West Schofields Precinct Plan

Flooding, Water Cycle Management and Riparian Corridor Assessment

PREPARED FOR DEPARTMENT OF PLANNING AND ENVIRONMENT

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Executive Summary

This Flooding, Water Cycle Management and Riparian Corridor Assessment has been prepared as part of the precinct planning for the West Schofields Precinct, part of the North West Growth Area in Sydney.

The West Schofields Precinct project involves investigations by the Department of Planning and Environment, working with Blacktown City Council to facilitate planning and development within the precinct. The precinct planning process involves input from specialist investigations, together with feedback from stakeholders to inform the land planning process.

This report has been prepared to outline the findings of the three engineering investigations of the flooding, water cycle management and riparian corridor assessment. The report is structured to present each of these studies in separate sections, with a consistent style and manner.

The strategy outlined in this report has been developed using an integrated approach to flood risk management, water cycle management and urban design based on the principles of water sensitive urban design (WSUD). The Indicative Layout Plan, incorporates urban design features with flood risk management measures, along with drainage, landscape, vegetation and habitat values, while addressing water quality targets.

Flooding

The extensive flooding within the precinct boundary has shaped the layout of the precinct, with almost half of the land within the precinct located under the 100 year flood level, making it unsuitable for many forms of development.

The planning constraints resulting from the outcomes of the flood modelling investigations have been incorporated in the development of the Indicative Layout Plan. These flood constraints include restriction of residential and commercial development to areas not inundated during the 100 year flood event, and layout of the road network to allow flood evacuation during extreme flood events.

Water Cycle Management

The objective of the water cycle management measures for the West Schofields Precinct are to achieve the treatment targets for the reducing pollutant export loads to the requirements of Blacktown City Council. The overall water management strategy for the West Schofields Precinct involves the implementation of water sensitive urban design features, along with traditional drainage infrastructure to achieve the objectives.

Integrated water cycle management measures have been incorporated into the masterplanning and development controls, with the development of the West Schofields Precinct Indicative Layout Plan incorporating the measures outlined in this report.

The planning outcomes resulting from the water cycle management study and design investigations have been incorporated in the development of the Indicative Layout Plan. These measures incorporate source control features and a traditional pit, pipe and overland flow network. The plan is shaped by constraints such as drainage crossings of the oil and gas pipelines located within the precinct. Treatment to meet water quality targets is to be provided by a total of six water quality (bio-retention) basins incorporating gross pollutant traps, filter media and vegetation. There is provision to include open water bodies for the potential re-use of harvested stormwater for sports field irrigation.

The water quality modelling of the measures outlined in the West Schofields Precinct Indicative Layout Plan indicate that the water cycle management have been designed as suitable to meet pollutant removal targets.

Riparian Corridor Assessment

The Indicative Layout Plan has been developed to accommodate the riparian corridor setbacks, along with the environmental constraints and flood extents. Riparian management measures include controls relating to discharge locations from bio-retention basins and overland flow paths.

Conclusion

The development of the Indicative Layout Plan has included effective masterplanning works in combination with drainage, water quality and flood management measures to achieve satisfactory planning outcomes for all stakeholders. The results of technical investigations developed as part of the precinct planning process, and the modelling of the measures outlined in this report demonstrate that the precinct plan is suitable for consideration and approval.

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1 Introduction

This report has been prepared as part of the precinct planning process for the West Schofields Precinct, within the North West Growth Area of Sydney, NSW. This report summarises the investigations into the flooding resulting from local and regional waterbodies, outlines the findings and proposed measures for water management on site, along with a geomorphologic and hydraulic assessment of the riparian corridor of the two creeks bordering the precinct.

1.1 Objective and Purpose of this Report

The objective of this report is to present the strategy for management of flooding, drainage and water quality from the West Schofields Precinct, along with management measures to rehabilitate and restore riparian corridors of Eastern and Bells Creeks within the precinct.

The strategy outlined in this report has been developed using an integrated approach to flood risk management, water cycle management and urban design based on the principles of water sensitive urban design (WSUD), incorporating urban design features with flood risk management measures, along with drainage, landscape, vegetation and habitat values, while addressing water quality targets.

Integrated Water Management outcomes are most effectively managed through incorporation of management plans into planning and development controls of future development areas. Effective masterplanning works in combination with drainage, water quality and flood management measures to achieve satisfactory planning outcomes for all stakeholders.

1.1.1 Structure of the Report

This report has been prepared to outline the findings of the three engineering investigations of the flooding, water cycle management and riparian corridor assessment. The report is structured to present each of these studies in separate sections, with a consistent style and manner. This approach, involving consistent viewports for figures, has been prepared to focus the reporting on the development outcomes.

1.2 Project Description

The West Schofields Precinct project involves investigations by the Department of Planning and Environment, working with Blacktown City Council, to facilitate planning and development within the precinct. The precinct planning process involves input from specialist investigations such as:

- Water management and flooding (the subject of this report)
- Ecological and bio-diversity
- Heritage, including indigenous heritage
- Traffic and transport
- Retail and commercial
- Infrastructure servicing and staging
- Social infrastructure and open space (including playing fields)

The studies, together with feedback from stakeholders have been used for inform the land planning process for the precinct. The culmination of these studies is the development of the precinct Indicative Layout Plan for the precinct, discussed in Section 2.2.

1.3 Site Location and Project Area

The precinct has an area of approximately 540 hectares and is located approximately 35 kilometres west-northwest of Sydney central business district.

The West Schofields Precinct is bordered to the east by Eastern Creek and to the west by Bells Creek, shown on Figure 1.1.

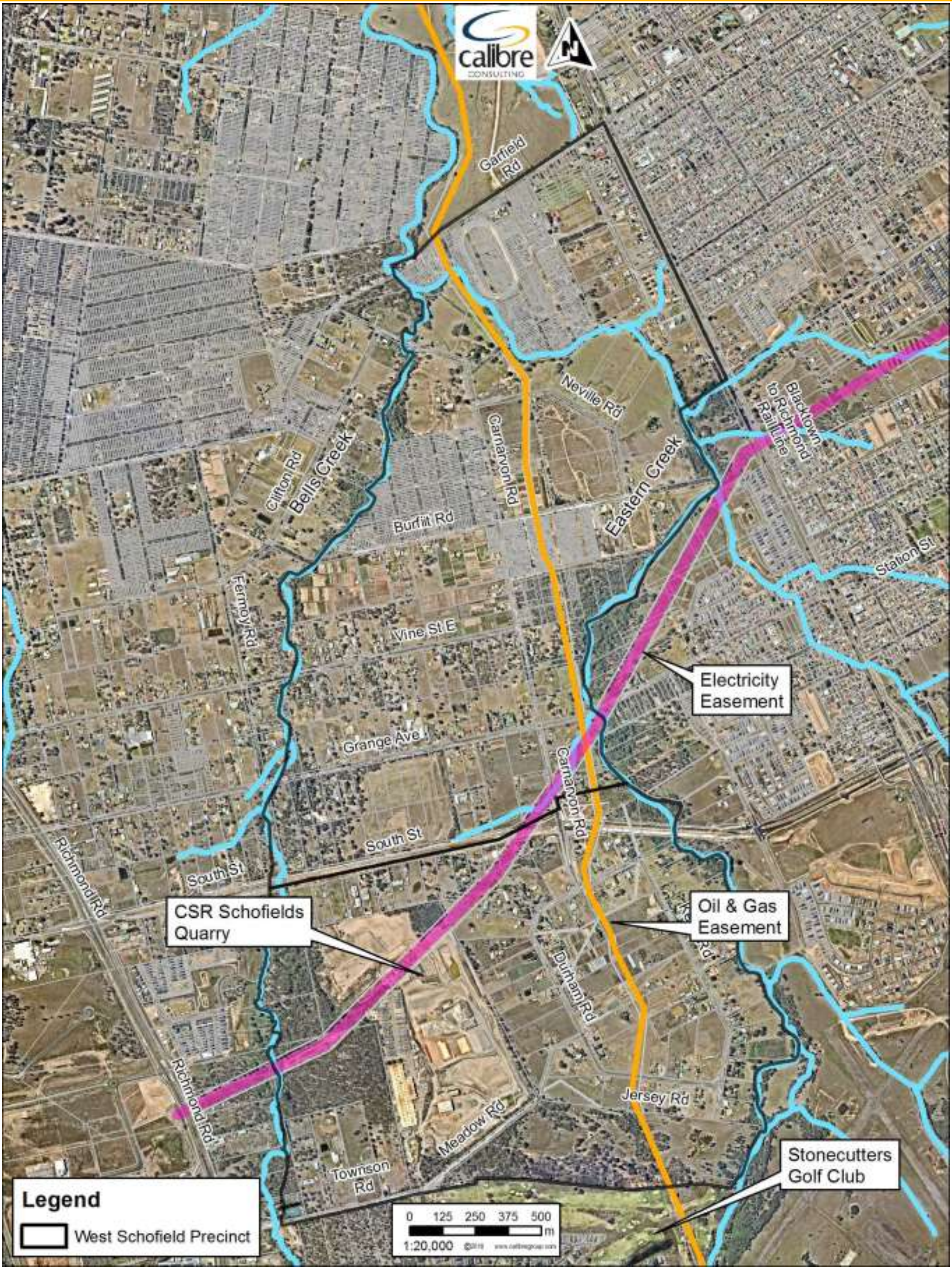


Figure 1.1: West Schofields Project Area

Eastern and Bells Creeks form the eastern and western boundaries of the site for the majority of the precinct. Townson Road and the Stonecutters Ridge Golf Club form the southern boundary, with Garfield Road West and the Blacktown–Richmond rail line forming the northern boundary of the precinct. The precinct includes the confluence of the Eastern and Bells Creeks.

The floodplains of the creeks, influenced primarily through regional flooding of the Hawkesbury River, limit the potential for development of land within the precinct (discussed in Section 5). The development potential and controls required for waterfront lands (discussed in Section 7.4) are primarily related to discharge locations, as development is not permitted within riparian corridor zones due to flooding.

There are no mapped or clearly defined creeks within the precinct area enclosed by Eastern and Bells Creeks. One small ephemeral water body, shown on Figure 1.1, is located between Grange Road and the extension of Schofields Road. This small creek is highly modified as a result of the construction of Schofields Road, the installation of the high voltage electricity pylon and the construction of Grange Road, along with modifications as a result of historical farming practices. This area is discussed in Section 6.4 as the location of the drainage infrastructure crossing the pipeline easement, along with the basin and discharge location to Eastern Creek.

There are a total of three landfill sites within the precinct boundary, along with easements for high voltage electricity transmission and the Jemena Eastern Gas Pipeline and the Caltex Newcastle Oil Pipeline.

1.3.1 Eastern Creek

Eastern Creek is a major creek system and forms part of the South/Wianamatta Creek sub-catchment the Hawkesbury-Nepean River System. Eastern Creek drains approximately south to north: from Horsley Park in the south, past the Prospect Reservoir, under the M4 Western Motorway, north through a green corridor to Schofields and further on to Riverstone then eventually into the Hawkesbury River at Windsor, located approximately 9.5 kilometres north of the precinct.

The catchment of Eastern Creek is highly developed, predominantly by residential subdivisions. The catchment includes industrial areas of Horsley Park, Eastern Creek (the suburb), Huntingwood, Rooty Hill and Glendenning. The northernmost section of the catchment, with in the suburb of Horsley Park, is located within Fairfield City Council local government area, the remainder of Eastern Creek catchment is within Blacktown City Council boundary.

The catchment in the location of the precinct consists of predominantly semi-rural and light industry and incorporates the development precincts of Alex Avenue, Schofields and Riverstone on the eastern side.

1.3.2 Bells Creek

Bells Creek is approximately 9 kilometres long and drains in a north-easterly direction. Bells Creek has a catchment area of approximately 13.8 km^2 from Rooty Hill in the south to the confluence with Eastern Creek, located in the northern area of the West Schofields Precinct.

The catchment to the south of the West Schofields Precinct (upstream of Townson Road) is predominantly residential, incorporating the suburbs of Rooty Hill, Mount Druitt, Hebersham, Plumpton, Hassall Grove and Bidwill, along with the M7 Motorway. The catchment in the location of the precinct consists of predominantly semi-rural and light industry and incorporates the bulk goods warehouse development in the suburb of Marsden Park on the western side. The entire catchment area of Bells Creek is within the local government area of Blacktown City Council.

2 Project Background

This section of the report outlines the overall planning background relating to the West Schofields Precinct, including the context within the overall North West Growth Area. Details of the precinct plan are discussed, along with the indicative layout plan, showing features and layout of the precinct.

2.1 North West Growth Area

The NSW Government established the North West and South West Growth Areas in 2005 with the aim of sustainably planning and managing growth on Sydney's urban edge. The precinct planning process, undertaken by the Department of Planning and Environment involves working with local councils to streamline planning in the Growth Areas. The aims of the planning process is to ensure it is strategic, efficient and delivery of attractive, well-serviced communities.

The aim of the Growth Areas is to create attractive, sustainable new communities for up to 500,000 people by supplying key infrastructure, employment areas, parks, health and education facilities, shops, services and public transport.

The package of works is located within the North West Growth Area. The North West Growth Area is approximately 10,000 hectares in size and includes parts of Blacktown, The Hills, and Hawkesbury local government areas.

Precinct Planning for the North West Growth Area has been underway since December 2008, with the rezoning responsibility with the Department of Planning & Environment in partnership with local councils.

The North West Growth Area is divided into sixteen 'Precincts' that are being progressively released and rezoned for sustainable urban development, shown on Figure 2.1, from the NSW Department of Planning and Environment website.

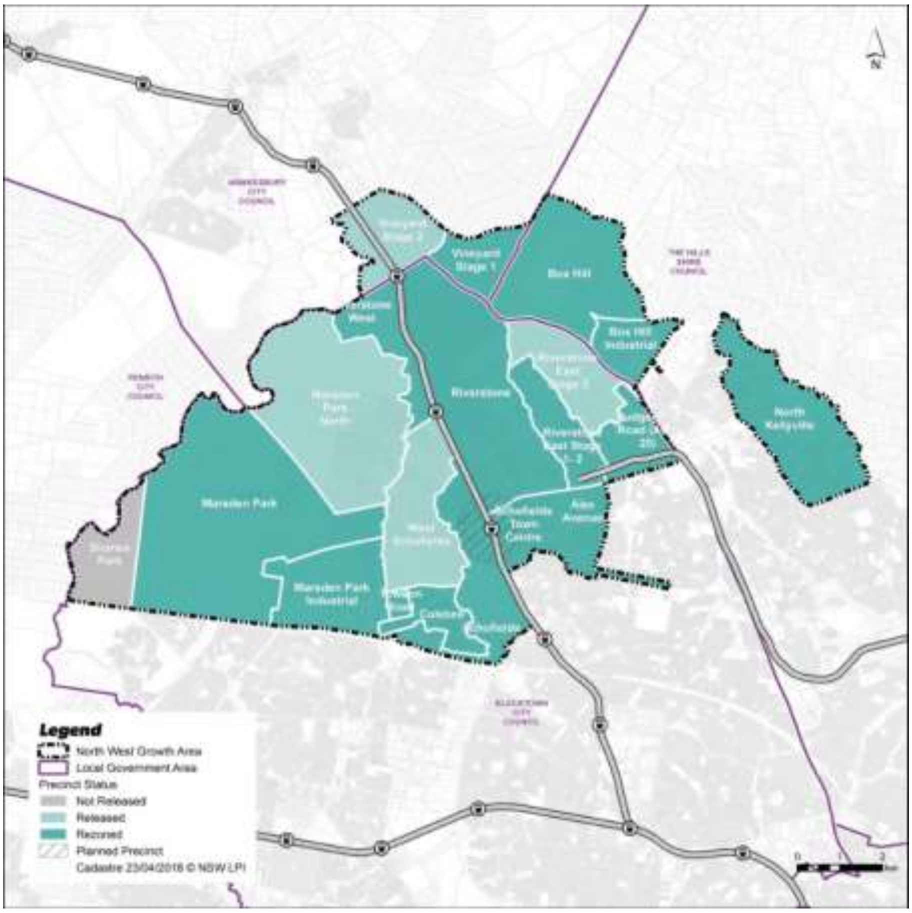


Figure 2.1 North West Growth Area Precincts

The North West Growth Area will be supported by major centres at Rouse Hill and Marsden Park and be serviced by the North West Rail Link and the upgraded Richmond rail line.

2.1.1 West Schofields Precinct

The West Schofields Precinct (shown in aqua on Figure 2.1), is one of the latter release precincts in the North West Growth Area. The West Schofields Precinct is bounded by Garfield Road to the north, to the west by Bells Creek, to the east by Eastern Creek and to the south by Townson Road and Stonecutters Ridge Golf Club.

West Schofields currently consists of a mix of rural residential areas and industrial uses. The main industrial site within the precinct is the CSR Schofields quarry, currently an active quarrying and brick making facility. Brickmaking and quarrying is to be decommissioned over coming years, with the site is proposed to be rehabilitated and suitable for residential development progressively until 2023.

The West Schofields precinct contains large parcels of remnant vegetation, including relatively intact areas. These intact areas include endangered Cumberland Plain Woodland, in particular the sub-communities of Shale Plains Woodland and Alluvial Woodland. These remnant areas are highly fragmented and weed infested. A detailed analysis of the ecology of the precinct is provided in the *West Schofields Precinct Biodiversity and Riparian Assessment*, prepared by Eco Logical in June 2017 as part of the precinct planning process.

The West Schofields Precinct Plan includes:

- Total Area – ~540 hectares
- Dwelling capacity – up to 4000 new dwellings
- Proposed primary school
- Allowance for transit corridor
- A town centre and space for a community centre
- Four double playing fields for the West Schofields residents and up to 8 double playing fields to meet the needs of the greater North West Growth Area
- Passive open space spread throughout the precinct
- Upgrades to major roads, walking and cycle paths along major roads and open space corridors

The West Schofields Precinct Plan is located entirely within the Blacktown City Council local government area.

2.2 Indicative Layout Plan

The Indicative Layout Plan prepared by URBIS as part of the precinct planning process has been prepared to accommodate the input from planning and specialist studies, including this flooding, water cycle management and riparian corridor assessment. The Indicative Layout Plan is provided in Figure 2.2.

Key issues to note on the Indicative Layout Plan, as they relate to this flooding and water cycle management are:

- The location of developed land, above the 100 year flood level (discussed in Section 5)
- The location of stormwater treatment basins (discussed in Section 6)
- The road layout, incorporating north–south roads to allow flood evacuation (discussed in Section 5.4)

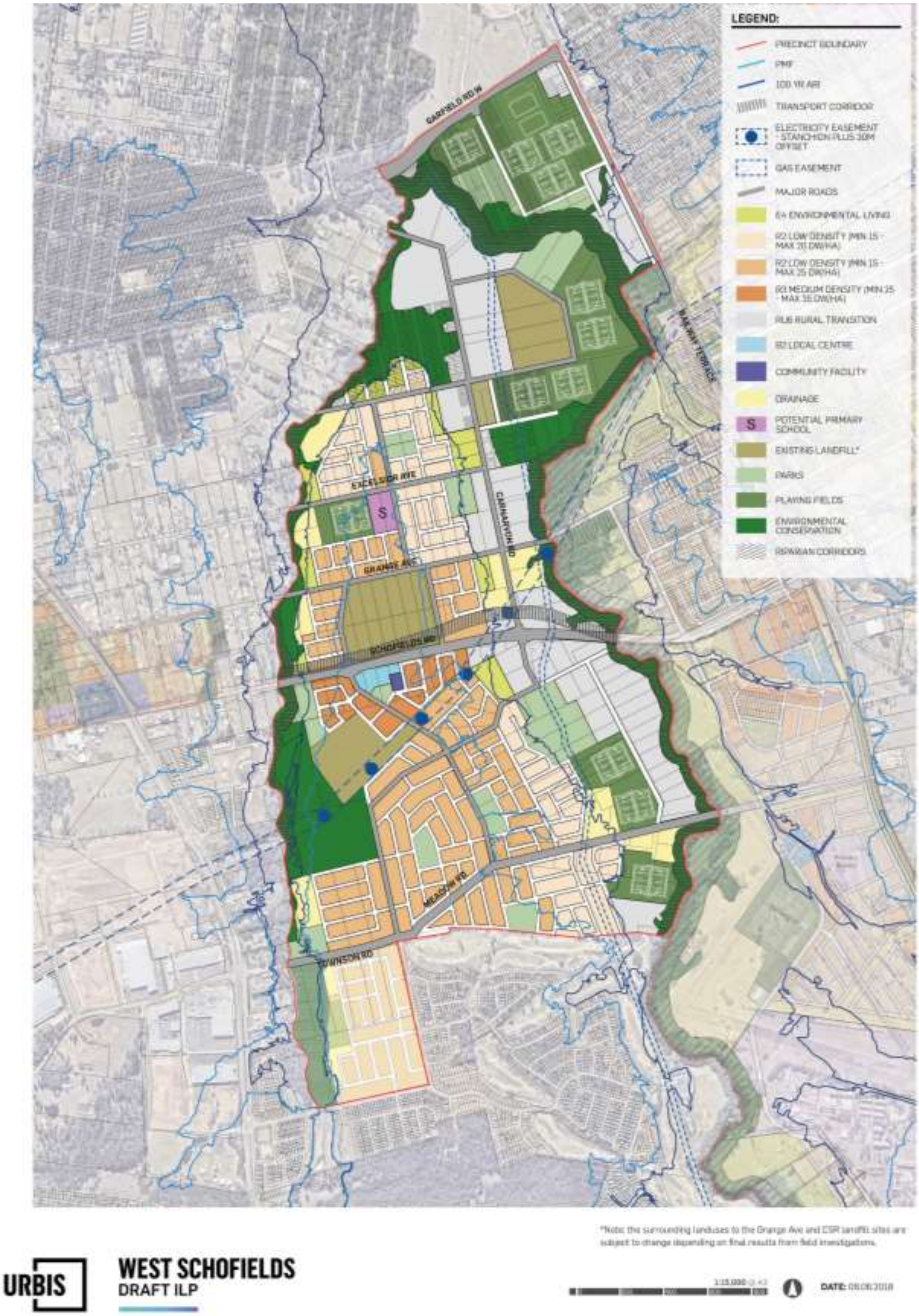


Figure 2.2: West Schofields Indicative Layout Plan (from URBIS)

3 Legislative and Planning Context

This section outlines the relevant state and Commonwealth legislation that is applicable to the planning, design and construction of the flooding and stormwater management infrastructure.

3.1 Relevant Legislation

This section introduces the legislation applicable to the project, providing explanations of how each Act relates to the development, including the relevant approvals required.

3.1.1 *NSW Environmental Planning and Assessment Act* 1979 (as amended)

This Act is the primary piece of land use and planning legislation in New South Wales. It allows for the creation, at various levels of government, of environmental planning instruments to control land use and planning. State environmental planning policies (SEPPs), regional environmental plans, Local Environment Plans (LEPs), development control plans (DCPs), and council codes and policies can all be established under Part 3 the Act. The rezoning of land as part of precinct planning is under Part 3 of the Act.

3.1.2 *Biodiversity Conservation Act* 2016

This Act replaces the *Threatened Species Conservation Act* lists threatened species, populations and ecological communities in NSW. If a threatened species, population or ecological community or its habitat, is likely to occur in any area which may be affected by a development proposal, then a 'seven part test' in accordance with Section 5A of the EP&A Act must be conducted to determine whether the proposal could have a significant impact. If it is concluded that there is likely to be a significant impact, then a Species Impact Statement (SIS) must be prepared and the proposed activity would then be subject to approval from the Chief Executive of Office of Environment and Heritage (OEH).

The key provisions of the Act are outlined in Section 8.4(5) and do not apply to proposed activities on biodiversity certified land in the North West Growth Centre. For the North West Growth Centre Precincts, compliance with the biodiversity certification order is achieved by protecting areas of Existing Native Vegetation (ENV) identified on the SEPP Maps and as described in the Assessment of Consistency between Relevant Biodiversity Measures of the Biodiversity Certification Order report for each precinct.

Where an activity is proposed on protected Existing Native Vegetation on certified land, compliance with the conditions of the biodiversity certification order is required.

3.1.3 *Water Act* 1912 / *Water Management Act* 2000

The objects of the Acts aim to provide for the sustainable and integrated management of the water sources and to apply the principles of ecologically sustainable development. The Acts set guides for the preparation of water management plans and direct the NSW Office of Water in decision making. The NSW Office of Water is a separate office within the NSW Department of Primary Industries. It is responsible for the management of the State's surface water and groundwater resources. The Office reports to the NSW Government for water policy and the administration of key water management legislation, including the Water Act 1912 and Water Management Act 2000.

3.1.4 *Water Management Amendment (Controlled Activities) Regulation* 2008

This Regulation of the *Water Management Act* 2000 replaces the *Rivers and Foreshores Improvement Act* 1948 from 4 Feb 2008. Under this Regulation a *Controlled Activity Approval* (CAA) is required from the NSW Office of Water for works within 40 metres of top of bank. This permit application is developed at the detailed design stage of these proposals and needs to outline:

- A map of the area depicting the site to be affected by the works in relation to the waterway
- Plans indicating works to be undertaken including elevations
- Existing condition and values of the adjoining intertidal and aquatic environment (such as seagrass, rock platforms, and sandy beaches)
- Recent photographs of the site (preferably from the water);
- Details of excavations, earthworks and/or filling, including the type of materials to be affected, *i.e*. soil and rock
- The potential for disturbance of acid sulphate soils
- The potential for disturbance of contaminated material
- Stability assessment
- Location of existing drainage and any alteration to drainage
- A description of the construction methods to be used (including plant and equipment) and methods to be used to access the site
- Vegetation and landscape plans (including: details of vegetation to be retained, removed and/or planted; numbers of each species to be planted; general indication of the location of plantings)
- Methods to be employed to manage potential environmental impacts such as erosion and sediment control plans, and remedial action plans

A controlled activity permit is not required under Clause 39A of this regulation, which provides exemption for public authorities and local councils.

3.1.5 *Fisheries Management Act* 1994

This Act deals with matters related to the dredging of waterways and the reclamation of land and provides guidelines for assessing barriers to aquatic fauna movement. The *Fisheries Management Act* is administered by the NSW Department of Primary Industries with the objective to ‘conserve key fish habitats’.

3.1.6 Local Land Services Act 2013

This Act establish a statutory corporation, Local Land Services, with responsibility for management and delivery of local land services in the social, economic and environmental interests of the State in accordance with State priorities. The Act establishes local boards for the purpose of devolving operational management and planning functions to regional levels to facilitate targeted local delivery of programs and services. This Act commenced on 1 January 2014 and replaced the *Catchment Management Authorities Act* 2003 which established catchment management authorities and committees to achieve coordinated, sustainable management of natural resources on a water catchment basis.

3.1.7 *Local Government Act* 1993

Creates local governments and grants them the power necessary to perform their functions, among which are the management, development, protection, restoration, enhancement and conservation of the environment of the area the local government is responsible for, in a manner that is consistent with and promotes the principles of ecologically sustainable development. The *Local Government (Ecologically Sustainable Development) Act* 1997 amended the *Local Government Act* so that ecologically sustainable development, including the sustainable use of resources, is now a guiding operational principle.

The *NSW Floodplain Development Manual: the management of flood liable land* relates to the management of flood liable land in accordance with Section 733 of the *Local Government Act*.

3.1.8 *Environment Protection and Biodiversity Conservation Act* 1999

This Act requires the approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for actions that have, or are likely to have, an impact on matters of National Environmental Significance, including matters of national environmental significance including:

- Ramsar wetlands.
- National threatened species and ecological communities.
- Migratory species.
- Water resources with regard to coal seam gas development and/or large scale coal mining development.

Under the EPBC Act, Commonwealth approval is required for any controlled action being a project or development that would have, or that would be likely to have, a significant impact on a matters of national environmental significance. Under the legislation, this action must be referred to the Commonwealth Minister for the Environment.

3.2 Planning Framework

This section introduces the planning documents that are applicable to the stormwater basin and associated infrastructure.

3.2.1 *State Environmental Planning Policy (Sydney Region Growth Centres)* 2006

State Environmental Planning Policy (Sydney Region Growth Centres) 2006 (Growth Centres SEPP) provides a planning framework for the delivery of key growth centre areas of Sydney including the south-west and north-west (which includes parts of the Blacktown LGA).

The Growth Centres SEPP establishes a number of precincts and precinct plans to guide development within the designated areas.

Under the Growth Centres SEPP, clause 7 effectively replaces the planning provisions outlined in the *Blacktown Local Environmental Plan* 1988 (Blacktown LEP) for identified precincts of the growth centre.

