



Northern Cemeteries

Always

FFBC NEW CHAPEL & FUNCTION CENTRE UPGRADE FLOOD ANALYSIS & RIPARIAN STUDY



MARCH 2020



Table of Contents

Executive Summary	3
Introduction	4
Site Description	5
Proposed Development	7
Reference Documents.....	7
Relevant Planning Policies.....	8
Scope of Works.....	9
Approach	9
Hydrologic Model.....	9
Hydraulic Model.....	10
Flood Behaviour.....	12
Flood Impact Assessment.....	13
Flood Planning Level	13
Compliance	13
Riparian Study.....	14
Appendix A – Flood Maps.....	17

Front cover image: GRC Hydro

EXECUTIVE SUMMARY

GRC Hydro have been engaged to undertake a flood analysis and riparian study for the proposed Frenchs Forest Bushland Cemetery (FFBC) redevelopment at 1 Hakea Ave, Davidson. Northern Metropolitan Cemeteries Land Manager is proposing to demolish the existing cottage and build a new chapel, expand the existing function room, and construct a new amenities block in the northern part of the cemetery. The redevelopment will enhance the capacity of the existing facilities.

Key policy documents and guidelines including those issued by Northern Beaches Council (Council) and NSW Office of Water were referred to in preparing this report.

As Council's Flood Risk Precincts were not available for the site, the proposed FFBC redevelopment herein was therefore assessed primarily against Council's LEP, Council's Flood Risk Management Policy and Flood Prone Land Design Standard, as well as in accordance with the objectives and processes set out in the NSW Government's Flood Prone Land Policy as outlined in the 2005 NSW Floodplain Development Manual.

The development is compliant with these plans and policies. The primary area of development is a chapel and function centre adjacent to a small creek through the cemetery. Both minimum floor level and flood impact requirements have been satisfied by the development. Other criteria are described in 'Compliance' section of this report.

INTRODUCTION

GRC Hydro have been engaged to undertake a flood analysis and riparian study for the proposed Frenchs Forest Bushland Cemetery (FFBC) redevelopment at 1 Hakea Ave, Davidson. Northern Metropolitan Cemeteries Land Manager is proposing to demolish the existing cottage and build a new chapel, expand the existing function room, and construct a new amenities block in the northern part of the cemetery. The redevelopment will enhance the capacity of the existing facilities.

The proposed site is located approximately 20 km north of the Sydney CBD within the Northern Beaches Council Local Government Area (LGA), in a primarily low-density residential area. An overview of the site is shown in Image 1 along with the location of the proposed buildings.

