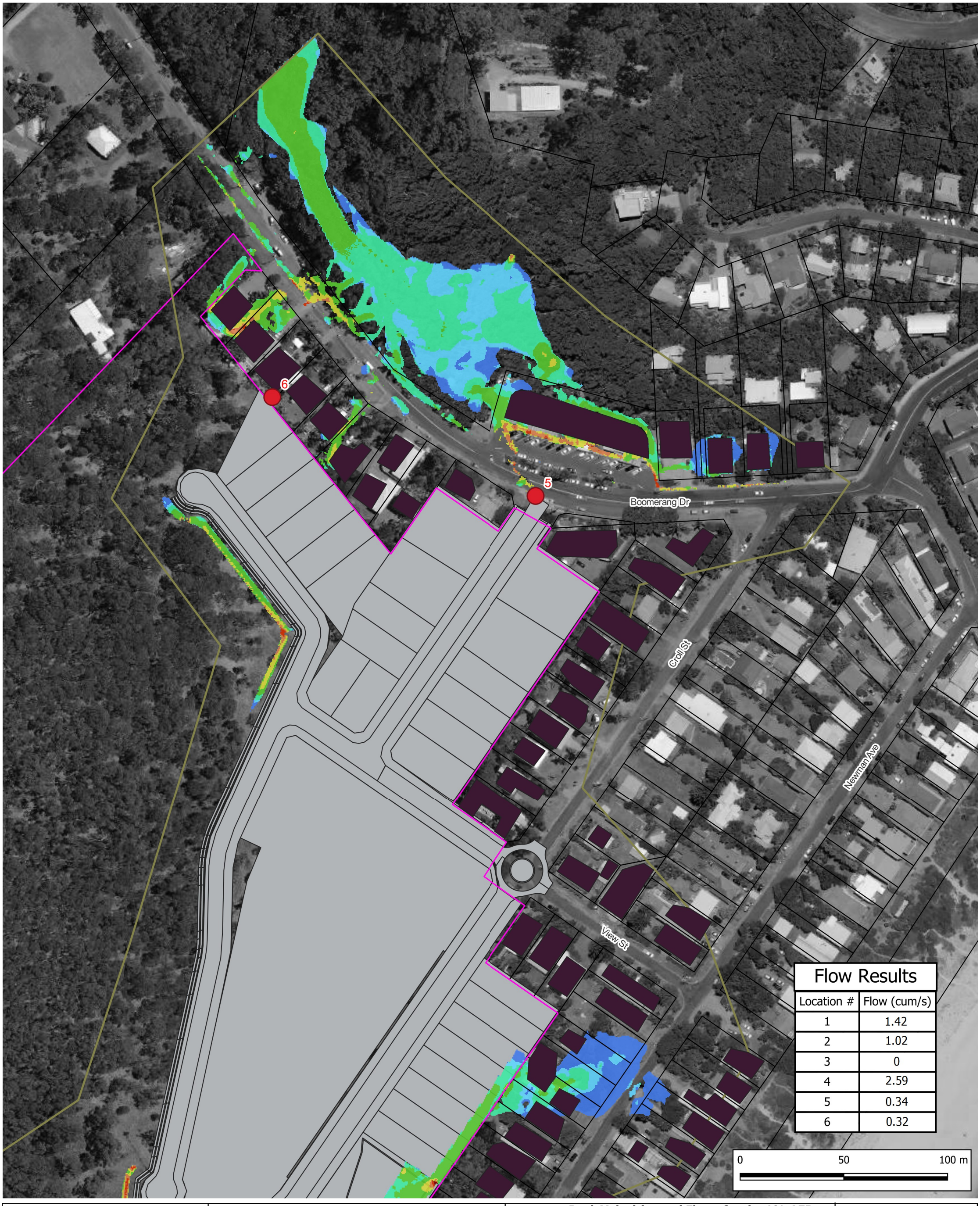
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **17-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**

DATE: **08-2022** | SCALE: **1:1,600** | FIGURE No. **17-2**

grc HYDRO

View St

Samuel St

Alamau Pl

Newman Ave

Ampat Pl

1

2

3

4

Flow Results	
Location #	Flow (cum/s)
1	3.98
2	31.53
3	0.58
4	16.54
5	1.87
6	3.35

0 50 100 m

Legend

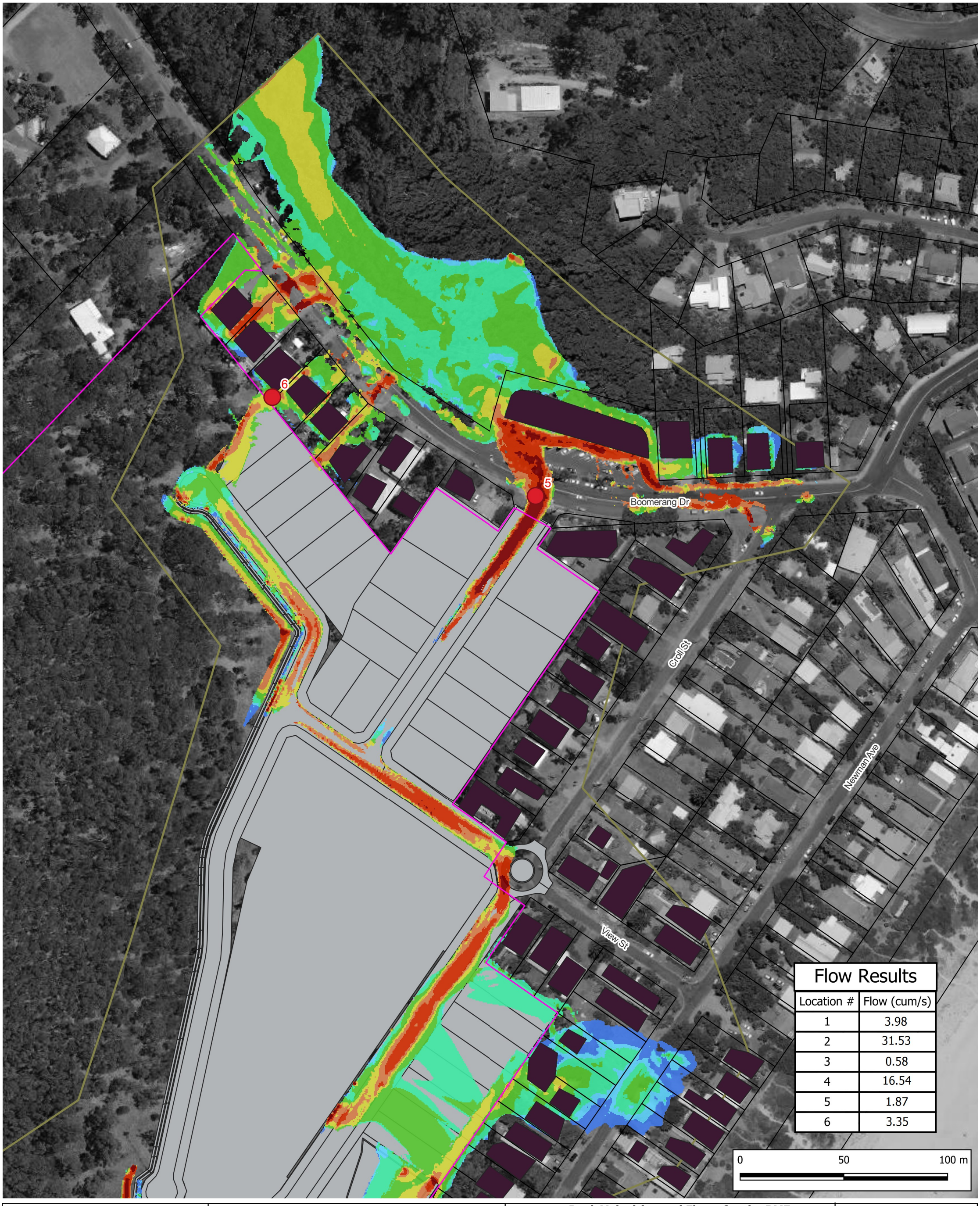
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the PMF Design Event- Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **18-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the PMF Design Event- Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**