The proposed activity is located on land established under the Growth Centres SEPP. The SEPP contains provisions in relation to protection of existing native vegetation. Under clause 18A public utility undertakings and clearing of native vegetation:

1) Development for public utility undertakings (other than electricity generating works or water recycling facilities) may be carried out without consent on land to which this Policy applies.
2) A public authority, or a person acting on behalf of a public authority, must not carry out development comprising the clearing of native vegetation (within the meaning of the *Native Vegetation Act* 2003) on land that is not subject land (within the meaning of clause 17 of Schedule 7 to the *Threatened Species Conservation Act* 1995) unless the authority or person has:
    (a) given written notice of the intention to carry out the development to the Department of Planning and Infrastructure, and
    (b) taken into consideration any response to the notice that is received from that Department within 21 days after the notice is given.

Additional requirements in relation to clearing of native vegetation are listed in the precinct-specific appendices of the SEPP.

3.2.2 *State Environmental Planning Policy (Infrastructure)* 2007 (Infrastructure SEPP)

State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP) is intended to facilitate the efficient delivery of infrastructure projects and activities by public authorities such as Council.

Clause (50(2) of the Infrastructure SEPP provides that development for the purpose of a flood mitigation work may be carried out by or on behalf of a public authority (which includes Council) without consent on any land. This includes construction, routine maintenance works and environmental management works (clause (50(2)).

Clause 111(1) of the Infrastructure SEPP provides that development for the purposes of a stormwater management facility may be carried out by, or on behalf of a public authority (which includes Council), without consent on any land. This includes construction, routine maintenance works and environmental management works (clause 111(2)).

3.2.3 *Growth Centres Development Code* 2006

This code establishes the process of precinct planning for the growth centres including a framework for the development of the Indicative Layout Plan. This document ensures that the technical analyses necessary to produce specific planning controls are carried out within the context of the formulation of an Indicative Layout Plan so that the appropriate infrastructure will support future development.

4 Data sources

This section of the document outlines the sources of data used in the flooding, water cycle management and riparian corridor investigations. Data used in the hydrologic and hydraulic modelling is presented in the Model Summary Sheet, provided in Appendix D.

4.1 Topographic Data

Initial topographic data for the base model was obtained from the NSW Department of Land and Property Information, Spatial Data Services. Land and Property Information (LPI) have medium and high resolution orthorectified digital imagery from their Digital Image Acquisition System (ADS40) and Leica ALS50 (Airborne Laser Scanner) as well Digital Elevation Data across NSW using the latest Light Detection and Ranging Systems Technology (LiDAR), ADS40 Imagery, Radar, and or Satellite Technologies.

The airborne digital imagery used in this investigation were sourced from the LPI and have an 800 millimetre horizontal and 300 millimetre vertical resolution. The imagery used in this study is on tiles;

- NepeanRiverEAST2011-MKP_2986266_56
- NepeanRiverEAST2011-MKP_2986268_56
- NepeanRiverEAST2011-MKP_3006266_56
- NepeanRiverEAST2011-MKP_3006268_56
- NepeanRiverEAST2011-MKP_3026266_56
- NepeanRiverEAST2011-MKP_3026268_56

The data obtained from LPI was converted into a TIN using the *12d* software package and sampled into the *TUFLOW* model by the model engine at a five–metre grid spacing for the entire catchment.

A number of developments have occurred in the area of this investigation and are either incomplete or not present in the 2011 data provided by LPI. Calibre commissioned to AAM Pty Ltd to undertake a photometric study using their 2015 stereo-imagery and special data captured between 2008–2015. The 2008 data was collected by their Optech (Airborne Laser Scanner) from February to June 2008, and was presented as XYZ point data with a vertical accuracy of 150 millimetre for all areas that have not changed since 2008.

A representation of this combined data, showing digital elevation information is presented on Figure 4.1.

The areas of the site that have changed and been developed since 2008 was presented as thyree-dimensional mapping of the break lines based on the September 2015 stereo-imagery taken with an A3 Edge photography camera system controlled with a RTK GPS photo control. The data obtained from AAM was converted into a TIN using the *12d* software package and sampled into the *TUFLOW* model by the model engine at five–metre grid spacing for the entire catchment.

4.2 Development Constraints

Constraints on the development potential of the land (other than flooding, which is discussed in detail in Section 5) within the precinct has been mapped for this investigation. These constraints are presented in Figure 4.2.

The constraints on Figure 4.2 indicate that the precinct includes areas of ecological, heritage constraints, along with engineering constraints of landfill sites, future transport corridors and easements for electricity and oil and gas pipelines.

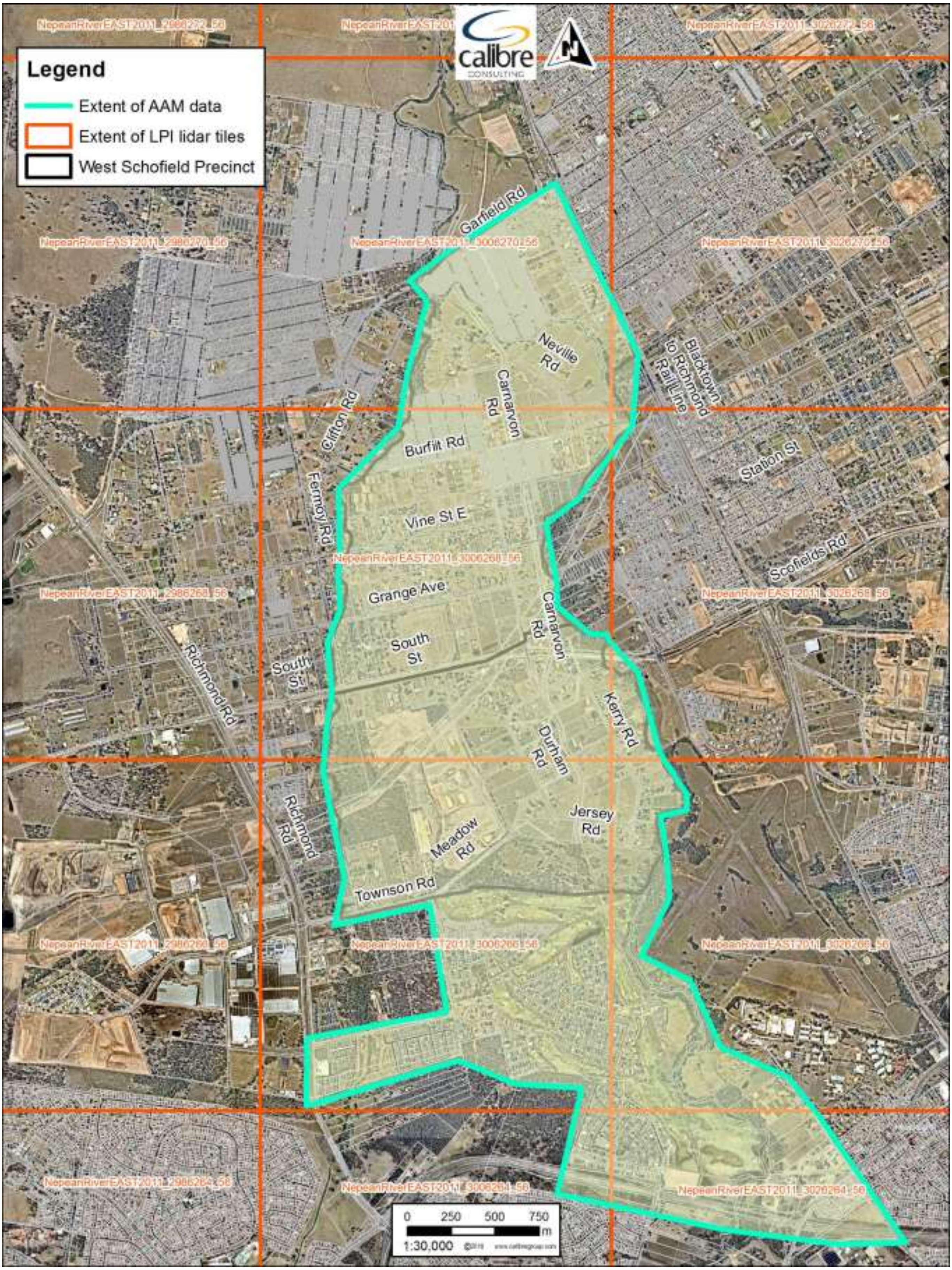


Figure 4.1 LiDAR topographical information

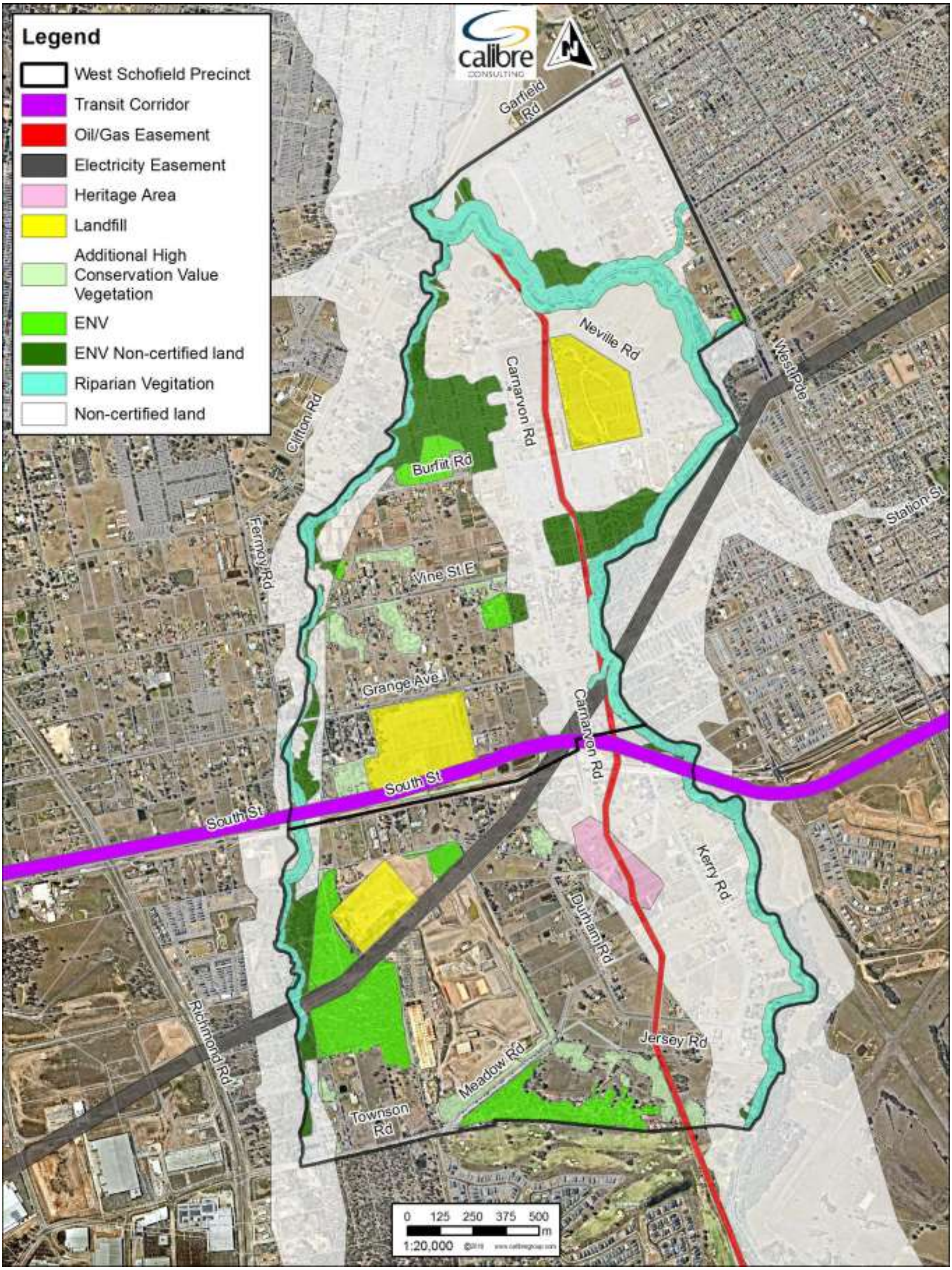


Figure 4.2 Constraints Map

4.2.1 Environmental Constraints

Environmental constraints relating to the West Schofields Precinct are discussed in detail in the *West Schofields Precinct Biodiversity and Riparian Assessment*, prepared by Eco Logical in June 2017 as part of the precinct planning process.

The Eco Logical investigation recommended that the precinct plan include a minimum of 52.55 hectares of Existing Native Vegetation (ENV), consisting of 46.95 hectares of ENV land on non-certified areas, with the additional 5.6 hectares from riparian areas.

4.2.2 Engineering Constraints

Landfill Sites

There are a total of three landfill sites within the precinct boundary. These sites, identified on Figure 4.2 include the two southern landfill sites resulting from quarry and brickmaking operations at Schofields Quarry, along with a former municipal landfill site, located in the north of the precinct, surrounded by Neville and Buffett Roads.

Future Transport Corridor

An allowance has been included at the precinct planning stage for the future transport corridor to service western Sydney. The nature of the transport planned for this corridor is not determined at this stage. No development area or permanent drainage infrastructure is proposed for this corridor.

Electricity easements

The precinct is crossed southwest to northeast by an easement for high voltage electricity transmission. This 60.96 metre wide easement includes the Transgrid owned and operated Sydney West – Sydney North No 1 330KV transmission line (feeder 20). Development within this easement has been minimised, with proposed works planned within the requirements of *TransGrid Easement Guidelines – Third Party Development*.

Oil and Gas Pipelines

The Precinct is crossed north–south by a 22.0 metre wide easement for the Jemena Eastern Gas Pipeline and the Caltex Newcastle Oil Pipeline. Consultation with Jemena and Caltex as part of the preparation of the precinct plan are discussed in detail in Section 6.4.4.

The potential impacts on the development of the West Schofields Precinct by the engineering constraint of the oil and gas pipelines required pipeline location and preliminary design of drainage within the precinct, outlined in Section 6.4.4.

4.3 Hydrologic Modelling Data

Flow rates within Eastern and Bells Creek were calculated for the project using Blacktown City Council's *XP-RAFTS* model. This model of Eastern and Bells Creeks has been developed by Council for use in the North West Growth Centre and has been peer reviewed. Council provide this model to consultants as a standardised baseline model. A discussion of the modelling undertaken for this project is provided in Section 5.1

4.3.1 Rainfall

Data from the existing Blacktown City Council *XP-RAFTS* model has been used for this investigation. Rainfall patterns within the model are those published for *Australian Rainfall and Runoff* (ARR) 1998. This differs from the contemporary standard methodology in the revised *Australian Rainfall and Runoff* 2016. The use of ARR 1998 rainfall patterns has been selected in consultation with Council for overall consistency with development within the North West Growth Area.

Rainfall volumes for the modelled storm events used include those for recurrence intervals for one event in 2, 5, 10, 20, 50, 100 and 500 year. These events are referred to in this report by recurrence interval e.g. the 100 year event has been estimated to occur (or be exceeded) once in every one hundred years. This is analogous to a storm that has a 1% chance of occurring in any given year, also referred to as the 1% annual exceedance probability event.

The Probable Maximum Flood (PMF) refers to flood event caused by the probable maximum precipitation, which is based on atmospheric conditions based on regional climatic factors and latitude, not statistical rainfall records. Rainfall was calculated using the Generalised Short-Duration Method (GSDM) outlined in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method* (BOM, June 2003).

No assessment of the impacts of climate change on rainfall patterns has been undertaken for this study. Sensitivity to the effects of climate change will be required to be modelled at later stages in the precinct development process.

4.3.2 Catchment Mapping

The catchment breakdown within the Council model for North West Growth Area is presented on Figure 4.3.

The council model catchment delineation was used for the existing scenario modelling, with adjustments made for the developed scenario relating to catchments within the precinct.

4.4 Hydraulic Modelling Data

The hydraulic modelling for this investigation used the Blacktown City Council model of Eastern and Bells Creek, prepared for use for development within the North West Growth Centre as the base model. Modifications to this model, developed in consultation with the Department of Planning and Blacktown City Council, included alterations to topography to incorporate modifications within the floodplains that have taken place since the model was provided at the commencement of this study. These modification include the construction of the Schofields Road upgrade and the development of Bridge Street, located to the north of Grange Avenue, on the eastern side of Eastern Creek, adjacent to the precinct.

4.4.1 Boundary Conditions

The upstream boundary conditions were modelled as inflow area polygons for sub-catchments or boundary condition point or line. These inflows were labelled to use the hydrographs extracted from the North West Growth Area regional hydrologic modelling, discussed in Section 4.3.

The inflow locations associated with the catchments are selected from the Blacktown City Council hydraulic model and utilised by Calibre in the modelling investigations for this report. Adjustments to inflow locations resulting from the layout of drainage infrastructure within the precinct

Hawkesbury River Flooding

During significant flood events in the Hawkesbury River, Eastern and Bells Creeks in the location of the precinct are inundated by backwater flooding. In order to represent this, the downstream model boundary was modelled to match the tail water conditions within the Hawkesbury River.

The tail water levels in the Hawkesbury River were taken from the Council's model and are presented in Table 4-1.

Table 4-1: Hawkesbury River Tail Water Level

Recurrence Interval	Tail water Level (m AHD)
2 year	9.0
5 year	10.9
10 year	12.3
20 year	13.7
50 year	15.7
100 year	17.3
500 year	20.2
Probable Maximum Flood	26.4

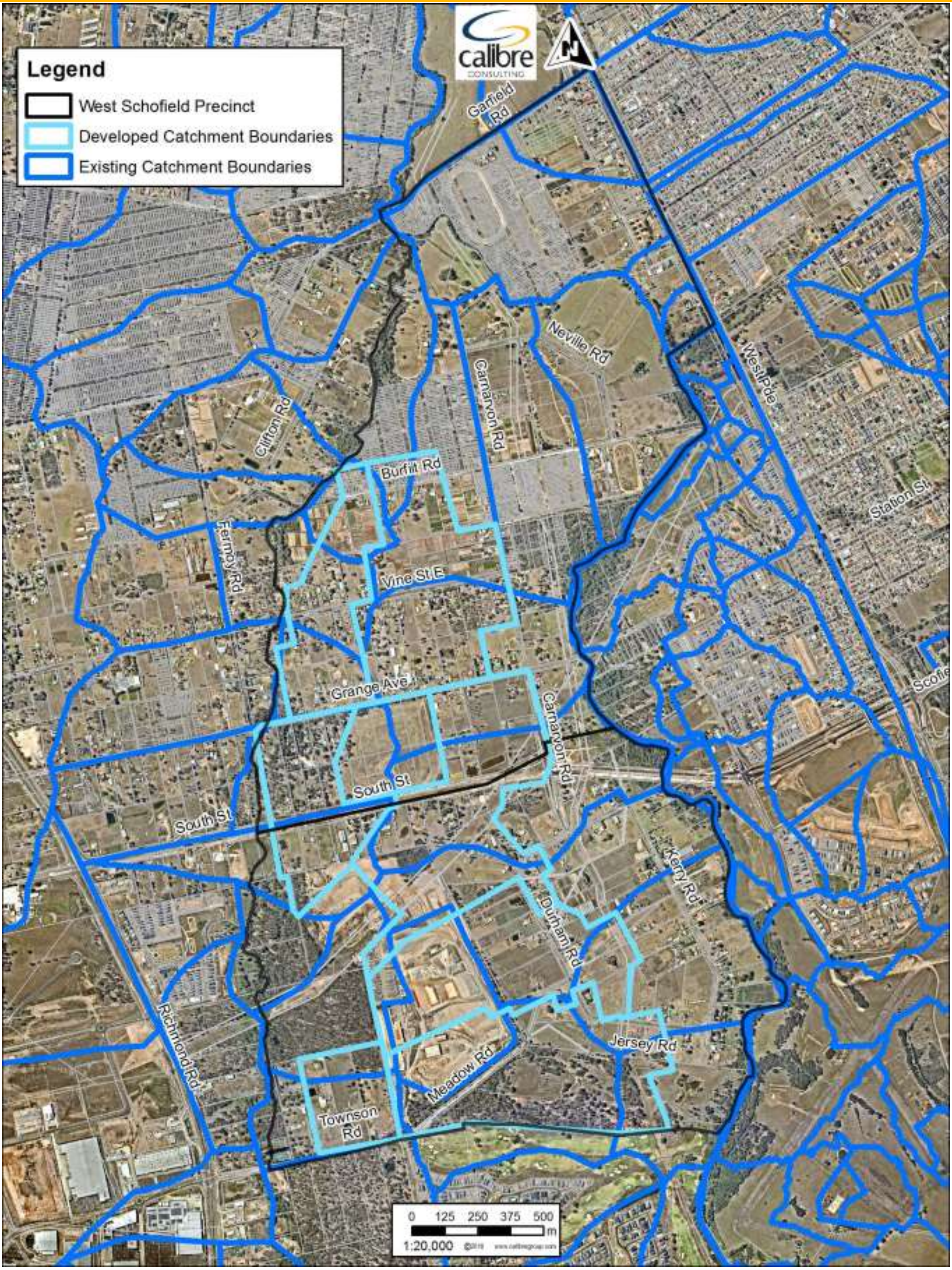


Figure 4.3: Catchment Map

4.4.2 Structures

Schofields Road Bridge

Roads and Maritime Services NSW (RMS) have recently undertaken upgrade works to the western end of Schofields Road to construct a new crossing of Eastern Creek and to link Schofields Road with South Street. This work is part of the overall regional development of the north west of Sydney and will be utilised to service the West Schofields precinct, and the entire North West Growth Area. The Department of Planning and Environment has provided Calibre with the final RMS supplied model for the flood analysis for the Eastern Creek Bridge and final Schofields Road design alignment and surface elevation.

The RMS model was analysed and the data and associated attributes for the Eastern Creek and Bells Creek Crossings including associated piers, flow constrictions, additional culverts and bulk earthworks have been incorporated into the modelling undertaken for this investigation.

4.4.3 Buildings/Obstructions

The complete topographic and processed land surface details of the area (LiDAR tiles discussed in Section 4.1), were read into the earthworks modelling package, *12d*. The full processed LiDAR tiles were used as this includes a 'buildings' category to the points based on the information received by the Aerial Laser Survey (ALS) system, where data from solid objects such as buildings are stored in a separate layer within the file.

This approach allows the buildings to be read into the models as a separate layer with the resultant shapes exported, mapped and converted to a flow boundary, i.e. removing buildings from the model. This approach has been determined by *Australian Rainfall and Runoff* to be the preferred method for the modelling of buildings within a two-dimensional flood modelling software packages such as *TUFLOW*. The buildings removed from the model surface as presented in Figure 4.4.

4.4.4 Land Use Categorisation (Roughness)

The catchment land use characteristics have been identified during analysis of aerial photography, confirmed during site visits as currently rural land, sparsely vegetated or pasture land.

As part of this preliminary investigation a uniform floodplain roughness of n = 0.1 was used for the entire existing catchment as the catchment is rural, undeveloped or low density residential, in accordance with previous modelling by Blacktown City Council.

Roadways and other hardstand areas was modelled as presented in Figure 4.4, and used the roughness value of 0.02. The values used for the site are presented in Table 4-2, with a map showing roughness categorisation on Figure 4.4.

Table 4-2: Site Roughness

Material	Colour	Roughness
Urban/Rural (Default)	Not shown for clarity	0.1
Roads	Red	0.02

The existing model of Eastern and Bells Creek was modified to incorporate development within the precinct by excluding all developed areas (show on the Indicative Layout Plan in Section 2.2 and presented in Figure 4.4) from the model.

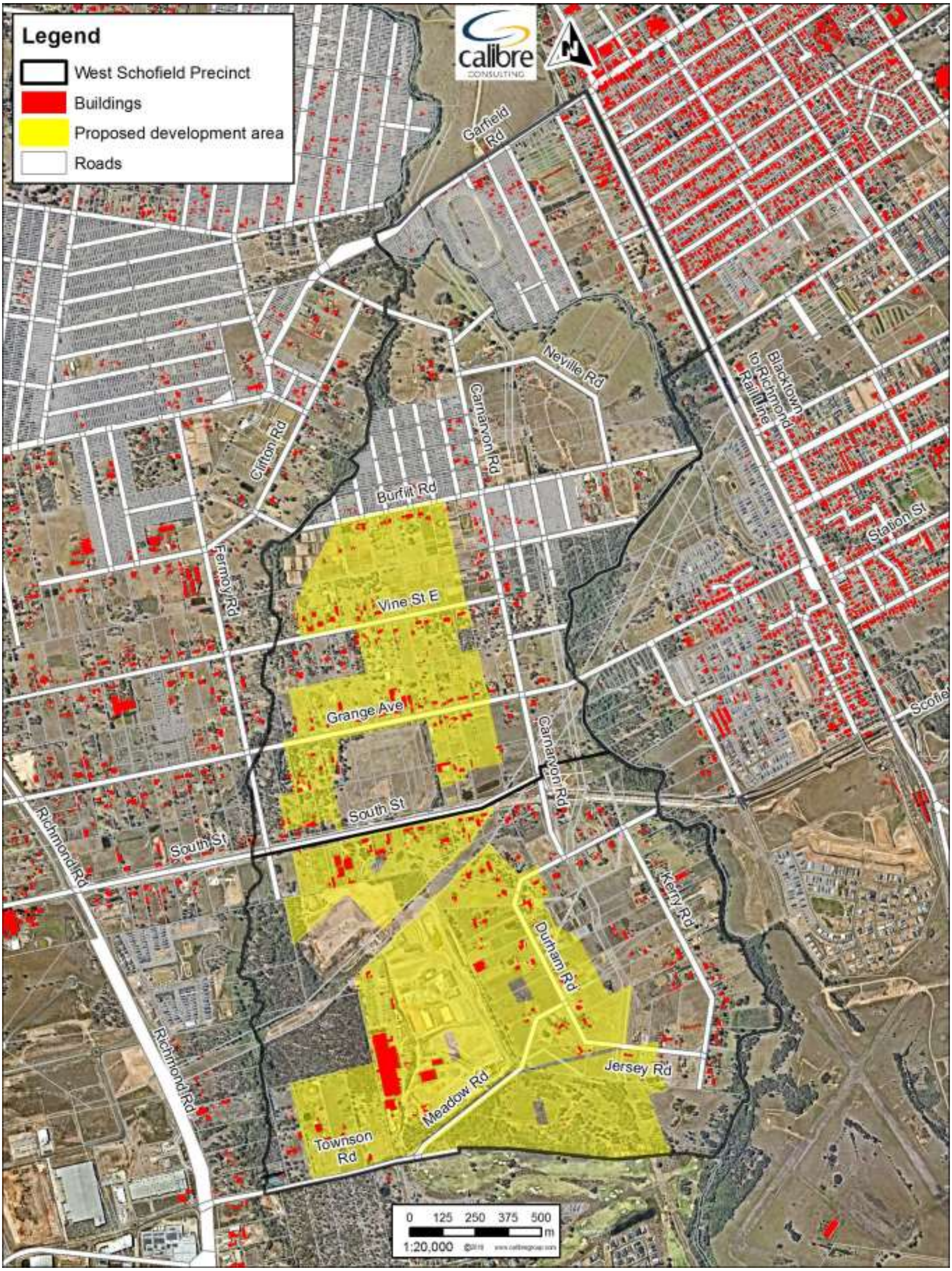


Figure 4.4: Roughness Map

4.5 Field Investigations

Field investigations were carried out over the course of the investigations for flood study, development of the water cycle management plan and assessment of the riparian corridor. These numerous investigations ranged from qualitative investigations during periods of high rainfall and flow, to detailed riparian mapping, survey and potholing, commenced in the initial phases of the project in 2015, concluding in 2018 prior to submission of the report.

4.5.1 Ground Survey

Ground survey investigations for use in the design of the oil and gas pipelines was carried out between October 2017 and February 2018 by Calibre Group surveyors. These survey investigations were focussed on obtaining ground surface levels in the location of the proposed pipeline crossings by drainage infrastructure discussed in Section 6.4.4.

No other survey was carried out for this investigation, with details of culverts and other hydraulic infrastructure taken from existing models provided by Blacktown City Council.

4.5.2 Services Location

Ground investigations were carried out to determine the location and depth of the oil and gas pipelines located within the pipeline easement. These field works involved potholing of the location and depth of the pipes by removal of overlying material. Investigations were carried out by Durkin Constructions between October 2017 and February 2018. The location and elevation of the pipelines were surveyed when exposed.

4.5.3 Riparian Corridor Assessment

Assessment of the health and condition of Eastern and Bells Creeks was assessed by field investigations held in May 2017. These field investigations involved walking along the entire length of the creeks within the precinct boundary, logging locations of creek features with the use of GPS enabled devices, including GPS enabled cameras. A detailed photographic record of these creek features is included in Section 7.2.

