Taylor Thomson Whitting

Civil Engineering Report and Stormwater Management Plan

Hurlstone Agricultural High School (Hawkesbury)

Prepared for Conrad Gargett / 11 May 2018 / Rev D

HASH-00-CD-CE-RP-180511 Civil Engineering SEARS Report

161108 P

Structural
Civil
Traffic
Facade
Consulting Engineers

Taylor Thomson Whitting (NSW) Pty Ltd, Consulting Engineers | ABN 81 113 578 377
48 Chandos Street, St Leonards NSW 2065 | +612 9439 7288 | ttw.com.au

Contents

Revision Control

Revision	Date	Description		Prepared by	Checked by	Approved by
A	11.09.2017	DRAFT ISSUE	**Name**	W. Webb	N. Biason	P.Yannoulatos
			Signature			
B	19.09.2017	FINAL ISSUE	**Name**	W. Webb	N. Biason	P.Yannoulatos
			Signature			
C	03.11.2017	FINAL ISSUE	**Name**	W. Webb	N. Biason	P.Yannoulatos
			Signature			
D	11.05.2018	ADDITIONAL FLOOD MODELLING	**Name**	W. Webb	N. Biason	P.Yannoulatos
			Signature			

1.0 Introduction

1.1 Preface

This civil engineering report and stormwater management plan has been prepared in accordance with Hawkesbury Council's Development Control Plan (DCP) objectives and performance targets to support the development of the new Hurlstone Agricultural High School, (Hawkesbury) Richmond. The NSW Department of Education is proposing to construct a new Hurlstone Agricultural High School (Hawkesbury) located within the Western Sydney University site in Richmond at 2 College Street Richmond. The school is located 50 km northwest of the Sydney CBD and 2 kilometres from Richmond CBD

A detailed assessment of the environmental factors expected to be encountered during the early works stages as well details of the final stormwater management strategy have been explored throughout this report by discussing the following segments; sediment and erosion control measures, earthworks operations, construction, maintenance, environmental site management issues, the primary components of the pit/piped drainage network, the permanent water quality/quantity systems and lastly a flood impact assessment.

Early works measures outlined in this report must be implemented prior to and maintained during the construction phase until the permanent measures are implemented. Ultimately this document forms a guide to the minimum controls to be installed and as such the final design, implementation and maintenance of all early works measures is the sole responsibility of the contractor. Furthermore, the permanent stormwater measures outlined in this report are required to be assessed and as such the final system may need to be revised during the detailed tender design period.

The following information and documents were utilised in this investigation:

- Concept Civil Engineering Drawings by TTW;
- Concept Architectural Plans by Conrad Gargett AMW
- "Managing Urban Stormwater – Soils and Construction, 4th Edition (2004)" by Landcom;
- EPA – Pollution control manual for urban stormwater.
- Geotechnical Investigation by Douglas Partners Project 85644.00 dated November 2016.
- Preliminary Environmental Site Investigation (Contamination) by Douglas Partners Project 85644.00 dated October 2016
- Hawkesbury Council Stormwater Drainage DCP
- Healthy Rivers Commission Investigation into Hawkesbury
- NSW Office of Environment and Heritage (formerly Department of Environment, Climate Change and Water (DECCW)) Guideline
- "Australian Runoff Quality – A Guide to Water Sensitive Urban Design", Engineers Australia (2006);
- "Australian Rainfall and Runoff – A Guide to Flood Estimation", Institute of Engineers, Australia (2016);
- "Draft NSW MUSIC Modelling Guidelines", Sydney Catchment Management Authority (August 2010)
- Hawkesbury City Council's Development of Flood Liable Land Policy (version 1) Adopted 31 July 2012.
- CSIRO and Bureau of Meteorology, Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au/), cited 10/05/2018
- Clarke JM, Whetton PH, Hennessy KJ (2011) 'Providing Application-specific Climate Projections Datasets: CSIRO's Climate Futures Framework.' Peer-reviewed conference paper. In F Chan, D Marinova and RS Anderssen (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Perth, Western Australia.

December 2011 pp. 2683-2690. ISBN: 2978-2680-9872143-9872141-9872147. (Modelling and Simulation Society of Australia and New Zealand)

- Whetton P, Hennessy K, Clarke J, McInnes K, Kent D (2012) 'Use of Representative Climate Futures in impact and adaptation assessment.' Climatic Change 115, 433-442. 10.1007/s10584-012-0471-z.
- CSIRO and Bureau of Meteorology 2015, Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report, CSIRO and Bureau of Meteorology, Australia

The increases in impervious areas, disturbance of existing topography and alteration of the natural terrain associated with land development has a potential to increase surface run off and subsequently concentrate peak storm flow rates. Consequently, existing flow regimes are adversely affected resulting in excessive flows and velocities through the downstream drainage network which may cause erosion of the associated waterways.

To mitigate any negative impacts to the downstream drainage network, the site stormwater management system has been designed to safely convey flows through the site and within the capacity of the downstream receiving drainage systems whilst also managing post development pollutants on site and erosion via a water quality treatment train and energy dissipater system.

The results of this assessment is an ecological sustainable development that ensures the safe discharge of stormwater whilst maintaining the existing flow regimes in a healthy environmental state.

1.2 SEAR General Requirements

This report addresses the relevant SEAR requirements as follows:

- **12. Sediment, Erosion and Dust Controls**

- **16. Drainage**
  Detailed drainage associated with the proposal, including stormwater and drainage infrastructure.

- **17. Flooding**
  Assess any flood risk on site (detailing the most recent flood studies for the project area) and consideration of any relevant provisions of:
  - The NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity; and
  - Hawkesbury Council's Flood Information/advice.

- **Plans and Documents:**
  - Stormwater Concept Plan;
  - Sediment and Erosion Control Plan

1.3 General Instructions

This report is to be read in conjunction with the concept engineering plans, and any other plans or specifications that may be issued in relation to the Project. Contractors shall ensure that all soil, sediment, erosion and water management works are undertaken as instructed in this report and constructed as per the guidelines stated in "Managing Urban Stormwater – Soils and Construction, 4th Edition (2004)" by Landcom. The Contractor shall ensure that all subcontractors are informed of their responsibilities in minimising the potential for soil erosion and pollution to downslope areas, Council's stormwater network and the receiving waterways.

2.0 Site Background

2.1 Locality

The proposed new Hurlstone Agricultural High School (Hawkesbury) site is located within the Western Sydney University land in Richmond at 2 College Street, Richmond. The site as shown on Figure 1 is located to the south of Vines Road and currently exists as a vacant agriculture land. The proposed site has a total area of approximately 10.3ha (excluding the Boarding Accommodation site)

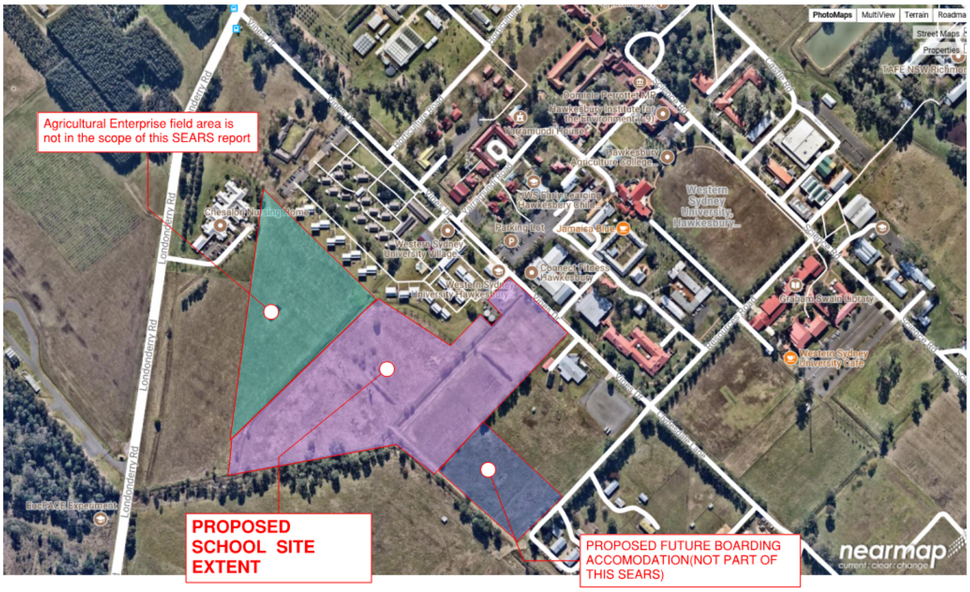


Figure 1 - Aerial Photo of the Proposed Site (Source: Nearmap)

The land is very flat with less than 1:100(1%) fall from Vines Rd to the north to the open channel watercourse to the south.

2.2 Key Issues

The key issues to be addressed in this report include:

- Sedimentation and erosion control
- Earthworks
- Construction sequencing
- Site maintenance
- Air quality and dust management
- Stormwater Quantity Control
- Stormwater Quality Control
- Flood Impact Assessment

2.3 Exclusions

Note that the Agricultural Enterprise field area is not in the scope of this SEARS report.

The Flood study and Stormwater Management of this report includes the 10.30ha however this SEARs report is submitted only just for the centrally located school site which is approximately 6ha in area.

3.0 Sedimentation and Erosion Control

3.1 Strategies

The proposed sedimentation and erosion control measures to manage runoff and ensure no detriment to the receiving environments have been divided into temporary and permanent strategies as summarised below.

