Lendlease – Retirement Living proposed DA at 207 Forest Way, Belrose

Review of waterway definition

Dr Christopher J Gippel

May 2019

FLUVIAL SYSTEMS

Lendlease – Retirement Living proposed DA at 207 Forest Way, Belrose. Review of waterway definition

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Document History and Status

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1 Statement of Engagement, Qualifications and Experience

I, Christopher James Gippel, have prepared this report at the request of Lendlease – Retirement Living and Ethos Urban.

I hold a PhD in hydrology and fluvial geomorphology awarded from the University of NSW in 1989 and a BSc (Hons I) awarded from the University of Newcastle, NSW in 1982.

Since I obtained my doctorate, I have worked continuously for 29 years in the water resources sector, undertaking academic research and consultancy. My expertise is evidenced by my numerous publications in this field. I also have expertise in technical aspects of methodologies required to undertake hydrological analysis, including hydrological and hydraulic modelling, and spatial analysis (objective numerical characterisation of landforms) using Geographic Information Systems (GIS). A copy of my curriculum vitae is provided with this expert report.

Currently, my employment is:

- Consultant Hydrologist and Geomorphologist, Fluvial Systems Pty Ltd, Newcastle, a company I founded in 1999 that provides specialist services in fluvial geomorphology and hydrology to the water resources sector.
- Adjunct Senior Research Fellow, Australian Rivers Institute, Griffith University, Queensland, since 2012.

Previously I have been employed, or worked on a Fellowship, at:

- Changjiang Water Resources Protection Institute, Ministry of Water Resources (China), High-end Foreign Recruitment Programme Visiting Fellow (Sep – Oct 2013)
- College of Water Resources and Hydropower Engineering, Wuhan University (China), High-end Foreign Recruitment Programme Visiting Fellow (Nov – Dec 2013, May – Jul 2014, June – July 2015)
- Fellow in the Department of Resource Management and Geography, Melbourne School of Land and Environment, The University of Melbourne (1999 – 2012)
- The University of Melbourne (Senior Research Fellow 1990 – 1999); The University of NSW (Teaching Fellow 1985 – 1989); Adelaide University (Tutor 1983 – 1984)
- Visiting Fellow, Loughborough University (U.K.) and Exeter University (U.K.) (1992 – 1993) – Australian Bicentennial Fellowship and British Council Academic Links and Interchange Scheme Grant

This report is independent and impartial.

2 Objectives of this report

I was instructed to undertake a peer review of documentation prepared by both a Lendlease engaged consultant (Cardno) and Northern Beaches Council in relation to a development application (DA) for a seniors housing development at 207 Forest Way, Belrose (Figure 1, Figure 2) that is currently under assessment by Northern Beaches Council.

Snake Creek, catchment area 158.4 ha, is a tributary of Oxford Creek (Figure 1). The land at 207 Forest Way, Belrose is located within the upper area of the Snake Creek catchment (Figure 2).

The main objective of this report is to provide an independent opinion on whether the drainage line within 207 Forest Way constitutes a first order stream, as Council contends (Northern Beaches

Council, 2019), or is a highly disturbed area with limited extent of stream flow, the preservation of which would not meet the objectives of Part E8 Waterways and Riparian Lands within the Development Control Plan (DCP) (Warringah Council, 2011), as Cardno contends (Cardno, 2018).

A number of design elements of the proposed development relate to impact, mitigation or enhancement of attributes of water or ecosystems. From the perspective of environmental impact, these are important aspects of the proposed development, but they have been described elsewhere, and are not the subject of this review. This report has a narrow focus on the definition of the drainage lines on the property with respect to the legislation and policy considered relevant to the case. The priority of policy to this case is a planning matter that is not addressed by this report.

Daniel West, Ethos Urban, advised that consent is being sought under Warringah Local Environment Plan (WLEP) 2000 (New South Wales Government, 2017), which is the applicable Environmental Planning Instrument (EPI) on the land, of which clauses 56 and 60 are of most relevance. The Environmental Planning and Assessment Act 1979 (EP&A Act 1979) is the overarching Act for development in NSW and is relevant, but indirectly to the issue at hand. Other legislation/guidelines relevant to the case are the Water Management Act 2000 (WM Act 2000), Waterways and Riparian Lands Map, and the Warringah Creek Management Study (2004).

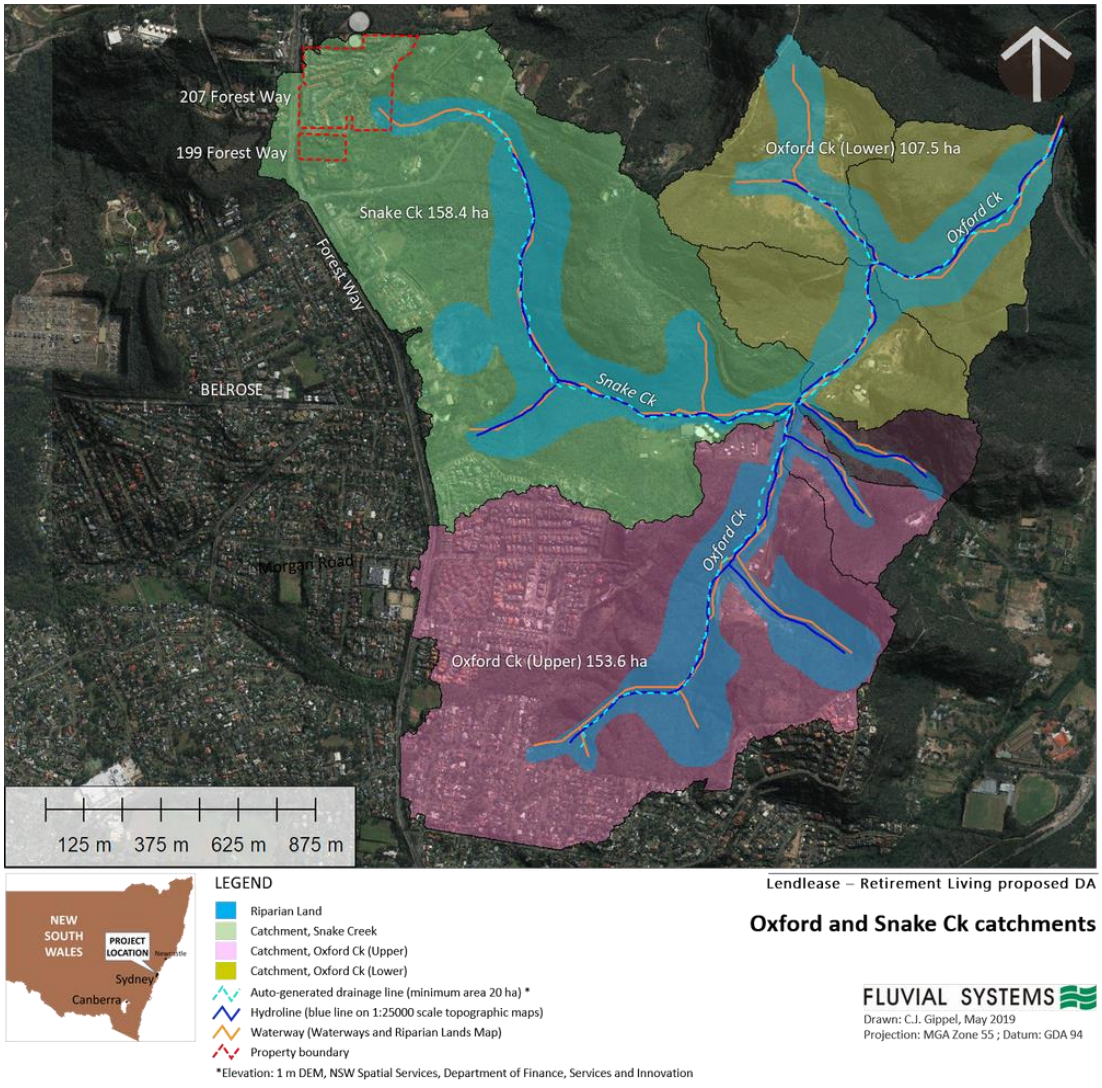

Figure 1. Location of proposed development at 207 Forest Way, Belrose, within the catchment of Snake Creek, a tributary of Oxford Creek.