5 Flood Study

This section discusses the flooding investigation undertaken as part of the precinct planning process. The extensive flooding within the precinct boundary has shaped the layout of the precinct, with almost half of the land within the precinct located under the 100 year flood level, making it unsuitable for many forms of development.

5.1 Hydrologic (*XP-RAFTS*) Modelling

Blacktown City Council supplied an *XP-RAFTS* model, discussed in Section 4.3, for the existing scenario for the entire Eastern and Bells Creeks. This model was adjusted for the developed scenario to include adjusted catchment boundaries. This model was run for the critical storm and the nodes associated with this precinct for the critical storm for the Schofields precinct were extracted to use in the flood model. The critical storm was determined as the 6 hour rainfall event from the 100 year Eastern Creek initial flood height data provided by Council from their *Eastern Creek Development Scenarios Progress Report 3 – Modelling and Mapping GIS data*.

The peak flow results of the hydrologic modelling at boundaries of the precinct and part precinct, along with the confluence of Eastern and Bells Creeks are provided for each of the modelled storm events in Figure 5.1. Detailed local flow rate time series for the modelled storm event from each individual sub-catchment, presented on Figure 4.3 is used in the hydraulic modelling as inflows, as discussed in Section 5.2.

5.2 Hydraulic (*TUFLOW*) Modelling

Flood Planning Mapping

The hydraulic modelling for this investigation was undertaken using the *TUFLOW* (Build: 2013-12-AD-iDP-w64) software package. A modelling summary sheet, outlining the data and methods used is provided in Appendix A.

The results of the hydraulic modelling undertaken for this investigation is discussed in Section 5.3. This modelling investigation uses the flows generated in the hydrologic modelling (Section 5.1, along with a discussion of the data input and parameters discussed in Section 4. The results of this modelling investigation are presented in figures, with geomorphology bed shear stress within the riparian corridor provided.

Emergency Scenario Mapping

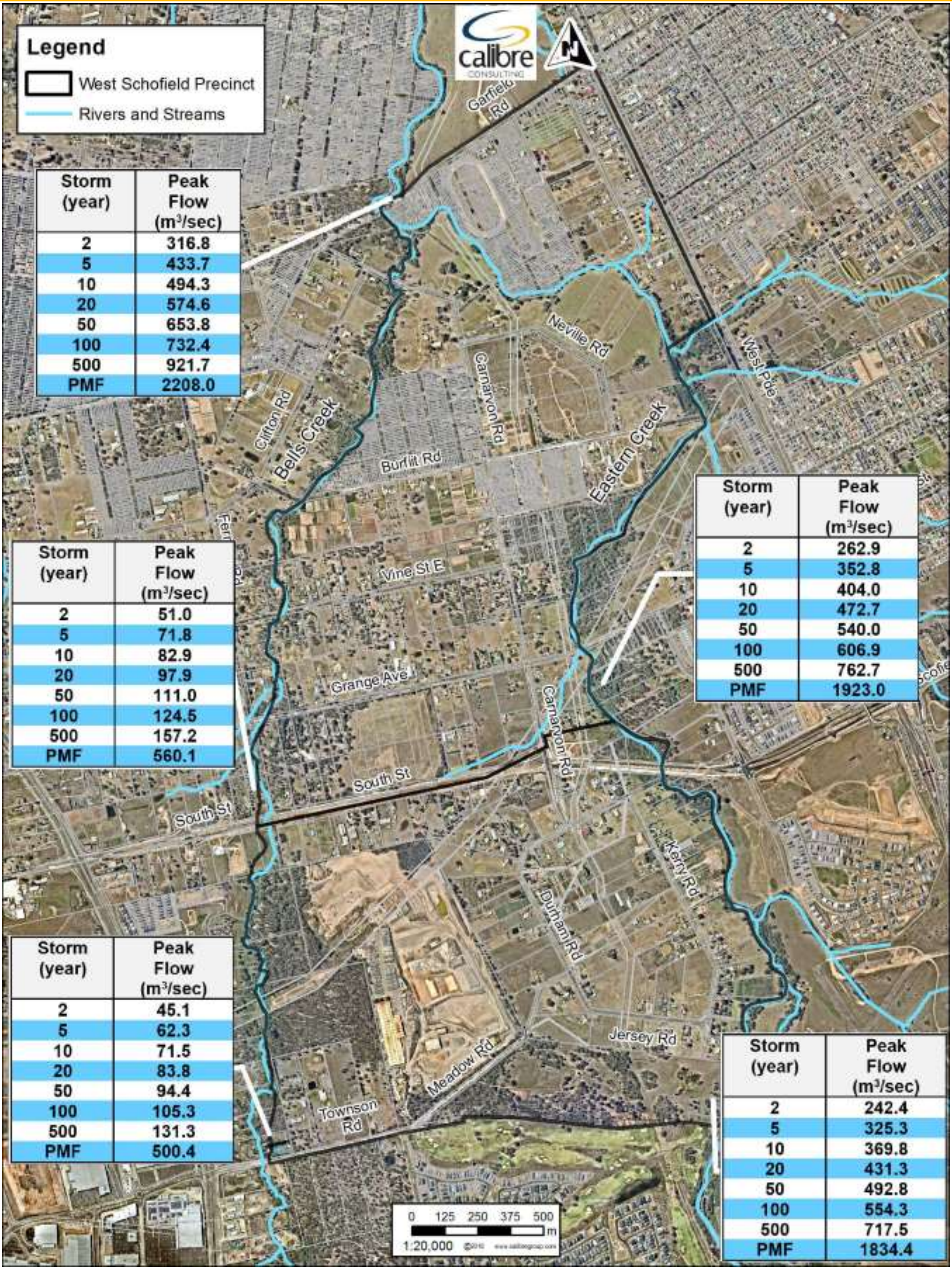
The scenarios modelled for this preliminary investigation have been selected based on the approach required for submission to Infrastructure NSW and the State Emergency Service (SES). These scenarios have been modelled as part of the precinct design and to allow mapping of a proposed of the evacuation of the precinct. This study has not been prepared for submission to the SES but has been prepared as a preliminary study to guide further investigations. The scenarios modelled are:

- 100 year local flows with 100 year tail water in the Hawkesbury River
- 500 year local flows with 500 year tail water in the Hawkesbury River
- PMF local flows with PMF tail water in the Hawkesbury River

The results of these scenarios are discussed in Section 5.4, including mapping of the proposed evacuation route.

Geomorphologic Mapping

The geomorphology and erosion potential of flows within Eastern Creek and Bells Creek were modelled as part of this investigation, discussed in Section 7.3. This modelling was carried out with no backwater occurring within the Hawkesbury River Catchment. The removal of any standing tail water within the downstream reaches of the two creeks will result in higher velocities and bed shear stress levels being modelled in the downstream reached of the precinct. This approach accounts for any storm occurrences where the local precinct experiences a significant rainfall event prior to the overall Hawkesbury River Catchment backing up and causing standing flood water which would help mitigate these effects.



Storm (year)	Peak Flow (m^3/sec)
2	316.8
5	433.7
10	494.3
20	574.6
50	653.8
100	732.4
500	921.7
PMF	2208.0

Storm (year)	Peak Flow (m^3/sec)
2	51.0
5	71.8
10	82.9
20	97.9
50	111.0
100	124.5
500	157.2
PMF	560.1

Storm (year)	Peak Flow (m^3/sec)
2	262.9
5	352.8
10	404.0
20	472.7
50	540.0
100	606.9
500	762.7
PMF	1923.0

Storm (year)	Peak Flow (m^3/sec)
2	45.1
5	62.3
10	71.5
20	83.8
50	94.4
100	105.3
500	131.3
PMF	500.4

Storm (year)	Peak Flow (m^3/sec)
2	242.4
5	325.3
10	369.8
20	431.3
50	492.8
100	554.3
500	717.5
PMF	1834.4

Figure 5.1: Flow rates at Precinct Boundaries and Creek Confluences

5.3 Results and Mapping

This section provides a summary of the results of the flood modelling for existing and developed conditions, along with a discussion of the impacts on flooding that would result from the development of the West Schofields Precinct. Mapping demonstrating correlation between existing modelling undertaken for Council of Eastern Creek, along with a sensitivity analysis to investigate the potential impacts from increased rainfall intensities as a result of climate change is included in Appendix B. No significant issues relating to previous mapping or climate change impacts were encountered as part of this investigation.

5.3.1 Flood Mapping - Existing

100 Year Results

The flood extent map for existing conditions calculated in the hydraulic modelling of the 100 year critical local storm event with 100 year tail water within the Hawkesbury River, is presented on Figure 5.2.

The flood mapping on Figure 5.2 shows that the 100 year storm event with 100 year tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 17.3 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional 100 year flood due to down stream flow conditions.

500 Year Results

The flood extent map for existing conditions calculated in the hydraulic modelling of the 500 year critical local storm event with 500 year tail water within the Hawkesbury River, is presented on Figure 5.3.

The flood mapping on Figure 5.3 shows that the 500 year storm event with 500 year tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 20.2 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional 500 year flood due to down stream flow conditions.

Probable Maximum Flood (PMF) Results

The flood extent map for existing conditions calculated in the hydraulic modelling of the PMF critical local storm event with PMF tail water within the Hawkesbury River, is presented on Figure 5.4.

The flood mapping on Figure 5.4 shows that the PMF storm event with PMF tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 26.4 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional PMF flood due to down stream flow conditions.

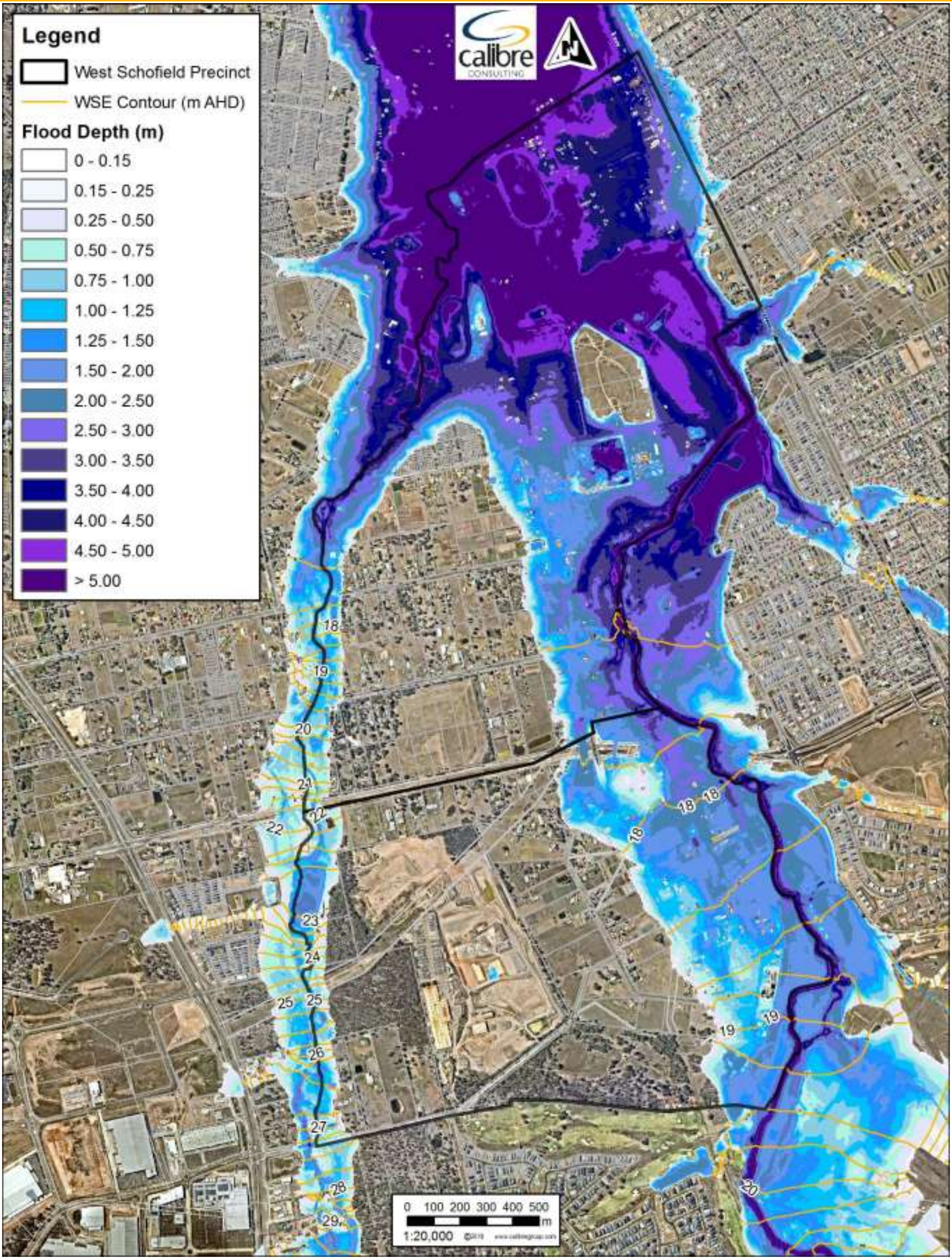


Figure 5.2: 100 year Flood Depth Map (Existing)

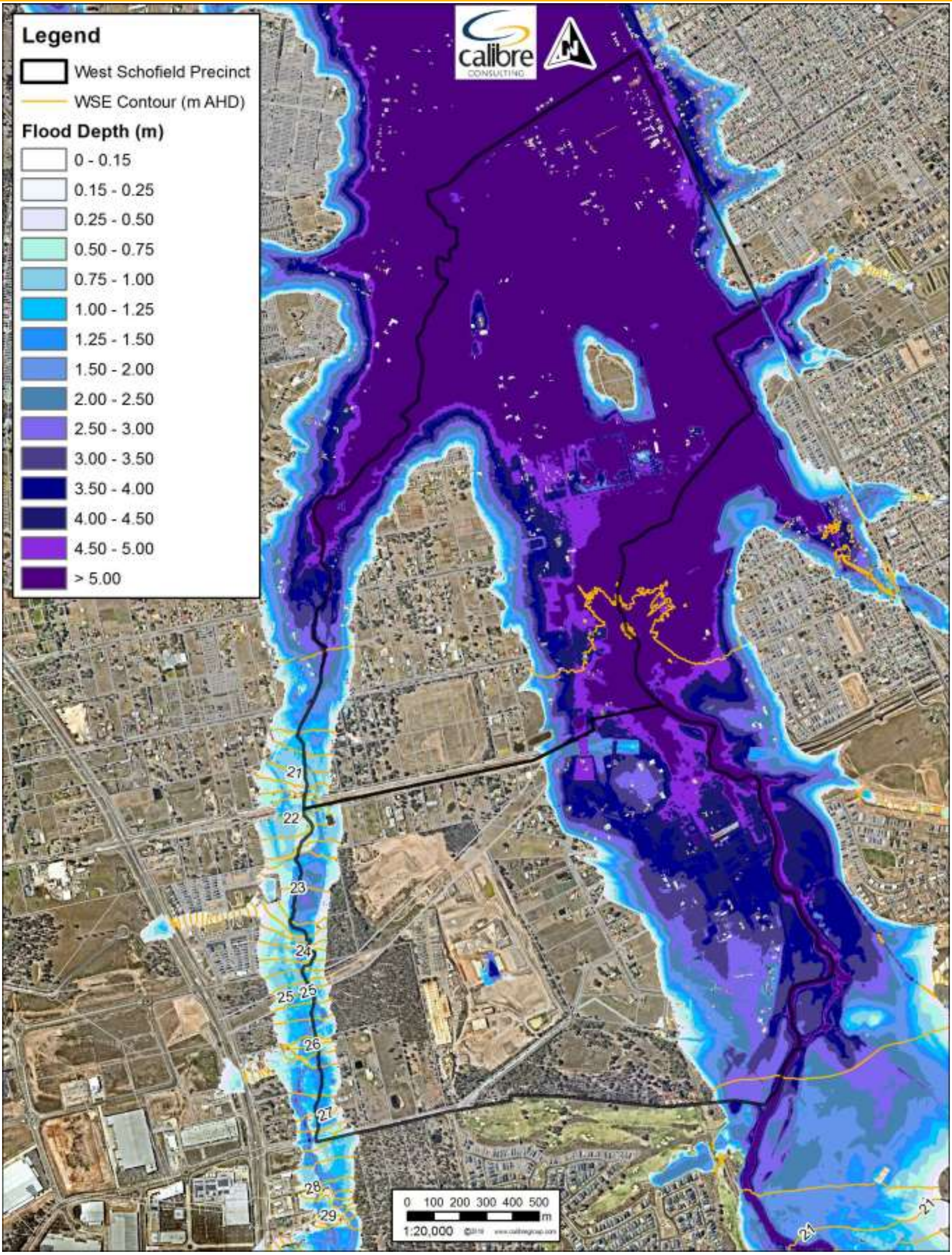


Figure 5.3: 500 year Flood Depth Map (Existing)

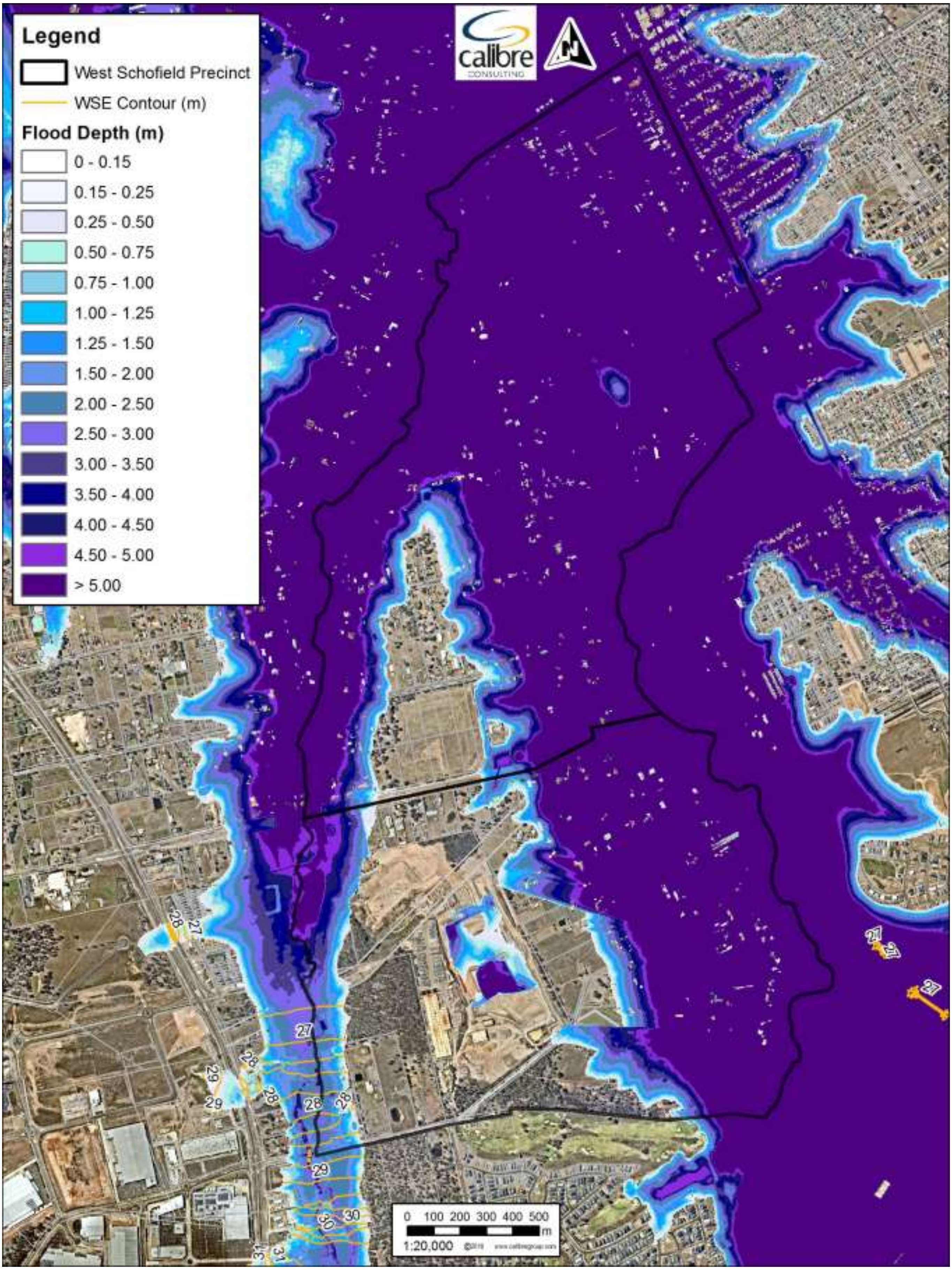


Figure 5.4: PMF Flood Depth Map (Existing)

5.3.2 Flood Mapping – Developed

The existing model of Eastern and Bells Creek was modified to incorporate development within the precinct by excluding all developed areas (show on the Indicative Layout Plan in Section 2.2 and presented in Figure 4.4) from the model. This approach assumes that all developed land will be above the flood extents and is suitable for precinct planning. Additional modelling will be required during revised layout and design stages of development within the precinct, in order to determine impacts of flooding.

100 Year Results

The flood extent map for developed conditions calculated in the hydraulic modelling of the 100 year critical local storm event with 100 year tail water within the Hawkesbury River, is presented on Figure 5.5.

As with the existing modelled scenario, the flood mapping on Figure 5.5 shows that the 100 year storm event with 100 year tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 17.3 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional 100 year flood due to down stream flow conditions.

500 Year Results

The flood extent map for developed conditions calculated in the hydraulic modelling of the 500 year critical local storm event with 500 year tail water within the Hawkesbury River, is presented on Figure 5.6.

As with the existing modelled scenario, the flood mapping on Figure 5.6 shows that the 500 year storm event with 500 year tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 20.2 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional 500 year flood due to down stream flow conditions.

Probable Maximum Flood (PMF) Results

The flood extent map for developed conditions calculated in the hydraulic modelling of the PMF critical local storm event with PMF tail water within the Hawkesbury River, is presented on Figure 5.7.

As with the existing modelled scenario, the flood mapping on Figure 5.7 shows that the PMF storm event with PMF tail water in the Hawkesbury River generates a significant flooded area at the north end of the precinct with flood depths in areas exceeding 5.0 metres near Eastern Creek. Large sections of this flooding are due to the terrain being situated lower than the 26.4 metre (AHD) tail water present in the Hawkesbury River. This water will be of low velocity and enter Eastern Creek as historically the Hawkesbury River gradually fills during a regional PMF flood due to down stream flow conditions.

Flood Difference Mapping

The difference between flood levels in the existing and developed scenarios was mapped for the 100 year flood event and is shown on Figure 5.7. The maximum difference between flood levels was an increase of 0.04 metres and decrease of 0.17 metres throughout the floodplain. These differences are spread throughout the floodplain of Eastern Creek in small isolated areas that are within the existing 100 year floodplain. The developed scenario modelled does not result in an increase in the extent of the 100 year flood in Eastern or Bells Creek floodplains.

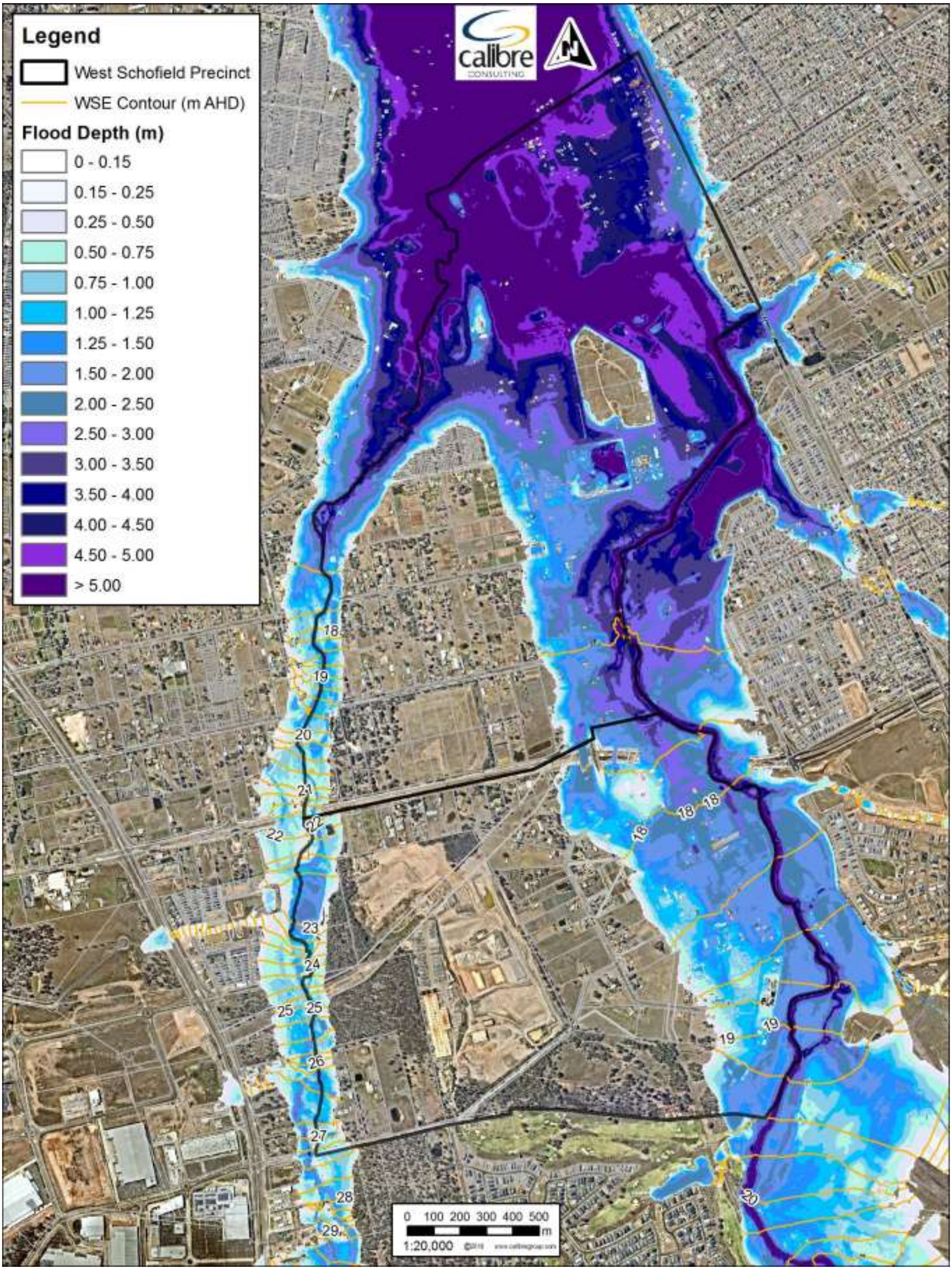


Figure 5.5: 100 year Flood Depth Map (Developed)