DATE: **08-2022** | SCALE: **1:1,600** | FIGURE No. **18-2**

grc HYDRO

View St
Samuel St
Alamau Pl
Newman Ave
Ampat Pl
1
2
3
4
0
50
100 m

Flow Results

Location #	Flow (cum/s)
1	1.19
2	1.03
3	0
4	2.02
5	0.19
6	0

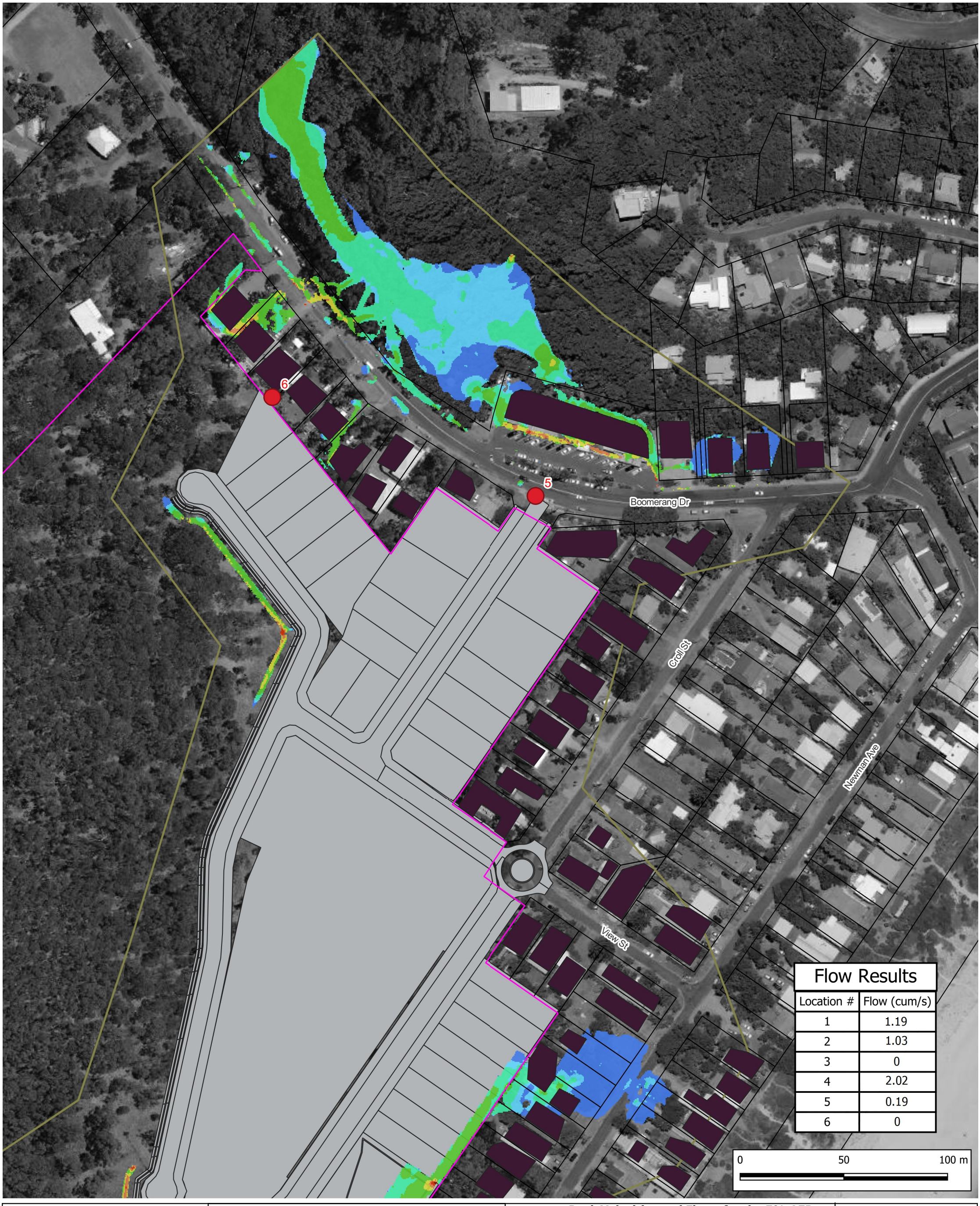
Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)
- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 5% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **19-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 5% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**

DATE: **08-2022** | SCALE: **1:1,600** | FIGURE No. **19-2**

grc HYDRO

View St
Samuel St
Alamau Pl
Newman Ave
Ampat Pl
1
2
3
4
0
50
100 m

Flow Results	
Location #	Flow (cum/s)
1	1.66
2	1.29
3	0
4	3.4
5	0.36
6	0.42

Legend

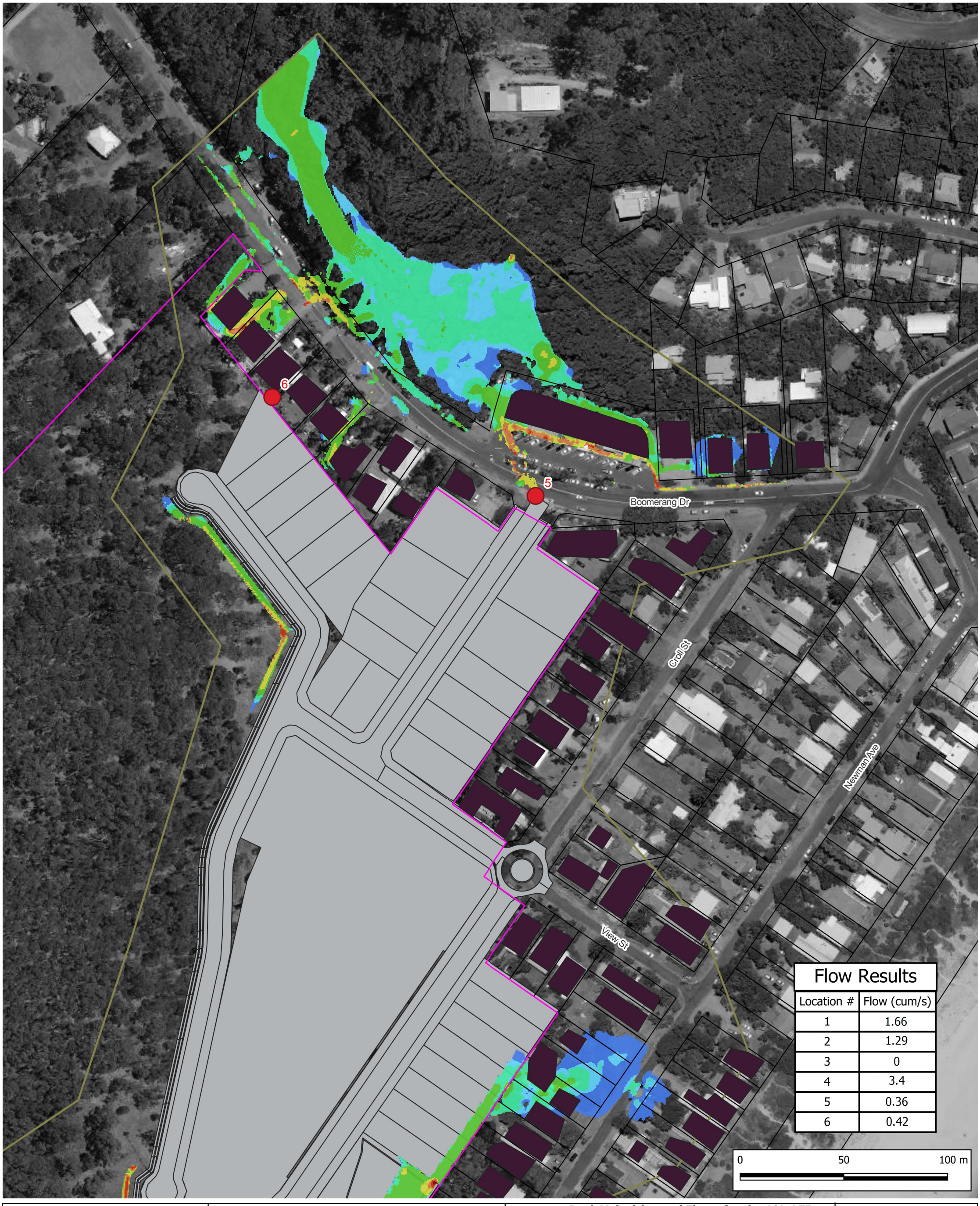
- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**20-1**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent
- Flow Recording Location

Velocity (m/s)

- <= 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 3.0
- > 3.0

TITLE:	**Peak Velocities and Flows for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**20-2**

grc HYDRO

Legend

Hydraulic Model Extent

Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 20% AEP Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**21-1**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 20% AEP Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **21-2**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 1% AEP Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**22-1**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 1% AEP Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **22-2**

grc HYDRO

Legend

Hydraulic Model Extent

Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the PMF Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**23-1**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the PMF Design Event**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **23-2**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 5% AEP Design Event in 2100**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **24-1**

grc HYDRO

Legend

Hydraulic Model Extent

Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 5% AEP Design Event in 2100**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**24-2**

grc HYDRO

Legend

- Hydraulic Model Extent
- Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 1% AEP Design Event in 2100**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**25-1**

grc HYDRO

Legend

Hydraulic Model Extent

Building Extent

Impact (m)