Image 1: Study area and location of proposed buildings



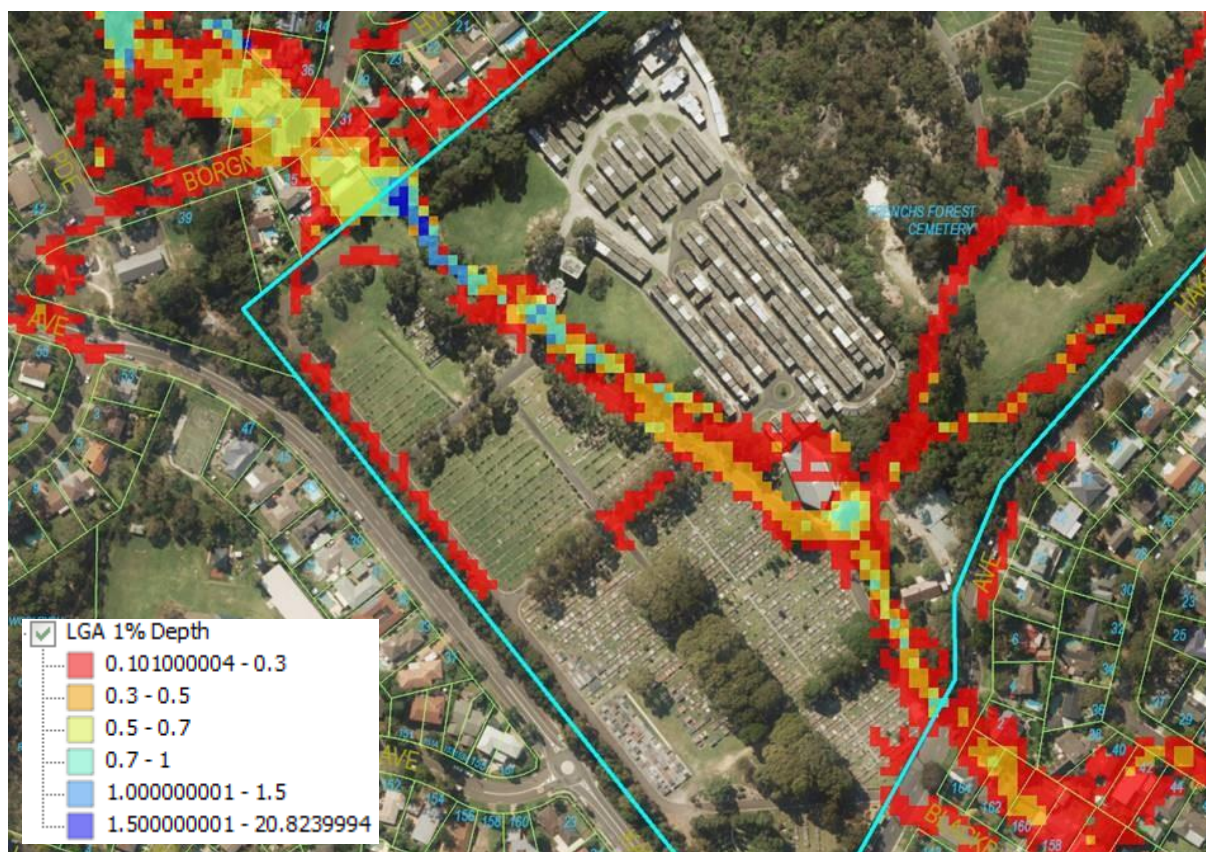
This report documents the flood analysis undertaken by GRC Hydro for the proposed development and the riparian study for the existing creeks located adjacent to the developments. This document has been prepared following *Guidelines for Preparing a Flood Management Report* issued by Northern Beaches Council (Council). Compliance of the proposed redevelopment against Council and State Government policies was assessed.

Site Description

FFBC covers an area of approximately 22 ha within the suburb of Davidson and is managed by Northern Metropolitan Cemeteries Land Manager. The site falls within the Frenchs Creek catchment but is outside the extent of the study area investigated as part of the Frenchs Creek Flood Study (2010) and Floodplain Risk Management Study (2010). Council have indicated that the site is affected by overland flow flooding based on an LGA-wide flood study undertaken by Council using a coarse flood model (see Image 2).

Several minor creeks can be found on site (shown in Image 3) with the main creek flowing in a north-westerly direction, located adjacent to the main access road into the cemetery (i.e. Kanooka Way). The majority of the cemetery drains towards this creek which eventually discharges to Frenchs Creek downstream. The upstream catchment contributing to the cemetery site is approximately 38 ha.

Image 2: Council's LGA-Wide Flood Study 1% AEP Peak Flood Depth and Extent



[illegible]

Proposed Development

The proposed development is comprised of construction of a new chapel, amenities block and expansion of the existing function room. The new chapel and function rooms are located close to the main access road while the amenities block is located further north in the cemetery. It is anticipated that the facilities will be used on an as-needed basis and are non-habitable.

Reference Documents

The following documents and guidelines have been referred to in preparing this report:

- Australian Rainfall & Runoff 2019 (ARR 2019);
- NSW Government – Floodplain Development Manual: the management of flood liable land, published April 2005;
- Warringah Council – Frenchs Creek Flood Study, final report by DHI, issued April 2010;
- Warringah Council – Frenchs Creek Floodplain Risk Management Study, final report by DHI, issued December 2010;
- Warringah Local Environmental Plan (LEP) 2011;
- Warringah Development Control Plan (DCP) 2011;
- Northern Beaches Council – Guidelines for Preparing a Flood Management Report, 2017;
- Northern Beaches Council – Draft Flood Risk Management Policy, issued 30 May 2017;
- Northern Beaches Council – Flood Prone Land Design Standard;
- NSW Office of Water – Guidelines for Riparian Corridors on Waterfront Land, June 2012; and
- Warringah Council Policy No. PL 740 Waterways – Protection of Waterways and Riparian Land Policy.