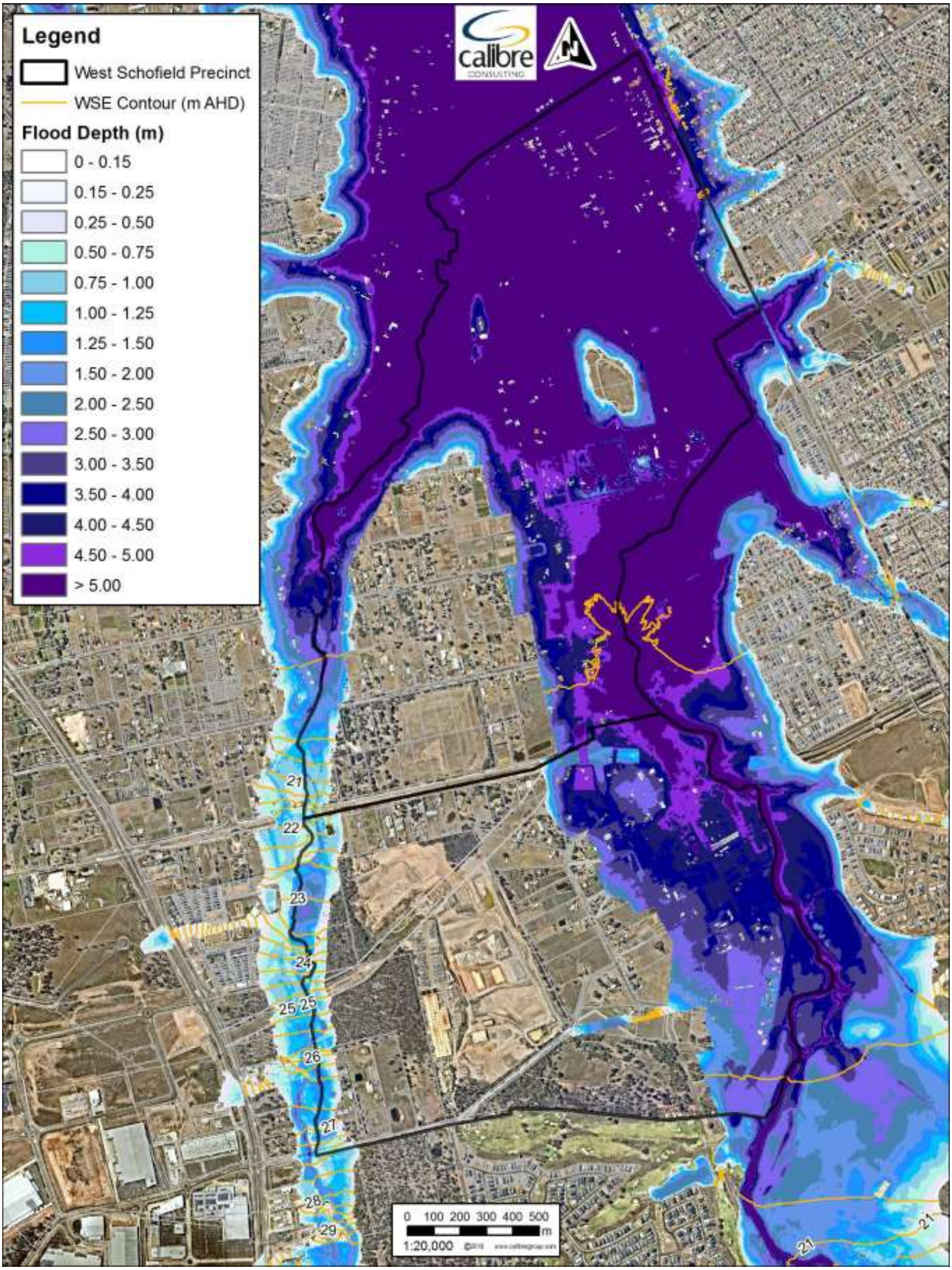


Figure 5.6: 500 year Flood Depth Map (Developed)

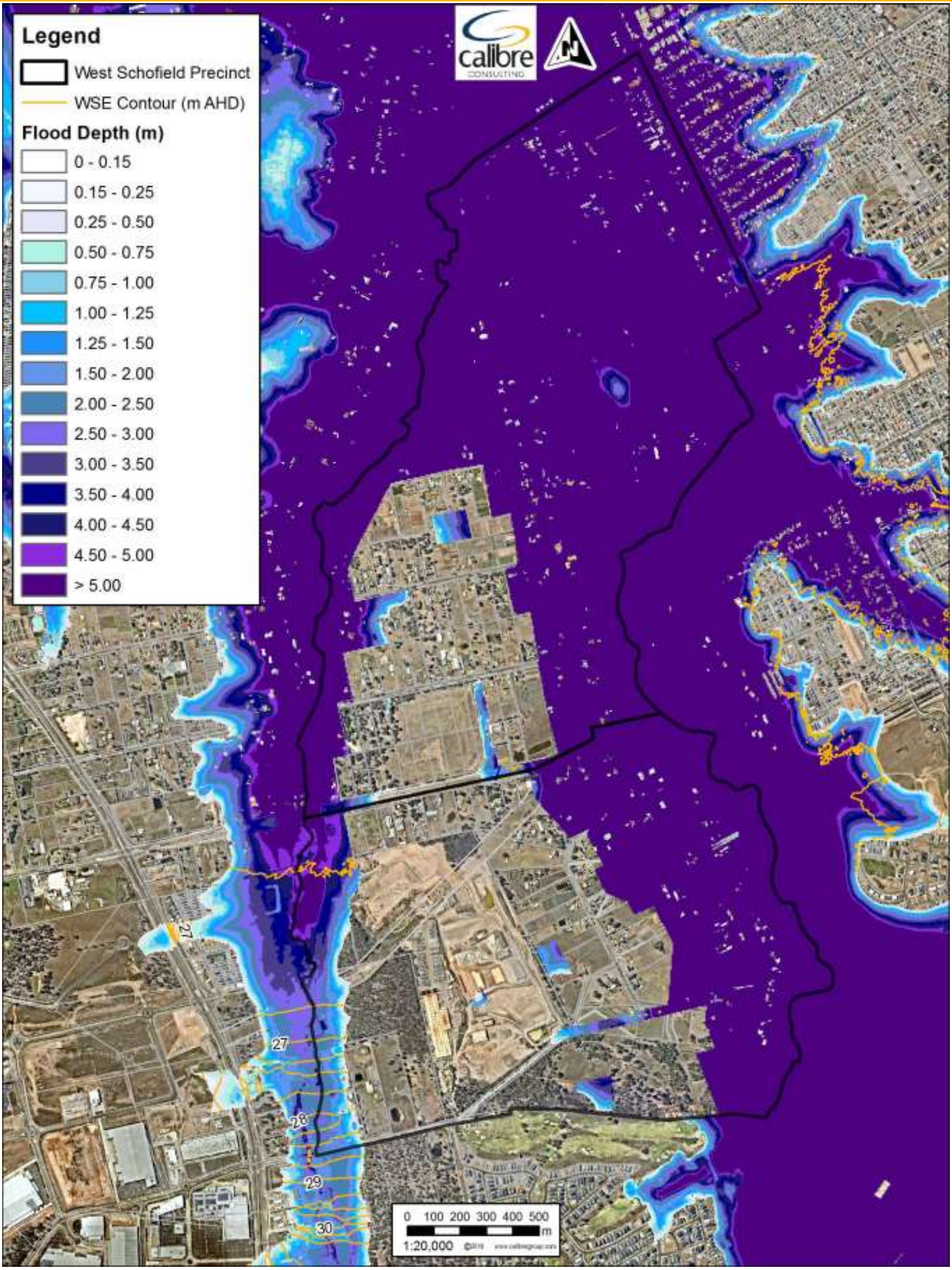


Figure 5.7: PMF Flood Depth Map (Developed)

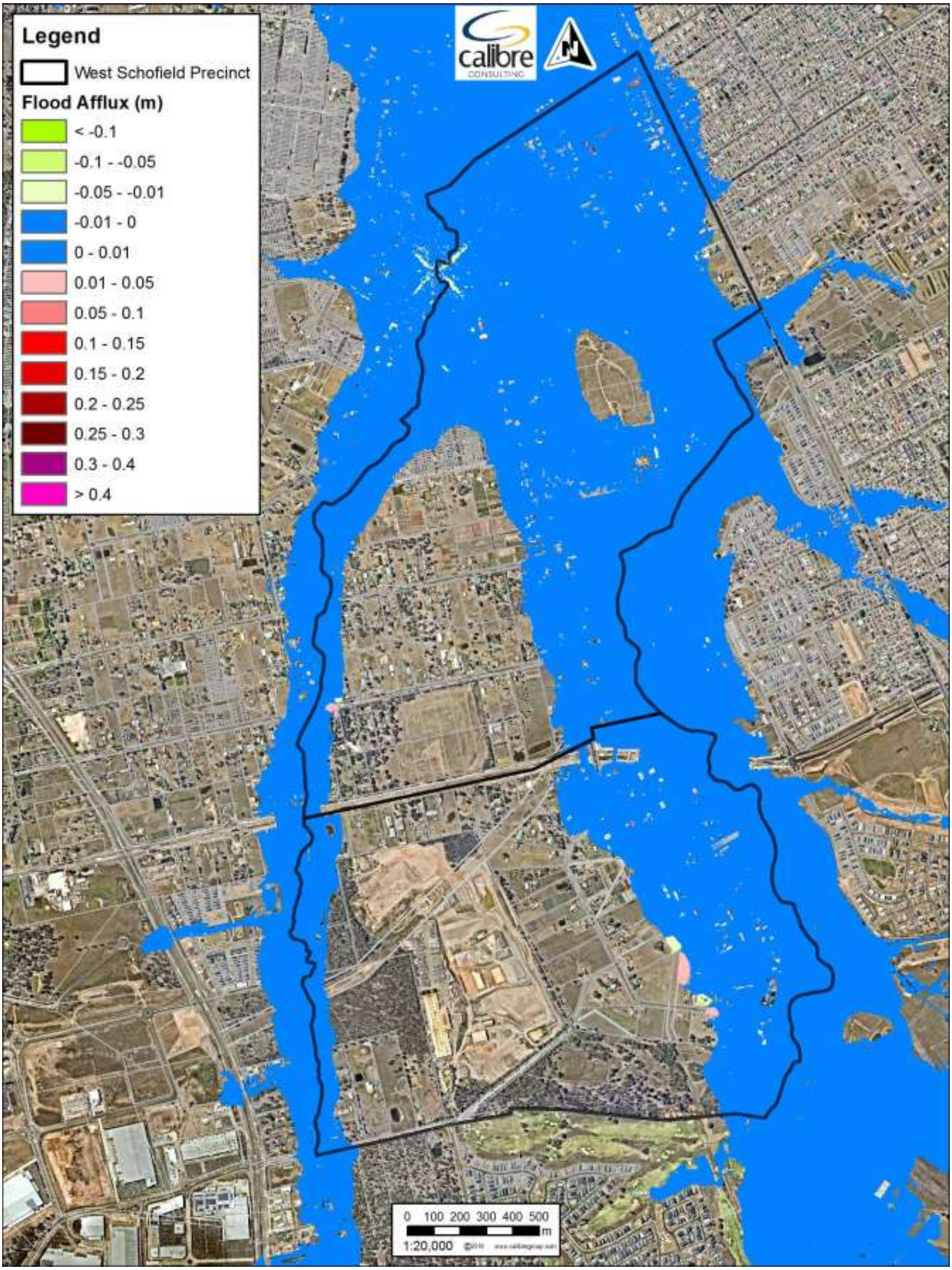


Figure 5.8: 100 year Flood Difference Map (Existing/Developed)

5.4 Flood Evacuation Planning

The road layout shown on the Indicative Layout Plan, discussed in Section 2.2, has been designed to allow movement of people and vehicles from lower lying areas on the western and eastern edges of the development area to higher ground located centrally with the precinct. The higher ground within the precinct is located above the Probable Maximum Flood level (shown on Figure 5.4), allowing safe refuge.

During periods of prolonged inundation, where refuge within the precinct may not be suitable, an evacuation route from the southern boundary of the precinct has been mapped, and is presented on Figure 5.9. This evacuation route relies on roads that are currently constructed

These scenarios have been modelled as part of the precinct design and to allow mapping of a proposed of the evacuation of the precinct. This study has not been prepared for submission to the SES but has been prepared as a preliminary study to guide further investigations. The scenarios modelled are:

- 100 year local flows with 100 year tail water in the Hawkesbury River (Figure 5.2)
- 500 year local flows with 500 year tail water in the Hawkesbury River (Figure 5.3)
- PMF local flows with PMF tail water in the Hawkesbury River (Figure 5.4)

This evacuation route on Figure 5.9 has been mapped for the 500 year peak flood elevation, in accordance with requirements discussed between Infrastructure NSW and the Department of Planning and Environment. This preliminary evacuation plan avoids using any of the potential routes to the east and west of the precinct, in particular Richmond Road north of the M7 Motorway. This is to avoid using evacuation routes that are already oversubscribed by residents to the north, including Marsden Park, Bligh Park and the township of Richmond.

The evacuation route has been designed to be above the 500 year peak flood for the entire route. This route provides access to the M7 Motorway, through the Stonecutters Ridge development in the suburb of Colebee, through Dean Park and onto Richmond Road, to the M7, approaching from the south. This route avoids the congested section of Richmond Road.

The Department of Planning and Environment separately commissioned a North West Flood Evacuation Study prepared by Stantec. It was completed in consultation with Infrastructure NSW, the Roads and Maritime Services and the State Emergency Service. Please refer to this study for the current evacuation approach for the Precinct.

Figure 5.9: Flood Evacuation Route Map

5.5 Flood Study Precinct Design Outcomes

The Hawkesbury-Nepean Flood Management Advisory Committee has prepared a series of flood specific planning guidelines for development within the Hawkesbury-Nepean Floodplain. Two documents relevant to the precinct plan of the West Schofields Precinct are *Managing Flood Risk Through Planning Opportunities: Guidance On Land Use Planning In Flood Prone Areas* and *Designing Safer Subdivisions: Guidance On Subdivision Design In Flood Prone Areas*. These documents provide general guidance on the considerations for development within the Hawkesbury River floodplain, which have been incorporated into the land use planning for the West Schofields Precinct.

The planning constraints resulting from the outcomes of the flood modelling investigations carried out as part of the precinct planning process have been incorporated in the development of the Indicative Layout Plan. These flood constraints include:

- Restriction of residential and commercial development to areas not inundated during the 100 year flood event
- Layout of the road network to allow flood evacuation during extreme flood events

The developed scenario flood modelling indicates that the precinct layout shown on the Indicative Layout Plan does not result in inundation of areas that are not flooded in existing conditions.

5.5.1 Flood Planning Levels

Flood planning levels within the West Schofields Precinct will be developed in accordance with Appendix D, Section 1.5 of Blacktown City Council's *Engineering Guide For Development* (February 2005). Flood planning levels will be set above the 100 year flood level

- Land level 100 year flood elevation + 0.5 metres
- Habitable floor level 100 year flood elevation + 0.5 metres
- Garage floor level 100 year flood elevation + 0.1 metres

The flood planning level requirements will be applicable to both Residential and Industrial/Commercial Areas within the precinct.

6 Water Cycle Management Plan

This section outlines the strategy and measures that are proposed as part of the West Schofields Precinct Plan that will meet the water management targets. These requirements are set in Section 2.3.1 of the 2010 Blacktown *Growth Centre Development Control Plan* which sets water cycle management planning requirements for the North West Growth Area. Engineering parameters and design guidelines to the Blacktown City Council – *Engineering Guide for Development* (February 2005).

Consultation with Blacktown City Council throughout the precinct planning process have indicated that as a result of flooding within the precinct primarily being the result of back water inundation from the Hawkesbury River, there will be no requirement for detention of flow from the West Schofields Precinct.

Bio-retention basins have been modelled based on providing treatment for all development areas, including commercial and residential areas zoned R3, which are normally treated on site. This strategy has been developed in order to maximise the developable land above flood planning levels by utilising land flooded by regional flooding for water quality measures.

6.1 Blacktown Council Engineering Documents

The Blacktown City Council – *Engineering Guide for Development* (February 2005) outlines Council's recommended practice for drainage design. Section 4 Drainage Design and Appendix D Drainage Design Manual of these guidelines specifies drainage design procedures and sets relevant design criteria for design of drainage infrastructure.

The Blacktown City Council – *Developer Handbook for Water Sensitive Urban Design* (Version 1.1 – November 2013) has been prepared by council to assist developers in achieving the objectives and implementing the controls relating to water conservation, water quality and waterway stability. Measures contained in the section on integrated water cycle management in Council’s Development Control Plan.

The Blacktown City Council *Works Specification Civil* (2005) contains technical design data for the calculation of flows, flood elevations and velocities along with technical standards for the design of drainage structures. The hydrologic parameters include rainfall intensity charts and runoff parameters for flow estimation. The handbook also outlines hydraulic parameters and design requirements for pits, culverts and pipes.

6.2 Objectives

The objective of the water cycle management measures for the West Schofields Precinct are to achieve the treatment targets for the reducing export loads to the requirements of Blacktown City Council. These target reduction rates are provided in the following documents:

- Blacktown City Council – *Growth Centre Precincts Development Control Plan* (November 2016)
- Blacktown City Council – *Engineering Guide For Development* (February 2005)
- Blacktown City Council – *Developer Handbook for Water Sensitive Urban Design* (Version 1.1 – November 2013)

The per cent reduction in pollutant load targets for the project are from Table 2.1 of the *Growth Centre Precincts Development Control Plan*:

- Gross pollutant (>5 mm) 90%
- Total suspended solids 85%
- Total phosphorus 65%
- Total nitrogen 45%
- Hydrocarbons 90%

These targets are consistent with other documentation, including the requirements of the *Sydney Metropolitan Catchment Management Authority, Draft NSW MUSIC Modelling Guidelines.* Targets for environmental flows (stream erosion control ratio) are not appropriate for this precinct as the discharge locations are within Eastern and Bells Creeks, which are almost exclusively influenced by flows from upstream catchments. A detailed geomorphologic study is incorporated in this report in Section 7.3.

6.3 Strategy

The overall water management strategy for the West Schofields Precinct involves the implementation of water sensitive urban design features, along with traditional drainage infrastructure to achieve the objectives for water quality. Stormwater and drainage measures within the precinct will include the following components:

- Source control features including rainwater tanks, street trees and permeable landscape features
- Transfer of flows through a traditional pit, pipe and overland flow network
- Water quality (bio-retention) basins incorporating gross pollutant traps, filter media and vegetation, including provision for open water bodies where space is available
- Re-use of harvested stormwater for sports field irrigation
- Discharge from the system to Eastern and Bells Creeks

Preliminary designs for the infrastructure required to all the water cycle management system to meet the objectives have been prepared as part of this study in order to determine the impacts on development patterns within the precinct. These preliminary designs are discussed in detail in Section 6.4.

6.4 Water Management Infrastructure

This section outlines the preliminary design of water management infrastructure undertaken as part of this study.

The potential for water management infrastructure to place constraints on the pattern of development, in particular the drainage crossings of the oil and gas pipelines on the eastern side of the precinct, required more detailed design of drainage infrastructure than would typically be required at the precinct planning stage.

The preliminary design and layout of the water management infrastructure has been part of the preparation of the Indicative Layout Plan, with the development of the drainage and layout plans occurring in consultation with URBIS. The catchments have been mapped based on the existing topography and the road layout in the Indicative Layout Plan. Preliminary pipe sizing and filling of land have been designed in accordance with the engineering requirements of Blacktown City Council.

The water cycle management measures proposed for West Schofields Precinct are discussed in Sections 6.4.1– 6.4.6 and presented on Figure 6.1.

6.4.1 Rainwater Tanks and Street Trees

Water quality treatment to manage runoff will be incorporated at source by the use of rainwater tanks on dwellings, along with street trees within the road. Blacktown City Council require that all residential, industrial and commercial developments install rainwater tanks to meet a minimum of 50 per cent of their potable water demand for outdoor use, toilets or laundry. Rainwater tank or tanks will be included in the design of residential, commercial areas within the West Schofields Precinct to harvest roof runoff to be reused for toilet flushing and external irrigation.

The roof runoff will be collected in standard roof guttering and collected in rainwater tanks draining to a *Building and Sustainability IndeX* (BASIX) compliant reuse system. Overflow from the roof drainage capture system will drain to the pit and pipe drainage network where it will be discharged into the precinct bio-retention basins. Rainwater tanks have not been modelled in *MUSIC*, discussed in Section 6.5 for two reasons; the development pattern and density of dwellings within the catchments have not been determined, and the stormwater harvesting for sports field irrigation, discussed in Section 6.4.7, may reduce the need for tanks on individual dwellings or developments. This conservative approach over calculates the bio-retention area that are in this report and will be reduced at later stages in the precinct design process.

Street trees will be incorporated into the road design, with details included on the road design and landscape drawings. Street trees will be irrigated passively by allowing for breaks in kerbs, appropriate set-down paths graded to drain to landscaped areas and scour protection at the edge of the landscaped bed. Street trees have been not modelled within the *MUSIC* models discussed in Section 6.5 and will be incorporated in later investigations, potentially reducing the area of bio-retention basin required.

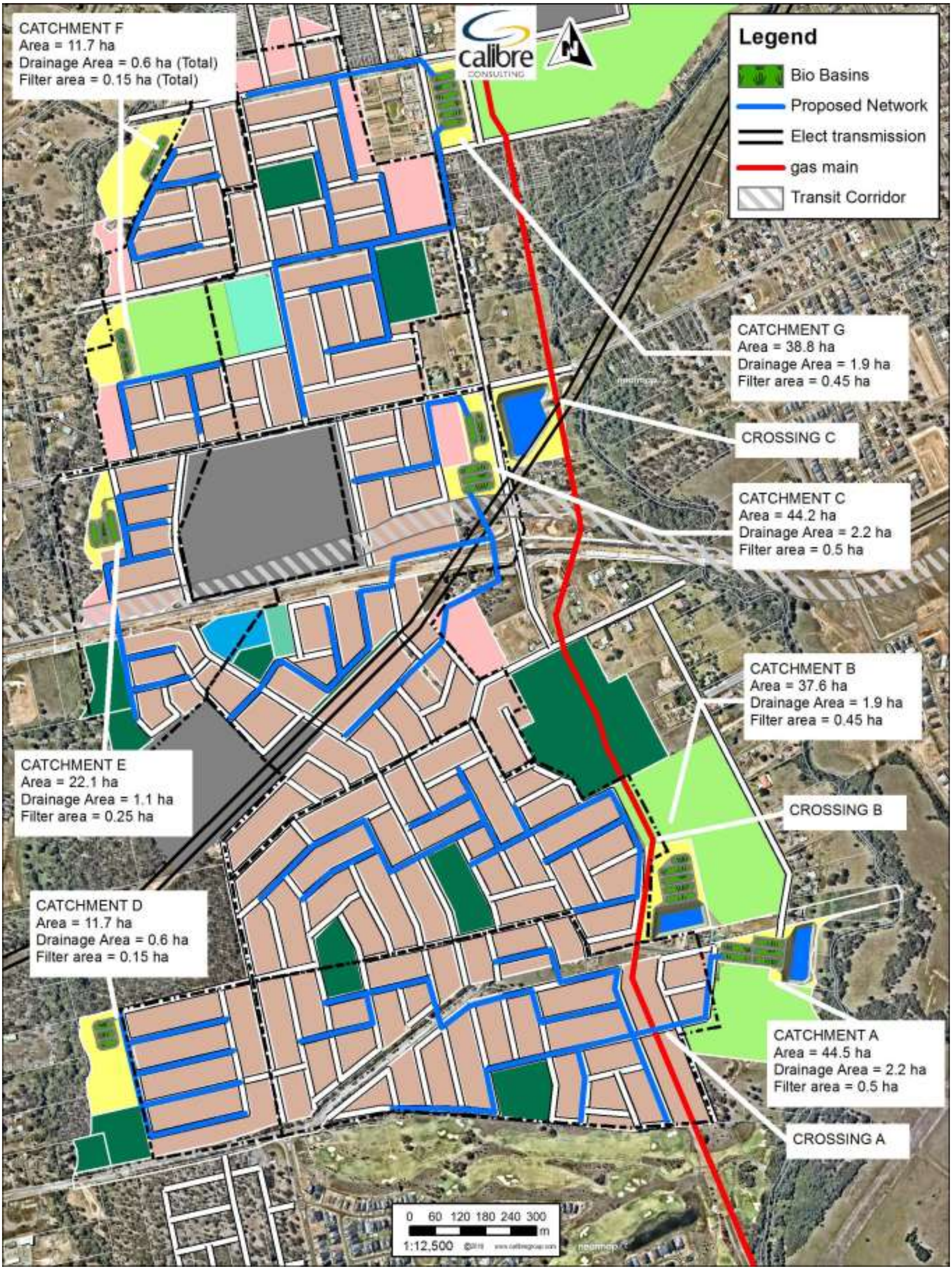


Figure 6.1: Water Cycle Management Features

6.4.2 Pit, Pipe and Overland Flowpath Drainage System

Stormwater runoff from lots and roads in excess of the capacity of source control measures will be directed to a trunk drainage system for minor storm events in a conventional pit and pipe system. Preliminary pipe sizes calculated based on the Indicative Layout Plan road and catchment layout are included on Figure 6.1.

Pipe diameters have been designed in accordance with Blacktown City Council guidelines, including gradient and cover requirements. The overland flow network has been incorporated into the road layout of the Indicative Layout Plan. This road layout has been designed to allow free drainage of all roads to discharge to Eastern and Bells Creeks. The road layout avoids trapped low points, which can result in localised flooding.

6.4.3 Existing Infrastructure (RMS Culverts under Schofields Road)

Two culvert crossings that were constructed by RMS as part of the Schofields Road upgrade have been included in the design of drainage infrastructure for the West Schofields Precinct.

The 2-cell culvert located to the west of Carnarvon Road, on drawing set (DS2014/005487) and the 8-cell culvert located to the west of Carnarvon Road, on drawing set (DS2014/005486), are presented on Figure 6.2.

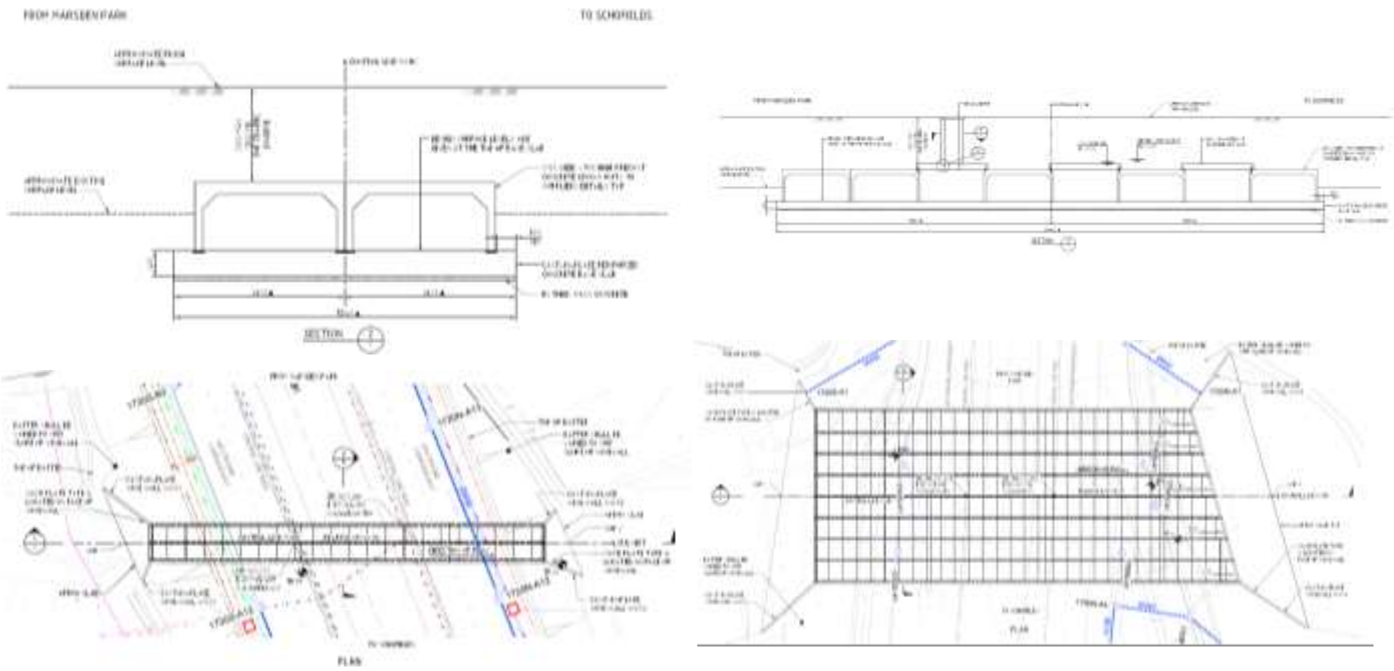


Figure 6.2: RMS Culverts

These culverts, constructed as part of Schofields Road upgrade, were incorporated in the flood modelling (in Section 5.2) and preliminary drainage design for the precinct. The large 8-cell culvert is designed as a flood relief culvert for Eastern Creek and is oversized for the proposed use as drainage culvert for the precinct.

6.4.4 Crossing of Oil and Gas Easement

The oil and gas easement located within the West Schofields Precinct, discussed in Section 4.2.2, provides a constraint to the development within the West Schofields Precinct. The crossing of the oil and gas pipeline easement has the potential to impact on the overall development layout and pattern within the West Schofields Precinct. Preliminary design of drainage infrastructure to cross the pipelines has been prepared in consultation with Jemena and Caltex, with meetings held to outline design and procedure requirements.

The design of drainage infrastructure to cross the oil and gas easement is required in order to facilitate precinct planning, with constraints related to crossing the easement having the potential to impact on levels required for infrastructure within the development area. The detailed design of drainage infrastructure is not usually undertaken at the precinct planning stage and has been prepared out of sequence with other design packages and with the overall design process.

The design of drainage infrastructure at the easement crossing requires preliminary design of upstream drainage networks in order to allow for design levels of roads and lots within the precinct. The development of the upstream catchment drainage plan, discussed in Section 6.4.2 is critical to developing the levels of drainage structures to cross the oil and gas pipelines. These crossing levels will set drainage and earthworks levels, which in turn will set development patterns within the precinct.