STRATEGY	DESCRIPTION
Temporary	Temporary strategies generally refer to the control of sediment erosion and water pollution during the construction phase. The primary risks occur when soil is excavated and exposed to the elements during construction works. It is at this stage that suspended solids and other construction activity associated pollutants can be washed into the receiving stormwater network and subsequently the downstream waterways. The strategies that are implemented to prevent potential soil degradation and pollution of waterways include the adequate provision of sedimentation and erosion control measures. Generally the measures outlined in this report form a minimum basis that should be considered and further documented by the contractor prior to commencement of the works through a Soil and Water Management Plan (SWMP). The temporary controls that are proposed in the concept plans by TTW will limit the displacement of sediment caused by runoff from disturbed areas, and are designed to remove sediment prior to discharging from site.
Permanent	For the permanent water quantity and quality measures refer to Section 8 of the report.

Table 1 - Temporary & Permanent Strategies

This section of the report addresses the temporary strategies and outlines the minimum short term measures required to reduce the impacts of the early works activities. For permanent strategies and long term measures (i.e. post construction phase) water quality control is achieved by implementing the recommendations outlined in Section 8.

3.2 Proposed Measures

The proposed measures are documented on the concept Erosion and Sediment Control Plan attached to this report under **Appendix A Drawing No's C101.**

3.3 Installation of Measures

The measures are to be installed as per the requirements outlined below:

- Clearly visible barrier, site fencing and hoarding shall be installed at the discretion of the Superintendent to ensure site security, safety of the public, manage traffic control and prohibit any unnecessary site disturbance. Vehicular access to the site shall be limited to only what is essential for the construction activities and shall enter the site only through the stabilised access points.

- All disturbed areas are to be stabilised within 14 working days of the completion of earthworks. All disturbed areas are to be protected so that the land is permanently stabilised within six months.
- Proprietary silt fencing shall be installed by the Contractor in accordance with the final approved Sedimentation and Erosion Control Plan and elsewhere at the discretion of the site superintendent to contain sedimentation to as near as possible to the original source.
- Sediment removed from any sediment trapping device shall be relocated where further pollution to downslope lands and waterways cannot occur.
- Stockpiles shall be located by the Contractor in accordance with the final approved Sedimentation and Erosion Control Plan and elsewhere at the discretion of the Project Manager and/or Superintendent. Where stockpiles are to be in place longer than 30 days they shall be stabilised.
- Water shall be prevented from entering the permanent drainage system unless it is sediment free. Drainage pits are to be protected in accordance with the final approved Sedimentation and Erosion Control Plan.
- Temporary sediment traps located at pits shall be retained throughout the early works stage and until the appropriate replacement measures for the subsequent stages are installed.

3.4 Land Disturbance

Where practicable, the soil erosion hazard shall be kept as low as possible. Limitations to access are to be in accordance with the following table:

Land Use	**Limitation**
Access areas	Access is to be limited to the designated work zones via the stabilised site access.
Truck cleaning areas	Any truck exiting out of the site shall be thoroughly cleaned and limit the exportation of soil and sediment on public roads.
Remaining undisturbed areas.	Access to any undisturbed areas and remaining lands is only permitted with permission from the Project Manager and/or Superintendent.

Table 2 - Limitations to Access

4.0 Earthworks

Note: The below earthworks review and recommendations is to be read in conjunction with the full geotechnical report by Douglas Partners Geotechnical and Contamination reports Project 85644.02 September 2017 and 85644.00 October 2016

4.1 Subsurface Conditions

Douglas Partners were engaged to undertake a geotechnical investigation and prepare an assessment which included the following:

- 11 new borehole locations spread throughout the site.

The results of the investigation indicated that the school is underlain by mainly topsoil to 0.9m deep which underlain by sands to a depths between 3.9m and 4.8m over clays to a depth of 7.5m.

A localised filling around the Borehole 6 was encountered which consists of silty sand with gravel, plastic bags, rags, and plastic bottles.

4.2 Groundwater and Seepage

Based on the Geotechnical investigation, groundwater was encountered at relatively shallow depths and due to the sandy nature of the near-surface soils, all sub-surface structures should be tanked.

4.3 Earthworks Recommendations

4.3.1 Batter Slopes & Retaining

Excavation during earthworks and construction of the main structures will involved filling on sandy soils.

Temporary and Permanent batters are expected throughout the site. Temporary Batters of 1(v):1.5(H) and Permanent Batters of 1(v):2(H) are recommended. Refer to Geotechnical Investigation report for details. However 1 Vertical to 3 Horizontal is preferable to reduce the possibility of erosion, enable maintenance access and allow planting/landscaping.

4.3.2 Treatment of Fill

The silty sandy fill encountered in Borehole 6 during the Geotechnical investigation is localised and is considered as uncontrolled fill and as such is unsuitable to support footings or slabs on ground. This existing fill will need to be reworked to reduce the potential of unacceptable settlements with poorly or variable compacted filling or that all foundations will be composed of piles driven down into a more stable ground. Refer to Geotechnical and Structural Engineer for details.

Excavated material is to only be reused on site as ‘form fill’ with nominal compaction (95% SMDD) to support the floor slabs whilst they are being poured. Prior to backfilling with the silty sandy fill, all vegetation and root affected soil is to be removed and the based rolled to ensure adequate surface compaction. The remainder of the excavated material is to be exported offsite as uncontrolled fill. Earthworks calculations are discussed in the section below.

4.3.3 Subgrade Strength

- The Geotechnical California Bearing Ratio (CBR) results show that the sands will provide good support for the pavement once the pavement layers provide some confinement. A design CBR of 10% is considered suitable as per the Geotechnical investigations report.

The design of all excavation or earthworks to be fit for purpose and with drainage, siltation and sediment controls satisfying all authority requirements.

Bulk earthworks will be designed to minimise impact on the environment and provide control measures during construction to this effect.

To maintain the water quality during the construction stage, soil and erosion control measures will need to be installed. These measures include silt fences around the site, hay bales upstream of culverts and an appropriate 'truck shake down' facility at the exit to the site.

Site preparation will include the following:

- Stripping of topsoil from work areas to be stockpiled for landscape areas.
- Tyne, water and roll the areas over which filling, paving or building slabs are to be placed. Six passes of a 10 tonne static roller are required. The final pass shall be a proof roll where movement of greater than 3mm under the roller will indicate Bad Ground.
- Placement of acceptable material from cut areas shall be placed in layers of not more than 200mm to the compaction requirements.
- Filled areas and cut areas to be overlain by buildings and pavements are to be protected to maintain constant moisture content in the soil. The protection is to remain in place until construction is complete.

Compaction of Earthworks

Location	Compaction	Allowable Variation from Optimum Moisture Content
Compaction of subgrade under pavements	98% SMDD (standard)	2%, -2%
Compaction of landscape areas	95% SMDD (standard)	+2%, -2%
Compaction of pavement base subbase	98% SMDD(modified)	+2%, -2%

Table 3 – Compaction of Earthworks

Maximum fill layer thickness is 200mm.

An independent approved NATA registered testing authority will be required to perform all the compaction testing of earthworks as shown in Table 3 and submit test certificates to the Superintendent.

Testing

The Contractor will be required to provide a plan of test sample locations and a schedule of testing to comply with the following minimum requirements. The following testing frequencies relate to acceptance on a “not one to fail” basis.

Location	Frequency of Tests
Building platforms	Not less than a) 1 test per layer per 100m^2 or b) 1 test per 200m^3 distributed evenly throughout full depth and area or c) 1 test per lot per layer whichever requires the most tests
Pavements	Not less than a) 1 test per 25 linear metres per layer for roadway b) 1 test per layer per 1000m^2 for carparks.
Trenches	a) 1 test per 2 layers per 40 linear metres
Filled landscape area	a) 1 test per layer per 1000m2 or b) 1 test per 200m^3 distributed reasonably through full depth and area whichever requires the most tests.

An independent approved NATA registered testing authority will be required to perform all the compaction testing of earthworks and submit test certificates to the Principal. Certification will be required that aggregates are suitable for use in roadwork and concrete.

5.0 Site Maintenance

At a minimum the following site maintenance procedures shall be adhered to:

- The site manager shall inspect the site at least weekly to review all measures;
- Waste bins are to be provided for all construction refuse. They are to be emptied at least weekly and refuse is to be disposed in accordance with the site manager’s recommendations;
- It is to be ensured that all drains are operating effectively. If required, the necessary repairs shall be undertaken to restore any damaged or inefficiently operating device;

- Any spilled material shall be immediately removed from areas subject to runoff or concentrated flow;

- Trapped sediment shall be removed where the capacity of the sedimentation trapping device falls below 60%;

- Sedimentation traps are to be inspected after each rainfall event and/or weekly to;
    - Ensure that all sediment is removed once the sediment storage zone is full;
    - Ensure that outlet and emergency spillway works are maintained in a fully operational condition at all times;
    - Ensure rehabilitated lands have effectively reduced the erosion hazard and initiate upgrading or repair as appropriate;

- Additional erosion or sediment control works may be required to be constructed as appropriate to ensure the protection of downslope lands and waterways;

- Erosion and sediment control measures are to be maintained in a fully functioning condition at all times until the site is rehabilitated or secondary stage measures are installed;

- Revegetation schemes are to be adhered to and that any grass coverings are kept healthy, including watering and mowing;

- The removal of the temporary soil conservation and sedimentation control structures is to be the last activity in the rehabilitation program.

6.0 Air Quality & Dust Management

Prior to construction, the Contractor shall prepare a Construction Environmental Management Plan (CEMP), which will include a section on Air Quality and/or Dust Management). The CEMP will distinguish include but not be limited to:

- Plant and equipment emissions shall be as per the relevant regulations and standards;
- Areas of exposed soil shall be minimised and long term stockpiles shall be stabilized with vegetation or covered;
- A water cart shall be available at all times for surface spraying exposed soil surfaces to reduce dust generation;
- The site compound and haul roads are to be covered with gravel or kept moist (by spraying with water cart) to reduce dust generation;
- Materials transported in open trucks shall be covered to prevent possible dust generation;
- Tailgates of all vehicles transporting soil materials to and from the construction site shall be securely fixed so as to prevent soil spilling which in turn could generate dust;
- The burning of materials is not permitted on site at any time.