- < -0.3
- -0.3 to -0.2
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

TITLE:	**Impacts for the 1% AEP Design Event in 2100**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**25-2**

grc HYDRO

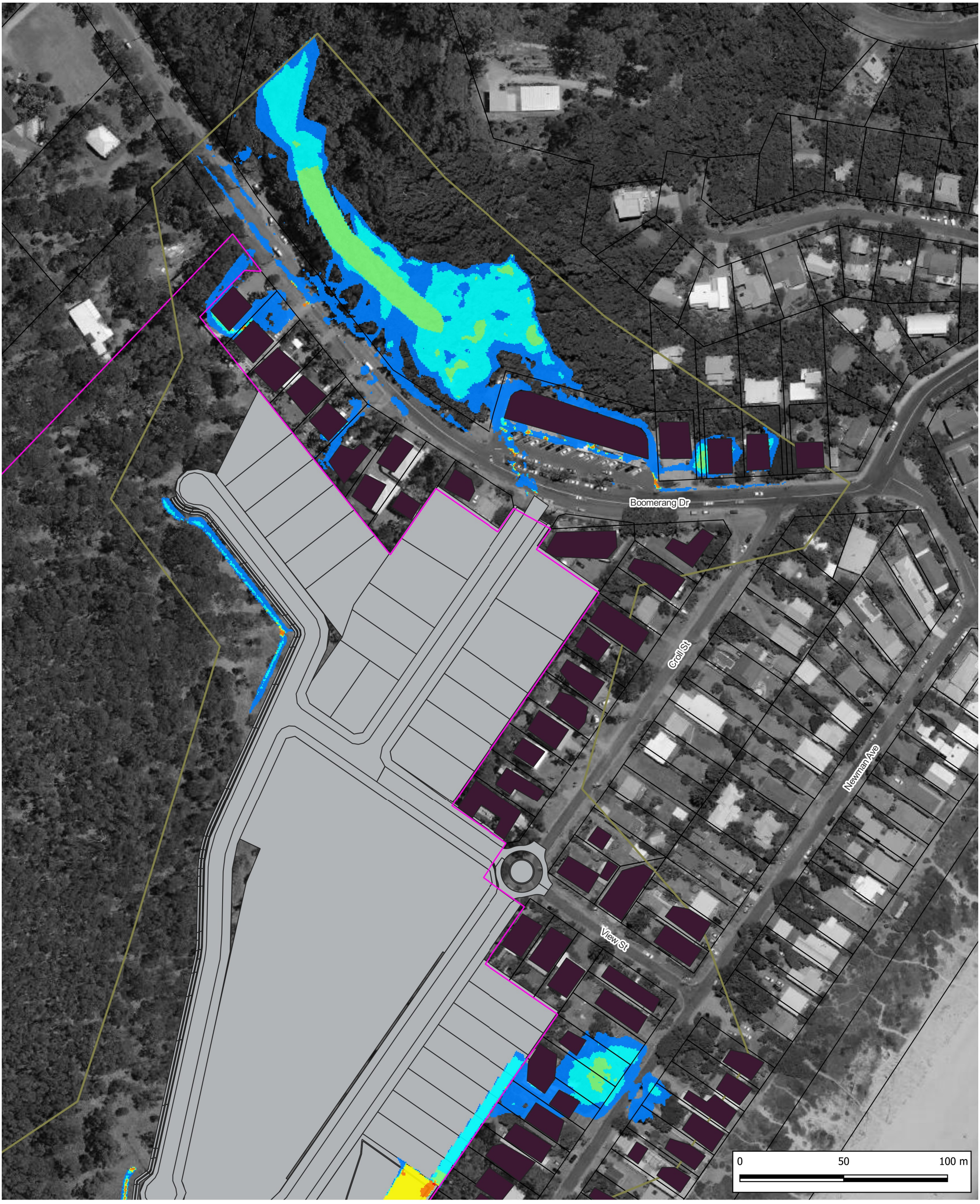
Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Hazard Category
- H1
- H2
- H3
- H4
- H5
- H6

TITLE:	**Hazard Categories for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **26-1**

grc HYDRO



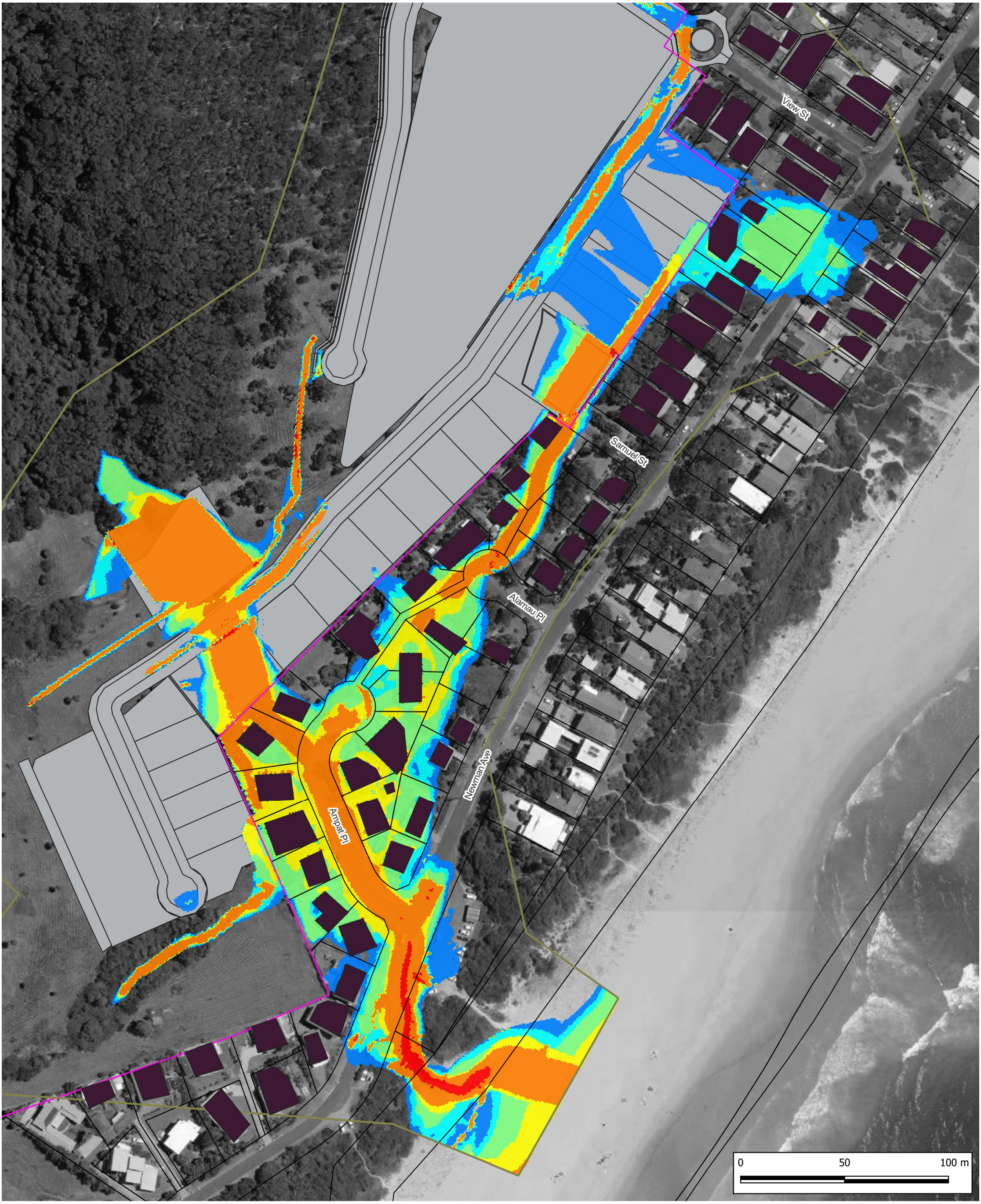
Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Hazard Category
- H1
- H2
- H3
- H4
- H5
- H6

TITLE:	**Hazard Categories for the 1% AEP Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **26-2**

grc HYDRO



Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Hazard Category
- H1
- H2
- H3
- H4
- H5
- H6