This preliminary drainage layout and culvert crossing designs have been developed for a three crossings in the locations shown on Figure 6.3, within the CSR owned land to the south of the precinct (Crossing A), adjacent to the proposed sports fields (Crossing B) to the south of Grange Road (Crossing C), north of the upgraded Schofields Road.

The preliminary designs of culvert and overland flow paths shown on Figure 6.3 have been prepared to address the design requirements outlined in Jemena's *Guideline to Designing, Constructing and Operating around Existing AS2885 Natural Gas Pipelines* (GAS-960-GL-PL-001 Rev: 8, Date: 4/11/2016), along with discussions with Jemena at the meeting held on Wednesday 30 August 2017 between Jemena, Department of Planning and Calibre. Caltex design requirements are outlined in a letter from Rob Moore of Caltex Australia Petroleum Pty Ltd to Nicole Franklin of Calibre Group, dated 16 August 2017.

The levels shown in the preliminary designs on Figure 6.3 were obtained by ground survey levels Section 4.5.1 and potholing investigations discussed in Section 4.5.2.

6.4.5 Filling of Land

Preliminary earthworks modelling has been carried out as part of this investigation in order to determine requirements for the filling of land required to drain development areas and roads within the precinct. This earthworks modelling incorporated the drainage network, described in Section 6.4.2, along with Schofields Road culvert constraints, described in Section 6.4.3, and the drainage crossing constraints of oil/gas pipelines described in 6.4.4. The areas requiring filling of the lots and roads are presented in Figure 6.4, along with areas of compensatory cut under the 100 year flood extents.

These earthworks levels have been developed to allow drainage within the requirements of Council guidelines and will require revision as the development process progresses.

6.4.6 Water Quality Basin Strategy

Water quality basins proposed for the West Schofields Precinct are bio-retention systems, to be designed in accordance with the requirements of Blacktown City Council. Bio-retention basins (also known as bio-retention systems, bio-filters, and rain gardens), are a form of natural water treatment that use natural processes to achieve water quality improvements from stormwater flows.

Bio-filtration systems use vegetated soil-based filters to attenuate flows, reduce runoff volumes, and improve water quality through sedimentation, filtration, sorption, and biological uptake by reed and sedge types of vegetation. Bio-retention basins have advantages over open water treatment systems such as wetlands or ponds due to decreased risk to human health via contact with untreated water. This lack of open water also provides mosquito control, odour control and minimises wildlife interactions with polluted water.

The preliminary design of bio-retention basins for the West Schofields Precinct have been prepared in accordance with the Blacktown City Council – *Developer Handbook for Water Sensitive Urban Design* (Version 1.1 – November 2013) and incorporate typical design features including:

- Gross pollutant trap
- Flow distribution/inlet structure
- Bio-retention filter comprising of:
    - filter media (coarse sand and organic material)
    - planting (grass and sedge species to remove pollutants)
    - sub-soil drainage and flow collection
- outlet and discharge location to creek
- maintenance access path for vehicles

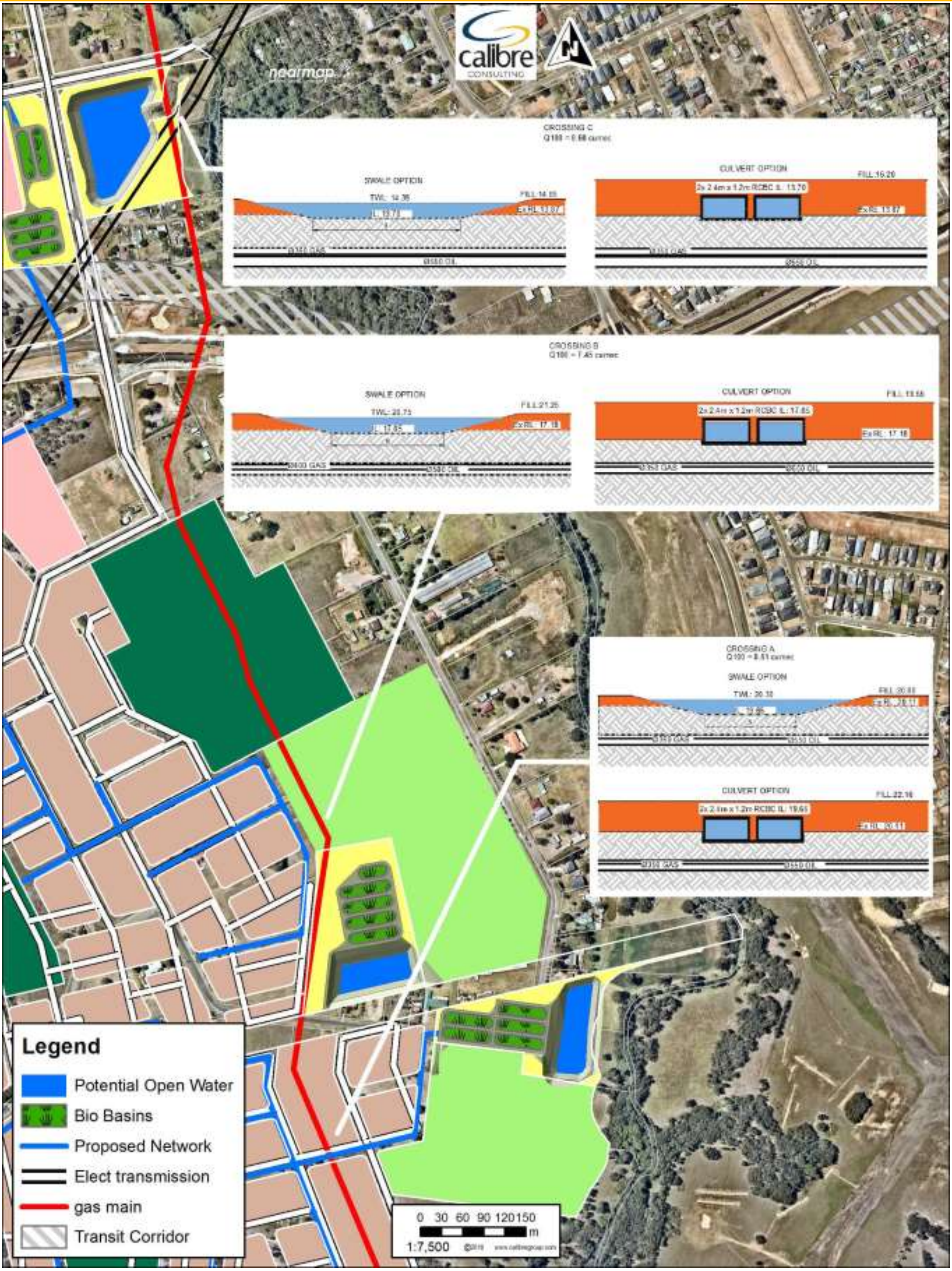


Figure 6.3: Drainage Crossings of Oil and Gas Pipeline

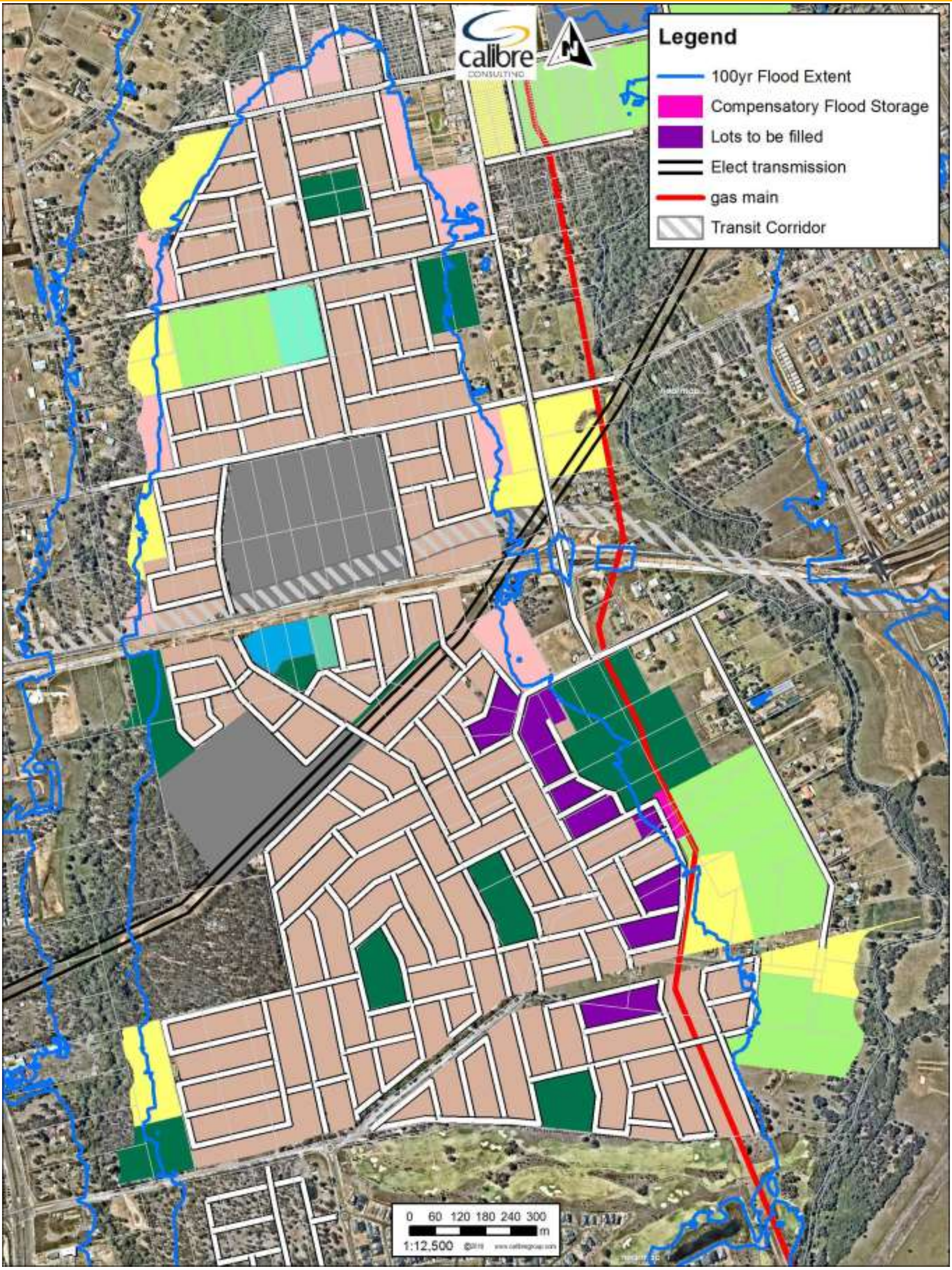


Figure 6.4: Areas Requiring Filling of Lots and Roads

The design of basins within West Schofields will receive flows from the developed sub-catchments, directed to a splitter pit, or high flow weir. This weir directs high flows away from the bio-retention basin to prevent damage to the vegetation and filter media during high flow, high energy events. Flows lower than the design recurrence interval (to be set at four exceedances-per-year or the 3 month peak event) will be directed to a gross pollutant trap (GPT). The purpose of the gross pollutant trap is to remove litter, debris and sediment to prevent blockage of the basin. Flow from the gross pollutant trap will be directed through a pipe network into a bio-retention treatment area. Flow in excess of the design event pass bypass the basin.

The bio-retention areas located downstream of the gross pollutant trap will be designed to incorporate several treatment cells. Flow from the gross pollutant trap will be distributed evenly within the cell or cells through a combination of pipe network, weirs, scour protection or flow spreaders. Water levels within the cells will be managed through hydraulic connections set at bio-retention cell operating level.

The bio-retention cell consists of a filter media, an enriched coarse sand, planted with nutrient removing vegetation. Nutrient removal occurs through sorption to soil particles, decomposition by subsoil biota, and removal by plants. An extended detention depth (ponding above the filtration media) will be provided to increase treatment volumes within a basin.

Potential open water areas have been incorporated in the layout shown on Figure 6.1, based on discussions with Blacktown City Council. Council have stated a preference for open water to be incorporated into stormwater basins within the West Schofields Precinct for aesthetic reasons and for possible stormwater re-use on sports field irrigation, discussed in Section 6.4.7

Basin A

Basin A, presented on Figure 6.1 is located in the south eastern area of the precinct and takes drainage from Catchment A, discharging to Eastern Creek. The basin has been designed in a five cell arrangement with a total filter area of 0.5 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 44.5 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin A is located within sports field area within the south east of the precinct and could potentially incorporate an area of open water for stormwater harvesting.

Basin B

Basin B, presented on Figure 6.1 is located in the south eastern area of the precinct and takes drainage from Catchment B, discharging to Eastern Creek. The basin has been designed in a two cell arrangement, elongated in order to allow area for sports fields. The bio-retention has a total filter area of 0.45 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 37.6 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin B is located within sports field area within the south east of the precinct and could potentially incorporate an area of open water for stormwater harvesting.

Basin C

Basin C, presented on Figure 6.1 is located on the eastern side, north of Schofields Road and the future transit corridor and south of Grange Road. The basin takes drainage from Catchment C, through the existing culverts on Schofields Road and discharges to Eastern Creek. The basin has been designed in a four cell arrangement with a total filter area of 0.5 hectares. The layout shown on Figure 6.1 has been designed to incorporate a large open water body adjacent to Grange Avenue. This water body will be located upstream of the crossing of the oil and gas pipelines. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 44.2 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin D

Basin D, presented on Figure 6.1 is located in the south western area of the precinct and takes drainage from Catchment D, discharging to Bells Creek. The basin has been designed in a two cell arrangement with a total filter area of 0.15 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 11.7 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin E

Basin E, presented on Figure 6.1 is located in the western area of the precinct and takes drainage from Catchment E, discharging to Bells Creek. The basin has been designed in a three cell arrangement with a total filter area of 0.25 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 22.1 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin F

Basin F, presented on Figure 6.1 is located in the north western area of the precinct and takes drainage from Catchment F, discharging to Bells Creek. The basin has been designed as two three cell arrangements in two locations with a total filter area of 0.15 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 11.7 hectares to meet the pollutant removal targets presented in Section 6.2.

Basin G

Basin G, presented on Figure 6.1 is located in the eastern area of the precinct and takes drainage from Catchment G, discharging to Eastern Creek. The basin has been designed in a two cell arrangement with a total filter area of 0.45 hectares. This filter area has been modelled (in Section 6.5) to reduce pollutant export from the catchment of 38.8 hectares to meet the pollutant removal targets presented in Section 6.2.

6.4.7 Stormwater Harvesting for Sports Field Irrigation

The indicative layout plan includes sports fields located adjacent to stormwater basins in order to facilitate the use of treated stormwater from bio-retention areas for the irrigation of fields.

Blacktown City Council require that water use within public open space (e.g. irrigation, water features, open water bodies / pools) should be supplied from non potable sources to meet a minimum of 80% of this demand. No modelling or design of sports field irrigation is required or possible at the precinct planning stage. Allowances for open water areas, including indicative layouts are shown on Figure 6.1.

6.5 Water Quality Modelling

Preliminary water quality modelling of the precinct water infrastructure presented on Figure 6.1 has been undertaken during the preparation of the Indicative Layout Plan. This modelling of the preliminary design, undertaken using the *MUSIC* water quality modelling software (Version 6.1) has been prepared in accordance with Blacktown City Council guidelines and is used to determine the required bio-retention areas needed to meet the pollutant removal targets presented in Section 6.2. The results of the MUSIC modelling are presented in Table 6-1.

Table 6-1: Preliminary MUSIC Model Results

Pollutant	Removal target	Basin A	Basin B	Basin C	Basin D	Basin E	Basin F	Basin G
Gross Pollutant	90%	100%	100%	100%	100%	100%	100%	100%
Total suspended solids	85%	87.2%	87.7%	87.1%	87.6%	86.2%	86.5%	87.5%
Total Phosphorus	65%	70.9%	72%	71%	71.8%	70.3%	70.5%	71.5%
Total Nitrogen	45%	53.3%	54.4%	53.4%	54.1%	51.9%	52.4%	53.6%

The results of the modelling in in Table 6-1 indicate that the water cycle management system shown on Figure 6.1 has been designed to address the pollutant removal targets presented in Section 6.2.

The layout of the basins and bio-retention areas will be updated for Contributions Plan and may also include open water to use in water harvesting. This may result in reductions to the filter area, dependent on the area of open water proposed, usage rates of the water, along with any additional treatment measures.

6.6 Water Cycle Management Precinct Design Outcomes

The planning outcomes resulting from the water cycle management study and design carried out as part of the precinct planning process have been incorporated in the development of the Indicative Layout Plan. These measures include:

- Incorporation of source control features including rainwater tanks. street trees and permeable landscape features
- Layout of a traditional pit, pipe and overland flow network
- Three drainage crossings of the oil and gas pipelines located within the precinct
- A total of six water quality (bio-retention) basins incorporating gross pollutant traps, filter media and vegetation, including open water bodies for the potential re-use of harvested stormwater for sports field irrigation

The developed scenario water quality modelling indicates that the precinct layout shown on the Indicative Layout Plan will incorporate water cycle management features able to meet pollutant removal targets.

7 Riparian Corridor Assessment

This section outlines the assessment of the riparian characteristics of Eastern and Bells Creeks in the location of the West Schofields Precinct. A detailed analysis of the ecology of the precinct is provided in the *West Schofields Precinct Biodiversity and Riparian Assessment*, prepared by Eco Logical in June 2017. The assessment contained in this section outlines the hydraulic, hydrologic and geomorphologic characteristics of the creeks.

7.1 Riparian Corridor Mapping

The NSW Office of Water released a policy and set of guidelines for riparian corridors on waterfront land in 2012 to simplify the controlled activities application and assessment process. The *Guidelines for riparian corridors on waterfront land* provide flexibility in determining riparian protection areas and make more land available for housing, support floodplain, stormwater and bush fire management, and allow riparian corridors to be used for public amenity whilst continuing to deliver environmental outcomes required under the *Water Management Act.*

The Officer of Water recommends a vegetated riparian zone width, presented in Table 7-1 based on watercourse order as classified under the Strahler System of ordering watercourses shown on Figure 7.1. Creeks are defined using current 1:25 000 topographic maps. The width of the vegetated riparian zone should be measured from the top of the highest bank on both sides of the watercourse.

Table 7-1: Recommended Riparian Corridor Widths

Watercourse type	Vegetated Riparian Zone width (each side of watercourse)	Total Riparian Corridor width
1st order	10 metres	20 m + channel width
2nd order	20 metres	40 m + channel width
3rd order	30 metres	60 m + channel width
4th order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40 metres	80 m + channel width

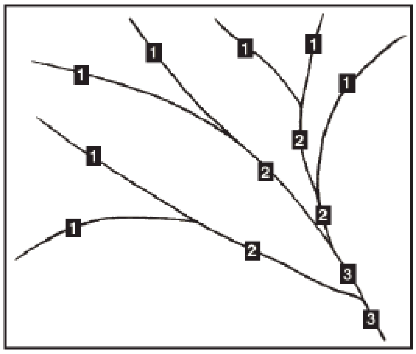


Figure 7.1: The Strahler Stream Ordering System

Stream Ordering of Eastern and Bells Creek have been mapped using the Strahler Stream Ordering System, shown on Figure 7.2.

Eastern Creek is classified using the Strahler Stream Ordering System as a fourth order creek, with Bells Creek a second order stream. The stream order mapping on Figure 7.2 includes a set-back showing the vegetated riparian zone widths recommended by NSW Office of Water, drawn to scale

The mapping in Figure 7.2 indicates that the development of the West Schofields Precinct will not include works within the vegetated riparian zone of Eastern Creek or Bells Creek. Upgrades to creek crossings and discharge points from drainage infrastructure within the precinct will be designed to mitigate erosion and scour at these locations and reduce impacts on the creeks.

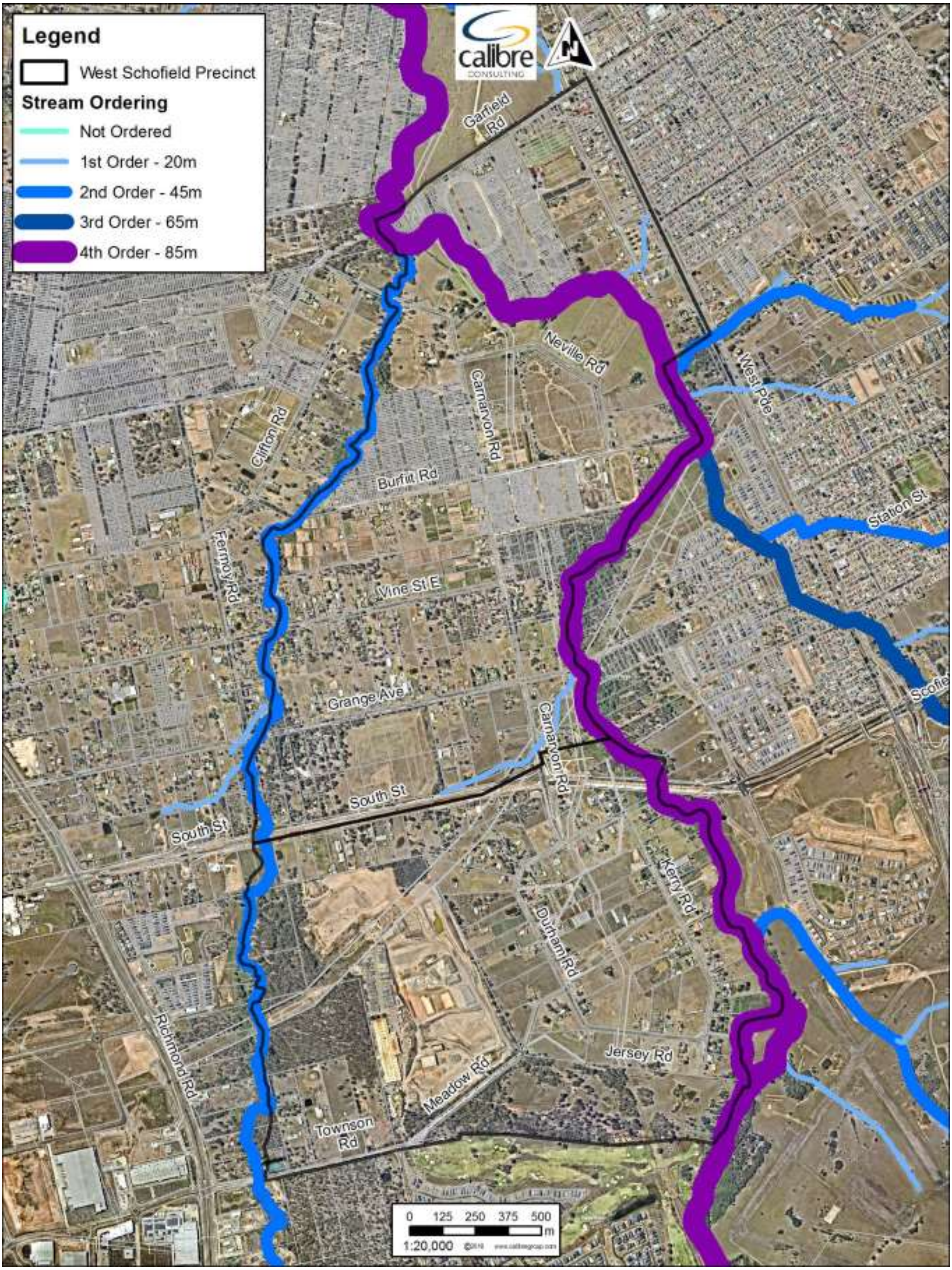


Figure 7.2: West Schofields Precinct Plan showing stream ordering

7.2 Riparian Characteristics

This section describes the geomorphologic characteristics of Eastern and Bells Creeks in the location of the West Schofields Precinct.

7.2.1 Eastern Creek Riparian Characteristics

Eastern Creek along the length of the West Schofields Precinct is a deep channel, scoured within the floodplain of the Hawkesbury River. Eastern Creek exhibits several geomorphologic characteristics alongside the precinct. These characteristics have been mapped using aerial photography and site inspections undertaken by Calibre staff in 2017. Mapping of the various characteristics of Eastern Creek is presented in Figure 7.3 to Figure 7.5, along with a discussion of the creek forms and photographs taken during field investigations.

Eastern Creek Upper Section – Golf Course to Schofields Road

The upper section of Eastern Creek is bordered on the eastern bank by Air Services Australia land (Department of Defence) and to the west by rural residential land. This section of the creek is primarily relatively deep and fast moving, with steep banked, with casuarina and larger trees limited to the banks. The floodplain is primarily cleared grazing or residential land, or in the case of the Defence land, cleared for other purposes. Photographs taken in the field showing examples of this are presented in Figure 7.3 and Figure 7.4, along with descriptions of geomorphologic features.

Eastern Creek Lower Section –Schofields Road to Confluence with Bells Creek

The lower section of Eastern Creek is bordered to the east by the Bridge Street development and includes the confluence of a large tributary that takes flow from the township of Schofields. A large amount of residential development is occurring to the east of this section. Lower sections downstream of Grange Avenue bridge, include casuarina on western bank and pasture grasses on eastern bank. There are also sections of creek with very large Eucalypt trees on banks, with trees and banks covered by invasive weed species. Photographs taken in the field showing examples of this are presented in Figure 7.5, along with descriptions.

7.2.2 Bells Creek Riparian Characteristics

Bells Creek exhibits several geomorphologic characteristics along the length of the West Schofields Precinct. These characteristics have been mapped using aerial photography and site inspections undertaken by Calibre staff in 2017. Mapping of the various characteristics of Bells Creek is presented in Figure 7.6 to Figure 7.8, along with a discussion of the creek forms and photographs taken during field investigations.

Bells Creek Upper Section – Townson Road to Schofields Road

The section of Bells Creek immediately downstream of the Townson Road culverts, extending downstream approximately 500 metres to the electricity easement is characterised by scour at the base of the channel, eroded banks and remnant Shale Plains Woodland on the eastern side of the creek (within the West Schofields Precinct).

The section of Bells Creek downstream of the electricity easement to the South Street (Schofields Road extension) is characterised by narrow channel sections, shallow and often eroded to bedrock, meandering through a flat floodplain. Vegetation and landforms on both creeks has been modified by farming and other activities. Photographs taken in the field showing examples of this are presented in Figure 7.6 and Figure 7.7, along with descriptions of geomorphologic features.

Bells Creek Lower Section –Schofields Road to Confluence with Eastern Creek

Bells Creek downstream of South Street (upgraded Schofields Road) is relatively consistent in shape and structure. The base of the channel is shallow and often contains vegetation, with sections of riffle zones eroded to bedrock. The creek banks are shallow and steep, with a broad floodplain containing remnant vegetation, including trees and shrub species, along with grasses and weed species, dependent on land use practices. Highly eroded sections are present where livestock have been kept adjacent to the creek. The creek was generally more eroded within the floodplain moving downstream towards the confluence with Eastern Creek. Photographs taken in the field showing examples of this are presented in Figure 7.8, along with descriptions.