RELEVANT PLANNING POLICIES

Warringah LEP 2011 has a flood planning clause in Section 6.3 applicable to land at or below the flood planning level (FPL/1% AEP flood level plus 0.5 m freeboard):

"Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- (a) is compatible with the flood hazard of the land, and*
- (b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*
- (c) incorporates appropriate measures to manage risk to life from flood, and*
- (d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and*
- (e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding."*

Additional prescriptive controls for flood prone land are provided in Section E11 of the Warringah DCP 2011 and categorised according to the various development types and flood risk precincts (FRP). However, these controls could not be applied since the FRP for the proposed development site has not been identified based on Council's GIS mapping (<https://services.northernbeaches.nsw.gov.au/icongis/index.html>).

The proposed FFBC redevelopment herein was therefore assessed primarily against the LEP clause, Council's Flood Risk Management Policy and Flood Prone Land Design Standard, as well as in accordance with the objectives and processes set out in the NSW Government's Flood Prone Land Policy as outlined in the 2005 NSW Floodplain Development Manual.

SCOPE OF WORKS

The scope of the flood analysis undertaken herein include:

1. For the area of development, determine the peak flood levels for the 1% AEP event, Probable Maximum Flood (PMF) and FPL (1% AEP + 0.5 m freeboard);
2. Impact on flood characteristics including depth, velocity, hazard and hydraulic category as a result of the proposed development; and
3. Assess compliance against Council and State Government policies.

APPROACH

Limited information pertaining to the site flood affectation was available since the site falls outside the extent of the study area investigated as part of the Frenchs Creek Flood Study (2010) and Floodplain Risk Management Study (2010). Council does not have a formal flood study covering the cemetery site, but they have undertaken an LGA-wide flood study using a coarse flood model which indicated that the site is affected by overland flow flooding. This coarse flood model does not include the modelling of pits and pipes network and is based on a larger grid size which may not accurately represent local overland flow flood behaviour.

Hence, the existing design flood behaviour for the subject site is defined by new hydrologic and hydraulic modelling developed as part of the current study and based on ARR 2019. This modelling is based on the use of a hydrologic model (WBNM) to convert rainfall into runoff and then a hydraulic model (TUFLOW) to convert applied runoff into parameters including depths, levels, velocities and flows. Both WBNM and TUFLOW are commonly used in Australia for flood modelling and can be considered best practice.

Hydrologic Model

A hydrologic model was developed using WBNM to convert rainfall into runoff for input into the hydraulic model. This process involves an analysis of the catchments surrounding the site. The following information was used in this model:

- Bureau of Meteorology 2016 design rainfalls (extracted on 21/11/2018);
- Default lag parameters as recommended by WBNM user guide;
- Initial loss and continuing loss as per ARR Data Hub (extracted on 7/1/2019, adopting 70% of rural initial loss and 1.8 mm/hr for continuing loss);
- Pre-burst depth as per ARR Data Hub (extracted on 7/1/2019); and
- Percentage impervious for each catchment based on latest aerial imagery.

A critical duration analysis was undertaken by considering the durations from 10 minutes to 24 hours for the 1% AEP event and 15 minutes to 3 hours for the PMF event. The results show that the 45 minutes storm duration is critical for the 1% AEP event, with the temporal pattern that is closest to generating the median peak flood levels across majority of the site adopted. For the PMF event, the critical storm duration is 15 minutes.

Hydraulic Model

TUFLOW was used as the hydraulic modelling tool for simulating the design flood behaviour utilising both one and two-dimensional model elements. This software package is widely used around Australia for similar flood assessments.