TITLE:	**Hazard Categories for the PMF Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600**
FIGURE No.	**27-1**

grc HYDRO

Legend

- Site Boundary
- Hydraulic Model Extent
- Building Extent

Hazard Category
- H1
- H2
- H3
- H4
- H5
- H6

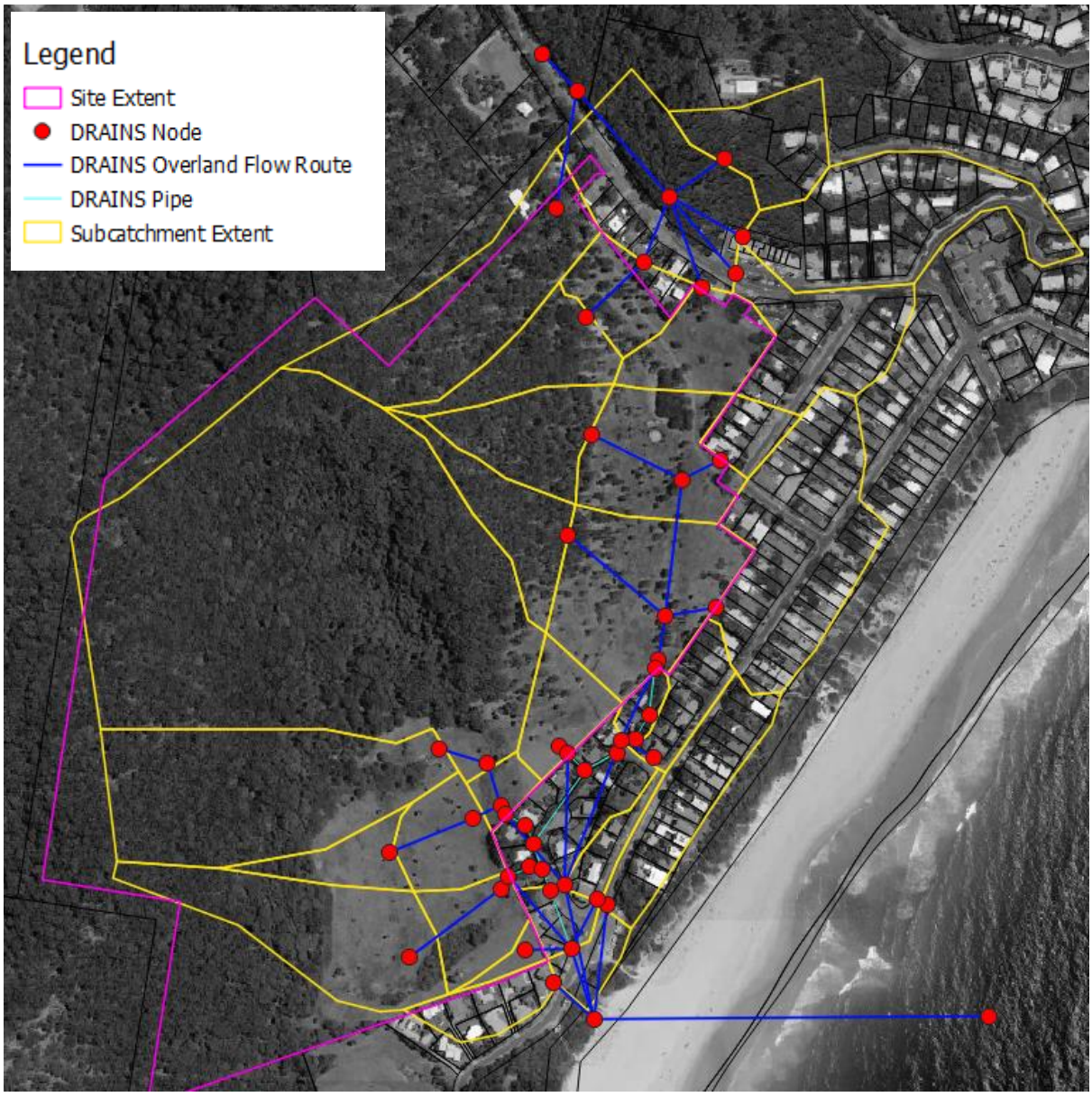
TITLE:	**Hazard Categories for the PMF Design Event in 2100 - Option 1 Development Site Conditions**
PROJECT:	**Blueys Beach Development Flood Impact Assessment**
PROJECT No.	**220058**
DATE: **08-2022**	SCALE: **1:1,600** FIGURE No. **27-2**