7.0 Stormwater Design

7.1 Local Authority Requirements

The proposed stormwater elements have been designed in accordance with the following:

- **Water Quantity Guidelines**:
  (i) Hawkesbury Development Control Plan Appendix E Civil Works Specification

A desirable outcome in development is to make the most of the site area available and increase useable space. Generally increases in useable space result in an increase in the total site impervious area. The consequence associated with increases in imperviousness is the potential to increase stormwater flows due to the reduction in available pervious and landscaped areas to absorb initial rainfall runoff. To mitigate the impact of increased site discharge on downstream properties it is essential to design the site stormwater system to attenuate the increased runoff and safely convey storm flows through the site and within the capacity of the receiving drainage network.

- **Water Quality Guidelines:**
  (i) Managing Urban Stormwater – Soils and Construction, 4th Edition (2004)" by Landcom;
  (ii) EPA – Pollution control manual for urban stormwater.
  (iii) Healthy Rivers Commission Investigation into Hawkesbury
  (iv) NSW Office of Environment and Heritage (formerly Department of Environment, Climate Change and Water (DECCW)) Guideline

Increases to impervious areas often results in the increase of gross pollutants, total suspended solids, and phosphorus and nitrogen nutrients. These pollutants are washed away into the stormwater network during rainfall events, transported from their site of origin into downstream waterways. To limit the impact of on the receiving water body, quality control measures have been designed within the site stormwater management system in the form of a treatment train that reduces pollutant loads prior to discharging into the drainage network.

7.2 Stormwater Design Objectives

The objective is to provide stormwater controls that ensure that the proposed development does not adversely impact on the quantity or quality of stormwater flows within, adjacent and downstream of the site. The table below outlines the objectives and targets compatible with the relevant authority legislations, policies and requirements:

DESIGN ELEMENT	OBJECTIVES
STORMWATER QUANTITY	• The existing flow regimes and discharge for the full range of storm events should be maintained. • A safe stormwater conveyance system should be provided for the major storm events. • Any existing flows from external catchments be safely mitigated through the site.

	• The existing runoff from the development should be maintained. • Safe mitigation measures should be provided to minimise any potential flooding impact on the site. • Downstream properties are not to be adversely affected by the development.
STORMWATER QUALITY	• Stormwater leaving the site should meet the full range of pollutant reduction targets of the relevant authority. • Site discharge should achieve natural dry and wet weather concentrations for the given catchment.

Table 5 - Objectives of the Stormwater System

7.3 Strategies

The proposed stormwater measures to manage runoff and ensure no detriment to the receiving environments have been divided into temporary and permanent strategies as summarised below:

STRATEGY	DESCRIPTION
Temporary	For the temporary sediment and erosion control details refer to Section 3 of the report.
Permanent	Permanent strategies generally refer to the installation of a number of permanent treatment measures to remove gross pollutants, total suspended solids, and phosphorus/nitrogen nutrients effectively in order to maintain stormwater quality discharged from the site.

Table 6 - Temporary & Permanent Strategies

This section of the report addresses the permanent strategies and outlines the long term measures required to reduce the impacts of development. For temporary strategies and short term measures (i.e. excavation and construction stage) water quality control is achieved by implementing the recommendations outlined in Section 3.

8.0 Stormwater Quantity Control

8.1 Introduction

The main goal for the stormwater quantity control measures is to ensure that the post-developed peak storm flows do not exacerbate flow regimes within Council's receiving drainage network and cause detriment to the downstream waterways.

8.2 Proposed Drainage System

The site stormwater system for the development has been designed to capture concentrated flows from impermeable surfaces including courtyards open to the sky. The proposed stormwater management system for the development includes:

- Pit and pipe drainage network to collect runoff from areas;
- Stormwater flows up to the 5% annual exceedance probability event are conveyed by a minor drainage system; and
- Stormwater flows above the 5% annual exceedance probability event are conveyed by a major drainage system;

It is to be noted that the flowrates generated to size the internal pit and pipe network are based off Australian Rainfall and Runoff – A Guide to Flood Estimation 2016.

A reduced set of the concept stormwater management plans are included in Appendix B.

8.3 On-Site Stormwater Detention Requirements

Hawkesbury Council is the responsible body for determining the onsite stormwater detention (OSD) permissible site discharges (PSD) and site storage volume (SSV) required. OSD is required for the proposed site.

The SSV and PSD requirements are set-out in Council's DCP Appendix E Civil Works Specification shown in Table 7 below.

TABLE 8. 11 ON SITE DETENTION DESIGN VALUES FOR PSD AND SSV

	Land Use	
	Residential/ Medium Density/ Commercial	Industrial
Permissible Site Discharge (l/s/ha)	65	39
Site Storage Volume (cu.m/ha)	200	283

Table 7 – Onsite Detention (OSD) Site Storage Volume and Permissible Site Discharge Requirement

The proposed site has a total site area of approximately 10.30ha. Using the site's PSD and SSV requirements, the following is the OSD requirement:

- OSD's Site Storage Volume (SSV) = 2,060 cu.m
- Permissible Site Discharge (PSD) = 669 litres/second

Two (2) above ground detention basins are proposed totalling 2,100cu.m of storage as shown in our Stormwater Concept Plan in Appendix B. The PSD will be controlled by using orifice plate either within a discharge control unit pit or headwall system to restrict the lower recurrence interval events and a weir system to restrict the rarer storms up to the 100-year ARI storm event.

Since the detention basin is above ground the following Council additional requirements are required:

- A maximum depth of 600mm can only be permitted. We recommend that the basin be fence off for security reason.
- Desirable maximum side slopes of 1:6 with absolute maximum of 1:4.
- The minimum slope of floor should be 1:50 due to the flat nature of the site. Departure from this Council requirement is proposed with a floor slope of between 1:200 and 1:100. As such a more rigorous maintenance regime is required.
- A minimum freeboard of 150mm to the finished floor level of the development
- A trash rack shall be located across the outlet.

9.0 Stormwater Quality Control

9.1 Introduction

The quality of site stormwater runoff depends upon a number of factors including land use, degree of imperviousness, population size, sanitation and waste collection methods, topography, geotechnical characteristics of the soil and the amount of rainfall based on climate. Litter, garbage, sediment, soils, nutrients, oils, hydrocarbons, grease, and heavy metals are all examples of pollutants that are typically transported off site by runoff. Whilst these pollutants have an adverse impact on the overall quality of the receiving water body it is gross pollutants, suspended solids and the nutrients phosphorus/nitrogen which are the most detrimental to the environment. Litter, garbage, oils, hydrocarbons and other pollutants that typically float on the surface generally have a bigger aesthetic impact to water quality.

Activities associated with development and urbanisation include the disturbance of vegetation/topsoil, earthworks, construction, services, and building works. It is during the earthworks and construction phase that sediment transportation is greatest with loadings up to six times higher than the pre development state. At the cessation of construction activities sediment loading may eventually return to pre development levels or remain slightly higher depending on land management practices and maintenance strategy.

As with every development, sediment erosion during the excavation and construction phase represents the largest potential risk to water quality levels. It is during this period that exposed earthworks are highly susceptible to being washed downstream by site runoff, carrying suspended solids and associated construction related pollutants.

This report addresses the permenent water quality measures to be implemented. For the temporary measures and short term effects (i.e. during the the early works phase) water quality is managed by implementing the measures covered in the Sedimentation & Erosion Control Plan.

9.2 Hawkesbury City Council's Requirements

The objectives for water quality are detailed within Section 8.24 of Hawkesbury City Council's DCP. Council requires that the pollutant discharge concentrations for the site under developed conditions are equivalent to or less than concentrations from the site under existing conditions.

The DCP also states that development should comply with the following three guidelines:

- Department of Housing – Blue Book
- EPA Management Urban Stormwater
- Council's Stormwater Management Plan

The current site is largely greenfield and in exception to a swale, there are no other water quality measures. The proposed development has been modelled using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) to determine compliance with water quality targets detailed within the guidelines referenced within Council's DCP.

The NSW Office of Environment and Heritage (formerly the Department of Environment and Climate Change) recommends that water quality targets as shown in Table 8.0 below be adopted by local governments and consent authorities for medium and large scale developments.

These targets are currently used by the Growth Centre Commission and widely adopted by other Council's within NSW. These targets are an update to those previously recommended by the EPA within the guideline referenced by the DCP.

Pollutant Type	Pollutant Reduction Target (Average Annual Load)
Gross Pollutants (GP)	90%
Total Suspended Solids (TSS)	85%
Total Phosphorus (TP)	65%
Total Nitrogen (TN)	45%

Table 8: Water Quality Targets (Source: NSW Office of Environment and Heritage)

These targets are generally in line with the Healthy Rivers Commission Independent Inquiry into the Hawkesbury Nepean, which identifies that phosphorus inputs to the river should be minimised where possible to prevent algal growth.

9.3 Stormwater Quality Control Measures

There are a number of measures that can reduce pollutant loadings with their effectiveness varying depending on the targetted pollutant, land use type, maintenance access or requirements and site topography. The proposed combination of measures aims to provide the most efficient and manageable measures suited to the site.