The hydraulic modelling system developed for the proposed site comprised of the following elements:

- LiDAR data obtained from the ELVIS website (<http://elevation.fsdf.org.au/>) has been used to inform a 2 m finite difference grid. The terrain data covering the proposed site is dated 2013 and has an accuracy of 0.3m (95% Confidence Interval) vertical and 0.8m (95% Confidence Interval) horizontal;
- Incorporation of the FFBC ground survey dated 19/10/2018 by Total Surveying Solutions into the Digital Elevation Model (DEM);
- Pipe and culvert elements located based on Council's GIS mapping and sizes verified based on site visit and ground survey. Inverts were either informed by the survey (if available) or assumed by an offset from LiDAR ground elevations. This methodology provides an appropriate level of accuracy given the intent to block such assets by 25-50% in the flood model following ARR 2019 blockage guidelines;
- Walls and bridges over the creek are hydraulic features that have a significant impact on flood behaviour. As such these features have been represented in the model as break lines with heights determined by analysis of the ground survey and LiDAR. Creek bed levels were informed by ground survey where information is available;
- Buildings can block flow paths and therefore significantly impact flood behaviour. As such, buildings in the vicinity of the proposed site were modelled as impermeable structures in the TUFLOW model;
- Manning's 'n' roughness values were applied as follows (in line with industry standard values):
 - Road and car park: 0.02;
 - Stable creek with vegetation and cobbles: 0.045;
 - Parks/light vegetation: 0.06;
 - Dense vegetation: 0.08; and
 - Remaining area: 0.05.
- A fixed tailwater was adopted at the catchment's downstream boundary. Tailwater analysis indicated a lack of sensitivity of the assumed boundary (located approximately 700 m downstream of the development) on the peak flood levels obtained for the proposed development site.

As historical flood data is not available to calibrate the model developed herein, model validation was undertaken instead by comparing the results against those derived by Council (see Image 4) as well as a flood photo obtained from FFBC staff as illustrated in Image 5.