grc HYDRO

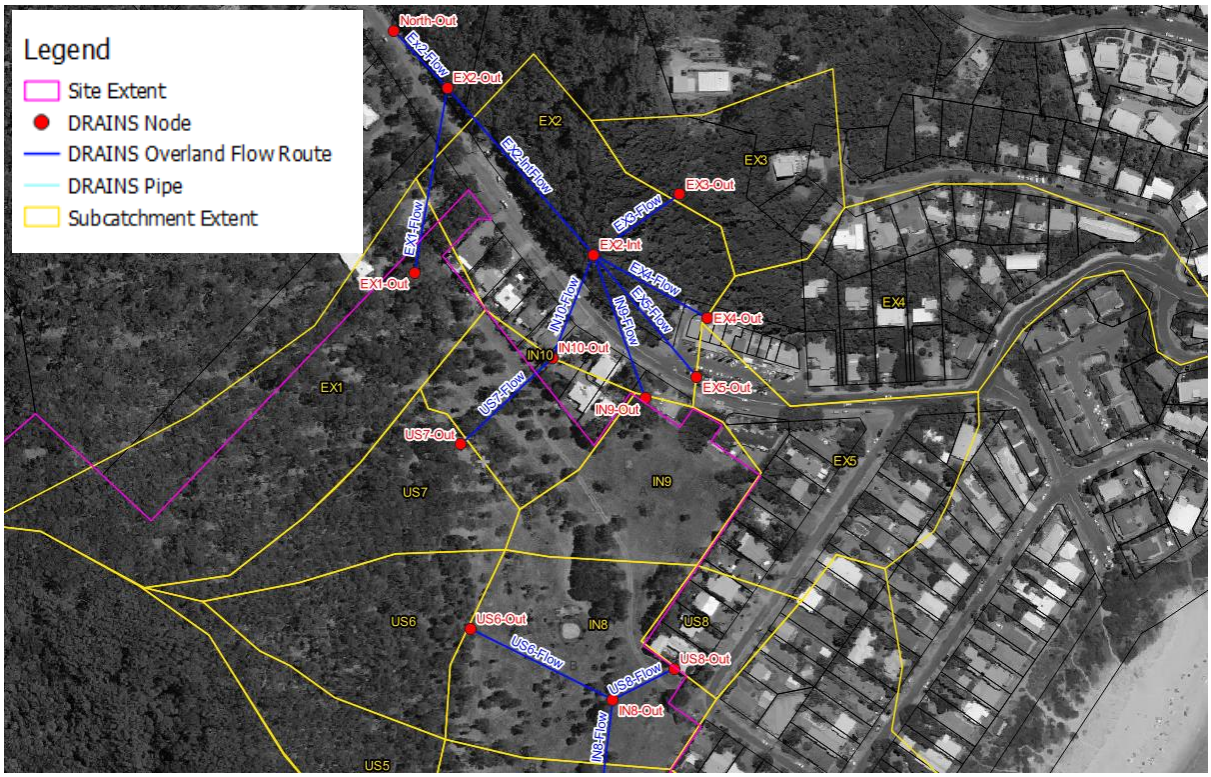
Appendix A

Drains Layout – Pre-Development

Overview

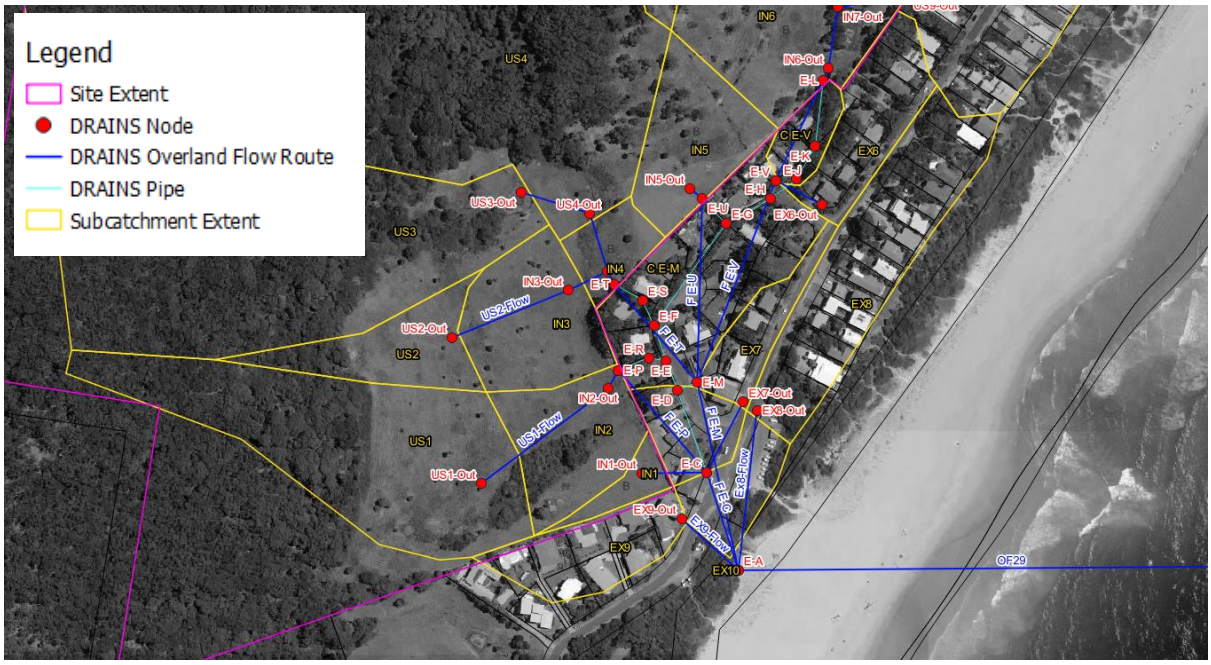


Upper Catchment



Middle Catchment

Lower Catchment



Drains Parameters – Pre-Development

SUB-CATCHMENT DETAILS					
Name	Pit or Node	Total Area (ha)	Impervious Area (%)	Avg Slope (%)	Mannings n
C E-V	E-V	0.207	60	2	0.015
C E-C	E-C	0.35	60	1	0.015
EX10	E-A	0.364	50	3	0.015
C E-M	E-M	1.252	60	1	0.015
IN1	IN1-Out	0.153	0	9	0.04
IN3	IN3-Out	0.805	0	24	0.04
US1	US1-Out	2.211	0	21	0.075
US2	US2-Out	0.568	0	30	0.075
IN5	IN5-Out	0.703	0	24	0.04
US3	US3-Out	3.49	0	28	0.1
US4	US4-Out	11.756	0	30	0.1
IN4	IN4-Out	0.267	0	4	0.04
IN6	IN6-Out	2.282	0	2	0.04
US9	US9-Out	2.792	60	4	0.015
US5	US5-Out	1.001	0	20	0.1
US8	US8-Out	0.408	60	6	0.015
IN8	IN8-Out	1.596	0	8	0.04
IN9	IN9-Out	0.986	0	19	0.04
US7	US7-Out	0.986	0	30	0.1
IN2	IN2-Out	0.715	0	4	0.075
EX2	EX2-Out	2.211	30	1	0.05
US6	US6-Out	1.099	0	30	0.1
EX1	EX1-Out	2.515	5	30	0.1
EX3	EX3-Out	1.06	5	24	0.1
EX4	EX4-Out	2.53	60	5	0.015
EX5	EX5-Out	1.551	60	5	0.015
EX6	EX6-Out	0.6	60	8	0.015
EX7	EX7-Out	0.339	60	7	0.015
EX8	EX8-Out	1.315	60	5	0.015
EX9	EX9-Out	0.552	60	11	0.035
IN10	IN10-Out	0.786	10	22	0.05

OVERFLOW ROUTE DETAILS							
Name	From	To	Travel Time (min)	Bed	U/S IL (mAHD)	D/S IL (mAHD)	Length (m)
F E-V	E-V	E-M	1.8	0.83	5.496	4.176	180
F E-C	E-C	E-A	0.8	1	4.06	3.31	80
OF29	E-A	PRE-DEV 1	0.1	1	3.31	3.01	10
F E-M	E-M	E-A	0.9	1	4.176	3.31	90
F E-L	E-L	E-V	0.7	1.6	6.7056	5.346	85
F E-T	E-T	E-M	0.9	1	4.31	4.176	89.6
F E-P	E-P	E-C	0.9	0.84	4.48	4.06	100
F E-U	E-U	E-M	1.3	1.55	5.725	4.176	150
IN1-Flow	IN1-Out	E-C	0.2	7	6.083	4.06	37.998
IN3-Flow	IN3-Out	IN4-Out	0.1	2	4.86	3.436	20.4
US1-Flow	US1-Out	IN2-Out	0.5	4	11.11	3.711	99.9
US2-Flow	US2-Out	IN3-Out	0.6	24	21.83	4.76	92.16
IN5-Flow	IN5-Out	E-U	0.1	0.01	5.19	5.18	1
US3-Flow	US3-Out	US4-Out	0.1	5.29	10.31	5.68	87.576
US4-Flow	US4-Out	IN4-Out	0.5	4	5.68	3.436	48.695
IN4-Flow	IN4-Out	E-T	0.1	0.01	3.436	3.426	1
IN6-Flow	IN6-Out	E-L	0.1	0.01	6.32	6.22	1
IN7-Flow	IN7-Out	IN6-Out	0.3	2	8.56	6.32	59.923
US9-Flow	US9-Out	IN7-Out	0.4	3	10.81	8.56	67.485
US5-Flow	US5-Out	IN7-Out	0.7	15	33.52	8.56	120
US8-Flow	US8-Out	IN8-Out	0.1	5.61	15.267	11.39	69.06
IN8-Flow	IN8-Out	IN7-Out	0.7	3.64	11.39	8.56	77.743
IN9-Flow	IN9-Out	EX2-Int	0.7	3	10.054	7.036	111.435
US7-Flow	US7-Out	IN10-Out	0.6	22	28.2	10.7	67
IN2-Flow	IN2-Out	E-P	0.1	0.01	3.711	3.701	1
Ex2-Flow	EX2-Out	North-Out	0.1	1	5.676	4.723	80
US6-Flow	US6-Out	IN8-Out	0.5	20	34.34	11.39	167.136
EX1-Flow	EX1-Out	EX2-Out	0.6	6	14.923	5.676	121.473
EX2-IntFlow	EX2-Int	EX2-Out	1.2	1	7.036	5.676	114.503
EX3-Flow	EX3-Out	EX2-Int	1.1	0.3	7.218	7.036	56.834
EX4-Flow	EX4-Out	EX2-Int	1.2	0.5	7.475	7.036	80.518
EX5-Flow	EX5-Out	EX2-Int	0.6	3	8.441	7.036	94.792
EX6-Flow	EX6-Out	E-V	0.1	0.01	5.446	5.436	1
EX7-Flow	EX7-Out	E-C	0.3	2	4.751	4.06	33
Ex8-Flow	EX8-Out	E-A	0.9	0.3	4.624	3.31	65
EX9-Flow	EX9-Out	E-A	0.4	1	5.051	3.31	36.5
IN10-Flow	IN10-Out	EX2-Int	0.1	4	10.7	7.036	78

PIT / NODE DETAILS						
Name	Type	Family	Size	Pressure Change Coeff. Ku	Surface Elev (mAHD)	Bolt-down lid
PRE-DEV 1	Node				3.01	
E-V	Sag	NSW RTA SA Inlet, 3% crossfall, 1% grade	SA1 (Type 2) - 1% longitudinal grade	4	5.346	No
E-H	OnGrade	Inlet Sump	900 sq pit	1.5	5.39	Yes
E-G	OnGrade	Inlet Sump	900 sq pit	1.7	5.64	Yes
E-F	OnGrade	Inlet Sump	1200 sq pit	2.1	4.63	Yes
E-E	OnGrade	Inlet Sump	1200 sq pit	1.5	4.45	Yes
E-D	OnGrade	NSW RTA SA Inlet, 3% crossfall, 3% grade	SA2 (Type 5) - 3% longitudinal grade	2.1	4.18	Yes
E-C	OnGrade	NSW RTA SA Inlet, 3% crossfall, 3% grade	SA2 (Type 5) - 3% longitudinal grade	1.7	4.06	No
E-A	Node				3.31	
E-M	OnGrade	NSW RTA SA Inlet, 3% crossfall, 3% grade	SA2 (Type 5) - 3% longitudinal grade	4	4.176	No
E-L	Headwall			0.5	6.915	
E-K	OnGrade	Inlet Sump	900 sq pit	1.7	5.85	Yes
E-J	OnGrade	Inlet Sump	900 sq pit	1.7	5.36	Yes
E-T	Headwall			0.5	4.576	
E-S	OnGrade	Inlet Sump	900 sq pit	1.7	4.72	Yes
E-P	Headwall			0.5	4.305	
E-R	OnGrade	Inlet Sump	900 sq pit	1.7	4.08	Yes
E-U	Headwall			0.5	5.725	
IN1-Out	Node				6.083	
IN3-Out	Node				4.76	
US1-Out	Node				11.11	
US2-Out	Node				21.83	
IN5-Out	Node				5.19	

US3-Out	Node				10.31	
US4-Out	Node				5.68	
IN4-Out	Node				3.436	
IN6-Out	Node				6.32	
IN7-Out	Node				8.56	
US9-Out	Node				10.81	
US5-Out	Node				33.52	
US8-Out	Node				15.267	
IN8-Out	Node				11.39	
IN9-Out	Node				10.054	
US7-Out	Node				28.2	
IN2-Out	Node				3.711	
EX2-Out	Node				5.676	
US6-Out	Node				34.34	
EX1-Out	Node				14.923	
EX2-Int	Node				7.036	
EX3-Out	Node				7.218	
EX4-Out	Node				7.475	
EX5-Out	Node				8.441	
EX6-Out	Node				5.446	
EX7-Out	Node				4.751	
EX8-Out	Node				4.624	
North-Out	Node				4.723	
EX9-Out	Node				5.051	
IN10-Out	Node				10.7	