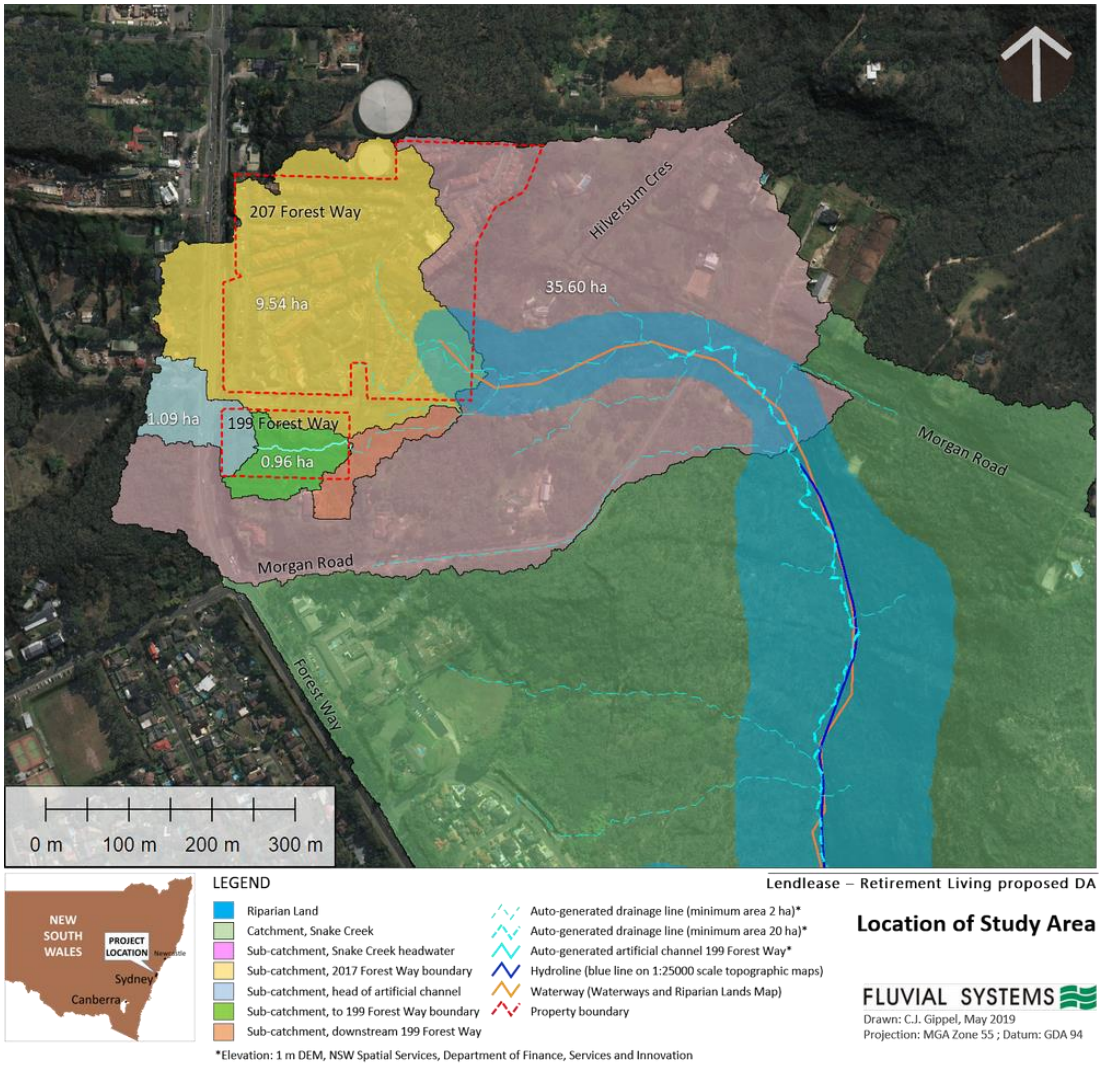

Figure 2. Location of proposed development at 207 Forest Way, Belrose, within upper part of the catchment of Snake Creek.

While Cardno (2018) included reference to Warringah LEP 2011 (New South Wales Government, 2019a) and Warringah DCP 2011 (Warringah Council, 2011), Daniel West noted that these policies do not (legally) apply to the site and are therefore not relevant for this site and surrounds. The objectives of Part E8 Waterways and Riparian Lands within the Warringah DCP are to protect, maintain and enhance ecology and biodiversity of waterways and riparian land, and applies to land identified as waterway or riparian land as shown on Warringah DCP 2011 Map Waterways and Riparian Lands, viewable at https://services.northernbeaches.nsw.gov.au/icongis/index.html. This map originates from Warringah Creek Management Study (2004). Thus, while Warringah DCP 2011 might not legally apply to the site, it uses the same definition of waterway as used in from Warringah Creek Management Study (2004), so the assessment by Cardno (2018) is relevant.

3 Methodology

This report is based on review of the site assessment by Cardno (2018) and response by Northern Beaches Council (2019), relevant legislation and policy documents, examination of spatial data (maps, aerial imagery, plans), and field inspection of the site on 2 April 2019.

4 Review of Waterway Definitions Under Legislation, Policy and Case Law

4.1 Warringah Local Environment Plan (WLEP) 2000

Clauses 56 and 60 of the WLEP 2000 are most relevant:

> *56 Retaining distinctive environmental features on sites*
>
> > *Development is to be designed to retain and complement any distinctive environmental features of its site and on adjoining and nearby land.*
> >
> > *In particular, development is to be designed to incorporate or be sympathetic to environmental features such as rock outcrops, remnant bushland and watercourses.*
>
> *60 Watercourses and aquatic habitat*
>
> > *Development is to be sited and designed to maintain and enhance natural watercourses and aquatic habitat.*
> >
> > *Note. Development within 40 metres of a watercourse requires a permit pursuant to the Rivers and Foreshores Improvement Act 1948, from the Department of Land and Water Conservation.*

Some terms in the WLEP 2000 are defined in the WLEP 2000 Dictionary (http://www5.austlii.edu.au/au/legis/nsw/consol_reg/wlep2000316/sch99.html). While the Dictionary defines the term 'tidal waterway', and mentions the words watercourse and waterbody, definitions of these terms are not provided.

A Dictionary is provided for Warringah Local Environment Plan (WLEP) 2011 (New South Wales Government, 2019a). The WLEP 2011 Dictionary does define terms for watercourses and waterbodies:

> *Waterbody means a waterbody (artificial) or waterbody (natural).*
>
> *Waterbody (artificial) or artificial waterbody means an artificial body of water, including any constructed waterway, canal, inlet, bay, channel, dam, pond, lake or artificial wetland, but does not include a dry detention basin or other stormwater management construction that is only intended to hold water intermittently.*
>
> *Waterbody (natural) or natural waterbody means a natural body of water, whether perennial or intermittent, fresh, brackish or saline, the course of which may have been artificially modified or diverted onto a new course, and includes a river, creek, stream, lake, lagoon, natural wetland, estuary, bay, inlet or tidal waters (including the sea).*
>
> *Watercourse means any river, creek, stream or chain of ponds, whether artificially modified or not, in which water usually flows, either continuously or intermittently, in a defined bed or channel, but does not include a waterbody (artificial).*
>
> *Waterway means the whole or any part of a watercourse, wetland, waterbody (artificial) or waterbody (natural).*

In the absence of a definition for watercourse in WLEP 2000, this report uses the definition provided in WLEP 2011. The legal validity of applying the WLEP 2011 definition to WLEP 2000 legislation was not determined by this report.