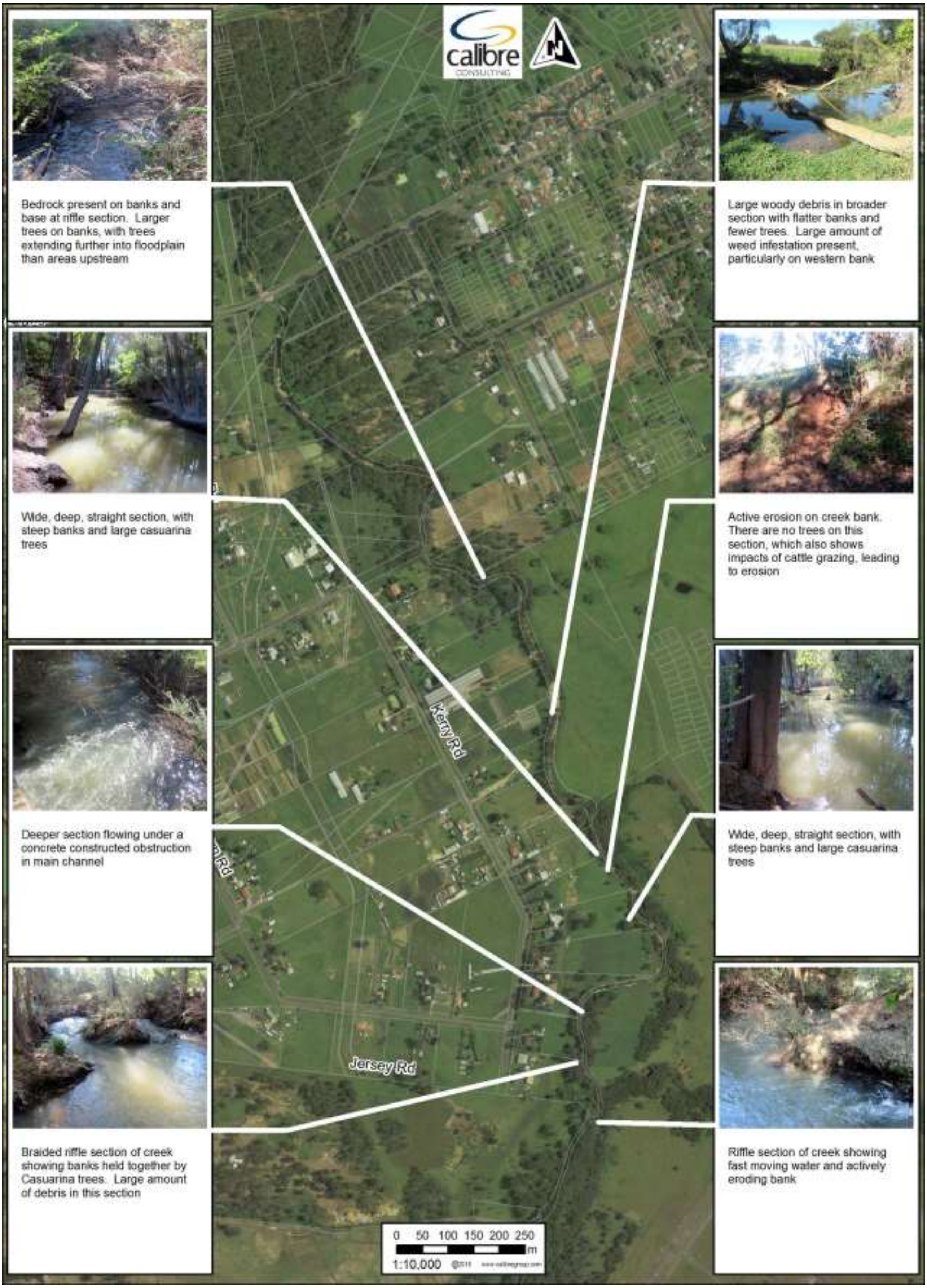


Figure 7.3: Eastern Creek Riparian Corridor Characteristics (Golf Course to Schofields Road 1 of 2)

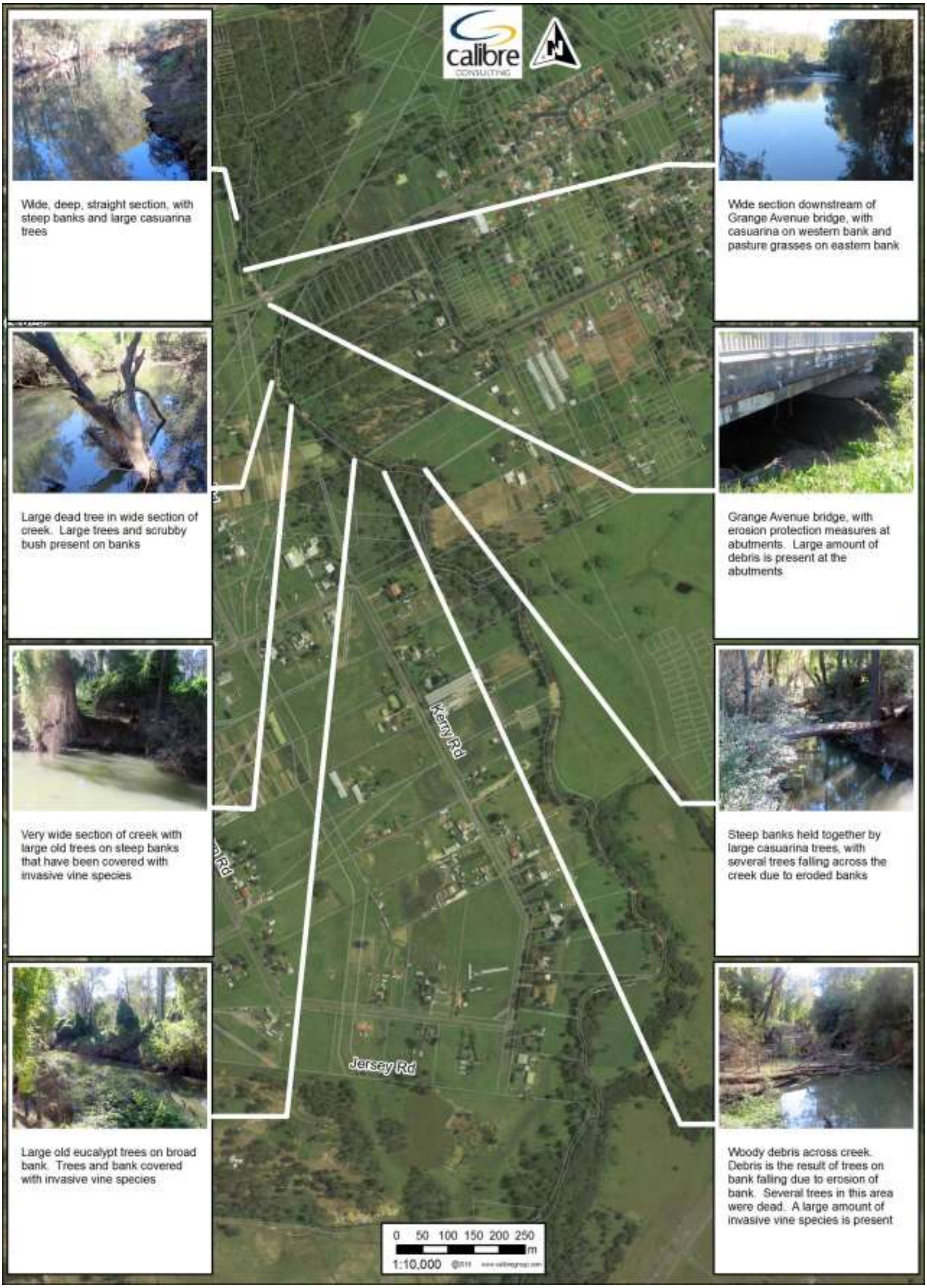


Figure 7.4: Eastern Creek Riparian Corridor Characteristics (Golf Course to Schofields Road 2 of 2)

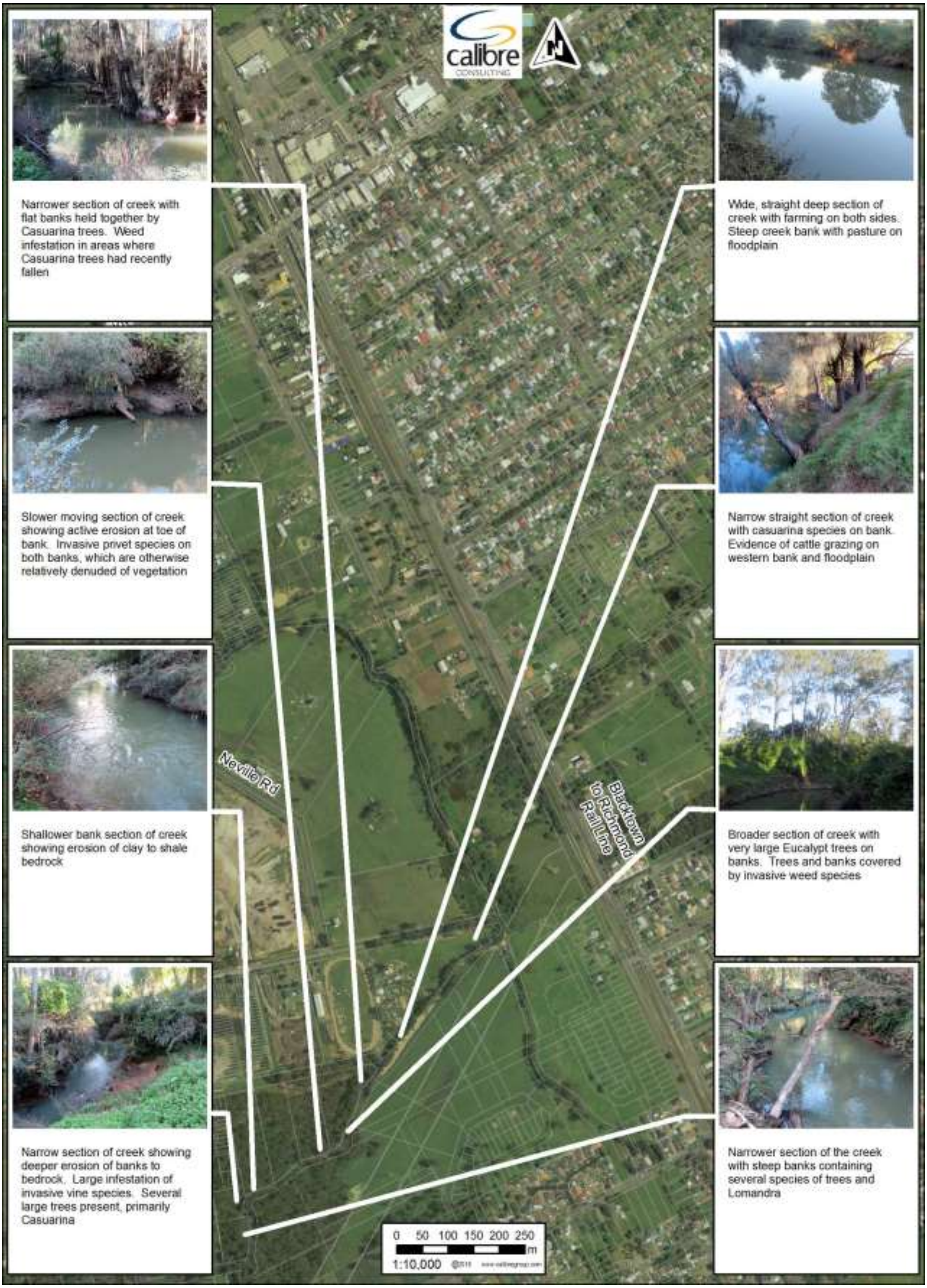


Figure 7.5: Eastern Creek Riparian Corridor Characteristics (Schofields Road to Confluence with Bells Creek)

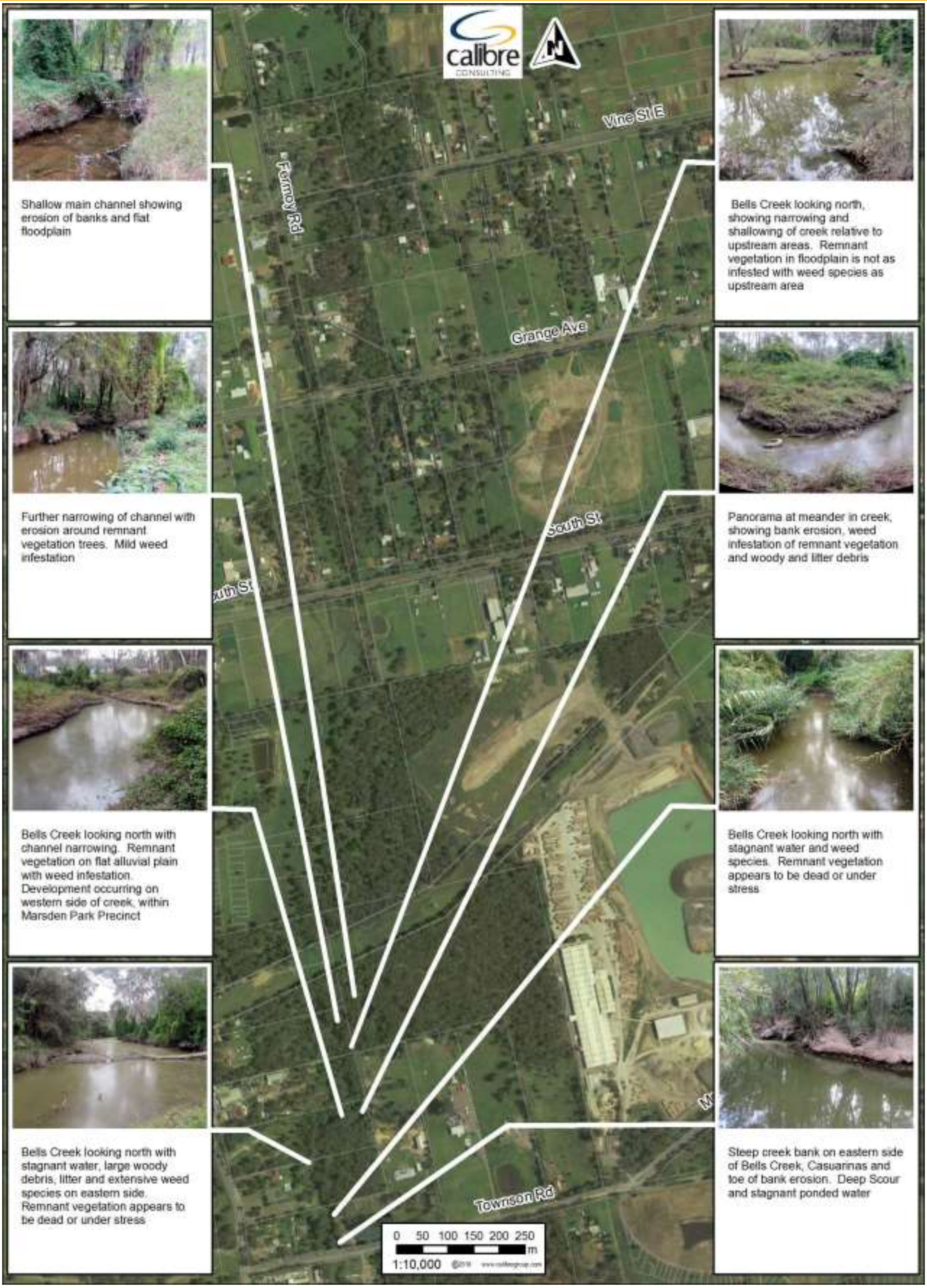


Figure 7.6: Bells Creek Riparian Corridor Characteristics (Townson Road to Schofields Road 1 of 2)

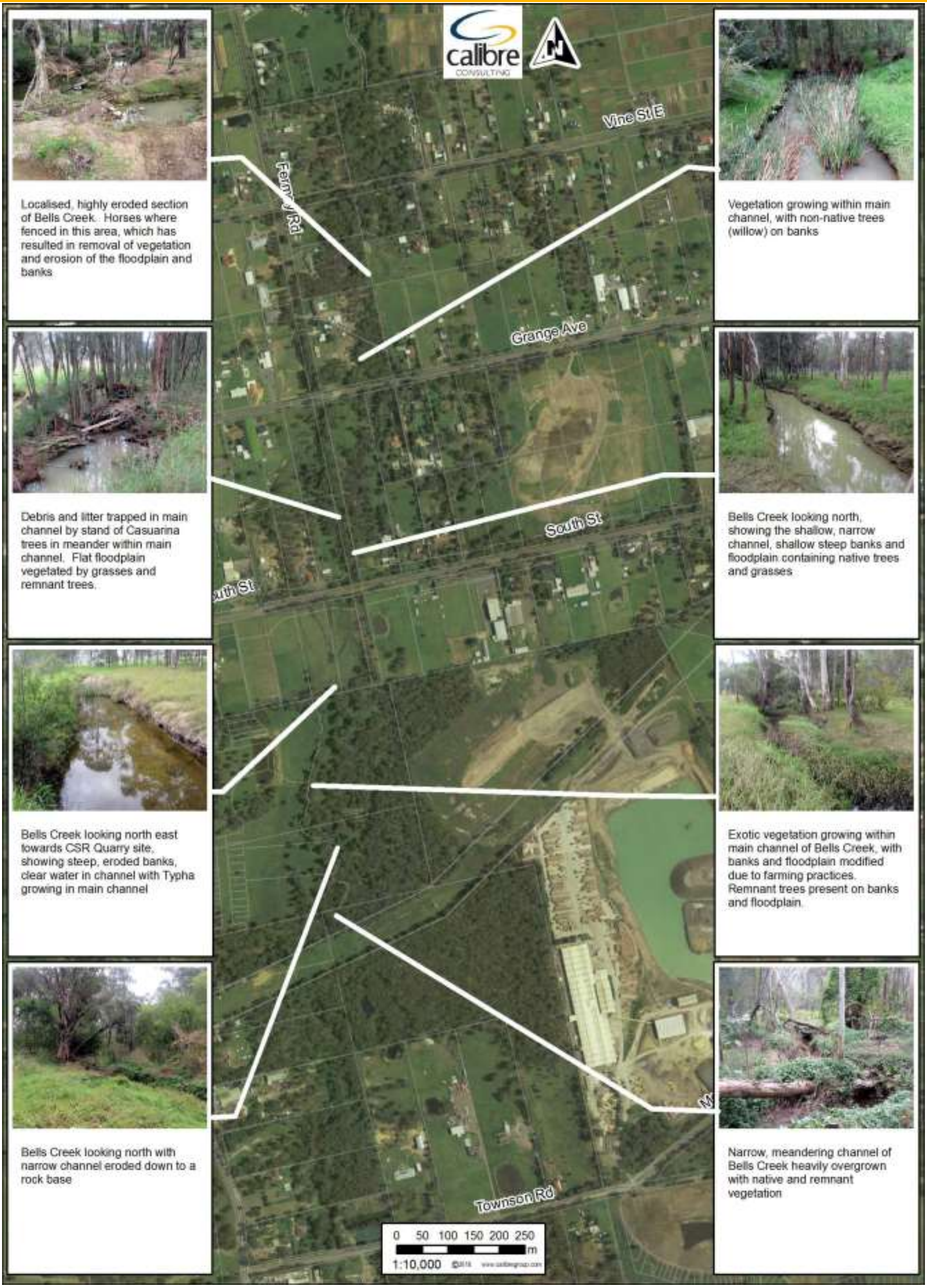


Figure 7.7: Bells Creek Riparian Corridor Characteristics (Townson Road to Schofields Road 2 of 2)

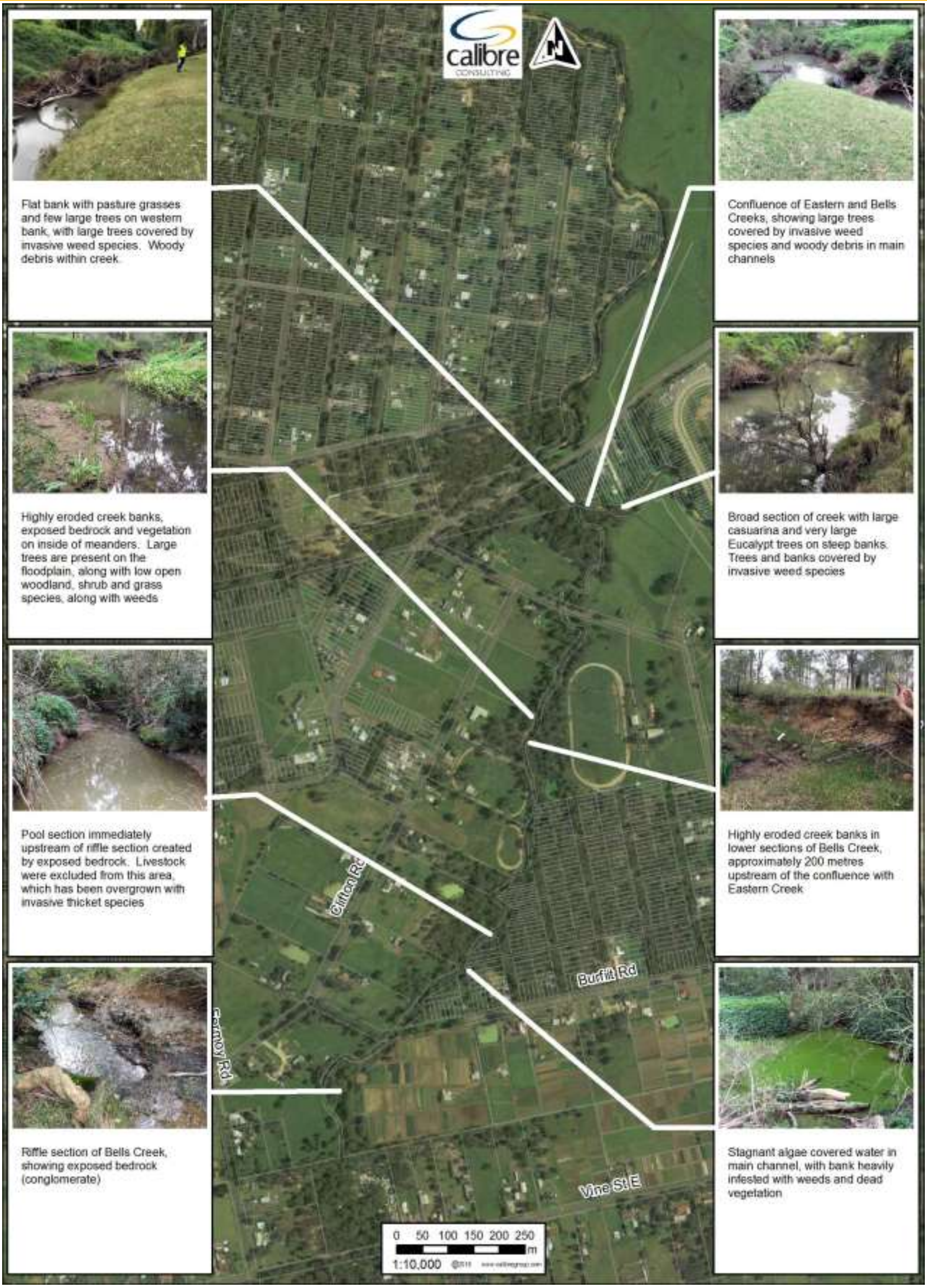


Figure 7.8: Bells Creek Riparian Corridor Characteristics (Schofields Road to Confluence with Eastern Creek)

7.3 Geomorphology Mapping

A detailed geomorphologic modelling investigation of Eastern and Bells Creeks has been undertaken as part of the precinct planning process in order to determine the overall stability and erosion potential in the area of the precinct. This investigation, including detailed mapping of the full range of modelled events in provided in Appendix D.

The geomorphologic mapping of Eastern and Bells Creeks outlined in Sections 7.3.1 and 7.3.2 summarises the outcomes of this investigation and describes the modelled creek characteristics in relation to the precinct plan. Mapping of the bed shear (a measure of the average tractive force in a creek. It can be directly related to the size of granular material (e.g. silt, sands, gravels) at incipient motion, i.e. the force from water flow that creates movement of the bed material at the base of the creek. Shear stress action affects the banks as well as the base of the channel and account needs to be taken into consideration on the side slopes of channels and the increased shearing action which occurs on the outer banks of bends.

Shear stress within Eastern and Bells Creeks have been mapped using the flow rates calculated in the *XP-RAFTS* model discussed in Section 5.1 and the flood model described in Section 5.2. Mapping was prepared using average shear stress for the following storm events:

- 2 year
- 5 year
- 10 year
- 20 year
- 50 year
- 100 year
- 500 year
- Probable Maximum Flood

No weighting was given to any of the storm events in averaging the results presented in Sections 7.3.1 and 7.3.2. This approach accounts for the impact of lower energy, more frequent events and the less frequent, higher energy events in identifying areas of high erosion potential.

Shear stress modelled within the channel is related to thresholds of the stability of surface features such as soil and vegetation. These thresholds, published by Brisbane City Council, are provided on the mapping on Figure 7.9.

7.3.1 Eastern Creek Geomorphology

Mapping of the average shear stress within Eastern Creek shown on Figure 7.9 indicate that erosive potential within the main channel encounters forces in excess of the capacity of grassed channels and gravels to withstand. Higher erosion potential is encountered at the bends within the main channel and in flow constrictions such as bridges.

The mapping on Figure 7.9 includes the location of the basin outlets included in the Indicative Layout Plan. Management measures for each outlet are discussed in Section 7.4.

7.3.2 Bells Creek Geomorphology

Mapping of the average shear stress within Bells Creek shown on Figure 7.9 indicate that erosive potential within the main channel encounters forces within the capacity of grassed channels and gravels to withstand. Higher erosion potential is encountered at the lower reaches of the main channel, downstream of Grange Avenue

The mapping on Figure 7.9 includes the location of the basin outlets included in the Indicative Layout Plan. Management measures for each outlet are discussed in Section 7.4.

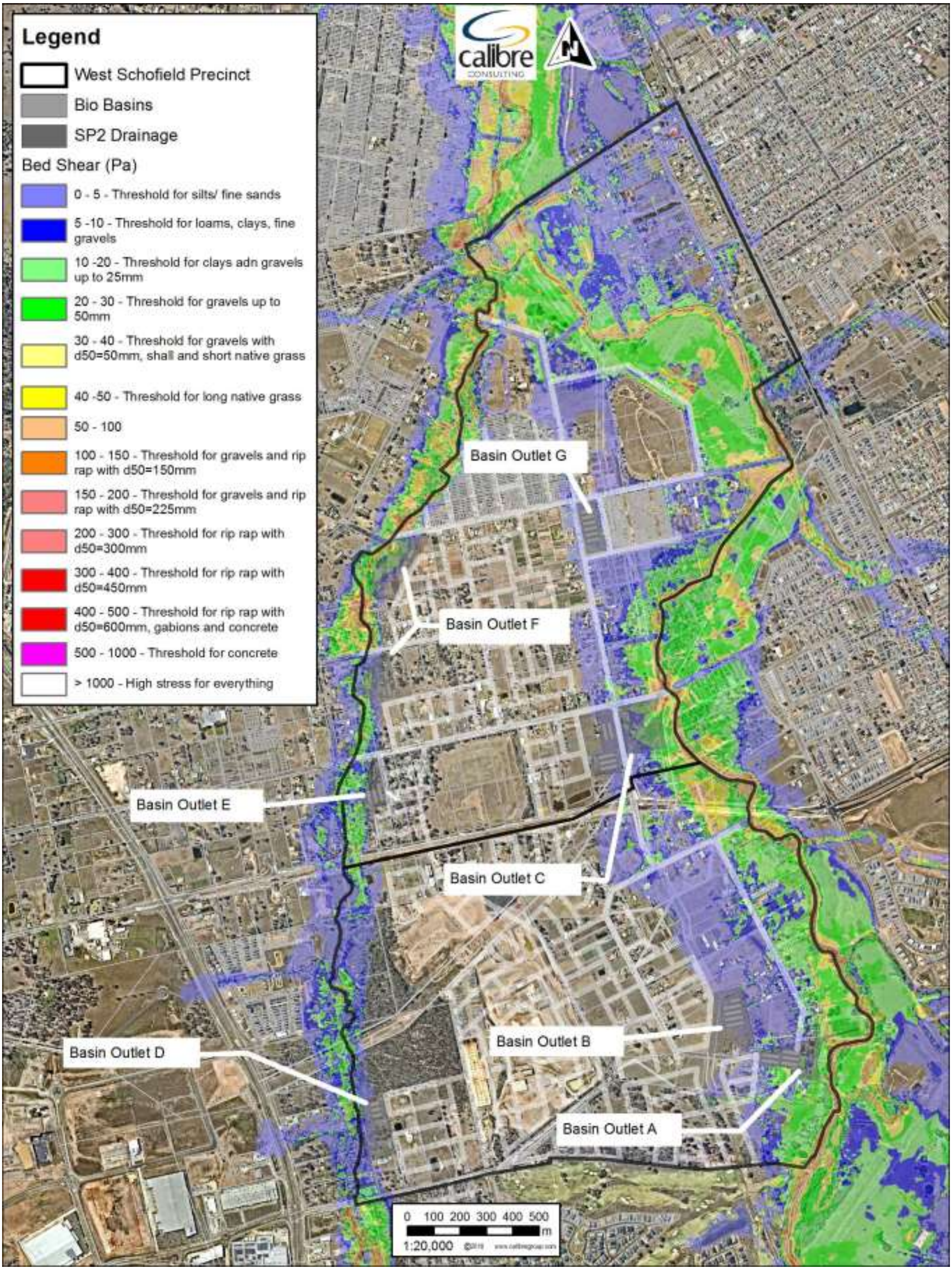


Figure 7.9: Geomorphology Map

7.4 Waterfront Lands Strategy and Riparian Corridor Precinct Design Outcomes

The Indicative Layout Plan has been developed to accommodate the riparian corridor setbacks, shown in Figure 7.2, along with the environmental constraints shown on Figure 4.2 and flood extents presented on Figure 5.5. The development pattern is controlled by flooding and vegetation setbacks, with no additional requirements for riparian constraints necessary for development patterns.

Riparian management measures do include controls relating to discharge locations from bio-retention basins and overland flow paths.