PIPE DETAILS									
Name	From	To	Length (m)	U/S IL (mAHD)	D/S IL (mAHD)	Slope (%)	Diameter (mm)	Rough	No. Pipes
P E-V	E-V	E-H	7.62	4.429	4.391	0.5	375	0.011	1
P E-H	E-H	E-G	35.356	4.014	3.795	0.62	750	0.011	1
P E-G	E-G	E-F	85.039	3.795	3.268	0.62	750	0.011	1
P E-F	E-F	E-E	25.908	2.818	2.74	0.3	1200	0.011	1
P E-E	E-E	E-D	21.336	2.734	2.67	0.3	1200	0.011	1
P E-D	E-D	E-C	60.35	2.67	2.49	0.3	900	0.011	2
P E-C	E-C	E-A	28	2.49	2.41	0.29	900	0.011	2
P E-M	E-M	E-D	7.925	3.188	3.149	0.49	375	0.011	1
P E-L	E-L	E-K	45.72	6.31	4.633	3.67	600	0.011	1
P E-K	E-K	E-J	24.384	4.632	4.298	1.37	600	0.011	1
P E-J	E-J	E-H	21.336	4.298	4.166	0.62	600	0.011	1
P E-T	E-T	E-S	23.774	3.426	3.241	0.78	1050	0.011	1
P E-S	E-S	E-F	15.24	3.241	3.122	0.78	1050	0.011	1
P E-P	E-P	E-R	24.688	3.701	3.258	1.79	600	0.011	1
P E-R	E-R	E-E	8.534	3.228	3.143	1	600	0.011	1
P E-U	E-U	E-G	24.384	5.18	4.179	4.11	375	0.011	1

Appendix B

BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

Developed by Paul Ollett
Hydralinc Pty Ltd

Project: Blueys Beach Development
Structure/Drawing:
Location & LGA:
Designer/Engineer:
Checked by:
Date: 1/07/2022

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

STEP 1: Setup Details		
Catchment Area:		ha or km2
Source Area (&Landuse):	rural grazing some steep forest	S6.3.3
Inlet Blockage Data (floating /non-floating debris)		
Description:	Sticks and loose grass/leaves	
How assessed:	site visit images	
Inlet Clear Width **(W)**	0.375	(m)
Inlet Clear Height **(D)**	0.375	(m)
Check W/D<=3	1.0	(m/m) S6.4.4.8
L_{10}	0.3	(m) S6.4.4.1
Barrel Blockage Data (sediment & bedload)		
Description:	Sandy soil	
How assessed:	visual assessment at site	
D_{50}	0.01	(mm)
Barrel velocity **(V)**	2	(m/s)

STEP 2: Debris Potential at Structure for 1% AEP			
Blockage Location	Inlet (debris)	Barrel (sediment)	
Availability (H,M,L)	H	L	S6.4.4.2 & T6.6.1
Mobility (H,M,L)	M	M	S6.4.4.3 & T6.6.2
Transportability (H,M,L)	M	M	S6.4.4.4 & T6.6.3
Combined Result	HMM	LMM	
1% Debris Potential	MED	LOW	S6.4.4.5 & T6.6.4

STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5)			
Event AEP(%) [1:yr]	HIGH	MED	LOW
>5% [<1:20]	Med	Low	Low
5%-0.5% [1:20 - 1:200]	High	Med	Low
<0.5% [>1:200]	High	High	Med

STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6)			
AEP Adjusted Debris Potential At Structure (Inlet)			
Control Dimension	High	Med	Low
$W < L_{10}$	100%	50%	25%
$L_{10} <= W <= 3*L_{10}$	20%	10%	0%
$W > 3*L_{10}$	10%	0%	0%

STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7)					
Sediment (Type & D_{50})	Clay/Silt	Sand	Gravel	Cobbles	Boulders
Structure Velocity (m/s)	<=0.04mm	>0.04-2mm	>2-63mm	>63-200mm	>200mm
>=3.0	*low*	*low*	*low*	*low*	*med*
1.0 to < 3.0	*low*	*low*	*low*	*med*	*med*
0.5 to < 1.0	*low*	*low*	*low*	*med*	*high*
0.1 to < 0.5	*low*	*low*	*med*	*high*	*high*
< 0.1	*low*	*med*	*high*	*high*	*high*

STEP 6: Depositional Blockage Levels (T6.6.8)			
AEP Adjusted Sediment Potential At Structure (barrel)			
Likelihood of Deposition	High	Med	Low
high	100%	60%	25%
med	60%	40%	15%
low	25%	15%	0%

STEP 7: BLK-DES%	**Inlet (Debris)**		**Barrel (Sediment)**	
Event AEP(%) [1:yr]	**MED**	**STEP 4**	**LOW**	**STEP 6**
>5% [<1:20]	Low	0%	Low	0%
5%-0.5% [1:20 - 1:200]	Med	10%	Low	0%
<0.5% [>1:200]	High	20%	Med	15%

STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS

ASSESS:

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

If CONSEQUENCES HIGH:

Flood Study: Review blockage parameters. Notify asset owner.

Design: Review blockage parameters. Mitigate Risk. **(see S6.6)**

BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

Developed by Paul Ollett
Hydralinc Pty Ltd

Project: Blueys Beach Development
Structure/Drawing:
Location & LGA:
Designer/Engineer:
Checked by:
Date: 1/07/2022

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

STEP 1: Setup Details		
Catchment Area:		ha or km2
Source Area (&Landuse):	rural grazing some steep forest	S6.3.3
Inlet Blockage Data (floating /non-floating debris)		
Description:	Sticks and loose grass/leaves	
How assessed:	site visit images	
Inlet Clear Width **(W)**	0.45	(m)
Inlet Clear Height **(D)**	0.45	(m)
Check W/D<=3	1.0	(m/m) S6.4.4.8
L_{10}	0.3	(m) S6.4.4.1
Barrel Blockage Data (sediment & bedload)		
Description:	Sandy soil	
How assessed:	visual assessment at site	
D_{50}	0.01	(mm)
Barrel velocity **(V)**	2	(m/s)

STEP 2: Debris Potential at Structure for 1% AEP			
Blockage Location	Inlet (debris)	Barrel (sediment)	
Availability (H,M,L)	H	L	S6.4.4.2 & T6.6.1
Mobility (H,M,L)	M	M	S6.4.4.3 & T6.6.2
Transportability (H,M,L)	M	M	S6.4.4.4 & T6.6.3
Combined Result	HMM	LMM	
1% Debris Potential	MED	LOW	S6.4.4.5 & T6.6.4

STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5)			
Event AEP(%) [1:yr]	HIGH	MED	LOW
>5% [<1:20]	Med	Low	Low
5%-0.5% [1:20 - 1:200]	High	Med	Low
<0.5% [>1:200]	High	High	Med

STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6)			
AEP Adjusted Debris Potential At Structure (Inlet)			
Control Dimension	High	Med	Low
$W < L_{10}$	100%	50%	25%
$L_{10} <= W <= 3*L_{10}$	20%	10%	0%
$W > 3*L_{10}$	10%	0%	0%

STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7)					
Sediment (Type & D_{50})	Clay/Silt	Sand	Gravel	Cobbles	Boulders
Structure Velocity (m/s)	<=0.04mm	>0.04-2mm	>2-63mm	>63-200mm	>200mm
>=3.0	*low*	*low*	*low*	*low*	*med*
1.0 to < 3.0	*low*	*low*	*low*	*med*	*med*
0.5 to < 1.0	*low*	*low*	*low*	*med*	*high*
0.1 to < 0.5	*low*	*low*	*med*	*high*	*high*
< 0.1	*low*	*med*	*high*	*high*	*high*

STEP 6: Depositional Blockage Levels (T6.6.8)			
AEP Adjusted Sediment Potential At Structure (barrel)			
Likelihood of Deposition	High	Med	Low
high	100%	60%	25%
med	60%	40%	15%
low	25%	15%	0%

STEP 7: BLK-DES%	**Inlet (Debris)**		**Barrel (Sediment)**	
Event AEP(%) [1:yr]	**MED**	**STEP 4**	**LOW**	**STEP 6**
>5% [<1:20]	Low	0%	Low	0%
5%-0.5% [1:20 - 1:200]	Med	10%	Low	0%
<0.5% [>1:200]	High	20%	Med	15%

STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS

ASSESS:

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

If CONSEQUENCES HIGH:

Flood Study: Review blockage parameters. Notify asset owner.