Note that although WLEP 2011 provided a definition of watercourse, it relied on the terms river, creek, stream or chain of ponds, which were not defined in detail, other than to say they had water flowing continuously or intermittently within a defined bed or channel. The definition did exclude

artificial waterbodies, and as only two types of waterbody were defined, it can be assumed that a watercourse is equivalent to a natural waterbody. Natural waterbodies include artificially modified or diverted waterbodies, but not artificial waterbodies. The distinction seems to be that in cases where an artificially modified or diverted waterbody was formerly a natural waterbody, then it remains a natural waterbody under the definition, whereas an artificial waterbody is one that is created independently of (i.e. not connected to or replacing) a former naturally occurring waterbody.

4.2 Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act 1979) does not define the terms river, watercourse or waterbody. On the other hand, the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation 2000), which contains many of the details for the various processes set out under the EP&A Act 1979, does provide definitions. This report assumes that these definitions apply under the EP&A Act 1979.

In the EP&A Regulation 2000 – Schedule 3, Part 4 - What do terms used in this Schedule mean? Under item 38 Definitions "waterbody" is defined as:

(a) a natural waterbody, including:

(i) a lake or lagoon either naturally formed or artificially modified, or

(ii) a river or stream, whether perennial or intermittent, flowing in a natural channel with an established bed or in a natural channel artificially modifying the course of the stream, or

(iii) tidal waters including any bay, estuary or inlet, or

(b) an artificial waterbody, including any constructed waterway, canal, inlet, bay, channel, dam, pond or lake, but does not include a dry detention basin or other stormwater management construction that is only intended to hold water intermittently.

Note that the above definitions are similar to those in WLEP 2011. The differences are subtle but potentially important. EP&A Regulation 2000 requires a waterbody to have an 'established bed', while WLEP 2011 refers to watercourses having a 'defined bed or channel'. Definitions of these terms cannot be found in the geomorphic literature. In my opinion, these terms were likely intended to mean that a valid watercourse or waterbody would convey flow along a relatively consistent path, within banks in confined manner, as opposed to unconfined flow, referred to as sheetflow, which can notably shift its course within and between runoff events.

The clumsy wording "*in a natural channel artificially modifying the course of the stream*" in EP&A Regulation 2000 was replaced by "*the course of which may have been artificially modified or diverted onto a new course*" in WLEP 2011.

Significantly, WLEP 2011 and EP&A Regulation 2000 are consistent in not constraining the definition of a stream by hydrology, as both perennial and intermittent streams are included. This binary classification of river flow regimes is important because a version of it appears in all potentially relevant legislation, and has been the topic of expert evidence in case law. It has been argued that in academic hydrology, a third class of 'ephemeral' flow regime is recognised, and because EP&A Regulation 2000 does not include it along with perennial and intermittent types, then such streams are excluded from the legislation. In hydrological classification literature, 'perennial and intermittent' is equivalent to 'permanent and temporary', and the hydrological class 'ephemeral' is a sub-type of the primary intermittent class (Gordon et al., 2004). Furthermore, the intermittent class can be subdivided into several sub-types, not just 'ephemeral', depending on degree of intermittency (Gordon et al., 2004). Following from that, it is my opinion that EP&A Regulation 2000, and by association, EP&A Act 1979, WLEP 2011 and WLEP 2000, do not exclude any river or stream on the basis of its flow regime.

4.3 Water Management Act 2000

In the Water Management Act 2000 (New South Wales Government, 2019b), Dictionary, "river" is defined as:

> "*(a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and*
>
> *(b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and*
>
> *(c) anything declared by the regulations to be a river,*
>
> *whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river*."

While an expert geomorphologist or hydrologist might be able to independently identify a waterbody that fits a scientific-based definition in the field or using aerial photographs and/or topographic data, it would be too expensive to apply routinely, and would still require a degree of subjective judgement. For the purposes of routine identification of rivers in application of the WM Act 2000, an expedient objective approach would be appropriate. Thus, it is common practice to accept the existence of a watercourse if it is represented by a blue line on a topographic map published by Land & Property Information, NSW Government. The density of blue lines on maps that designate watercourses varies with map scale. The largest scale maps available for an area, generally 1: 25,000, have more blue lines marked than smaller scale maps, such as 1:50,000 and 1:100,000. This conventional practice was recognised by Taylor and Stokes (2005), who wrote that: "*Disputes regarding the determination of a watercourse are often dealt with by the Department of Infrastructure, Planning and Natural Resources (DIPNR)* [now the responsibility of NSW Office of Water, NSW Department of Primary Industries]*, which currently uses two informal methods to determine whether a watercourse is a bona fide river or stream sensu the RFIA. If a blue line (indicating a watercourse) is present on a 1:25 000 topographic mapsheet and/or if the catchment has a minimum area of 20 ha then DIPNR expects a natural channel to be present*."

Drainage lines and sub-catchments for Oxford Creek catchment, including Snake Creek sub-catchment, were automatically generated using the 'Generate Watershed' algorithm in Global Mapper GIS (Geographic Information System), with the minimum sub-catchment area set to 20 ha. This produced drainage lines that were less extensive than the 1:25,000 blue lines (hydrolines) (Figure 1), indicating that some of the catchments draining to the top of blue lines are less than 20 ha in area. This was not the case for upper Snake Creek, where the blue line was shorter than the auto-generated drainage line (Figure 2). The catchment draining to the top of the blue line was 35.60 ha. In preparing the topographic map, the cartographers decided to begin Snake Creek blue line at the base of a 10 m high, near vertical (slope up to 70 degrees) rock knickpoint (Figure 3).

Setting the 'Generate Watershed' algorithm minimum sub-catchment area to 2 ha generated many more drainage lines (Figure 2). This demonstrates the scale-sensitivity of defining drainage lines. It is also worth noting that the blue lines are smoothed representations of the actual stream courses, the alignments of which are much more accurately mapped by the automatic terrain analysis technique.

The practice of using 1:25,000 topographic mapsheets to identify watercourses under the WM Act 2000 is not specified in the Act itself, but is specified in associated documents. For example, in the document NSW Office of Water (2010) "*Application for approval for water supply works and/or water use, Application for Minister's consent under section 92 of the Water Management Act 2000*", the official definition of "river" under the WM Act 2000 is given, followed by the statement "*For the practical purposes of this application, NOW* [NSW Office of Water] *defines 'river' as any blue line on the largest topographical map of that area (ie. at least 1:25,000)*". In another example, the document Department of Primary Industries, Office of Water (2012) "*Controlled activities on waterfront land, Guidelines for riparian corridors on waterfront land*" described a system of setting the width of vegetated riparian zones (VRZs) "*…based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps*".