Image 4: Design Flood Comparison

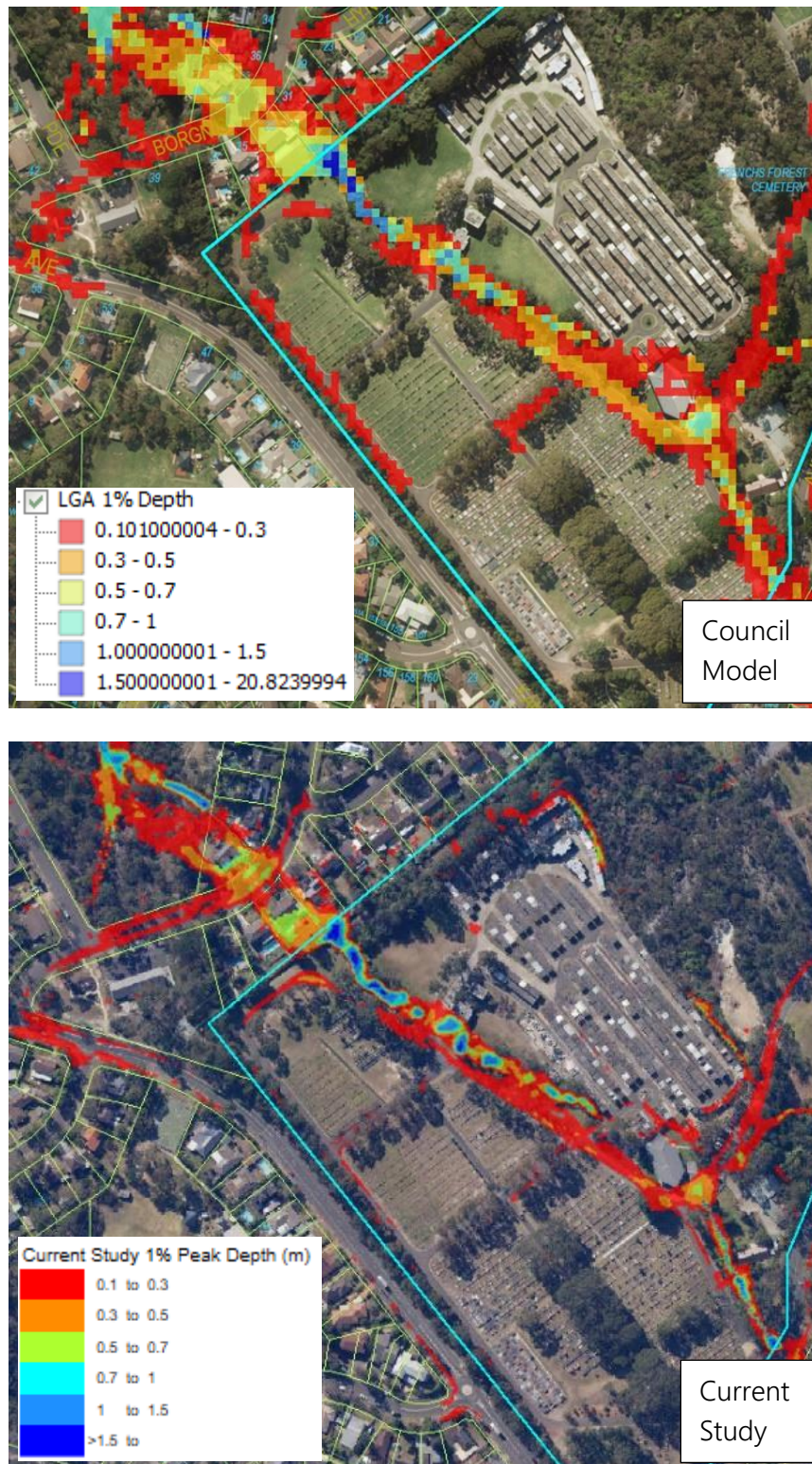
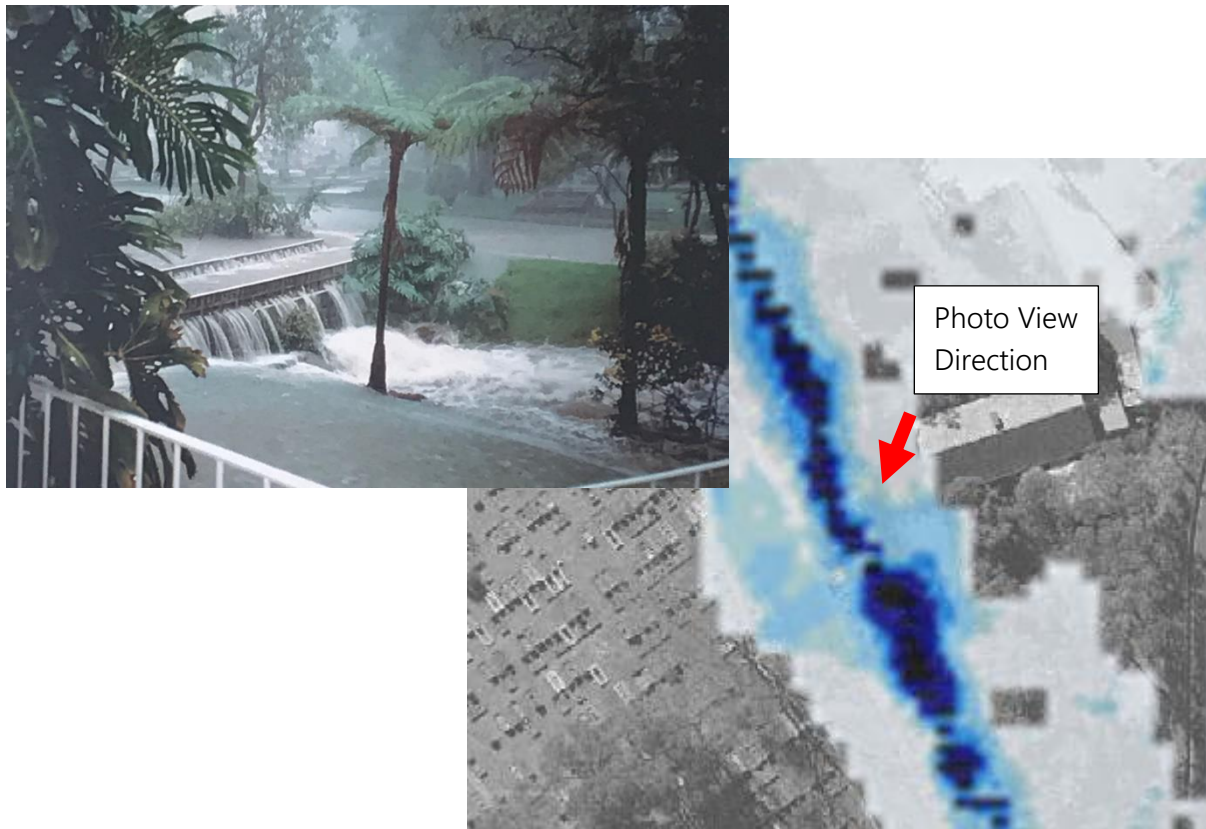