Design: Review blockage parameters. Mitigate Risk. **(see S6.6)**

BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

Developed by Paul Ollett
Hydralinc Pty Ltd

Project: Blueys Beach Development
Structure/Drawing:
Location & LGA:
Designer/Engineer:
Checked by:
Date: 1/07/2022

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

STEP 1: Setup Details		
Catchment Area:		ha or km2
Source Area (&Landuse):	rural grazing some steep forest	S6.3.3
Inlet Blockage Data (floating /non-floating debris)		
Description:	Sticks and loose grass/leaves	
How assessed:	site visit images	
Inlet Clear Width **(W)**	0.6	(m)
Inlet Clear Height **(D)**	0.6	(m)
Check W/D<=3	1.0	(m/m) S6.4.4.8
L_{10}	0.3	(m) S6.4.4.1
Barrel Blockage Data (sediment & bedload)		
Description:	Sandy soil	
How assessed:	visual assessment at site	
D_{50}	0.01	(mm)
Barrel velocity **(V)**	2	(m/s)

STEP 2: Debris Potential at Structure for 1% AEP			
Blockage Location	Inlet (debris)	Barrel (sediment)	
Availability (H,M,L)	H	L	S6.4.4.2 & T6.6.1
Mobility (H,M,L)	M	M	S6.4.4.3 & T6.6.2
Transportability (H,M,L)	M	M	S6.4.4.4 & T6.6.3
Combined Result	HMM	LMM	
1% Debris Potential	MED	LOW	S6.4.4.5 & T6.6.4

STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5)			
Event AEP(%) [1:yr]	HIGH	MED	LOW
>5% [<1:20]	Med	Low	Low
5%-0.5% [1:20 - 1:200]	High	Med	Low
<0.5% [>1:200]	High	High	Med

STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6)			
AEP Adjusted Debris Potential At Structure (Inlet)			
Control Dimension	High	Med	Low
$W < L_{10}$	100%	50%	25%
$L_{10} <= W <= 3*L_{10}$	20%	10%	0%
$W > 3*L_{10}$	10%	0%	0%

STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7)					
Sediment (Type & D_{50})	Clay/Silt	Sand	Gravel	Cobbles	Boulders
Structure Velocity (m/s)	<=0.04mm	>0.04-2mm	>2-63mm	>63-200mm	>200mm
>=3.0	*low*	*low*	*low*	*low*	*med*
1.0 to < 3.0	*low*	*low*	*low*	*med*	*med*
0.5 to < 1.0	*low*	*low*	*low*	*med*	*high*
0.1 to < 0.5	*low*	*low*	*med*	*high*	*high*
< 0.1	*low*	*med*	*high*	*high*	*high*

STEP 6: Depositional Blockage Levels (T6.6.8)			
AEP Adjusted Sediment Potential At Structure (barrel)			
Likelihood of Deposition	High	Med	Low
high	100%	60%	25%
med	60%	40%	15%
low	25%	15%	0%

STEP 7: BLK-DES%	**Inlet (Debris)**		**Barrel (Sediment)**	
Event AEP(%) [1:yr]	**MED**	**STEP 4**	**LOW**	**STEP 6**
>5% [<1:20]	Low	0%	Low	0%
5%-0.5% [1:20 - 1:200]	Med	10%	Low	0%
<0.5% [>1:200]	High	20%	Med	15%

STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS

ASSESS:

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

If CONSEQUENCES HIGH:

Flood Study: Review blockage parameters. Notify asset owner.

Design: Review blockage parameters. Mitigate Risk. **(see S6.6)**

BLOCKAGE CALCULATIONS - ARR (2016) Book 6 Chapter 6

Developed by Paul Ollett
Hydralinc Pty Ltd

Project: Blueys Beach Development
Structure/Drawing:
Location & LGA:
Designer/Engineer:
Checked by:
Date: 1/07/2022

User Defined Text & Parameters

Side notes: S=Section, T=Table in ARR Bk6 Ch6

STEP 1: Setup Details		
Catchment Area:		ha or km2
Source Area (&Landuse):	rural grazing some steep forest	S6.3.3
Inlet Blockage Data (floating /non-floating debris)		
Description:	Sticks and loose grass/leaves	
How assessed:	site visit images	
Inlet Clear Width **(W)**	1.05	(m)
Inlet Clear Height **(D)**	1.05	(m)
Check W/D<=3	1.0	(m/m) S6.4.4.8
L_{10}	0.3	(m) S6.4.4.1
Barrel Blockage Data (sediment & bedload)		
Description:	Sandy soil	
How assessed:	visual assessment at site	
D_{50}	0.01	(mm)
Barrel velocity **(V)**	2	(m/s)

STEP 2: Debris Potential at Structure for 1% AEP			
Blockage Location	Inlet (debris)	Barrel (sediment)	
Availability (H,M,L)	H	L	S6.4.4.2 & T6.6.1
Mobility (H,M,L)	M	M	S6.4.4.3 & T6.6.2
Transportability (H,M,L)	M	M	S6.4.4.4 & T6.6.3
Combined Result	HMM	LMM	
1% Debris Potential	MED	LOW	S6.4.4.5 & T6.6.4

STEP 3: AEP Adjusted Debris Potential (S6.4.4.6 & T6.6.5)			
Event AEP(%) [1:yr]	HIGH	MED	LOW
>5% [<1:20]	Med	Low	Low
5%-0.5% [1:20 - 1:200]	High	Med	Low
<0.5% [>1:200]	High	High	Med

STEP 4: Inlet Blockage Level (S6.4.4.7 & T6.6.6)			
AEP Adjusted Debris Potential At Structure (Inlet)			
Control Dimension	High	Med	Low
$W < L_{10}$	100%	50%	25%
$L_{10} <= W <= 3*L_{10}$	20%	10%	0%
$W > 3*L_{10}$	10%	0%	0%

STEP 5: Likelihood of Sediment Deposition in Barrel (T6.6.7)					
Sediment (Type & D_{50})	Clay/Silt	Sand	Gravel	Cobbles	Boulders
Structure Velocity (m/s)	<=0.04mm	>0.04-2mm	>2-63mm	>63-200mm	>200mm
>=3.0	*low*	*low*	*low*	*low*	*med*
1.0 to < 3.0	*low*	*low*	*low*	*med*	*med*
0.5 to < 1.0	*low*	*low*	*low*	*med*	*high*
0.1 to < 0.5	*low*	*low*	*med*	*high*	*high*
< 0.1	*low*	*med*	*high*	*high*	*high*

STEP 6: Depositional Blockage Levels (T6.6.8)			
AEP Adjusted Sediment Potential At Structure (barrel)			
Likelihood of Deposition	High	Med	Low
high	100%	60%	25%
med	60%	40%	15%
low	25%	15%	0%

STEP 7: BLK-DES%	**Inlet (Debris)**		**Barrel (Sediment)**	
Event AEP(%) [1:yr]	**MED**	**STEP 4**	**LOW**	**STEP 6**
>5% [<1:20]	Low	0%	Low	0%
5%-0.5% [1:20 - 1:200]	Med	0%	Low	0%
<0.5% [>1:200]	High	10%	Med	15%

STEP 8: RISK ASSESSMENT & SENSITIVITY ANALYSIS

ASSESS:

1). Extreme blockage consequences using 2*BDES% (S6.4.4.11)

2). Worse case downstream flooding using "All Clear" case (S6.4.5)

If CONSEQUENCES HIGH:

Flood Study: Review blockage parameters. Notify asset owner.

Design: Review blockage parameters. Mitigate Risk. **(see S6.6)**

Appendix C

Pit Inlets

Type 1

- 1.83m long kerb inlet combined with grate
- 3% crossfall, 3% grade and 3% longitudinal grade