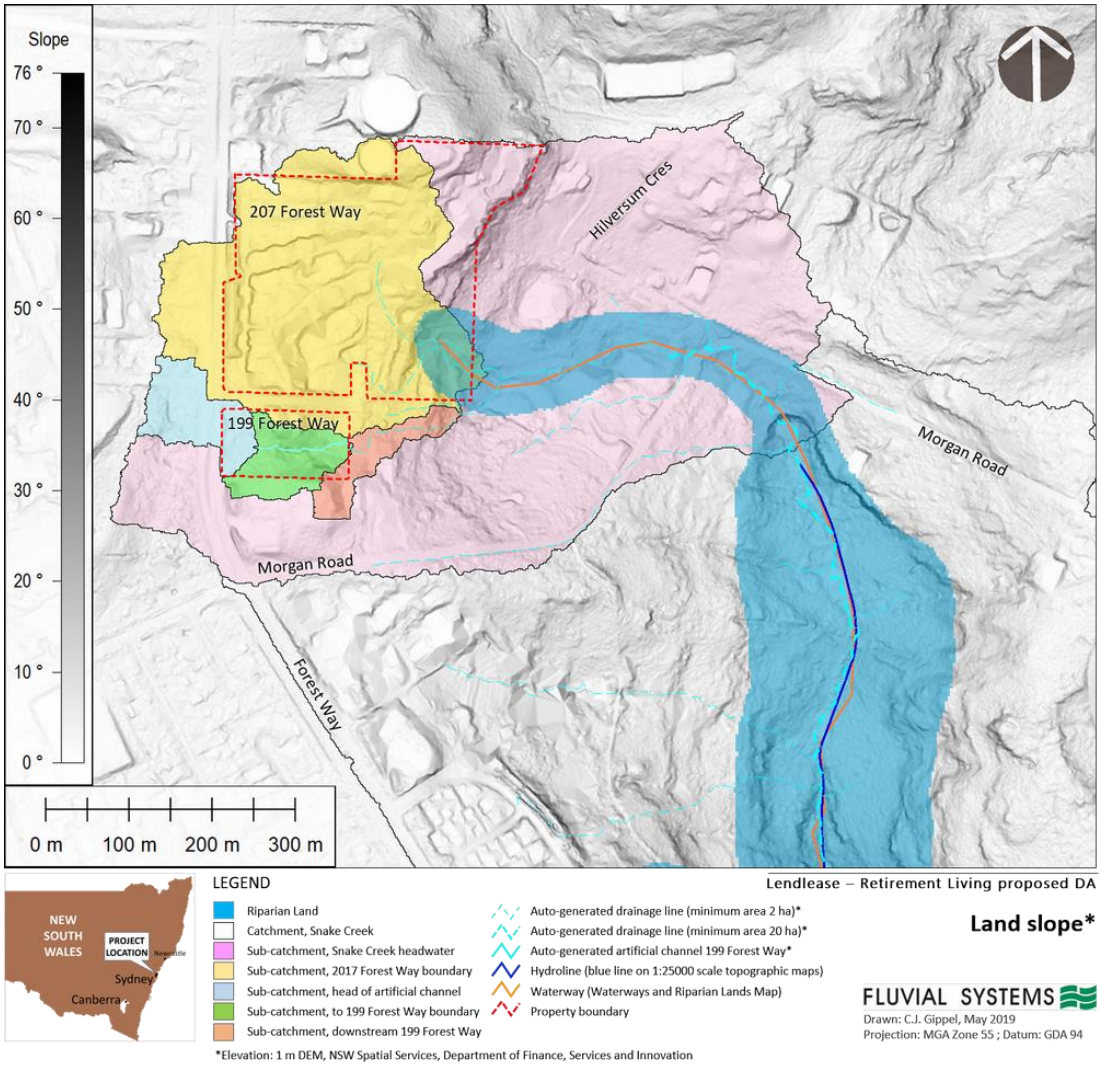

Figure 3. Slope of the upper part of the catchment of Snake Creek.

Since the time when Taylor and Stokes (2005) wrote that the practice of identifying rivers using mapped blue lines was an informal method used by the responsible agency, it is has been established as a formal method used in application of the WM Act 2000 "*…to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity*" (Department of Primary Industries, Office of Water, 2012).

As for the WLEP 2011 and EP&A Regulation 2000, the WM Act 2000 recognises two hydrological classes of waterbody in the definition of a river as "*any watercourse, whether perennial or intermittent*".

4.4 Warringah Creek Management Study (2004)

The Warringah Creek Management Study (MWH, 2004) spent considerable effort defining riparian zones, but less so on defining waterbody, watercourse, or river. Although these terms were not defined, a definition for creek, and by association, watercourse, was provided (p. E28):

> *Creek - any watercourse, whether ephemeral, intermittent or perennial, whether on its natural course or altered by human interference, whether channelled or not. It also includes any drainage lines able to be identified by a linear vegetation assemblage reflective of regularly moist soil conditions or by a weed plume consistent with regularly moist soil conditions.*

The hydrological part of this definition is similar to the definition of WLEP 2011 and EP&A Regulation 2000. The geomorphic part of the definition differs, because WLEP 2011 and EP&A Regulation 2000 require a channel shape to be present. The final part is a departure from all other legal definitions of watercourses, as it relies entirely on the presence of a certain vegetation structure.

One paragraph in MWH (2004, p. D6) provides hints about what the study included as watercourses:

> *The riparian zone is taken to start at the edge of the low flow channel (i.e. the edge of the water in average dry weather flow. For ephemeral streams without a defined channel, the start of the riparian zone is the creek centre line). This side steps the issue that in many of Warringah's creeks, the top of bank is difficult to define and therefore may lead to inaccuracies*.

This suggests that no stream was excluded on the basis of the degree of intermittency of its hydrological regime. Also, a watercourse did not require a defined channel or a well-defined channel.

Overall, the Warringah Creek Management Study (MWH, 2004) would be expected to include more streams as valid watercourses than would be defined under WLEP 2011, EP&A Regulation 2000 and WM Act 2000.

4.5 Map of Waterways and Riparian Lands (from Warringah Creek Management Study, 2004)

The Map of Waterways and Riparian Lands originates from Warringah Creek Management Study (MWH, 2004). The Map indicates zones of riparian land that enclose waterways, as defined and mapped by MWH (2004) (Figure 1, Figure 2). The waterways mapped by MWH (2004) are broadly based on the 1:25000 blue lines (hydrolines), but most first order streams were extended upstream for a variable distance, and some new first order streams were added (Figure 1, Figure 2). The method used to extend these stream lines was not clearly stated.

It is also worth noting that the waterway lines are smoothed representations of the actual stream courses, the alignments of which were much more accurately mapped by the automatic terrain analysis technique. Also, the alignments of the waterway lines are not exactly the same as those of the blue lines, so it appears likely that the waterway lines were drawn by hand.

4.6 Warringah Council Policy, Policy No. PL 740 Waterways, Protection of Waterways and Riparian Land Policy

Warringah Council Policy No. PL 740 Waterways, Protection of Waterways and Riparian Land Policy sets out definitions and policies for protecting waterways and riparian land (Warringah Council, 2010). The definitions are virtually identical to those in the WLEP 2011 Dictionary (see above), except that creek was stated to be equivalent to watercourse, and the definition of watercourse was elaborated to include a definition of Strahler Stream Order, as follows:

> *Watercourse means any river, creek, stream or chain of ponds, whether artificially modified or not, in which water usually flows, either continuously or intermittently, in a defined bed or channel, but does not include a waterbody (artificial). This may include drainage lines, concrete channels and ephemeral streams. First order watercourses are those with no tributaries, second order streams form following the confluence of two first order streams, third order streams form where two second order streams meet, and so on.*

Council Policy No. PL 740 also included a definition of river, taken directly from WM Act 2000 (see above). Given that this definition of river is consistent with that of watercourse, creek is equivalent to watercourse, and waterway (*the whole or any part of a watercourse*) is equivalent to watercourse, there is only need to use one term, watercourse, even though Council policy prefers to use the term waterway.