The individual elements of the proposed treatment train for the redevelopment of the school are summarised in the table below:

Element	Description
Rainwater Tank: **Refer to hydraulic plans for details.**	• Rainwater tanks are an effective measure as they can remove pollutant loads at source. • The pollutant removal process occurs through harvesting roof runoff for reuse, thereby reducing the nutrients that are discharged into the stormwater network. • It is proposed to provide two 80kL rainwater reuse tank plumbed for landscape irrigation as detailed on the hydraulic engineer's plans. A minimum of 2 hectares of landscaping is to be irrigated by the rainwater tank. • The rainwater tank shall receive a mains top up from a potable water source.
Swales	• A number of swales have been proposed to both direct water to the stormwater management system and to treat water that is conveyed via sheet flow.
Bioretention Ponds	• Two bioretention ponds are proposed to total a minimum surface area of 250 m^2. • These two ponds are proposed to treat landscaping and the overflow of the rainwater tank.
Wetlands	• A wetland is proposed within the site to treat stormwater from the northern portion of the site.

	• Wetlands remove pollutants through extended detention times, root filtering and nutrient uptake by the plant bed.
Buffer Zones	• Buffer nodes consist of vegetated areas that act as filters for stormwater conveyed via sheet flow. • As the majority of the site contains landscaping adjacent to impervious areas, the sheet run off of these impervious areas is treated by the buffer zones available.
Infiltration System	• Landscaped areas to the north of the site are to be treated by an infiltration system built within the roof. This will be provided by an atlantis cell infiltration system.

Table 9 - Proposed Water Quality Measures

9.4 MUSIC Modelling

The effectiveness of the combination of treatment train measures has been assessed using numerical modelling within MUSIC (Model for Urban Stormwater Improvement Conceptualisation version 6). The results of the modelling were compared against the Council's pollutant reduction targets to determine the effectiveness of the proposed measures.

MUSIC simulates the performance of a group of stormwater management measures, configured in series or in parallel to form a "treatment train" against historic rainfall event data sets. It is the industry standard water quality modelling software developed by the MUSIC Development Team of the Cooperative Research Centre for Catchment Hydrology (CRCCH).

The MUSIC User Manual suggests that the time-step should not exceed the time of concentration of the smallest sub-catchment however due consideration must also be made regarding the shortest detention time of nodes within the treatment train.

9.5 Event Mean Concentration

MUSIC uses different event mean concentrations (EMC) to determine the pollutant loads generated by different land uses. The standard EMCs adopted within MUSIC were based on research undertaken by Duncan (1999) through the CRCCH and the results are reproduced in Australian Runoff Quality – A Guide to Water Sensitive Urban Design (ARQ). The EMC values used in the MUSIC models for this project were based on the Sydney Catchment Management Authority (CMA) Source Node(s) utilising modified % impervious area, rainfall threshold, soil properties & pollutant concentrations. The table below summarises the parameters used for the development site;

NODE TYPE	**MEAN BASE FLOW CONCENTRATIONS Log_{10} (mg/L)**			**MEAN STORM FLOW CONCENTRATIONS Log_{10} (mg/L)**		
	TSS	**TP**	**TN**	**TSS**	**TP**	**TN**
Roof	Not Applicable*Note			1.300	-0.890	0.300
Impervious	Not Applicable*Note			2.150	-0.600	0.300

Pervious	1.200	-0.850	0.110	2.150	-0.600	0.300

Table 10 - EMC Inputs for MUSIC

**Note – Impervious areas do not have base flows.*

9.6 Catchment Breakdown

The catchments were split into roof and non-roof catchments with varying imperviousness ratios to replicate the development condition. The catchment breakdown is attached to this report as Appendix C.

Table 11 provides a breakdown of the catchment areas and the respective impervious percentages used in the MUSIC model:

	CATCHMENT	AREA (m2)	IMPERVIOUSNESS RATIO (%)	PERCENTAGE OF SITE (%)
Zone 1	**Roof to Rainwater Tank**	10,795	100	17%
	Landscaped Roof	4,690	0%	7%
	Paving and Footpaths	6,195	100%	10%
	Loading and Service Driveway	1,232	100%	2%
	Landscaping	41,257	0%	64%
Zone 2	**Bus Layover and Driveway**	273	100%	<1%
	Paving and Footpaths	117	100%	<1%
	Sub Total	64,559		

Table 11 - Catchment Breakdown

9.7 Treatment Train Devices

The final number of Stormwater Quality Improvement Devices (SQID) within the treatment train are listed in the following table:

DEVICE	NO. OF UNITS
Vegetated Buffer Zones	Integrated within Design

Rainwater Tanks	2x80kL
Bioretention Ponds	2 ponds totaling 250 m^2 surface area
Media Filtration	Atlantis Cell
Wetland Pond	1 pond approximately 600 m^2 in surface area
Swales	2 swales to treat with other swales for redirecting stormwater

Table 12 - Stormwater Quality Improvement Devices (SQID)

9.8 Results

The results of the modelling are summarised below with the pollutant loads expressed in kilograms per year. The reduction rate is expressed as a percentage and compares the pollution from the post developed site to that of the existing developed state of the site to determine whether the reduction targets have been achieved.

Treatment Train Effectiveness - Receiving Node

	Sources	Residual Load	% Reduction
Flow (ML/yr)	46.3	29.3	36.7
Total Suspended Solids (kg/yr)	6270	891	85.8
Total Phosphorus (kg/yr)	14.4	4.47	68.9
Total Nitrogen (kg/yr)	109	39.3	63.9
Gross Pollutants (kg/yr)	608	0.00299	100

Table 13 - MUSIC Results

GP	=	Gross Pollutants	TSS	=	Total Suspended Solids
TP	=	Total Phosphorus	TN	=	Total Nitrogen

The final MUSIC model layout is attached to this report as Appendix D.

From the above results table it can be seen that the proposed treatment train will achieve the reduction targets for full range of pollutants. Through the implementation of the proposed water quality measures stormwater discharge from the site can be effectively managed to ensure that there is no detrimental effect to the water quality downstream of the subject site.

It is noted that there are proposed future works at the site. It is assumed that these locations will be treated by separate water quality systems which will likely include a bioretention pond and swales.

10.0 Permanent Stormwater Recommendations

The key strategies to be adopted for this development include the following:

1. A pit and pipe network to collect all stormwater runoff up to the 5% AEP event with overflows up to the 1% AEP to be directed to the adjacent open channels/box culverts as shown in the Stormwater Concept Plan in **Appendix B**.

2. Bioretention System, swale, and Wetland.

3. Provision of above ground OSD detention basins with a total volume of 2,100cu.m with 600mm maximum depth and incorporating a child-proof perimeter fence.

4. A 160kL total rainwater harvesting and retention system to reduce the reliance on potable water whilst providing an improvement of the quality of stormwater runoff and also providing a level of stormwater detention. The harvested rainwater will be plumbed for landscaping use and toilet flushing as per the hydraulic engineer’s details.

The results from the investigations and modelling summarised in this report indicate that the development can provide a safe and ecologically sustainable environment with the proposed stormwater network and water sensitive urban design management strategy.

11.0 Flood Risk Assessment

The site is affected by two flooding mechanisms; mainstream riverine flooding from the Hawkesbury River and overland flooding from the local catchment. Liaison with Council revealed that the 1% AEP flood level due to riverine flooding of the Hawkesbury River was RL 17.3m AHD which is several metres lower than existing surface levels. As a result, TTW have undertaken modelling to ascertain the effects of catchment flooding due to local overland flow.

11.1 Catchment Area

The local catchment area for the development site was determined using a combination of LiDAR data, survey information and site inspection of the topography. The site is essentially flat and flood flows generated from rainfall run off propagate in a Southerly direction as overland flow towards a number of minor open channels. These smaller open channels flow towards a main channel running in an East to West direction at the lower region of the site. The upstream local catchment area for the site was estimated to be 57 hectares. A plan showing the flood study catchment area draining to the main open channel at the bottom of the subject site is indicated in the figure below:

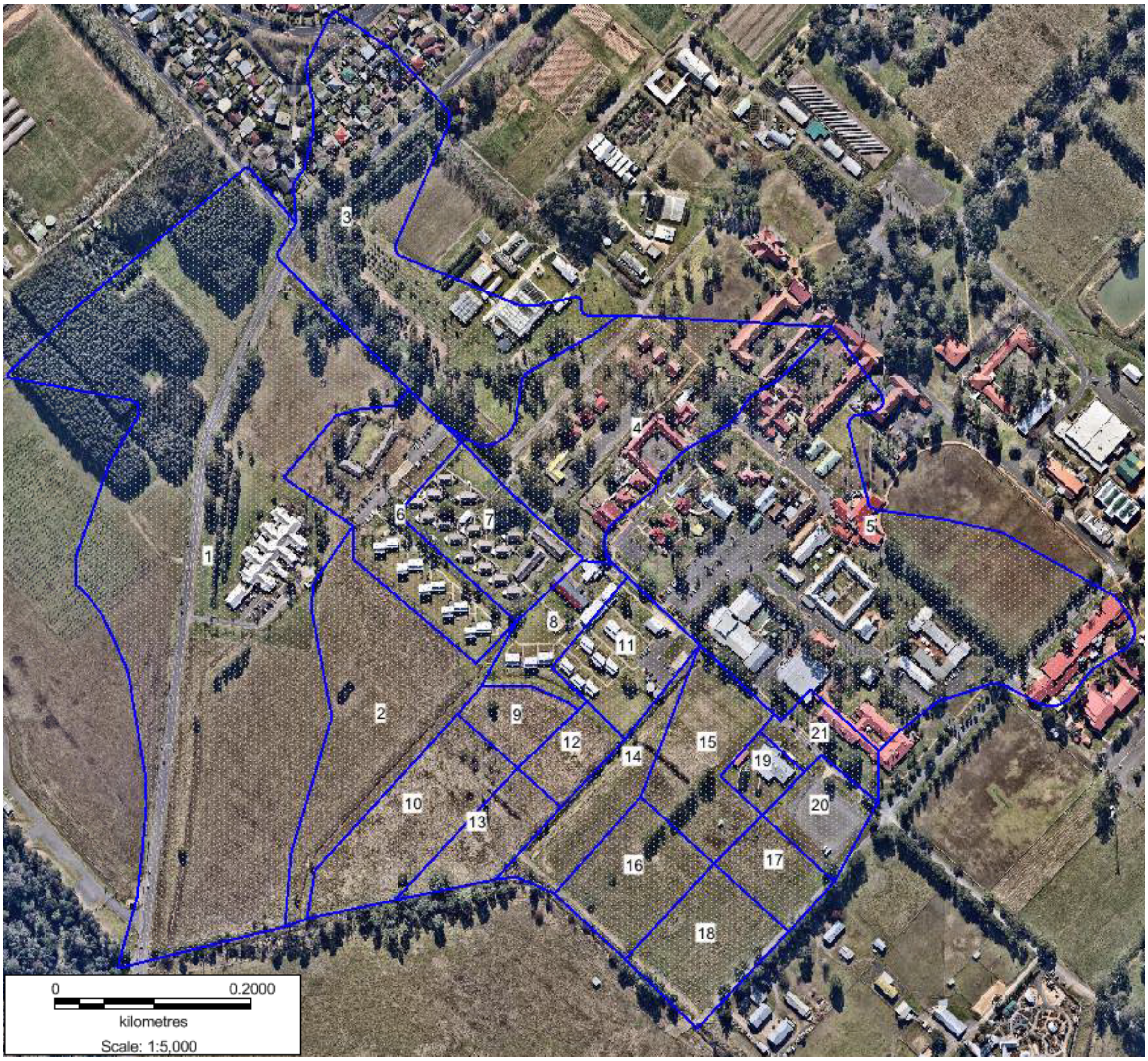


Figure 2 - Catchment Area

11.2 Hydrological Model Assumptions – 1% AEP

The following design attributes were assumed for the purpose of a creating a conservative flood model:

- The Intensity-Frequency-Distribution design rainfall chart was generated from the Australian Government Bureau of Meteorology ARR 2016 IFD data system.

- Hydrological analysis to determine the 1% AEP storm event is the runoff routing method as set out in Australian Rainfall and Runoff (ARR 2016).

- Flow rates were generated using DRAINS and then input into TUFLOW using “SA” inflow-time boundary conditions.

- The school will provide on-site stormwater detention as part of the permanent water management strategy to attenuate post development flows to mimic existing site conditions. For this reason, hydrographs remain unaltered between the pre-and post-development scenarios for the 1% AEP analysis.

11.3 Design Flowrates for 1% AEP

The hydrological analysis was conducted using the runoff routing based modelling software DRAINS to determine the peak flowrate for the 1% Annual Exceedance Probability (AEP) storm event. The model was run for a range of durations with catchment peak flow rates varying from the 5 minutes to the 6-hour storm burst. Peak flow rates and the corresponding storm bursts for the catchments are provided in the table below. The design storm used for the modelling was that which gave a peak flow rate in CH01; 1% AEP, 20 min burst storm 9.

Refer to Appendix E for catchment layout and peak flow hydrographs.

Name	Q (cu.ms^{-1})	Impervious Tc (mins)	Pervious Tc (mins)	Storm
Cat3	1.595	15.48	61.65	1% AEP, 15 min burst, Storm 8
Cat4	1.595	15.12	60.19	1% AEP, 15 min burst, Storm 8
Cat6	0.982	9.48	37.76	1% AEP, 10 min burst, Storm 7
Cat7	0.645	6.58	26.19	1% AEP, 10 min burst, Storm 1
Cat8	0.374	7.05	28.05	1% AEP, 10 min burst, Storm 1
Cat11	0.65	9.98	39.73	1% AEP, 10 min burst, Storm 7
Cat9	0.142	6.54	26.05	1% AEP, 45 min burst, Storm 6
Cat12	0.077	12.78	50.88	1% AEP, 1 hour burst, Storm 2
Cat10	0.185	22.27	88.68	1% AEP, 2 hour burst, Storm 1
Cat13	0.118	13.09	52.12	1% AEP, 1 hour burst, Storm 2
Cat5	3.935	14.41	57.37	1% AEP, 15 min burst, Storm 8
Cat21	0.171	5.86	23.32	1% AEP, 20 min burst, Storm 3
Cat19	0.165	6.71	26.72	1% AEP, 10 min burst, Storm 5
Cat20	0.395	4.74	18.86	1% AEP, 5 min burst, Storm 1
Cat15	0.196	13.9	55.35	1% AEP, 45 min burst, Storm 7
Cat17	0.145	7.94	31.6	1% AEP, 45 min burst, Storm 9
Cat2	0.256	34.51	137.38	1% AEP, 3 hour burst, Storm 9
Cat16	0.17	14.28	56.85	1% AEP, 1 hour burst, Storm 2
Cat18	0.221	11.37	45.28	1% AEP, 1 hour burst, Storm 7
Cat14	0.166	12.88	51.27	1% AEP, 1 hour burst, Storm 7
Cat1	1.916	24.44	97.28	1% AEP, 25 min burst, Storm 1

Table 15 - Peak Flow Rates

11.4 Hydraulic Model Assumptions

The two-dimensional flood modelling software TUFLOW was used for the hydraulic analysis of the pre-and post-development flow conditions. Assumptions were made during the development of the TUFLOW model to support the proposed development. These include:

- Buildings within the catchment were modelled as areas with a high manning's roughness value of 3, reflecting any existing freeboard provisions that may prevent the ingress of floodwater.
- Property pit and pipe networks draining towards the channels were assumed to be blocked and generally excluded from the model. The exception to this was the existing 450mm pipe draining the university. To simulate incoming flows from this pipe, a pit with a large inlet capacity was located towards the low point within the catchment's SA inflow boundary. Any flows exceeding the pipe capacity would then become overland flow based on the falls of the site.
- During development it was noted that the digital elevation model may not direct flows into the channels due to the flat nature of the site. In combination with the omittance of property pit and pipe networks a concern was that flows within the channels may be underrepresented. To offset the lack of flow concentration, peak flows were initially modelled as inflow time hydrographs at the top of each respective channel. Following additional model calibration this approach was found to be overly conservative and the inflow hydrographs were amended to SA inflow boundaries based on catchment area.
- Proposed buildings were modelled as obstruction to flood flows to set flood planning levels and ensure that no flood storage would be provided within the new buildings.
- Roughness values applied to the catchment in the pre-and post-development scenarios are outlined in the ID table and figures on the following page. The unshaded areas of the catchment were allocated a manning's roughness of 0.045 to represent open space (ID1). This value was based on most of the open space being grassed with some additional obstructions to flow such as trees, kerbs, and landscaping.

ID	Land Use Type	Manning's 'n'
1	Open Space	0.045
2	Carparks/impervious	0.022
3	Buildings	3
4	Ponds and other water bodies	0.030
5	Newly built / resurfaced roads	0.018
6	New residential blocks	0.100
7	Trees	0.200
8	Creeks and permanent water	0.040
9	Grass paddocks	0.065
10	Channel – concrete base with grass sides	0.025
11	Channel – grass base with grass sides	0.035
12	Main channel – reeds	0.080
13	Shotcrete unfinished channel with pier obstructions less than 15% of surface area	0.037
14	Channel with brush on sides	0.050
15	New urban space	0.025

Table 16 - Manning's "n" Roughness Values

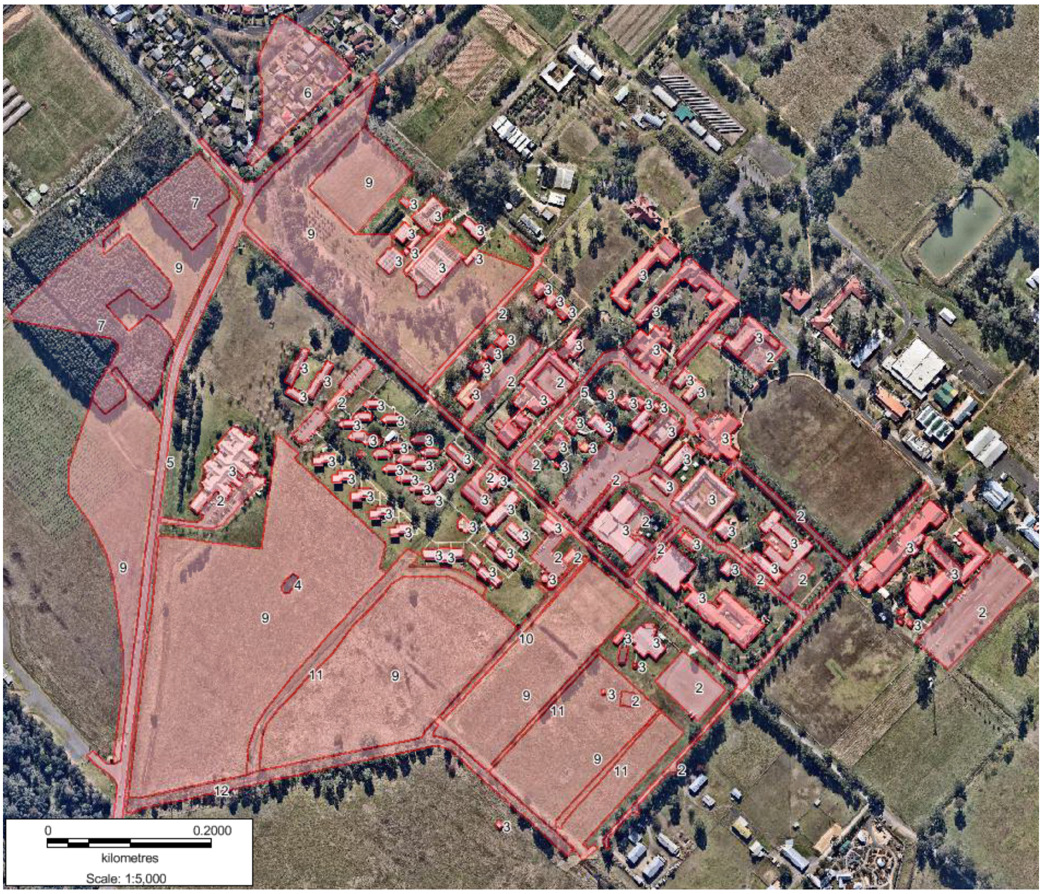


Figure 3 - Pre-Development Manning's "n" Values (s01_004)