Image 5: Historical flood photo of the main creek in FFBC (date unknown)



FLOOD BEHAVIOUR

Figure 1 shows the existing flood behaviour in the vicinity of the FFBC in the 1% AEP event based on 25% culvert blockage as determined using the prescribed methodology in ARR 2019. Flows arrive at the proposed site mainly as shallow overland flows overtopping Hakea Avenue or as creek flows from upstream catchments to the west of the FFBC property boundary. Flows traverse through the site predominantly in the north-westerly direction which eventually discharges to Frenchs Creek downstream.

Examination of these results reveals flood depths in excess of 1 m flow along the small creek adjacent to the main access road. The flow velocity-depth product is less than $0.4 \text{ m}^2/\text{s}$ outside of the riparian corridor, indicative of low hazard level beyond the creek floodway (see Figure 2). Overall, velocities and depths in the 1% AEP event outside of the riparian corridor where the development is proposed are relatively low and this corresponds to mostly the lowest level of hazard (H1).

In the Probable Maximum Flood (PMF) flood levels in the creek adjacent to the chapel are around 0.5 m higher than the 1% AEP event.

Flood Impact Assessment

A flood impact assessment has been undertaken using the hydraulic model developed herein. As per Council's requirements, developments in flood affected areas must not increase flood levels on neighbouring properties in the 1% AEP event (any increase above 0.01 m which is the model accuracy limit is categorised as an adverse impact) and this has been demonstrated herein (see Figure 5). The impact map shows the change in peak flood level between the existing and proposed development conditions for the 1% AEP event. It is shown that the impact of the new chapel and expansion of the existing function room result in highly localised increases in the 1% AEP peak flood levels and the impacts are not located outside of the FFBC site. Hence no mitigation works are required as part of the proposed redevelopment as neighbouring properties are not affected.

Flood Planning Level

Flood planning level (FPL) for the proposed new chapel is determined based on the 1% AEP peak flood levels plus 0.5 m freeboard as per Warringah LEP 2011. The Flood Planning Levels for the new buildings is therefore 139.3 mAHD (chapel) and 156.5 mAHD (toilet block). The proposed floor levels are 139.4 mAHD (chapel) and 156.5 mAHD (toilet block) – therefore the criteria is satisfied.

COMPLIANCE

To demonstrate compliance against Council's LEP and DCP, as well as Council's Flood Risk Management Policy and Flood Prone Land Design Standard, Table 1 provides a summary of items addressed as part of the current assessment. As previously described, the development is not within a defined Flood Risk Precinct. It has therefore been assessed against the performance criteria listed in DCP section E11 Flood Prone Land.