Council Policy No. PL 740 applies to all land containing watercourses and riparian land identified on Council's Map Waterways and Riparian Land. In cases where a waterway has not yet been identified

on the Map, the riparian land widths are to be applied from NSW Government Guidelines (Office of Water, 2012), which defines streams based on blue lines on 1:25:000 map sheets.

Council Policy No. PL 740 recommends that development within waterways and riparian land should be avoided. The Policy includes a paragraph with advice for situations when development is proposed within waterways and riparian land :

> *Where development is proposed within waterways and riparian land, a Waterway Impact Statement shall be submitted with the development application to enable Council to assess how the application meets the policy objectives, and identify potential impacts. A Waterway Impact Statement is to demonstrate to Council the development will either enhance, or as a minimum, will not adversely affect ecological function or limit opportunities to reinstate the area in the future to the greatest possible extent.*

In the case of 207 Forest Way, a small area of the proposed development lies within the buffer of Snake Creek drainage network, on the end of a first order stream line that has been extended a distance of about 534 m upstream from the end of the blue line mapped on the 1:25,000 sheet (Figure 2, Figure 3). The waterway line extends about 55 m into the area of the property proposed for development. The buffer around the end of the waterway line projects over land that is already partially developed. This report assumes that the report of Cardno (2018) constitutes a Waterway Impact Statement.

4.7 Definition of watercourses using guidelines of Taylor and Stokes (2005)

Taylor and Stokes (2005) tabulated variables to use in field identification of watercourses with respect to the legislative framework that applied in NSW at the time. Their table (reproduced here as Table 1) was presented as a series of present/absent criteria that according to Taylor and Stokes (2005) are normally associated with a river. Taylor and Stokes (2005) did not indicate whether all or just some of the features had to be present for a channel to qualify as a river, but they noted that features associated with a 'normal' river system would usually include fluvial sediments, well-defined beds and banks or habitat for aquatic flora and fauna. They also noted that the criteria would generally be more applicable to lower order, e.g. first and second order tributary channels where the start of a channel or river is ambiguous.

Taylor and Stokes (2005) cited a case where the variables in Table 1 had been used in a legal dispute regarding the definition of a river (Outhet and Taylor, 2004), and it was used in another later case of Silva v Ku-Ring-Gai Council [2009] NSWLEC 1061. Taylor and Stokes (2005) were of the opinion that first and second order headwater drainage depressions were unlikely to be deemed bona fide 'rivers' under any of the relevant legislation, and their table of criteria (Table 1) essentially excludes them. Firstly, small headwater streams do not usually have bedforms such as pools, riffles, and sediment point bars, which are required by feature b) in Table 1. Such bedforms are more characteristic of mid-catchment and lowland alluvial streams with continuous or discontinuous floodplains. Although, this criterion could unintentionally exclude bona fide rivers, because some large rivers also lack these bedforms. Secondly, feature d) in Table 1 mentions perennial or seasonally intermittent flow, which, on the basis of Taylor and Stokes (2005) stated preference for three primary hydrological classes of stream, implicitly excludes ephemeral streams. Feature e) in Table 1 also implicitly excludes ephemeral streams. The flow regime of most first order streams would be of the ephemeral sub-type of intermittent stream, as was recognised by Taylor and Stokes (2005). The origins of the feature list (Table 1) was not explained by Taylor and Stokes (2005), but the list undoubtedly supports the exclusion of ephemeral streams as bona fide rivers for the purposes of applying the legislation. This hinges on the assumption by Taylor and Stokes (2005) that the legislation, which describes streams as 'perennial or intermittent', implicitly excludes the ephemeral sub-type of intermittent stream.

Table 1. Features associated with a 'normal' river system that can be used in field identification of rivers for legal purposes. Source: Taylor and Stokes (2005).

a)	Are there definable channel banks and a channel bed?
b)	Are there fluvial bedforms e.g. pools, riffles, sediment point bars etc. and if so what are they?
c)	Is there any evidence for substantial erosion from water flow within the drainage feature?
d)	Are there any spring lines that may indicate seasonally intermittent or perennial flow?
e)	Is the catchment large enough to sustain perennial or intermittent groundwater flow?
f)	Are there any indicators of prolonged wetness within the drainage feature?
g)	If surface flow is present, is it continuous and how extensive across the base of the drainage feature is it?
h)	Are there any visible habitats that might sustain aquatic fauna?
i)	Are there any aquatic flora present that would require periods of uninterrupted moisture?

4.8 Definition of watercourses in case law

In Don Burke and [16] Others v Hawkesbury City Council & Ors [2001] NSWLEC 222 (28 September 2001) the respondents' expert, Dr Wayne Erskine, a fluvial geomorphologist, distinguished three hydrological stream types: perennial, intermittent and ephemeral. He defined a 'river' as "*a stream of flowing water that is contained within well-defined bed and banks, and that lays down water-deposited material*". He said that an ephemeral flow regime is one where the stream flows only "*during and immediately after rain*", but an intermittent stream flows "*for a longer period of time*". These definitions are consistent with the definitions I provided earlier in this expert report. In this case, the Court accepted the opinion of Dr Eskine, who determined that the stream in question was ephemeral. In contrast, the other expert (Mr Rick Morse) regarded the stream as intermittent. In my opinion the primary hydrological classification of streams is binary – either perennial or intermittent – with ephemeral one of several possible sub-types of intermittent. Also, whether a stream is classified as intermittent, or in more detail as the ephemeral sub-type of intermittent, is immaterial to the EP&A Regulation 2000 (and similarly worded legislation) which uses the binary classification to define a natural waterbody as "*a river or stream, whether perennial or intermittent*".

In an earlier case, Knezovic v Shire of Swan-Guildford [1968] HCA 38; (1968) 11CLR 468 (21 June 1968), the Australian High Court followed established common law definition of 'watercourse' for a ruling on a case in Western Australia. In paragraph 17, the decision referred to Gartner v. Kidman [1962] HCA 27; (1962) 108 CLR 12, where the majority of the Justices participating adopted a passage from Angell (1854) as stating the meaning at common law of a watercourse, namely:

> "…*a watercourse consists of bed, banks and water: yet the water need not flow continuously and there are many watercourses which are sometimes dry. There is, however, a distinction to be taken between a regular flowing stream of water which at certain seasons is dried up and those occasional bursts of water which at times of freshet or melting of ice and snow descend from the hills and inundate the country*." (p. 475)

On the basis of this, in paragraph 18, Barwick CJ determined that a watercourse comprises a channel with a bed, banks, and flowing water. Barwick CJ regarded permanently flowing streams and streams that flow most of the time as proper watercourses, but he was of the opinion that infrequently flowing streams did not have the capacity to shape well-defined channels, and were thus not watercourses by meaning at common law. The morphology of a stream is closely linked to its hydrology. The more frequent is reasonably deep flow, the less likely the bed and bank surface will be covered by vegetation that binds the sediment, and the greater the depth of flow and the slope, the greater the bed shear stress, which, once a threshold is overcome, will be sufficient to scour binding vegetation. In the absence of vegetation, bed and bank sediments are more easily scoured and moved, which results in more pronounced bed and bank morphology. This is a relatively straightforward concept, but it remains difficult to unequivocally determine cases where the morphology or flow regime is borderline for watercourse, or where distinct watercourse morphology is discontinuous.