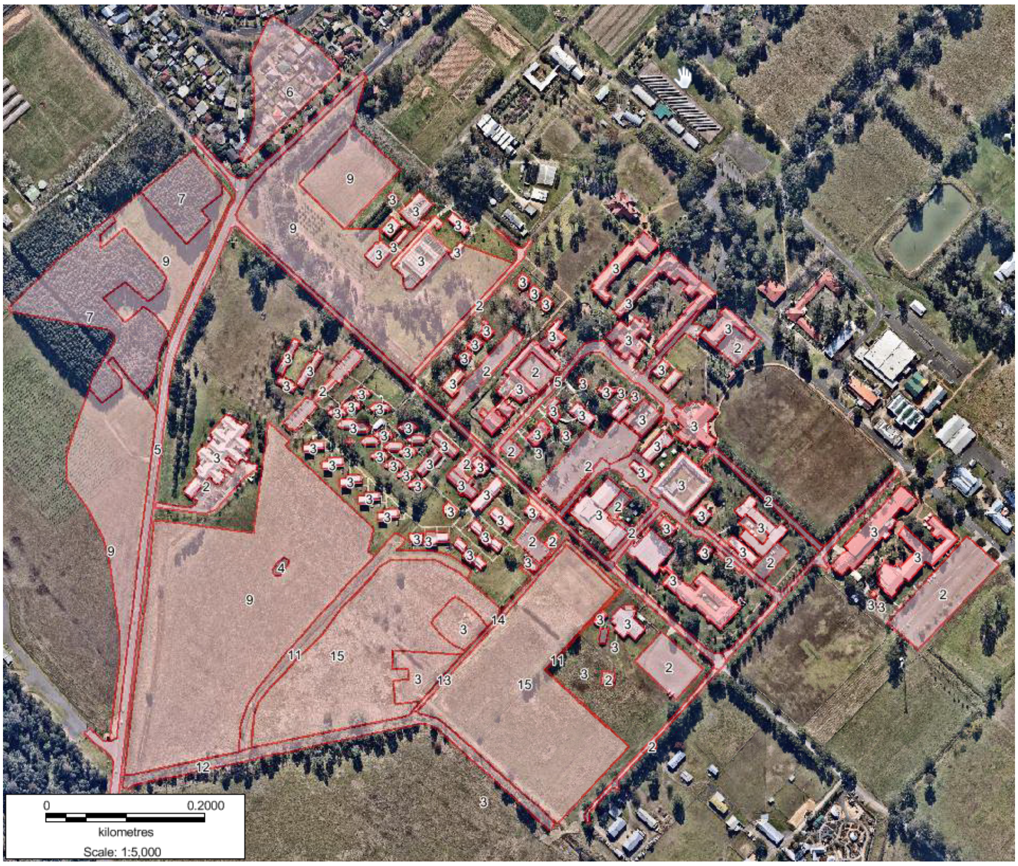


Figure 4 - Post Development Manning's "n" Values (s02_011)

11.5 Pre-Development Layout (s01_004)

The pre-development layout was modelled using higher manning's n values to represent the vegetation in the open paddocks and channels currently running through the site. The open channels and swales were represented in the two-dimensional domain using the digital elevation model generated from a combination of LIDAR and survey data whilst existing headwalls, pipes and culverts were represented as one dimensional elements.

Figure 5 - Pre-Development Model Layout for TUFLOW (s01_004)

11.6 Post Development Layout (s02_011)

The architectural layout was overlayed onto the pre-development model and the one/two dimensional elements altered to reflect the proposed buildings, changes to levels and drainage infrastructure required to mitigate flood flows. To allow the construction of the future buildings the following measures are proposed:

- Minimum 6.0m wide shotcrete channel with a 1.2m wide concrete base underneath buildings 3 and 4.
- Minimum 6.0m wide landscape open channel with a 1.2m wide concrete base incorporating maximum batter slopes of 1(V):2(H) to capture any incoming overflow from the university.
- Culvert/bridge crossings over the landscape open channel
- Culvert/bridge crossings over the shotcrete channel with a minimum flow cross sectional area of 1.7m^2.
- New headwalls and piped drainage to divert existing swales and convey stormwater to the main channel South of the site. Pipe diameters are indicated on the figure below and have been modelled with a 50% blockage factor to allow for reductions in flow area by debris.

The layout of the post development model is indicated below. In addition to the above flood mitigation measures the manning's n values from Figure 4 were applied to simulate reductions in flow resistance due to the increase in impervious area as a result of development.

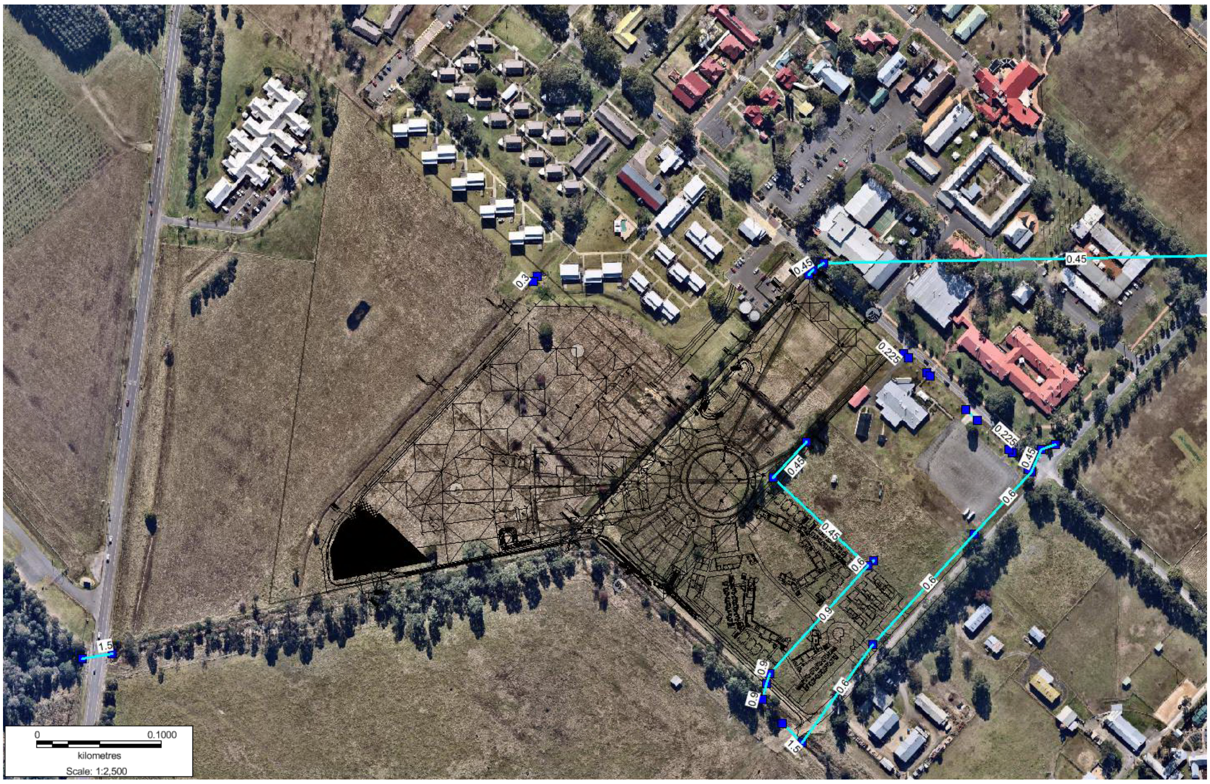


Figure 6 - Post Development Model Layout for TUFLOW (s02_011)

11.7 1% AEP Flood Modelling Results

TUFLOW was used to generate pre-and post-development results based on the parameters discussed above. The results of the modelling are shown in the figures on the following page. To better represent the flooding mechanism of the catchment and open channels, sheet flows have been omitted from the mapping results by filtering out flood depths less than 20mm.