Eastern Creek Management Measures

Riparian corridor management measures for Eastern Creek for each basin outlet should include the following measures:

- The Basin A/B outlet to Eastern Creek is required to accommodate the following measures
  - The outlet for Basins A and B is located at a meander on Eastern Creek, in the location of the proposed Townson Road link to Burdekin Road, located to the east of the precinct.
  - The erosive potential in this area of the creek is around the threshold for gravels.
  - The creek in this area is comprised of pool and riffle systems.
  - The combined outlet from Basins A and B should incorporate a constructed riffle zone, in the location of an existing riffle.
- The Basin C outlet to Eastern Creek is required to accommodate the following measures
  - The outlet for Basin C is proposed to be upstream of the existing bridge on Grange Avenue.
  - This outlet should in incorporated into the re-design of the Grange Avenue bridge crossing and should include measures to prevent erosion upstream and downstream of the bridge.
  - The new bridge structure should also incorporate measures to prevent blockage and build-up of debris, which can result in altered flow patterns of the creek, resulting in in erosion and sedimentation.
- The Basin G outlet to Eastern Creek is required to accommodate the following measures
  - The outlet location for Basin G is within a deep, straight section of Eastern Creek.
  - The outlet should be designed to avoid any erosion of the bank on either side of the creek, or to alter the direction of flows in the creek.

Bells Creek Management Measures

Riparian corridor management measures for Bells Creek for each basin outlet should include the following measures:

- The Basin D outlet to Bells Creek is required to accommodate the following measures
  - The outlet for Basin D is located in an area of wide, slow moving or stagnant water, with creek banks heavily infested with weed species.
  - The erosive potential of the creek in this area is low
  - The outlet should aim to rehabilitate the creek banks, removing weed species and should not introduce rock to within the channel
- The Basin E outlet to Bells Creek is required to accommodate the following measures
  - The outlet for Basin E is located in an area of Bells Creek characterised by narrow, vegetated main channel
  - The outlet should incorporate vegetation and reduce erosion potential of basin outflows by reducing velocity
- The Basin F outlets to Bells Creek is required to accommodate the following measures
  - The outlets for Basin F are in vegetated areas, with narrow shallow creek sections, with areas impacted by vegetation
  - The outlet should incorporate vegetation and reduce erosion potential of basin outflows by reducing velocity

8 Conclusion and Recommendations

The Indicative Layout Plan prepared by URBIS as part of the precinct planning process has been prepared to accommodate the input from planning and specialist studies, including this flooding, water cycle management and riparian corridor assessment. The Indicative Layout Plan is provided in Figure 2.2.

Key issues to note on the Indicative Layout Plan, as they relate to this flooding and water cycle management are:

- The location of developed land, above the 100 year flood level (discussed in Section 5)
- The location of stormwater treatment basins (discussed in Section 6)
- The road layout, incorporating north–south roads to allow flood evacuation (discussed in Section 5.4)

Flooding

The planning constraints resulting from the outcomes of the flood modelling investigations carried out as part of the precinct planning process have been incorporated in the development of the Indicative Layout Plan. These flood constraints include:

- Restriction of residential and commercial development to areas not inundated during the 100 year flood event
- Layout of the road network to allow flood evacuation during extreme flood events

The developed scenario flood modelling indicates that the precinct layout shown on the Indicative Layout Plan does not result in inundation of areas that are not flooded in existing conditions.

Water Cycle Management

The planning outcomes resulting from the water cycle management study and design carried out as part of the precinct planning process have been incorporated in the development of the Indicative Layout Plan. These measures include:

- Incorporation of source control features including rainwater tanks. street trees and permeable landscape features
- Layout of a traditional pit, pipe and overland flow network
- Three drainage crossings of the oil and gas pipelines located within the precinct
- A total of six water quality (bio-retention) basins incorporating gross pollutant traps, filter media and vegetation, including open water bodies for the potential re-use of harvested stormwater for sports field irrigation

The developed scenario water quality modelling indicates that the precinct layout shown on the Indicative Layout Plan will incorporate water cycle management features able to meet pollutant removal targets.

Riparian Corridor Assessment

The Indicative Layout Plan has been developed to accommodate the riparian corridor setbacks, shown in Figure 7.2, along with the environmental constraints shown on Figure 4.2 and flood extents presented on Figure 5.5. The development pattern is controlled by flooding and vegetation setbacks, with no additional requirements for riparian constraints necessary for development patterns.

Riparian management measures include controls relating to discharge locations from bio-retention basins and overland flow paths.

Recommendation

The Indicative Layout Plan incorporates measures to address the flooding, water quality and riparian corridor requirements for approval by the Department of Planning and Environment, along with Blacktown City Council and other stakeholders. The results of technical investigations developed as part of the precinct planning process, and the modelling of the measures outlined in this report demonstrate that the West Schofields Precinct Plan is suitable for consideration and approval by relevant determining authorities.

FLOODING, WATER CYCLE MANAGEMENT AND RIPARIAN CORRIDOR ASSESSMENT

Appendix A Model Summary Sheet

DEPARTMENT OF PLANNING AND ENVIRONMENT

16-000352 – WEST SCHOFIELDS
MODEL SUMMARY SHEET – 18 MAY 2018

Date:	18 May 2018	**Prepared By:**	Daniel Hoogesteger
Distribution:	Sarah Waterworth	DPE	
	Nigel Bosworth Daniel Hoogesteger	Calibre Consulting Calibre Consulting	

Criteria/Parameter/ Type	Value/Description	Source/link	Comments/departures
Models used			
TUFLOW	TuFLOW folder on external drive		Calibre model based on TuFLOW model provided by Blacktown City Council Version: TuFLOW.2013-12-AD-w64
RORB/XP-RAFTS	Eastern_Creek_EC.xp		Provided by Council
Topography			
Coordinate System	MGA Zone 56 GDA 94		
Work-as-ex design for current project	Bridge St Development final work-as-executed design Tin	Extracted from the Calibre Consulting project and exported as a .12da tin	tin WAE 151104.12da
Ground survey	Photometric Data (provided by AAM)	Provided as an xyz scatter set and a .dwg with 3d break lines	This data was read into a separate 12D model tinned and exported as a .12da file Meta data readme file in tins folder. AAM_data.12da
Preliminary Lot and road grading	Calibre preliminary lot grading used in initial runs		Preliminary data only, data overwritten by AAM data ROAD.12da
Ground survey	Lidar Data	LPI data MKP data sets for tiles from the NepeanRiverEAST2011-MKP data set for grids 2986264 3006264 3026264 3046264 2986266 3006266 3026266 3046266 2986268 3006268 3026268 2986270 3006270 3026270 2986272 3006272 3026272 2986274 3006274 3026274	This data was read into a separate 12D model tinned and exported as a .12da files. lidar.12da additional lidar.12da .xf8 from existing Council model not used
Existing culverts under road			Extracted from supplied Council model

16-000352 – WEST SCHOFIELDS
MODEL SUMMARY SHEET – 18 MAY 2018

Recurrence Interval			
IFD Coefficients	50yr 1hr – 59.8 50yr 12hr – 13.3 50yr 72hr – 4.5 100yr 1hr – 30.7 100yr 12hr – 6.8 100yr 72hr – 2 G – 0.01 f2 – 4.3 f50 – 15.82	Blacktown City Council XP-RAFTS model	The TuFLOW model used the SA polygons and inflow boundaries as extracted from the existing Blacktown City Council XP-RAFTS model.
PMF	PMF 30min – 320mm/hr PMF 1hr – 250mm/hr PMF 1.5hr – 193mm/hr PMF 2hr – 165mm/hr PMF 3hr – 123mm/hr PMF 4.5hr – 96mm/hr PMF 6hr – 80mm/hr	Blacktown City Council XP-RAFTS model	The TuFLOW model used the SA polygons and inflow boundaries as extracted from the existing Blacktown City Council XP-RAFTS model.
Design ARI	100yr 500yr PMF	BC Database was extracted from existing Council provided model	
Durations modelled			
Storm events	100yr 6 hour, 500yr 6 hour, PMF 1 hour		6 hour determined to be critical for 100 and 500 year, 1 hour for PMF
Climate Change Scenarios Modelled			
Council defined storm events	100yr +5% 100yr +10% 100yr +20%	Scenarios provided in Blacktown City Council XP-RAFTS model	
Roughness			
One dimensional roughness	Applied individually to each item in 1D network.	Extracted from Council's provided model	Refer to mapping/surface feature West_Schofields.ecf 1d_nwke_Structures_000.mif
Land use Categoriation	Urban Re-development		
Floodplain roughness	Default material n= 0.1 Roads n=0.02 Urban lots n=0.02	Extracted from Council's provided model	2d_mat_roads.mif
Aerial photography			
Google satellite/Nearmap	-Nearmap has been downloaded to the project directory in W: drive	-	List details of aerial required to use in final mapping
Site Inspections			
27/04/2016	29/06/2016	24/02/2017	17/03/2017
12/05/2017	16/05/2017		

16-000352 – WEST SCHOFIELDS
MODEL SUMMARY SHEET – 18 MAY 2018

Recurrence Interval			
Building obstructions			
Buildings mapped from Lidar data and nulled from model	-	*ARR Project 15* *2d_bc_buildings.mif*	
Grid size			
grid	5m grid, x=8250, y=12150, Origin = 297855.00,6263980.00 Angle = 0.00		
Boundary conditions			
Upstream	SA polygons and BC boundaries extracted from Blacktown Council model.	SA mi\2d_sa_2d_sa_NWGC_000.mif BC 2d_bc_NWGC_USInflows_000.mif 2d_revised_1d_inflow_000.shp	
Downstream	BC boundary and HT relationship extracted from Blacktown council model.	BC 2d_bc_NWGC_EasternCkDS1.MIF	Downstream IWL: 2yr – 9.0m (AHD) 5yr – 10.9m (AHD) 10yr – 12.3m (AHD) 20yr – 13.7m (AHD) 50yr – 15.7m (AHD) 100yr – 17.3m (AHD) 500yr – 20.2m (AHD) PMF – 26.4m (AHD)
Hazard Categorisation			
No Hazard mapping currently undertaken.			To be completed as part of future work.
Previous studies or modelling investigations			
External	Previous studies provided to compare with current results	Blacktown City Council model provided for Eastern Creek as basis for Calibre Consulting's model	-
Calibre/Brown	No previous studies provided to compare with current results		Bridge Street WAE used

FLOODING, WATER CYCLE MANAGEMENT AND RIPARIAN CORRIDOR ASSESSMENT

Appendix B Council Modelling Comparison and Climate Change Sensitivity Mapping

DEPARTMENT OF PLANNING AND ENVIRONMENT

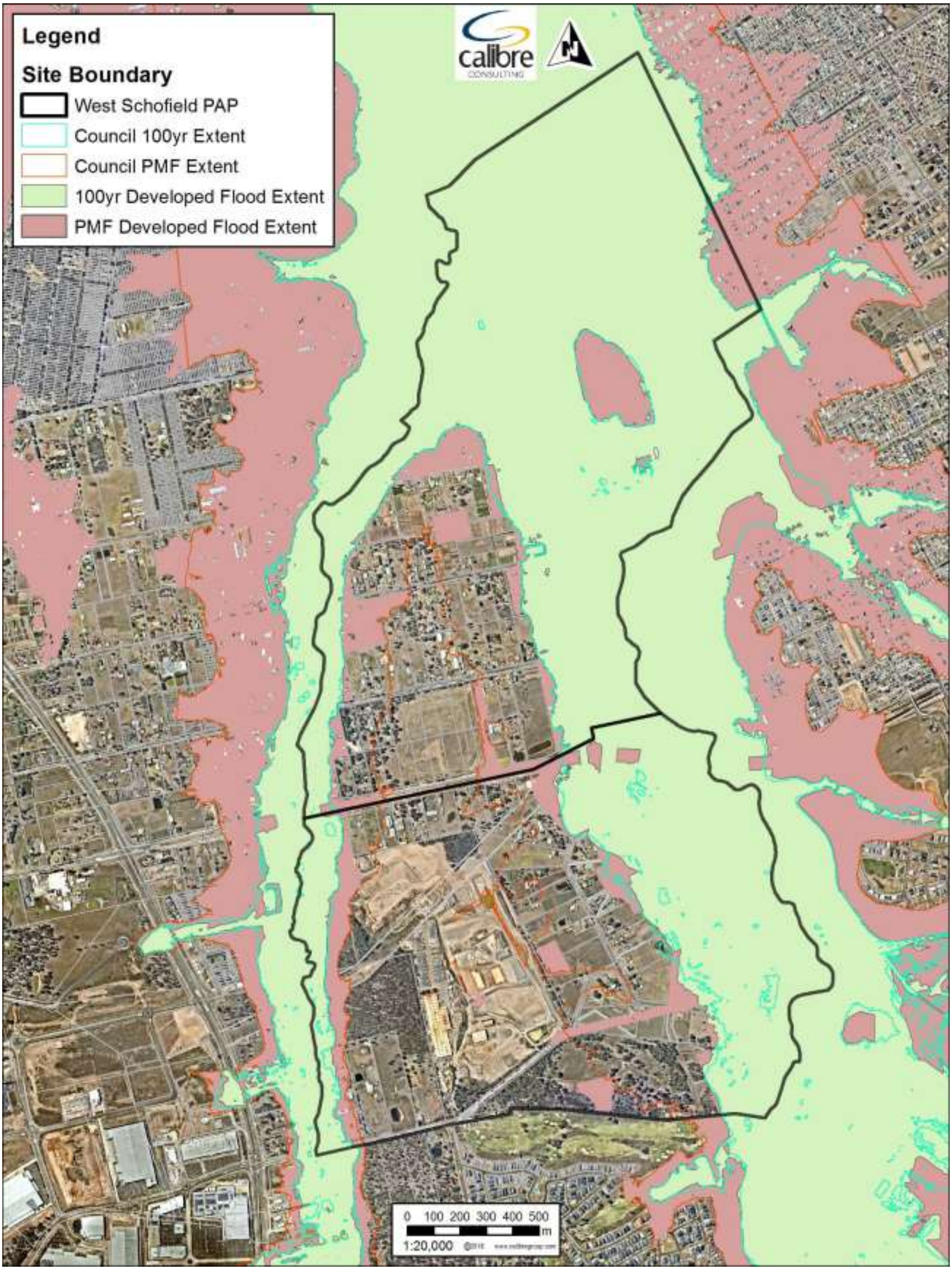


Figure B.1: Comparison with Council flood modelling

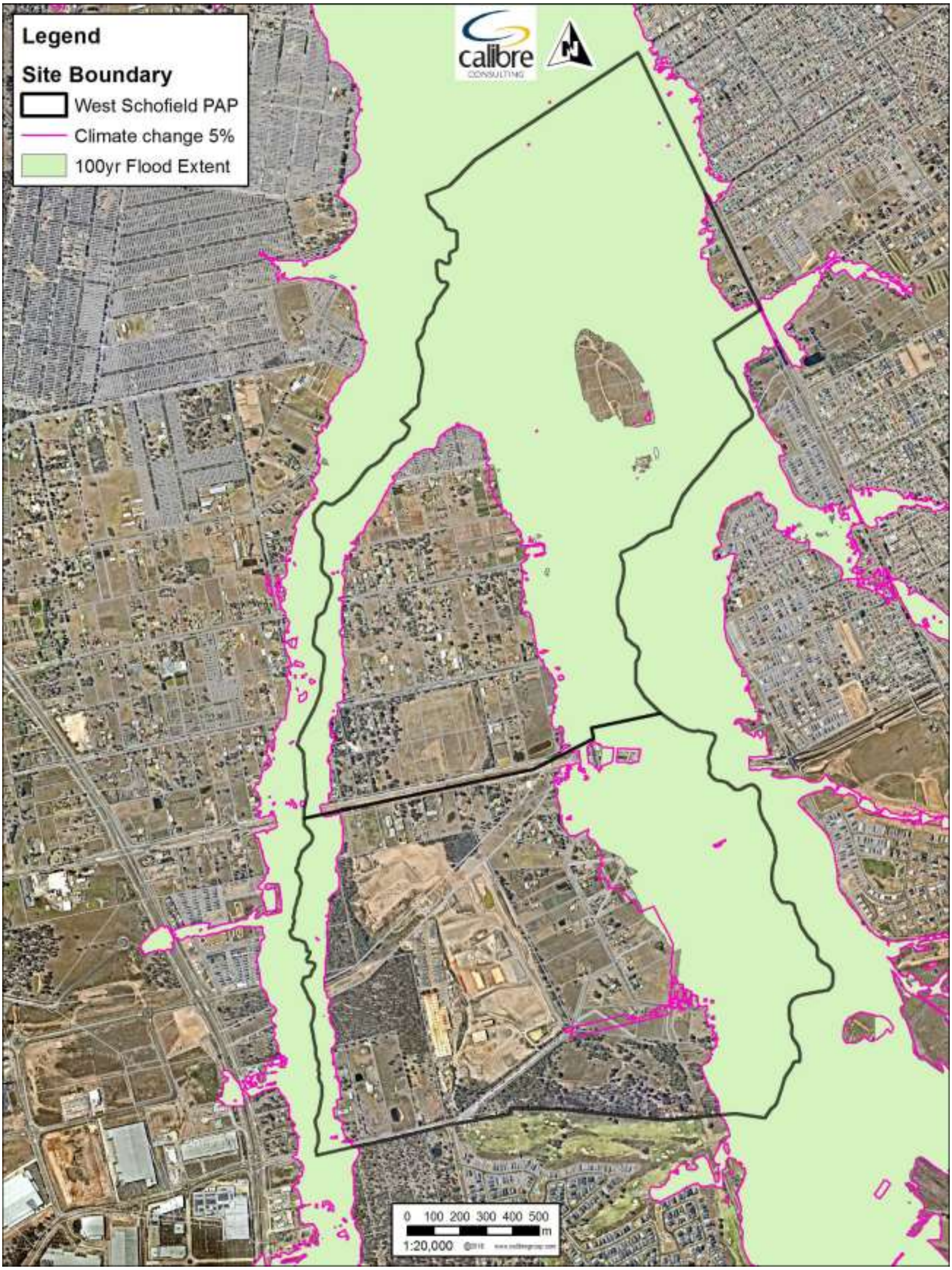


Figure B.2: Climate Change 5% increase in rainfall

Figure B.3: Climate Change 10% increase in rainfall

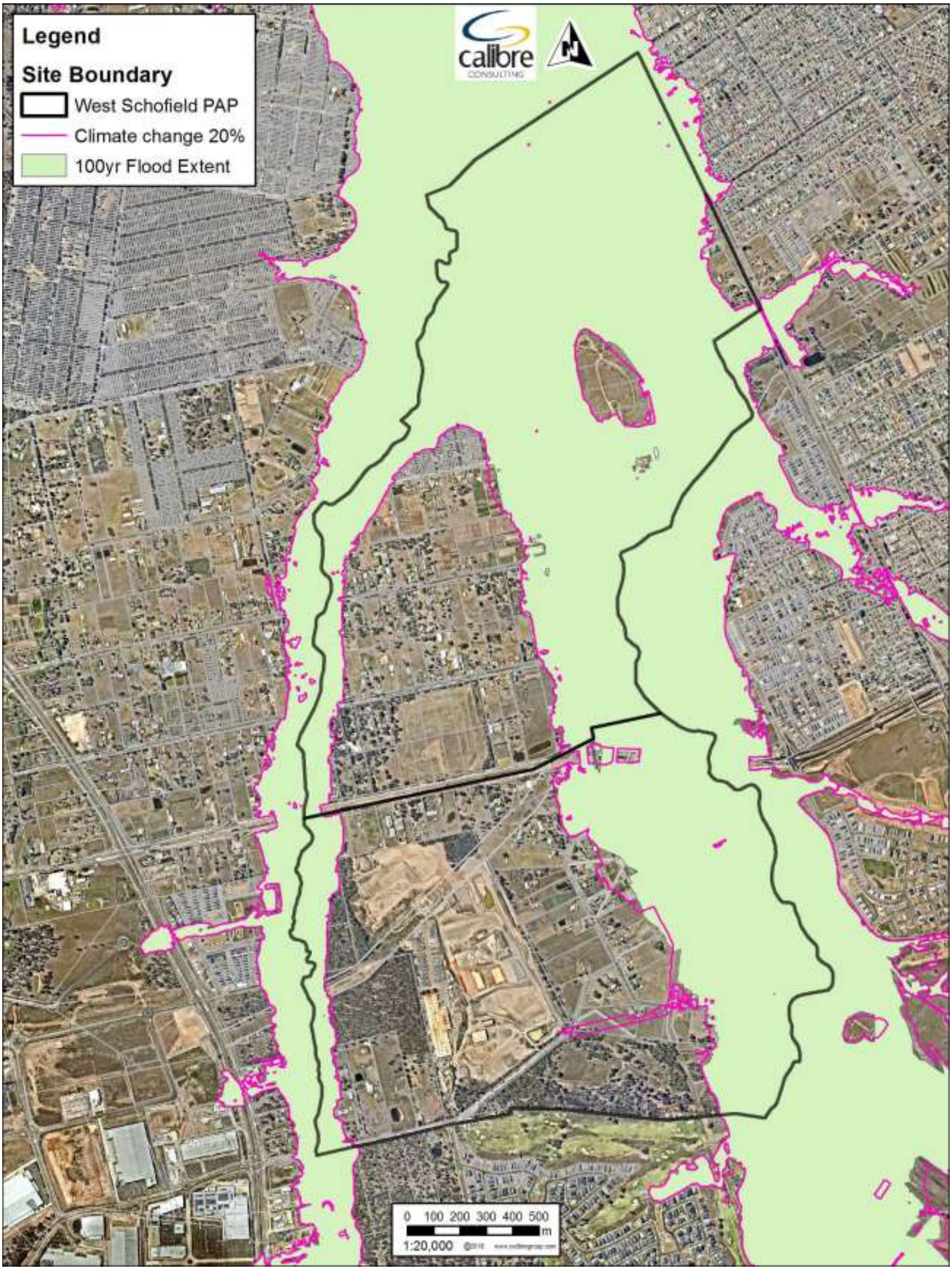


Figure B.4: Climate Change 20% increase in rainfall

FLOODING, WATER CYCLE MANAGEMENT AND RIPARIAN CORRIDOR ASSESSMENT

Appendix C Preliminary Costing of Drainage Infrastructure

DEPARTMENT OF PLANNING AND ENVIRONMENT

Figure C.5: Basin A

Preliminary s94 Potential Cost - Basin A

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 75,000	$ 75,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 50,000	$ 50,000
SUBTOTAL				$ 150,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$100,000	$ 100,000
EROSION AN SEDIMENT CONTROL	1	Item	$50,000	$ 50,000
SUBTOTAL				$ 150,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	45700	m3	$55	$ 2,513,500
BULK EARTHWORKS - Pond	35000	m3	$55	$ 1,925,000
SUBTOTAL				$ 4,438,500
ROADWORKS - Maintenance Access				
GROUNDWORKS	5000	m2	$150	$ 750,000
PAVING	5000	m2	$60	$ 300,000
SUBTOTAL				$ 1,050,000
STORMWATER DRAINAGE				
MAJOR CULVERT	3	item	$50,000	$ 150,000
TRUNK DRAINAGE	2100	m	$500	$ 1,050,000
OIL/GAS PIPELINE CROSSING	1	item	$500,000	$ 500,000
SUBTOTAL				$ 1,700,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	4900	m2	$250	$ 1,225,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	2500	m	$50	$ 125,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,775,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$1,000,000	$ 1,000,000
OPEN WATER BODY	1	item	$250,000	$ 250,000
SUBTOTAL				$ 1,250,000
TOTAL				$ 10,513,500
CONTINGENCY				$ 2,102,700
GRAND TOTAL				**$ 12,616,200**

Figure C.6: Basin B

Preliminary s94 Potential Cost - Basin B

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 75,000	$ 75,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 50,000	$ 50,000
SUBTOTAL				$ 150,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$150,000	$ 150,000
EROSION AN SEDIMENT CONTROL	1	Item	$50,000	$ 50,000
SUBTOTAL				$ 200,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	30200	m3	$55	$ 1,661,000
BULK EARTHWORKS - Pond	27200	m3	$55	$ 1,496,000
SUBTOTAL				$ 3,157,000
ROADWORKS - Maintenance Access				
GROUNDWORKS	3000	m2	$150	$ 450,000
PAVING	3000	m2	$60	$ 180,000
SUBTOTAL				$ 630,000
STORMWATER DRAINAGE				
MAJOR CULVERT	1	item	$50,000	$ 50,000
TRUNK DRAINAGE	2400	m	$500	$ 1,200,000
OIL/GAS PIPELINE CROSSING	1	item	$500,000	$ 500,000
SUBTOTAL				$ 1,750,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	4700	m2	$250	$ 1,175,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	2300	m	$50	$ 115,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,715,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$1,000,000	$ 1,000,000
OPEN WATER BODY	1	item	$250,000	$ 250,000
SUBTOTAL				$ 1,250,000
TOTAL				$ 8,852,000
CONTINGENCY				$ 1,770,400
GRAND TOTAL				**$ 10,622,400**

Figure C.7: Basin C

Preliminary s94 Potential Cost - Basin C

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 100,000	$ 100,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 50,000	$ 50,000
SUBTOTAL				$ 175,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$250,000	$ 250,000
EROSION AN SEDIMENT CONTROL	1	Item	$50,000	$ 50,000
SUBTOTAL				$ 300,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	45500	m3	$55	$ 2,502,500
BULK EARTHWORKS - Pond	38200	m3	$55	$ 2,101,000
SUBTOTAL				$ 4,603,500
ROADWORKS - Maintenance Access				
GROUNDWORKS	3000	m2	$150	$ 450,000
PAVING	3000	m2	$60	$ 180,000
SUBTOTAL				$ 630,000
STORMWATER DRAINAGE				
MAJOR CULVERT	5	item	$50,000	$ 250,000
TRUNK DRAINAGE	3550	m	$500	$ 1,775,000
OIL/GAS PIPELINE CROSSING	1	item	$750,000	$ 750,000
SUBTOTAL				$ 2,775,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	4800	m2	$250	$ 1,200,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	2500	m	$50	$ 125,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,750,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$1,000,000	$ 1,000,000
OPEN WATER BODY	1	item	$250,000	$ 250,000
SUBTOTAL				$ 1,250,000
TOTAL				$ 11,483,500
CONTINGENCY				$ 2,296,700
GRAND TOTAL				**$ 13,780,200**

Figure C.8: Basin D

Preliminary s94 Potential Cost - Basin D

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 50,000	$ 50,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 25,000	$ 25,000
SUBTOTAL				$ 100,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$50,000	$ 50,000
EROSION AN SEDIMENT CONTROL	1	Item	$25,000	$ 25,000
SUBTOTAL				$ 75,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	900	m3	$55	$ 49,500
BULK EARTHWORKS - Pond	0	m3	$55	$ -
SUBTOTAL				$ 49,500
ROADWORKS - Maintenance Access				
GROUNDWORKS	1500	m2	$150	$ 225,000
PAVING	1500	m2	$60	$ 90,000
SUBTOTAL				$ 315,000
STORMWATER DRAINAGE				
MAJOR CULVERT	1	item	$50,000	$ 50,000
TRUNK DRAINAGE	1300	m	$500	$ 650,000
OIL/GAS PIPELINE CROSSING	0	item	$750,000	$ -
SUBTOTAL				$ 700,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	1700	m2	$250	$ 425,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	750	m	$50	$ 37,500
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 887,500
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$150,000	$ 150,000
OPEN WATER BODY	0	item	$0	$ -
SUBTOTAL				$ 150,000
TOTAL				$ 2,277,000
CONTINGENCY				$ 455,400
GRAND TOTAL				**$ 2,732,400**

Figure C.9: Basin E

Preliminary s94 Potential Cost - Basin E

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 50,000	$ 50,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 25,000	$ 25,000
SUBTOTAL				$ 100,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$50,000	$ 50,000
EROSION AN SEDIMENT CONTROL	1	Item	$25,000	$ 25,000
SUBTOTAL				$ 75,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	1500	m3	$55	$ 82,500
BULK EARTHWORKS - Pond	0	m3	$55	$ -
SUBTOTAL				$ 82,500
ROADWORKS - Maintenance Access				
GROUNDWORKS	1000	m2	$150	$ 150,000
PAVING	1000	m2	$60	$ 60,000
SUBTOTAL				$ 210,000
STORMWATER DRAINAGE				
MAJOR CULVERT	2	item	$50,000	$ 100,000
TRUNK DRAINAGE	1100	m	$500	$ 550,000
OIL/GAS PIPELINE CROSSING	0	item	$750,000	$ -
SUBTOTAL				$ 650,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	2500	m2	$250	$ 625,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	1000	m	$50	$ 50,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,100,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$150,000	$ 150,000
OPEN WATER BODY	0	item	$0	$ -
SUBTOTAL				$ 150,000
TOTAL				$ 2,367,500
CONTINGENCY				$ 473,500
GRAND TOTAL				**$ 2,841,000**

Figure C.10: Basin F

Preliminary s94 Potential Cost - Basin F

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 50,000	$ 50,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 25,000	$ 25,000
SUBTOTAL				$ 100,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$50,000	$ 50,000
EROSION AN SEDIMENT CONTROL	1	Item	$25,000	$ 25,000
SUBTOTAL				$ 75,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	5100	m3	$55	$ 280,500
BULK EARTHWORKS - Pond	0	m3	$55	$ -
SUBTOTAL				$ 280,500
ROADWORKS - Maintenance Access				
GROUNDWORKS	1500	m2	$150	$ 225,000
PAVING	1500	m2	$60	$ 90,000
SUBTOTAL				$ 315,000
STORMWATER DRAINAGE				
MAJOR CULVERT	2	item	$50,000	$ 100,000
TRUNK DRAINAGE	1250	m	$500	$ 625,000
OIL/GAS PIPELINE CROSSING	0	item	$750,000	$ -
SUBTOTAL				$ 725,000
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	2600	m2	$250	$ 650,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	1100	m	$50	$ 55,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,130,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$150,000	$ 150,000
OPEN WATER BODY	0	item	$0	$ -
SUBTOTAL				$ 150,000
TOTAL				$ 2,775,500
CONTINGENCY				$ 555,100
GRAND TOTAL				**$ 3,330,600**

Figure C.11: Basin G

Preliminary s94 Potential Cost - Basin G

DESCRIPTION		Unit	Rate	Cost (excl GST)
PRELIMINARIES				
CONSTRUCTION MANAGEMENT	1	Item	$ 50,000	$ 50,000
INSPECTION, TESTING & CERTIFICATION	1	Item	$ 25,000	$ 25,000
SURVEYING	1	Item	$ 25,000	$ 25,000
SUBTOTAL				$ 100,000
EARLY WORKS				
DEMOLITION AND CLEARING	1	Item	$100,000	$ 100,000
EROSION AN SEDIMENT CONTROL	1	Item	$45,000	$ 45,000
SUBTOTAL				$ 145,000
BULK EARTHWORKS				
BULK EARTHWORKS - Bio-retention	1250	m3	$55	$ 68,750
BULK EARTHWORKS - Pond	0	m3	$55	$ -
SUBTOTAL				$ 68,750
ROADWORKS - Maintenance Access				
GROUNDWORKS	1500	m2	$150	$ 225,000
PAVING	1500	m2	$60	$ 90,000
SUBTOTAL				$ 315,000
STORMWATER DRAINAGE				
MAJOR CULVERT	2	item	$50,000	$ 100,000
TRUNK DRAINAGE	2425	m	$500	$ 1,212,500
OIL/GAS PIPELINE CROSSING	1	item	$750,000	$ 750,000
SUBTOTAL				$ 2,062,500
WATER QUALITY BASIN				
BIO-RETENTION MEDIA + PLANTING	2600	m2	$250	$ 650,000
BASIN SPILLWAY	1	item	$25,000	$ 25,000
SUBSOIL DRAINAGE	1500	m	$50	$ 75,000
GPT	2	item	$200,000	$ 400,000
SUBTOTAL				$ 1,150,000
OPEN SPACE EMBELLISHMENT				
DRAINAGE LAND	1	item	$150,000	$ 150,000
OPEN WATER BODY	0	item	$0	$ -
SUBTOTAL				$ 150,000
TOTAL				$ 3,991,250
CONTINGENCY				$ 798,250
GRAND TOTAL				**$ 4,789,500**

FLOODING, WATER CYCLE MANAGEMENT AND RIPARIAN CORRIDOR ASSESSMENT

Appendix D Geomorphology Mapping

DEPARTMENT OF PLANNING AND ENVIRONMENT

Geomorphology Modelling

The geomorphology modelling for the precinct planning used the hydraulic models discussed in Section 5.2 with no tail water levels from the Hawkesbury River. Hydraulic modelling of Eastern and Bells Creeks with no tail water gives an estimation of maximum potential bed shear stress in the areas that would normally be influenced by back water.