The question of channel discontinuity arose in the case of Narrambulla Action Group v Mulwaree Council [1966] NSWLEC 199. For the definition of watercourse, the decision by Banon J referred to the cases of Gartner v Kidman and Knezovic v Shire of Swan-Guildford (see above). One expert Dr M.C. Thoms, a fluvial geomorphologist, said that the alleged watercourse No 3a had an established bed and defined banks, although they were discontinuous. Another expert, Dr E.M. O'Loughlin, a hydrologist, supported this view, explaining that such channels are in a state of evolution, "…*and may not necessarily form a continuous bed of alluvium until the channel slope flattens out*…[and furthermore]…*a continuous channel or bank may not be apparent, but this does not negate the fact that the creeks and tributaries are flowing in a 'natural channel with an established bed'. As described above, the channel bed may be degrading along some reaches, and aggrading along others, depending on local slope and the presence of obstructions to flow*." Referring to the evidence of O'Loughlin, Banon J noted that "*while his views deserve respect, he thinks of waterbodies in a scientific way, which includes waters such as Coopers Creek, but does not fit the definitions given by the Courts, taken as they are, from European conditions*." As such, Banon J classified the stream in question as "…*a drainage line with gullies to the East and West, together with intermittent ponds and flood plane, where water flows are rare intervals, under the influence of rain*." In this decision, the Court preferred expert evidence on the legal definition of watercourses which are based on European conditions, over scientific evidence concerning hydrological and geomorphological processes in Australian streams.

In the case of Warringah Council v Ardel Limited and Anor [2000] NSWLEC 7, the expert Dr Steven John Perrens, an engineer, referred to the definition of a river in the Rivers Act and set out the well-known passage in the judgment of Barwick CJ in Knezovic v Shire of Swan-Guildford. Dr Perrens attributed significance to the bed and banks in the channel as defining it as a river. However, the Court was not satisfied, on the balance of probabilities, that the bed and banks were created naturally, rather that they may have been scoured by re-directed stormwater. This case demonstrated that, although a channel may have the morphological features of a natural river, it must be the product of natural flows to be defined as a river in that location. If the natural flows would not have formed a river channel, then it is not a river. Thus, banks are important in defining a river, but banks alone do not automatically define a channel as a river.

In the case of Silva v Ku-Ring-Gai Council [2009] NSWLEC 1061, in his decision, Taylor C noted the importance of ephemeral streams, citing Thoms and Sheldon (2000) that "…*at least 83 % of Australia's river networks are characterised by ephemeral systems that experience semi-arid to arid (dryland) climatic regimes*…". However, referring to Narrambulla Action Group Inc v Mulwaree Council, he pointed out that scientific definitions do not necessarily prevail in the determination and definition of what constitutes a river in the Australian sense. Nevertheless, Taylor C applied the '9 part test' of Taylor and Stokes (2005) (see Table 1). Crucially, the watercourse in question had a channel with well-defined bed and banks, and modelling, ironically by the expert who claimed the watercourse was not a river, suggested that it flowed for around 80 percent of the time, which would surely qualify as an intermittent, not ephemeral, flow regime. After weighing the evidence, Taylor C found that "…*the applicant has not established that there is a preponderance of evidence to show that the watercourse at 27 Miowera Road is not a river*." There seemed little doubt that the watercourse in question had characteristics of a river, with the main point of contention whether the processes that resulted in the river were natural or artificial (due to urban development and piping).

The legal arguments about definition of the term 'river' in Australia have not been based on thorough consideration of ecological and geomorphological processes. Rather there has been a reliance on long-standing existing definitions. These definitions date back to a time when property boundaries, flood mitigation and access to water for consumptive uses were the main river management issues; concern about ecological issues is a relatively recent phenomenon of the past 20-40 years. The definitions of 'river' and 'watercourse' in the current river management legislation are based on simple considerations of gross morphology (i.e. a river requires bed and banks and does not include the floodplain) and have either perennial or intermittent flow.

Referring to the case of Don Burke, where the expert Dr Wayne Erskine distinguished three primary hydrological classes of stream – perennial, intermittent and ephemeral – Taylor and Stokes (2005) argued that for the purpose of a legal definition, these three classes of river flow regime "…*should form the basis for describing the characteristics of a drainage line or depression that transfers water*

from hill slopes to lower ground and ultimately to the ocean or an inland basin." On this matter I disagree with Taylor and Stokes (2005). My reasoning is that the legislation does not mention the ephemeral stream type, and well-regarded academic literature on the subject identifies two, not three, primary hydrological classes – perennial and intermittent – with the ephemeral flow regime one of several possible sub-types of the intermittent class. I also realise that alternative classification schemes are used in applied hydrology. For example, Berhanu et al. (2015) is an example where the authors used a statistical method to fit rivers in Ethiopia within three flow regime classes – ephemeral, intermittent and perennial. By assuming the validity of three primary flow classes, Taylor and Stokes (2005) argued that relevant Australian legislation, by defining waterbodies and rivers as 'perennial or intermittent' (in the EP&A Regulation 2000 and WM Act 2000), and not specifically including the ephemeral sub-type of stream in the definitions, therefore excluded ephemeral streams.

5 Review of Site Assessment by Cardno and Response by Northern Beaches Council

5.1 Site Assessment by Cardno

The Riparian Assessment by Cardno (2018) argued that the Map of Waterways and Riparian Lands (MWH, 2004) erred in extending the Snake Creek headwater tributary drainage line into the land covered by 207 Forest Way, Belrose (Figure 4).