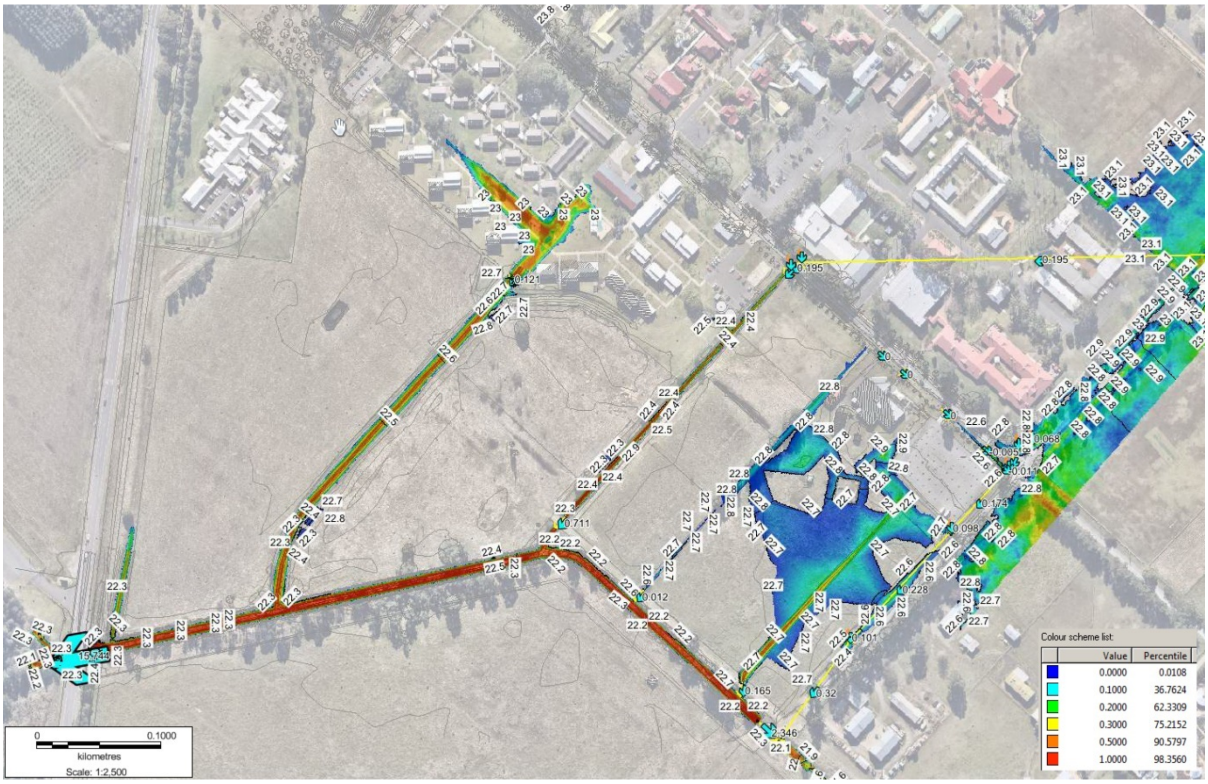


Figure 7 – Pre-Development Indicative Depths of Inundation & 1% AEP Flood Contours (s01_004)

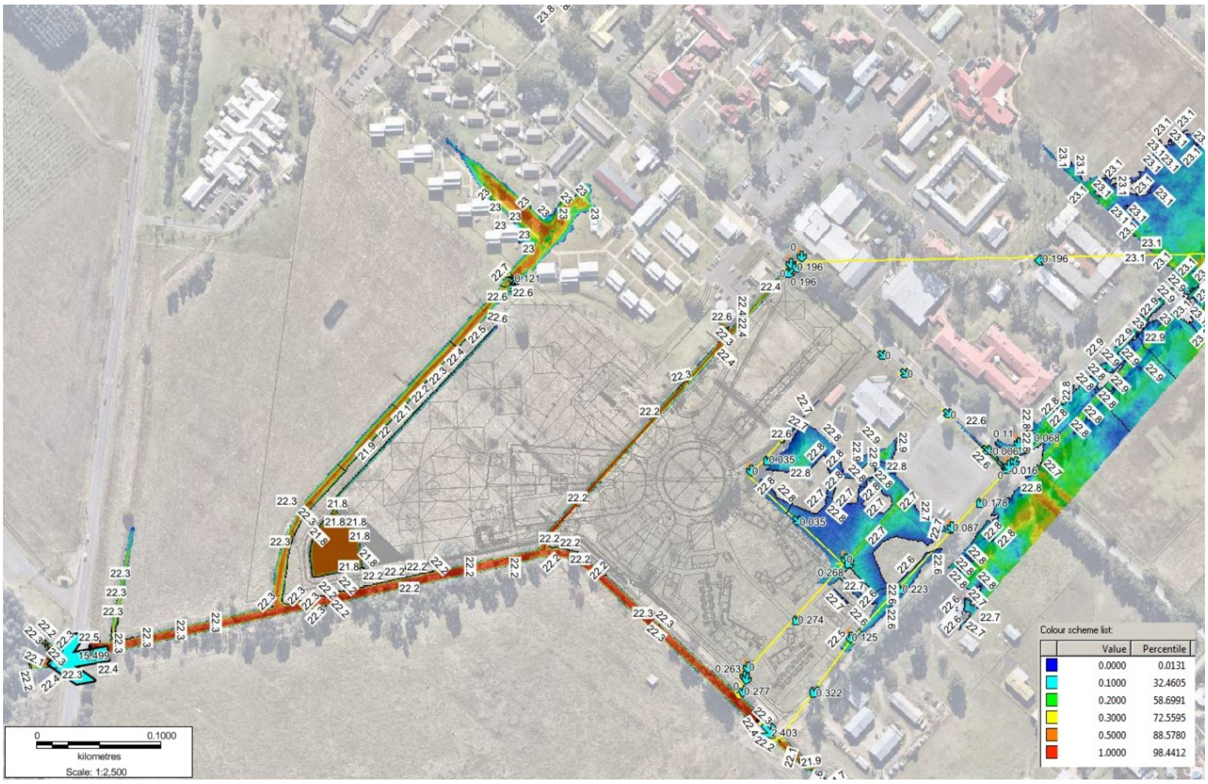


Figure 8 - Post Development Indicative Depths of Inundation & 1% AEP Flood Contours (s02_011)

11.8 Afflux Comparison (s02_011 vs. s01_004)

To evaluate the changes to flood behaviour in the 1% AEP event an afflux comparison was undertaken by comparing the post-development and pre-development flood levels and extents. The pre-development surface was subtracted from the post-development surface and maps produced with grading based on the level difference. The afflux comparison maps below contain the following information:

- Changes to flood levels (afflux)
- Was wet, now dry; shaded in light blue (areas that are now inundation free)
- Was dry, now wet; shaded in red (newly inundated areas)

Generally, the mapping results show that flooding conditions outside of the site area remain unchanged with minor fluctuations to flood levels generally between 0.01 to 0.02m. Localised fluctuations in flood levels of up to 0.09m were observed to occur where a channel is being regraded.

Figure 9 - Post vs Pre-Development Afflux Comparison (s02_011 vs. s01_004)

The wet versus dry plot on the following page indicates that the light blue shaded regions of the site which were previously shown to be affected by sheet flow are now inundation free. This is due to the provision of the new piped drainage and raising of finished levels. The red shaded regions represent areas that were previously flood free and now experience inundation. For the most part these areas are newly graded swales, a bio retention and detention basin as well as widening of an existing landscaped channel. The small areas of newly inundated areas shaded in red due West of the site are very minor pockets of new inundation between 0.01 to 0.02m of sheet flow which is negligible.

The afflux results indicate that the development of the school will have a negligible impact on water surface levels on the surrounding properties as flood levels are generally consistent between the existing site conditions and the proposed site conditions.

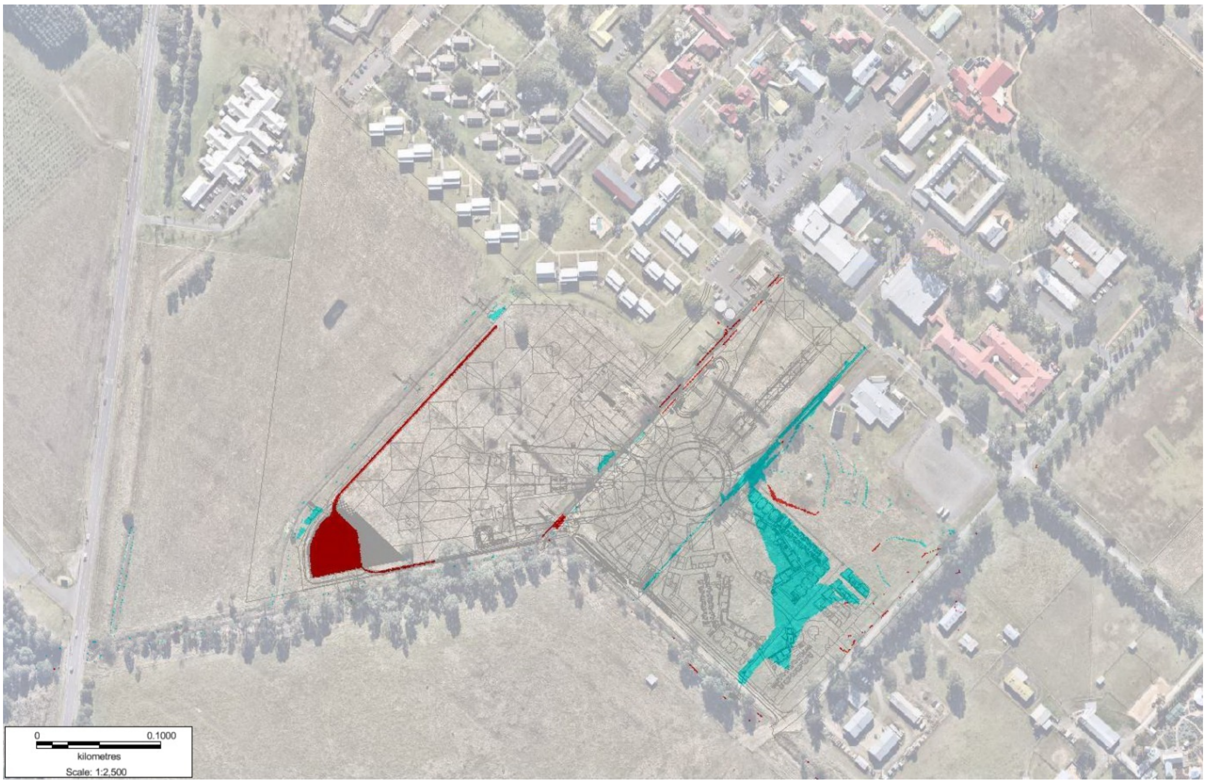


Figure 10 - Post vs. Pre-Development Wet vs Dry (s02_011)

11.9 Additional 1% AEP Flood Mapping (s02_011)

As part of a detailed analysis several additional post development flood mapping results were undertaken on the 1% AEP post development model. In addition to the following sections, the full flood maps have been included in this report as Appendix F.