Table 1: Summary of flood-related compliance

	Not Applicable	Yes	No	Comments
A) Flood effects caused by development		✓		The development causes no adverse impacts outside the site. See previous section for further information.
B) Drainage infrastructure and creek works	✓			The development does not involve any drainage infrastructure nor creek works.
C) Building components and structural		✓		Proposed buildings are generally not flood affected in the 1% AEP event, though some walls may experience depths of around 0.1 m due to shallow overland flow.
D) Storage of goods		✓		No goods will be stored below design flood levels that would amplify the damages arising from flood events

E) Flood Emergency Response		✓		The proposed development involves buildings that have minimal flood risk. In a large flood (e.g. 1% AEP) the building will not be flooded and shelter-in-place is appropriate if attendees and staff need to wait a short time (typically 15-30 minutes) for flooding to subside.
F) Floor levels		✓		New building finished floor levels are set at or above the 1% AEP peak flood level plus 0.5m freeboard. See previous section for further information.
G) Car parking		✓		Car parking spaces are located on existing roads and are not above-ground structures. Nearly all roads consist of shallow overland flow that is not hazardous to cars. While Kanooka Way is an exception, as it has hazardous flow adjacent to the function centre, there are no car parking spaces located on that section of road.
H) Fencing	✓			The development does not involve fencing or pools.
I) Pools	✓			

RIPARIAN STUDY

As part of the riparian study, GRC Hydro have undertaken a review of Council's and State Government policies pertaining to managing development on riparian land. The relevant policies, in accordance with the legislative framework of the *Water Management Act 2000*, are:

- NSW Office of Water – Guidelines for Riparian Corridors on Waterfront Land (2012); and
- Council's Protection of Waterways and Riparian Land Policy, which guides the management, development and protection of waterways and their associated riparian land in Council's LGA.

The FFBC site has been identified in Council's DCP as "Waterways and Riparian Land" and as such there is also a requirement as per Council's policy for a Waterways Impact Statement to be prepared to assess development impacts on the riparian corridors.