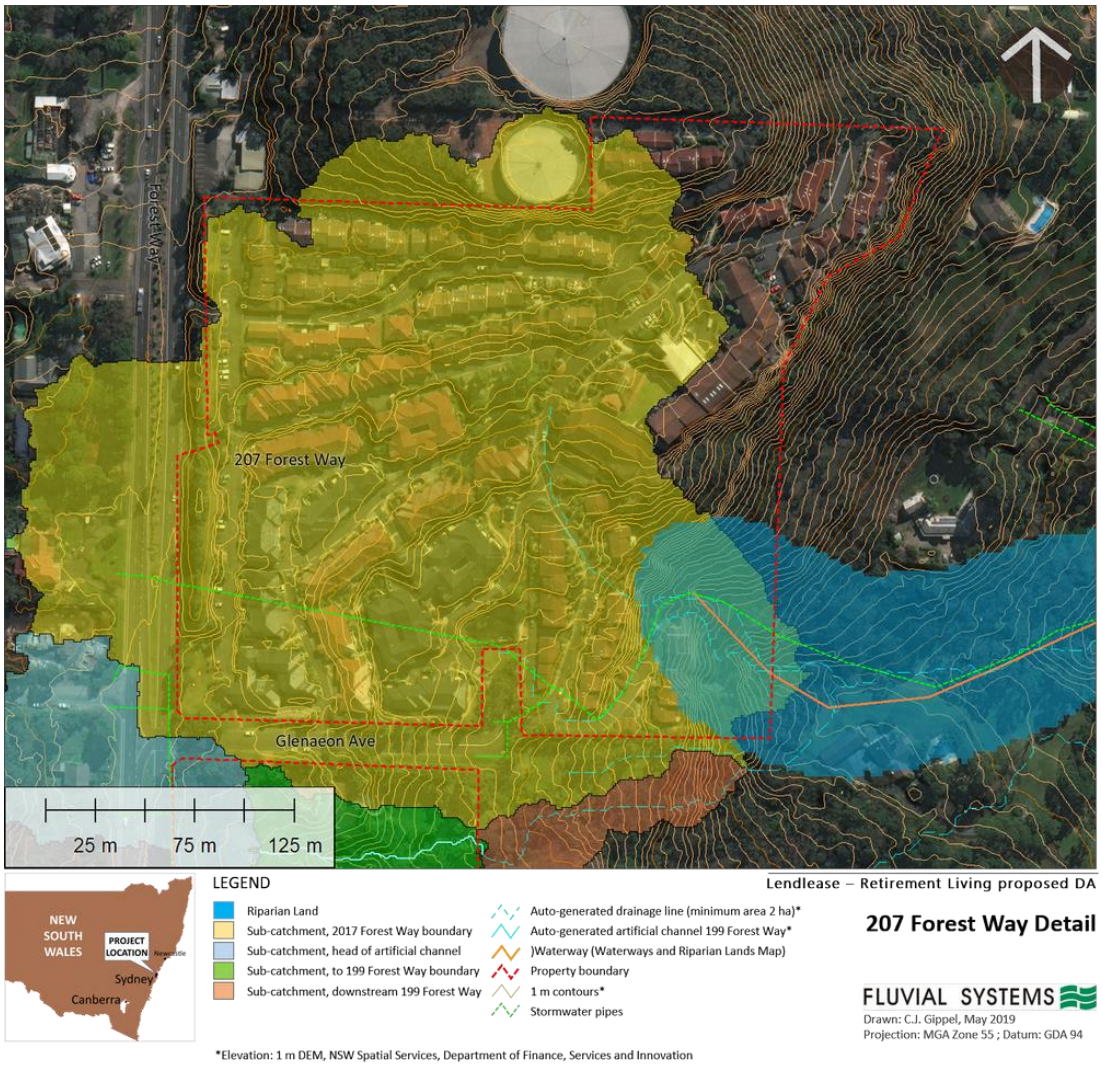

Figure 4. Detail of drainage of land around 207 Forest Way, Belrose.

Cardno (2018) accurately described the area in question as heavily modified by urbanisation and stormwater management. This includes Council-owned stormwater drainage (Figure 4) that empties to a series of three existing sedimentation basins that lie within the area of the proposed development. Downstream of the sediment basins, on the adjoining property, a dam was constructed some time between October 2012 and April 2013. The Council Waterways line projects through these structures to approximately the base of a sandstone escarpment (Figure 3, Figure 4). For a distance of about 70 m downstream of the dam, the land over which the Council Waterways line is drawn is grassed, and no channel is evident.

I agree with the conclusion of Cardno (2018) that the upper reaches of the Waterways line drawn by Council that projects into 207 Forest Way is artificial and does not possess characteristics that define a watercourse according to the legislation, policy and case law reviewed in this report. The watercourse satisfies the Warringah Creek Management Study (2004) liberal morphology and hydrology requirements, but lacks a continuous linear vegetation assemblage that could also define a watercourse.

From the perspective of WLEP 2000, EP&A Act 1979 and WM Act 2000 definitions, the issue mainly hinges on whether the section of drainage line in question is an artificial waterbody, or an artificially modified natural waterbody. Topographically, the area naturally was, and is, a runoff flow path, but nearly all land in catchments drains water downhill under storm event conditions, so a runoff path alone does not make a watercourse. According to most legal definitions of watercourse, the flow must be confined, and a channel and other characteristic properties would be present. When the 1:25,000 maps were drawn, the cartographers decided the drainage path did not possess sufficient characteristics of a watercourse to be marked as a blue line. For this reason the flow path would not normally meet the WM Act 2000 definition of a watercourse. An earlier 1917 Parish Map did draw the drainage line extending further upstream than the 1:25,000 blue line, but it stops just short of the boundary of 207 Forest Way (Figure 5).

On the basis of the variables suggested by Taylor and Stokes (2005) that define a watercourse for legal purposes (Table 1), the flow path in question would fail criteria a) to g) at least.

Case law has tended to rely on common law definitions of watercourses, which regards permanently flowing streams and streams that flow most of the time as proper watercourses. Areas where the flow is largely driven by re-directed urban stormwater (as is the case for 207 Forest Way) would not normally be considered a natural watercourse, unless a natural watercourse was there previously.

5.2 Response by Northern Beaches Council

The response to Cardno (2018) by Northern Beaches Council (2019) contends that the site contains a first order stream. This is contentious because, although the methodology for assigning stream order using the Strahler system is straightforward, the outcome depends entirely on the cartographic representation, or field identification, of the stream network. According to the Department of Lands 1:25,000 topographic mapping (a commonly used standard for defining watercourse presence or absence) there is no first order stream on the property (Figure 2). A first order stream extending into the property was drawn on a map produced by MWH (2004) as part of Warringah Creek Management Study. The basis for drawing this line was not provided in MWH (2004), but regardless, on the basis of a desktop and field assessment, Northern Beaches Council (2019) agreed that it was a watercourse and as such, the development would be contrary to Warringah Council Policy No. PL 740 Waterways, Protection of Waterways and Riparian Land Policy and WLEP 2000.