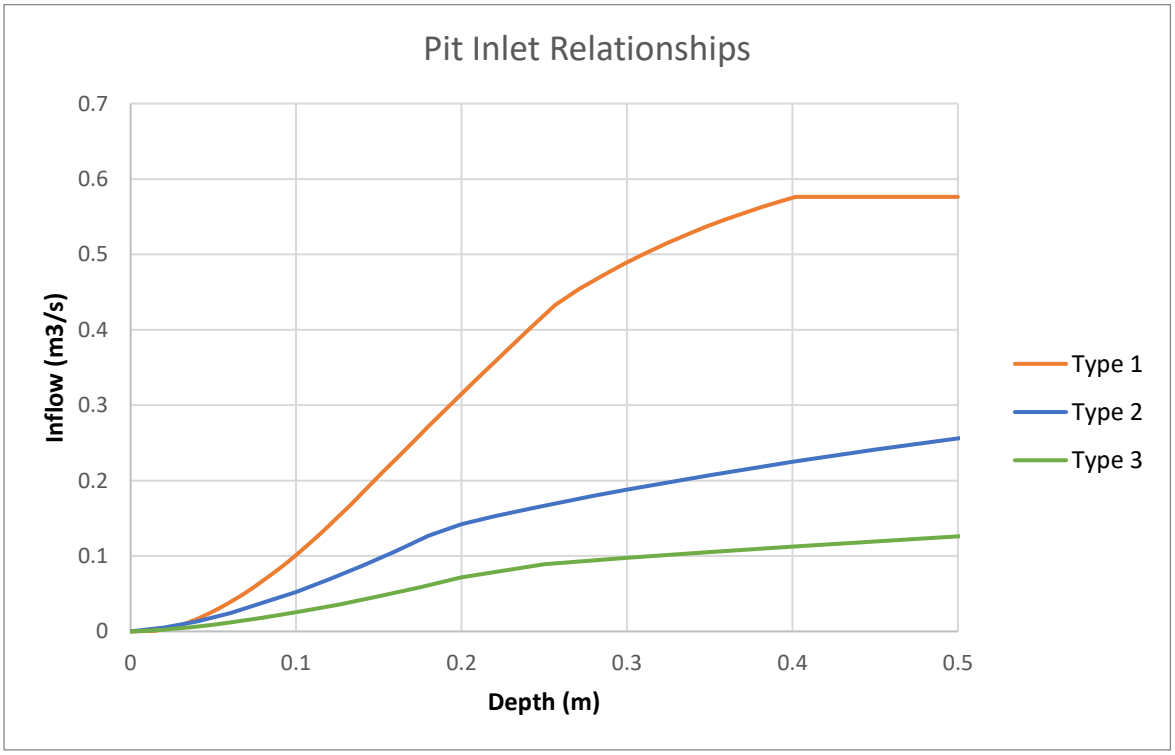
Type 2

- 1m long kerb inlet combined with grate
- 3% crossfall, sag pit

Type 3

- 0.5m wide, letterbox style sag inlet

Pit Inlet Relationships



Appendix D

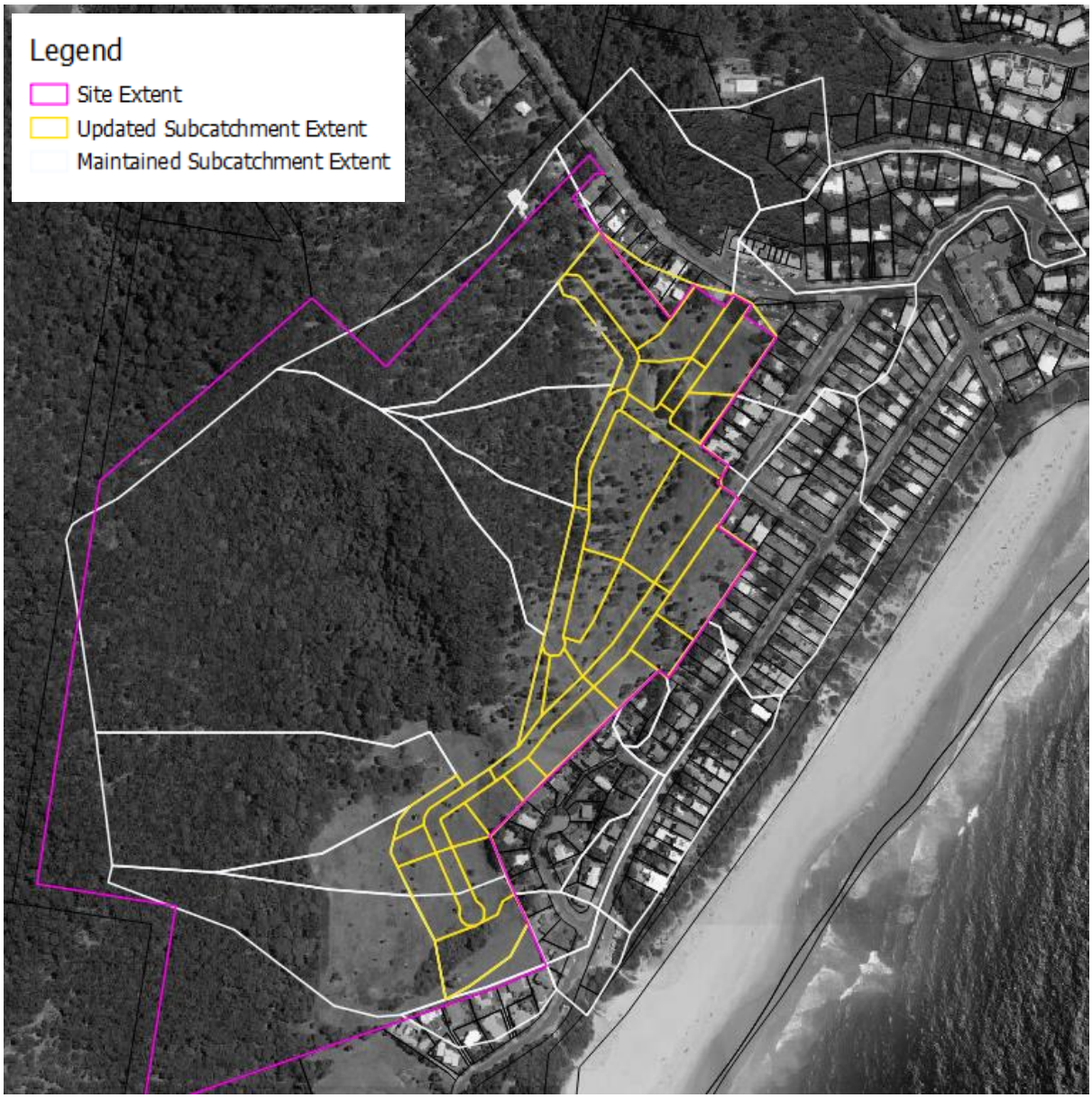
Drains Parameters – Post-Development

SUB-CATCHMENT DETAILS					
Name	Pit or Node	Total Area (ha)	Impervious Area (%)	Avg Slope (%)	Mannings n
C E-V	E-V	0.207	60	2	0.015
C E-C	E-C	0.35	60	1	0.015
EX10	E-A	0.364	50	3	0.015
C E-M	E-M	1.252	60	1	0.015
IN1	IN1-Out	0.153	0	9	0.04
US1	US1-Out	2.211	0	21	0.075
US2	US2-Out	0.568	0	30	0.075
US3	US3-Out	3.49	0	28	0.1
US4	US4-Out	11.756	0	30	0.1
US9	US9-Out	2.792	60	4	0.015
US5	US5-Out	1.001	0	20	0.1
US8	US8-Out	0.408	60	6	0.015
US7	US7-Out	0.986	0	30	0.1
EX2	EX2-Out	2.211	30	1	0.05
US6	US6-Out	1.099	0	30	0.1
EX1	EX1-Out	2.515	5	30	0.1
EX3	EX3-Out	1.06	5	24	0.1
EX4	EX4-Out	2.53	60	5	0.015
EX5	EX5-Out	1.551	60	5	0.015
EX6	EX6-Out	0.6	60	8	0.015
EX7	EX7-Out	0.339	60	7	0.015
EX8	EX8-Out	1.315	60	5	0.015
EX9	EX9-Out	0.552	60	11	0.035
IN2_PD	IN2_PD_Out	0.417	0	22	0.04
Res1A	Res1A_Out	0.244	60	21	0.05
Res1B	Res1B_Out	0.109	60	23	0.05
Road4A	Road4A_Out	0.135	75	9	0.015
Road4B	Road4B_Out	0.149	75	11	0.015
Res2A	Res2A-Out	0.28	60	15	0.05
Res2B	Res2B_Out	0.1	60	22	0.05
Res2C	Res2C_Out	0.109	60	22	0.05
Res3A	Res3A_Out	0.086	60	14	0.05
Res3B	Res3B_Out	0.277	60	18	0.05
Res3C	Res3C_Out	0.163	60	16	0.05
Road4C	Road4C_Out	0.178	75	9	0.015
Res4A	Res4A_Out	0.1	60	22	0.05
Res4B	Res4B_Out	0.116	60	29	0.05
Road4D	Road4D_Out	0.19	75	6	0.015
Res4C	Res4C_Out	0.323	60	23	0.05
Road4E	Road4E_Out	0.24	75	2	0.015

Res4D	Res4D_Out	0.525	60	11	0.05
Res5A	Res5A_Out	0.451	60	2.5	0.05
Road3A	Road3A_Out	0.206	75	11	0.015
Res4E	Res4E_Out	0.248	60	21	0.05
Res4F	Res4F_Out	0.73	60	14	0.05
Road1A	Road1A_Out	0.242	75	1	0.015
Road1B	Road1B_Out	0.172	75	2	0.015
Road2B	Road2B-Out	0.13	75	11	0.015
Res6B	Res6B_Out	0.32	60	9	0.05
Res7B	Res7B_Out	0.312	60	15	0.05
Res7A	Res7A_Out	0.168	60	13	0.05
Road2A	Road2A_Out	0.085	75	7	0.015
Res6A	Res6A_Out	0.167	60	11	0.05
Road1C	Road1C_Out	0.219	75	2	0.015
Res7C	Res7C_Out	0.448	60	20	0.05
Res7D	Res7D_Out	0.174	60	12	0.05
Y1	Y1-Out	0.159	10	0.1	0.04
Y2	Y2-Out	0.185	10	0.1	0.04

Drains Layout – Post-Development

Overview



Upper Catchment

Middle Catchment

Lower Catchment