Image 6: Hydro Line spatial data from NSW Department of Industry¹

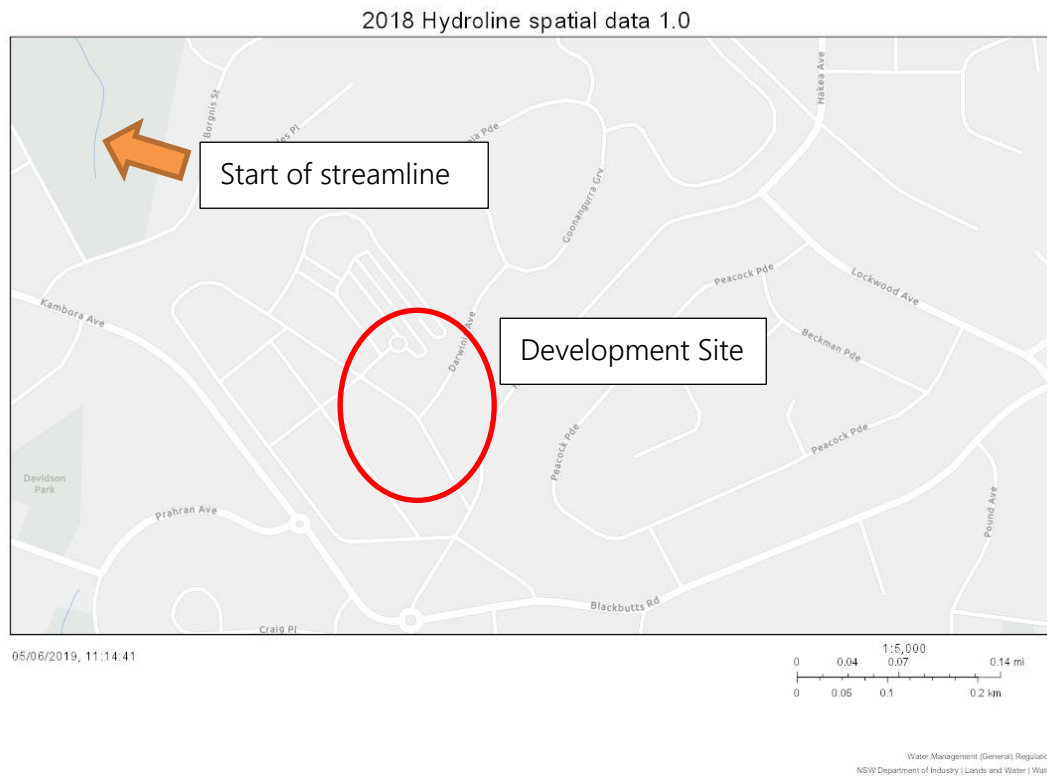
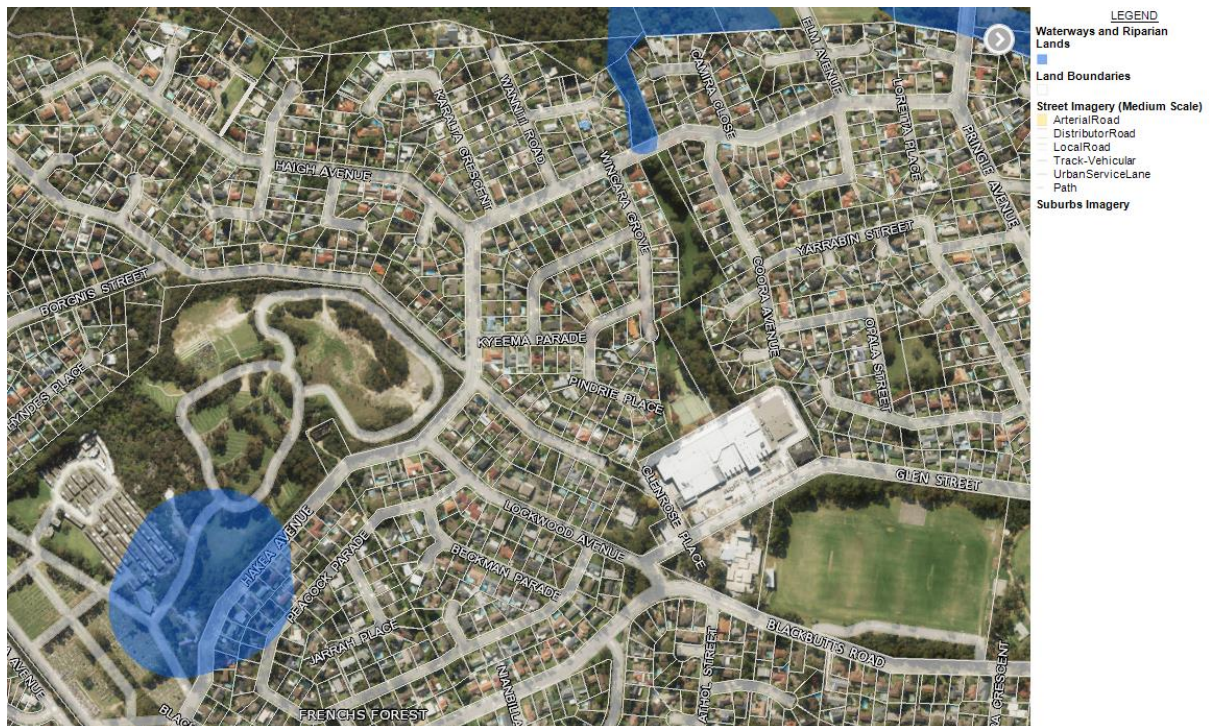


Image 7: Waterways and Riparian Lands as per Council's GIS mapping²



¹ From NSW Department of Industry web mapping portal

² From Northern Beaches Council GIS mapping portal

Based on guidelines provided by the NSW Office of Water in determining the watercourse type and width for the riparian corridor, the minor creeks located adjacent to the proposed redevelopment site (refer Image 3) have not been identified as present in topographic maps available from the State Government (based on the smallest 1:25,000 scale) as shown in Image 6. However, the cemetery site has been identified in Council's 2004 Warringah Creek Management Study and subsequently in Council's DCP as "Waterways and Riparian Land" as shown in Image 7.

Hence, to comply with Council's policy the creeks around the proposed site have been classified as first order watercourse under the Strahler System following NSW Office of Water guidelines. With this categorisation, the constraints and permissible works which can be undertaken within the first order riparian corridor have been adopted and implemented for the development herein. A 10 m riparian buffer is therefore adopted to protect the integrity of the riparian corridor. The riparian zone is shown on the design drawings for the site.

APPENDIX A – FLOOD MAPS