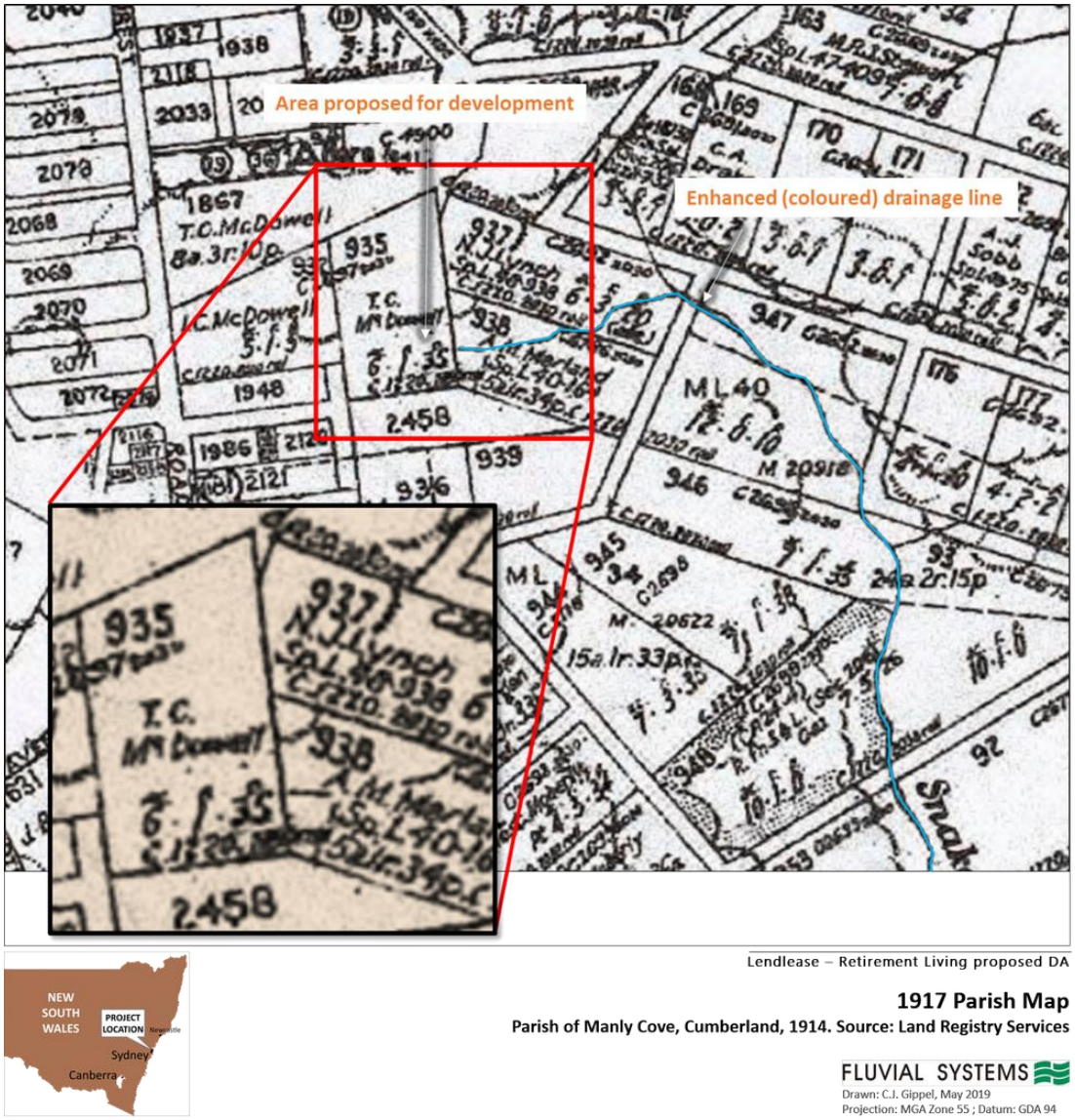

Figure 5. Parish Map of area covering location of proposed development.

6 Conclusion

Watercourses emerge from drainage paths that collect runoff from hillslopes. There is not necessarily a point along that continuum when the drainage path unequivocally transforms to a watercourse. Part of the reason for this is that watercourses are recognised as such on the basis of multiple attributes, and those attributes might change character at different locations.

Whilst it would be theoretically possible to develop a scientific method to define a point along the continuum where the stream dominantly possessed the characteristics of a watercourse, as opposed to a drainage path, this approach cannot be readily applied to the definitions of watercourse provided in legislation and policy documents, because the criteria are too few, or are not described with sufficient detail. Taylor and Stokes (2005) attempted to overcome this problem by providing a checklist of nine features that could define watercourses for legal purposes, but their use of subjective language to describe the features means that it might not be a reproducible method. Nonetheless, the drainage line on 207 Forest Way would likely fail to meet most of the criteria, which are oriented to larger streams with continuous flow and bedload transport.

Finally, when compared to case law, the drainage line on 207 Forest Way would likely not be regarded a watercourse, because the decisions have tended to regard watercourses as streams that are unequivocally naturally formed, flow most of the time and have continuous, well-defined beds and banks.

In conclusion, on the basis of geomorphic and hydrologic considerations, in my opinion, the length of stream drawn on the Map of Waterways and Riparian Lands on 207 Forest Way, Belrose is not a natural watercourse under Warringah Local Environment Plan (WLEP) 2000, but an artificial watercourse.

7 References

Angell, A.K. 1854. A treatise on the law of watercourses: with an appendix containing statutes of flowing and forms of declarations. 5th Ed, Boston: Little, Brown.

Berhanu, B., Seleshi, Y., Demisse, S.S. and Melesse, A.M. 2015. Flow regime classification and hydrological characterization: A case study of Ethiopian rivers. *Water* **7**: 3149-3165

Cardno 2018. Riparian Assessment, Glenaeon Retirement Village Redevelopment. Prepared for Lendlease, 14 May.

Department of Primary Industries, Office of Water 2012. Controlled activities on waterfront land, Guidelines for riparian corridors on waterfront land. NSW Government, Department of Primary Industries, Office of Water, July. URL: http://www.water.nsw.gov.au/__data/assets/pdf_file/0004/547222/licensing_approvals_controlled_activities_riparian_corridors.pdf (accessed 25 April 2019).

Don Burke and [16] Others v Hawkesbury City Council & Ors [2001] NSWLEC 222 (28 September 2001). New South Wales Land and Environment Court. http://www.austlii.edu.au/au/cases/nsw/NSWLEC/2001/222.html (accessed 24 April 2019).

Gartner v. Kidman [1962] HCA 27; (1962) 108 CLR 12. High Court of Australia. URL: http://www.austlii.edu.au/au/cases/cth/HCA/1962/27.html (accessed 24 April 2019).

Gordon, N.D., McMahon, T.A., Finlayson, B.L., Gippel, C.J. and Nathan, R.J. 2004. Stream Hydrology: An Introduction for Ecologists. Second Edition, John Wiley & Sons, Chichester

Knezovic v Shire of Swan-Guildford [1968] HCA 38; (1968) 11CLR 468 (21 June 1968). High Court of Australia. URL: http://www.austlii.edu.au/au/cases/cth/HCA/1968/38.html (accessed 24 April 2019).

MWH 2004. Warringah Council Creek Management Study. Montgomery Watson Harza (MWH) Australia Pty Ltd in association with 4 Site Natural Solutions. Warringah Council. March.

Narrambulla Action Group v Mulwaree Council [1966] NSWLEC 199. Land and Environment Court of New South Wales. URL: http://www.austlii.edu.au/cgi-bin/sinodisp/au/cases/nsw/NSWLEC/1996/199.html (accessed 24 April 2019).

New South Wales Government 2017. Warringah Local Environmental Plan 2000. Current version for 30 June 2017 to date. URL: https://www.legislation.nsw.gov.au/#/view/EPI/2000/690 (accessed 25 April 2019).

New South Wales Government 2019a. Warringah Local Environmental Plan 2011. Current version for 28 February to date. URL: https://www.legislation.nsw.gov.au/#/view/EPI/2011/649 (accessed 25 April 2019).

Northern Beaches Council 2019. Natural Environment Referral Response – Riparian. Application Number: DA2018/1332. Updated comments dated 14/03/19 and Comments dated 26/10/18.

NSW Government 2019b. Water Management Act 2000, as at 1 April. Act 92 of 2000. URL: http://www.austlii.edu.au/au/legis/nsw/consol_act/wma2000166/ (accessed 25 April 2019).

NSW Office of Water 2010. Application for approval for water supply works and/or water use, Application for Minister's consent under section 92 of the Water Management Act 2000. NSW Office of Water, September. URL: http://www.water.nsw.gov.au/__data/assets/pdf_file/0006/547224/form_licence_wmaf030_water_supply_works_use.pdf (accessed 25 April 2019).

Outhet, D. and Taylor, M.P. 2004. Lumley Creek Dam Joint expert witness report. Summary of agreements and disagreements between David Outhet and Mark Taylor as discussed during a joint site inspection on 27 January, 2004. Dobbie v. WAMC, Macquarie Research Limited, Macquarie University, North Ryde, NSW, Australia.

Silva v Ku-Ring-Gai Council [2009] NSWLEC 1061. Land and Environment Court of New South Wales. URL: http://www.austlii.edu.au/au/cases/nsw/NSWLEC/2009/1060.html (accessed 24 April 2019).

Taylor, M.P. and Stokes, R. 2005. When is a river not a river? Consideration of the legal definition of a river for geomorphologists practising in New South Wales, Australia. Australian Geographer 36(2): 183-200.

Warringah Council 2010. Warringah Council Policy, Policy No. PL 740 Waterways, Protection of Waterways and Riparian Land Policy.

Warringah Council 2011. Warringah Development Control Plan 2011. Warringah Council. URL: https://eservices.northernbeaches.nsw.gov.au/ePlanning/live/pages/plan/Book.aspx?exhibit=DCP&hid=6 (accessed 25 April 2019).

Warringah Council v Ardel Limited and Anor [2000] NSWLEC 7. Land and Environment Court of New South Wales. URL: http://www.austlii.edu.au/au/cases/nsw/NSWLEC/2000/7.html (accessed 24 April 2019).