2 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 2 year critical local storm event with no tail water within the Hawkesbury River, is presented on Figure D.12

The bed shear stress mapping on Figure D.12shows that the 2 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450–600 millimetres.

5 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 5 year critical local storm event with no tail water within the Hawkesbury River, is presented on Figure D.13

The bed shear stress mapping on Figure D.13 shows that the 5 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450-600 millimetres.

10 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 10 year critical local storm event with no tail water within the Hawkesbury River, is presented on.Figure D.14

The bed shear stress mapping on Figure D.14 shows that the 10 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450-600 millimetres.

20 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 20 year critical local storm event with no tail water within the Hawkesbury River, is presented on Figure D.15

The bed shear stress mapping on Figure D.15 shows that the 20 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450-600 millimetres.

50 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 50 year critical local storm event with no tail water within the Hawkesbury River, is presented on Figure D.16.

The bed shear stress mapping on Figure D.16 shows that the 50 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450-600 millimetres.

100 Year Results

The bed shear stress map calculated in the hydraulic modelling of the 100 year critical local storm event with no tail water within the Hawkesbury River, is presented on Figure D.17.

The bed shear stress mapping on Figure D.17 shows that the 100 year storm event with no tail water in the Hawkesbury River generates some small areas that require bank stabilisation with riprap or some other council approved method. The majority of these areas would require riprap using rocks with an average diameter of 150 millimetres. There are a few areas of higher bed shear stress that would require riprap using rocks with an average diameter of 450-600 millimetres.

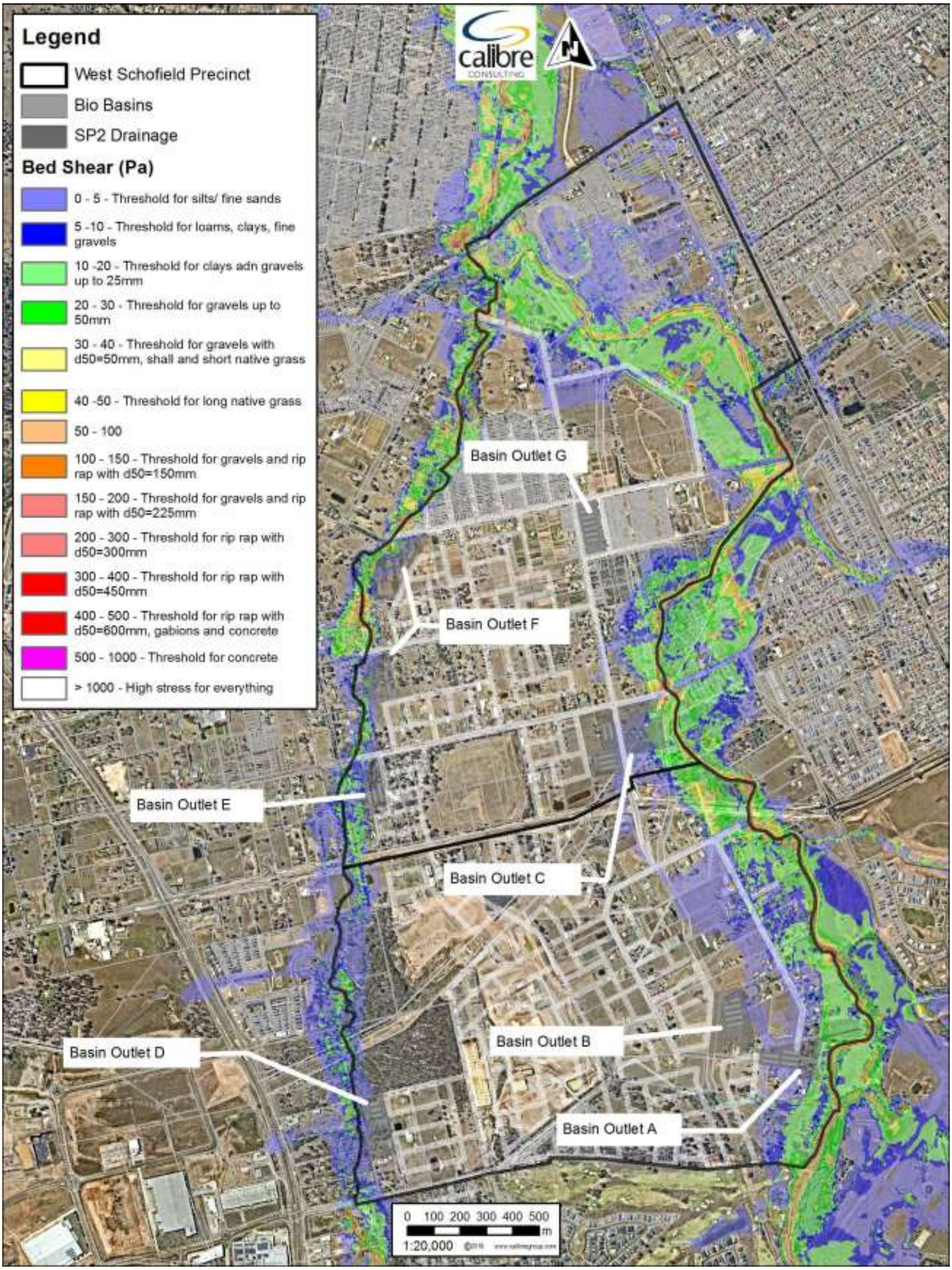


Figure D.12: Geomorphology Map – 2 year

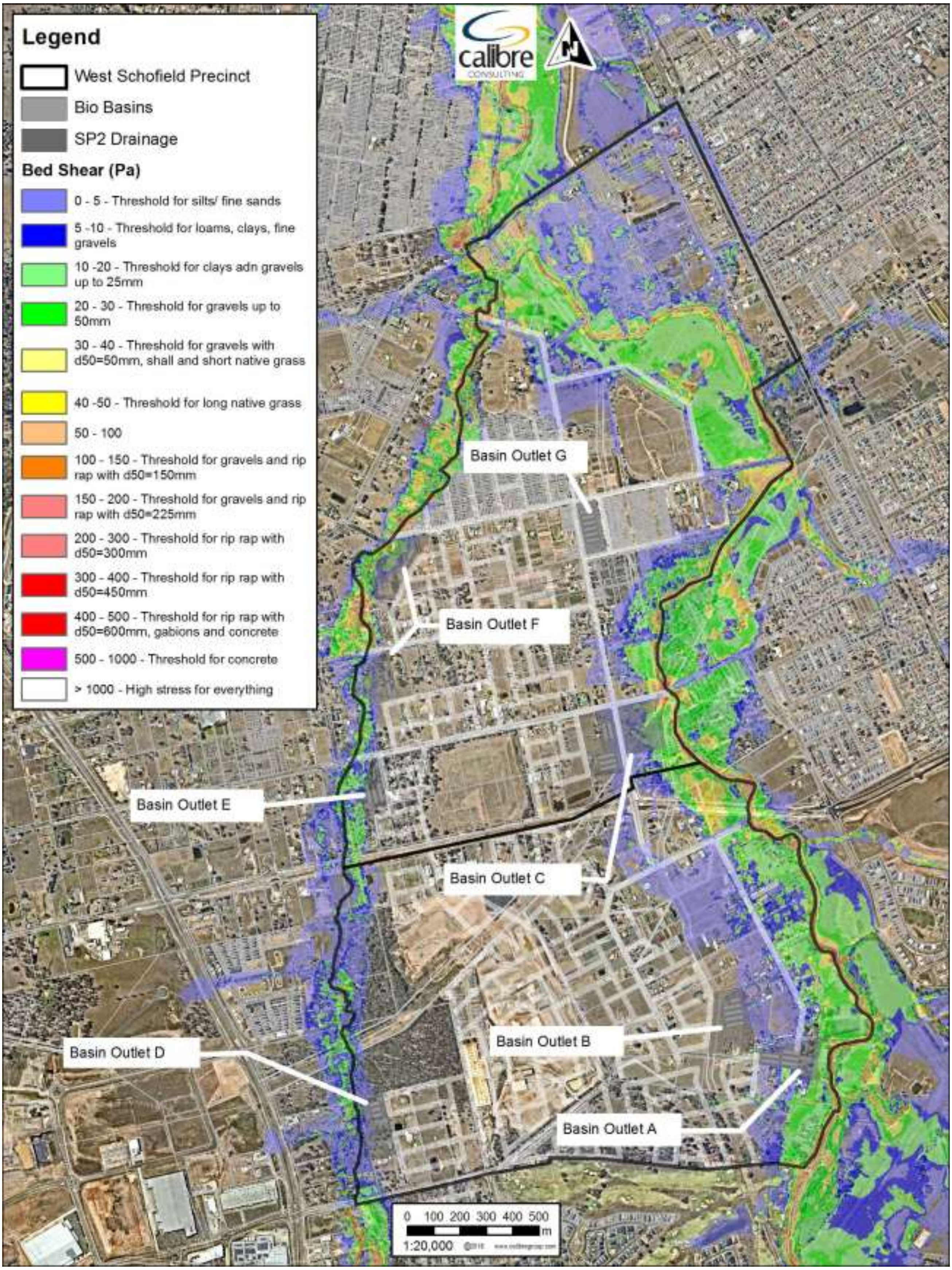


Figure D.13: Geomorphology Map – 5 year

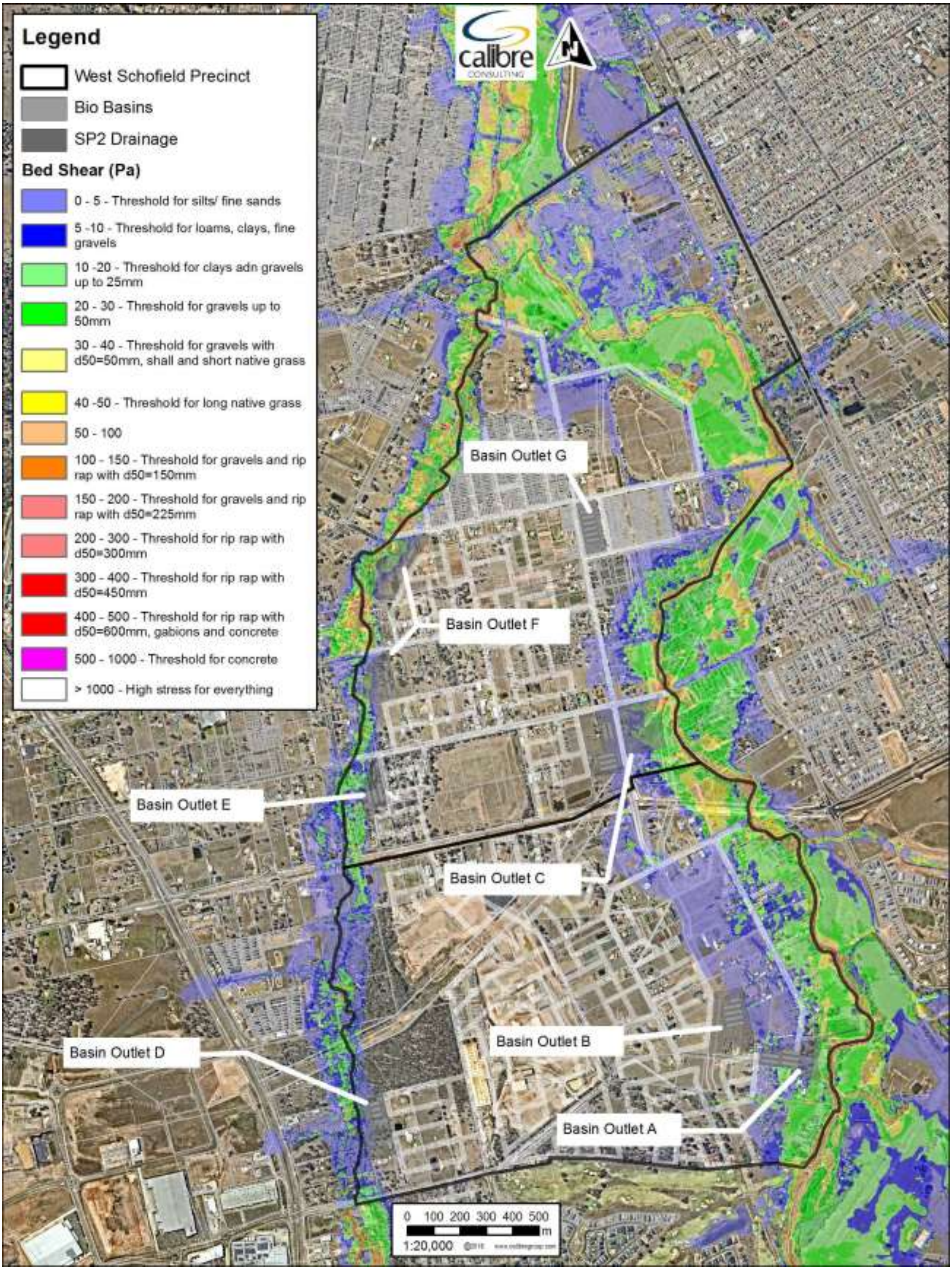


Figure D.14: Geomorphology Map – 10 year

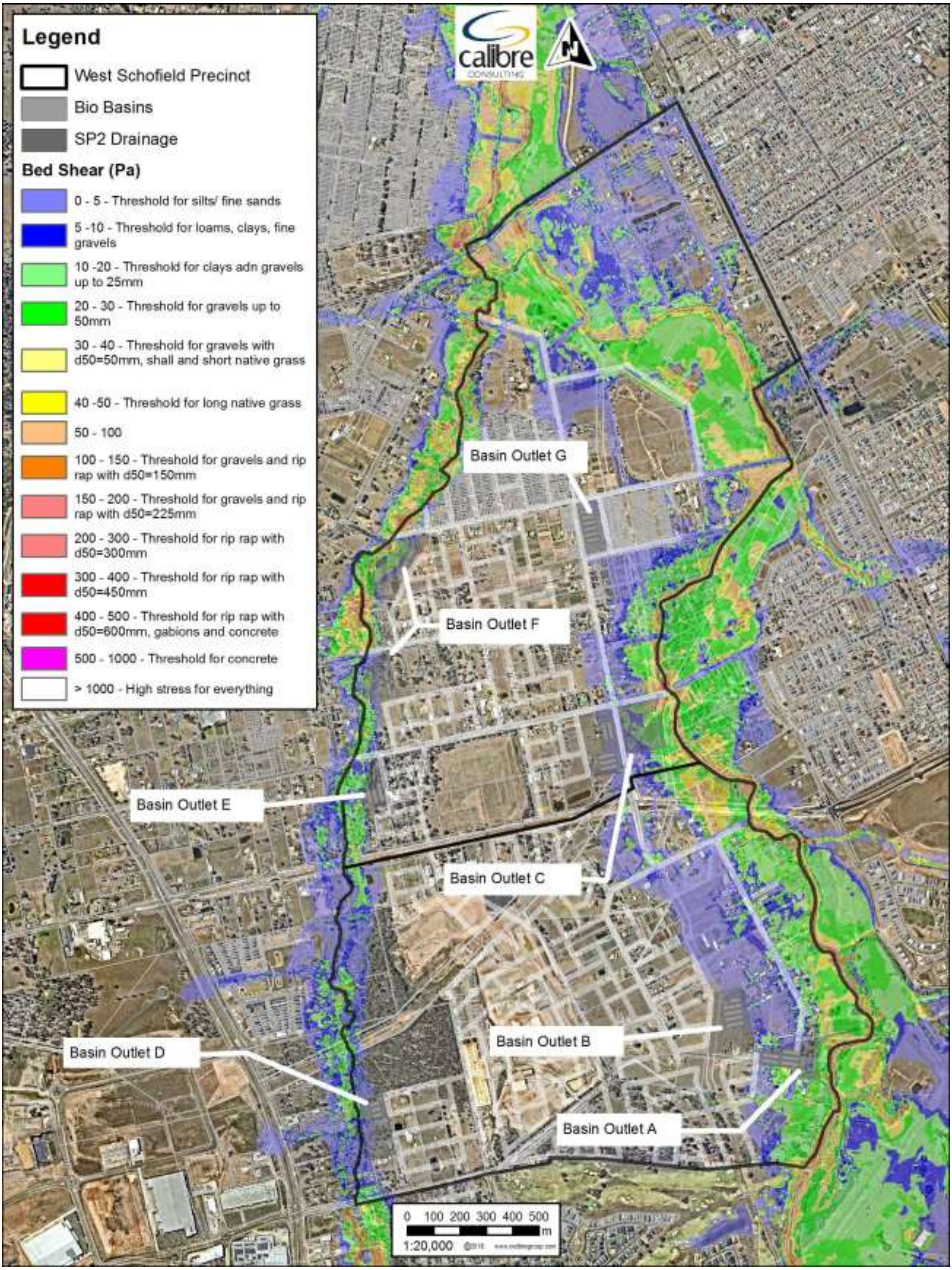


Figure D.15: Geomorphology Map – 20 year

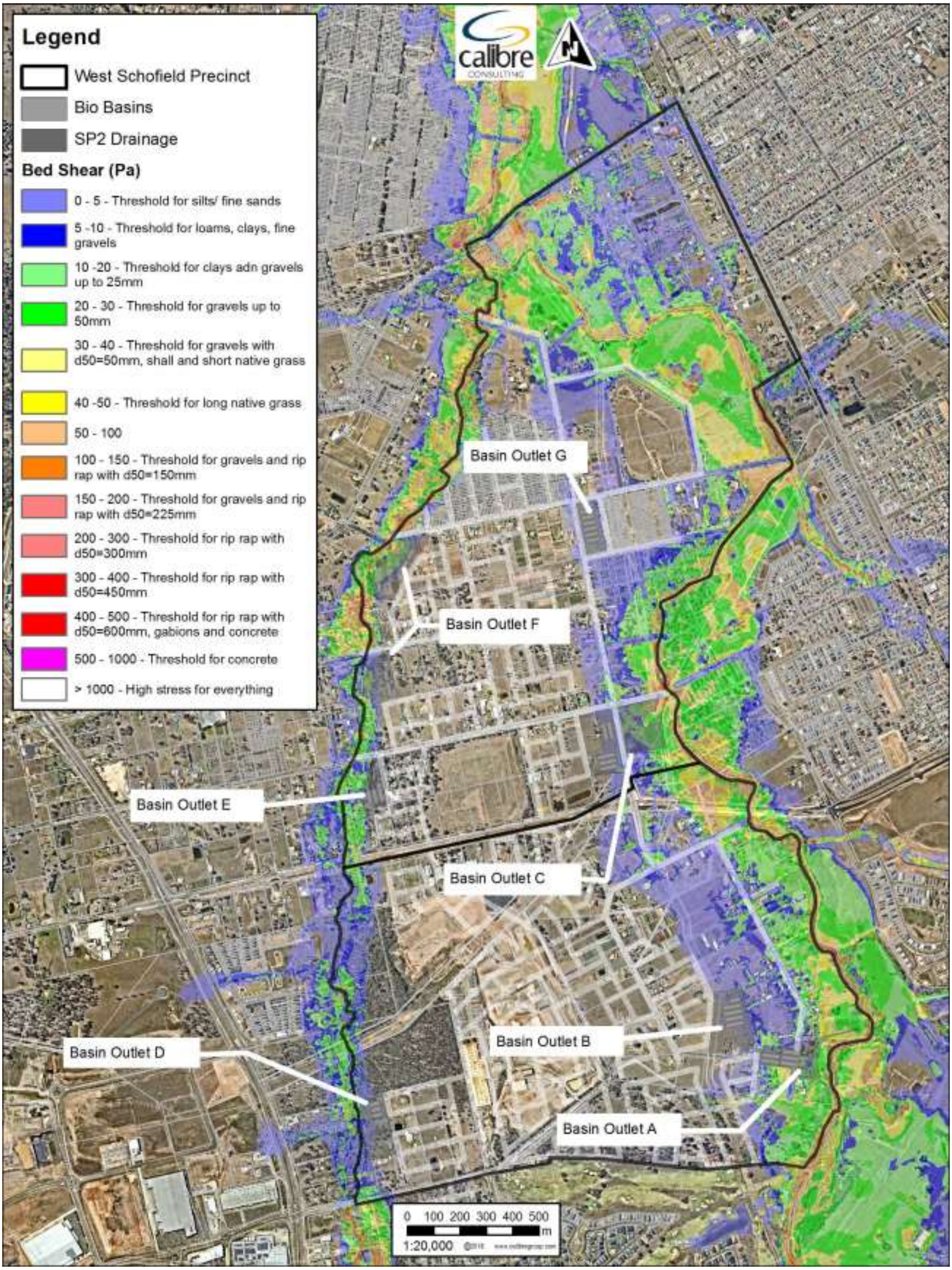


Figure D.16: Geomorphology Map – 50 year

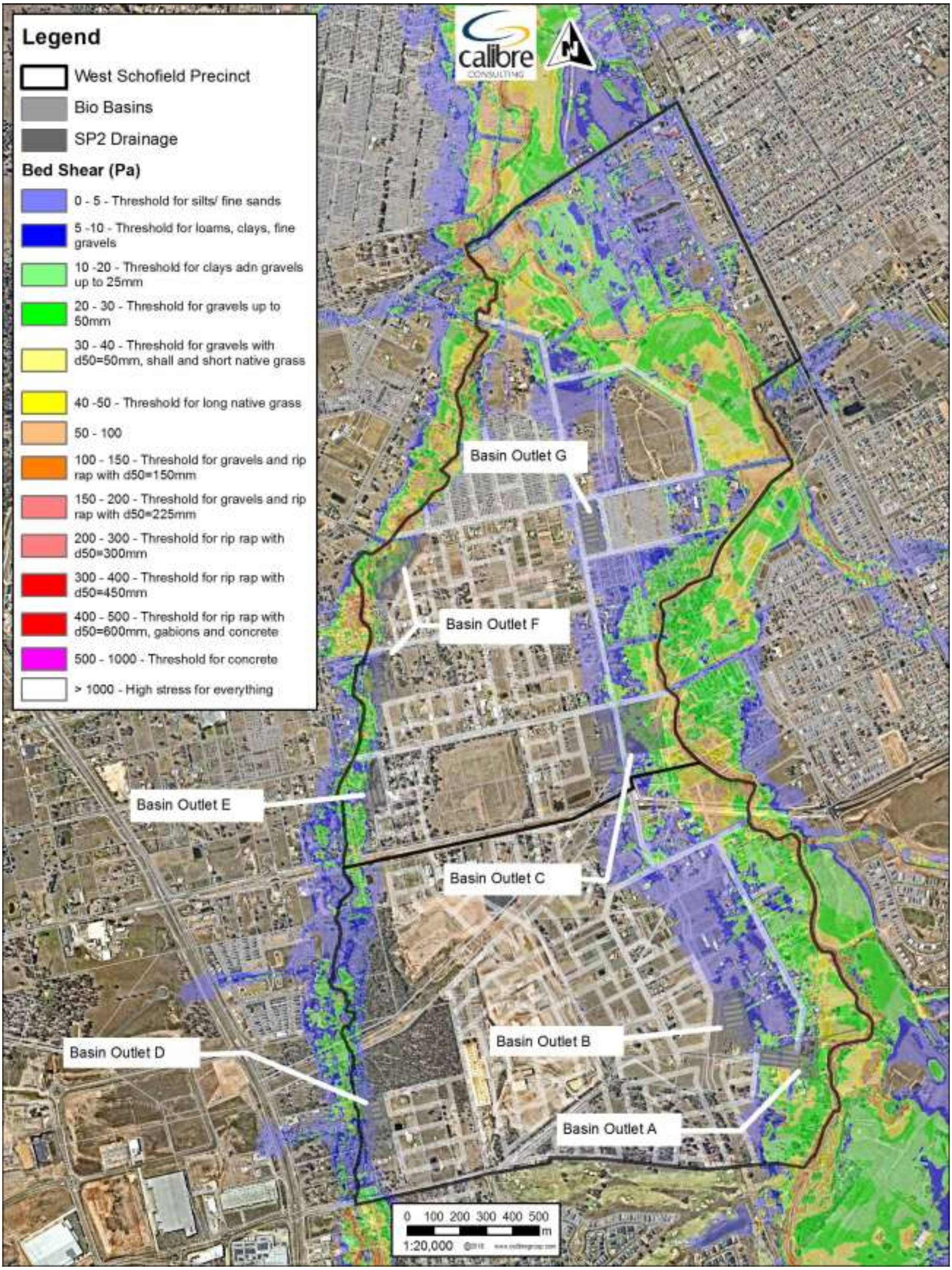


Figure D.17: Geomorphology Map – 100 year

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