11.9.1 Post Development Velocity Gradients and Contours

Besides the open channel and culvert flows, velocity throughout the study area was largely shown to be around 0.1ms^{-1} as sheet flow. Velocities within the open channel increased to 1ms^{-1} as would be expected due to the concentration of flood flows.

Figure 11 - Post Development Velocity Analysis (s02_011)

11.9.2 Post Development Velocity-Depth Hazard Analysis

Velocity Depth products (herein referred to as VD) are a measure of stability and potential hazard to pedestrians and vehicles. Higher VD products indicate higher risk areas of deeper depth, higher velocity, or combination of the two. The typical industry adopted VD limits are:

- Pedestrian safety is a VD product of 0.3.
- The above figure can be increased up to a VD product of 0.4 in areas that are inaccessible for children, the elderly and mobility disadvantaged.
- Vehicles are typically able to remain stable and resist effects of buoyancy up to a VD product of 0.6.

Figure 12 on the following page shows the grading and contours for velocity mapping. Based on results of the analysis the flood hazard can be considered “Low” throughout much of the site as the velocity depth products are generally less than 0.3. Flows within the channels have VD products up to 0.6 due to the increase in depth and velocity associated with the concentration of flood flows.

NOTE: Due to the increased velocity depth product and associated hazard within the open landscape and undercover shotcrete channel it is recommended that these areas be fenced off to prevent access to ensure the safety of students, staff and the general public.

11.9.1 Post Development NSW Floodplain Manual Hazard Analysis

TUFLOW is able to output the hazard mapping results as an integer numbered 1 through to 3 depending on the hazard categorisations set out in the Australian NSW Floodplain Management Manual (2005). Figure 13 on the following page indicated the mapping results. As per the VD product comparison the mapping indicates that the majority of the study area is considered a low hazard (light blue regions rated “1”) with the areas of high hazard confined to within the channelized flows (orange and red regions rated “2” to “3”).

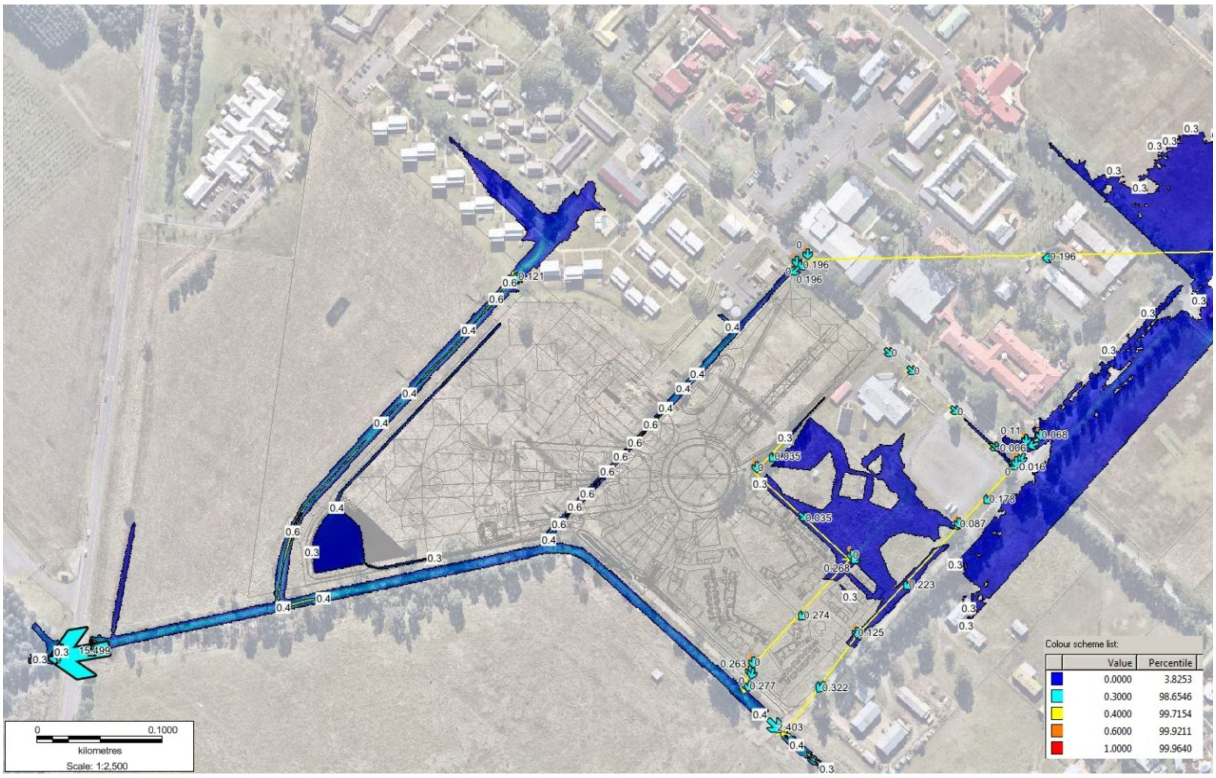


Figure 12 - Post Development Hazard Analysis: VD Products (s02_011)

Figure 13 - Post Development Hazard Analysis: NSW Floodplain Manual 2005 (s02_011)

The breakdown of the catchment for velocity & depth relationships as well as provisional hydraulic hazard categories provided by the NSW Floodplain Manual (2005) are shown on the following figure:

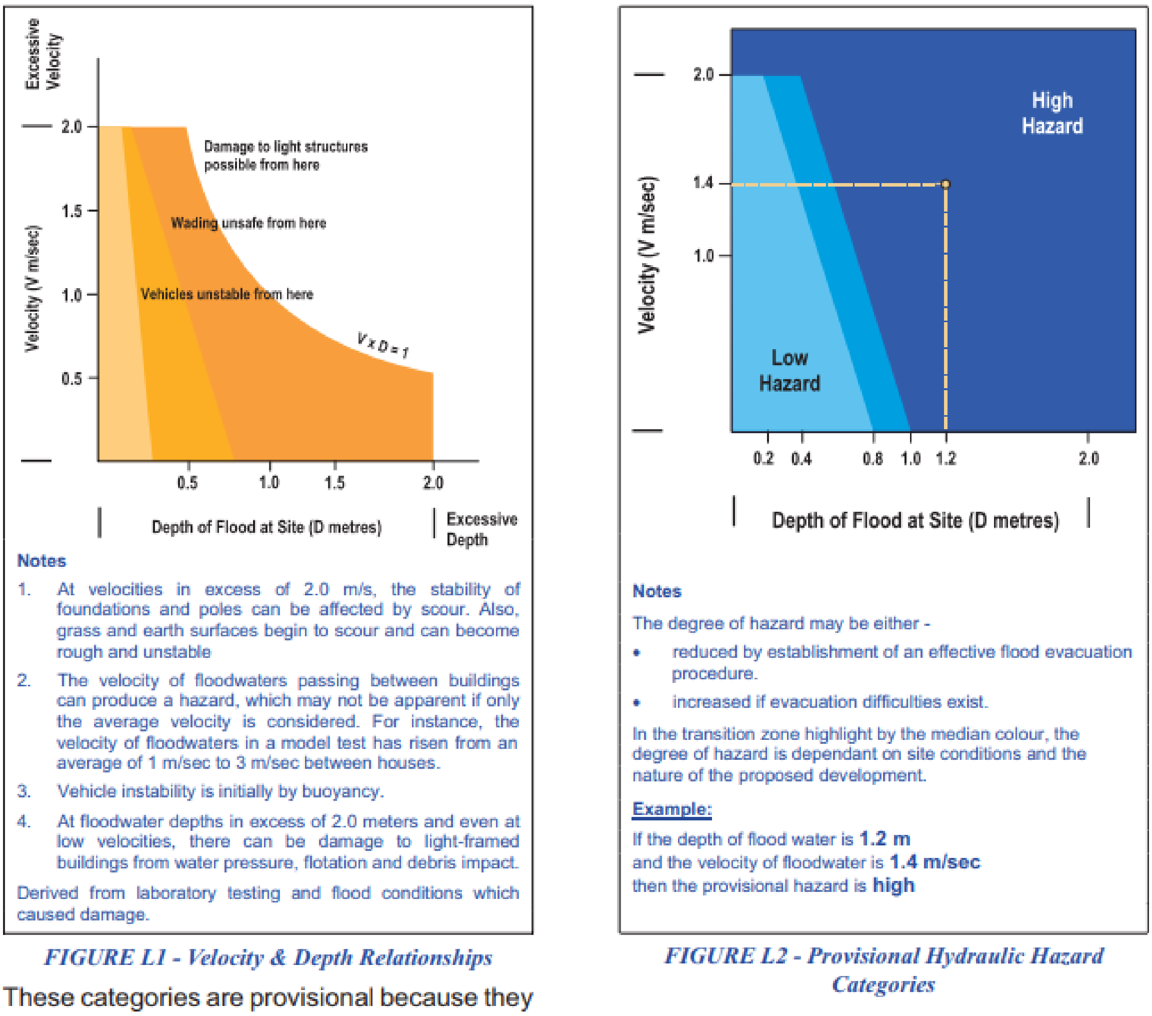


Figure 14 - NSW Floodplain Management Manual Hazard Categories (2005)

11.10 Probable Maximum Flood (s02_010)

XP RAFTS was utilised to estimate the PMP and peak flow hydrograph generated by the local overland flow flooding mechanism. The catchment characteristics were input into the model and ran for a range of durations ranging from 15 minutes to 6 hours which is the limit under the General Short Duration Method for calculating the Possible Maximum Precipitation (PMP). The same sub catchment areas used for the 1% AEP analysis in DRAINS were set up within the RAFTS model based on impervious and pervious ratios. The peak flowrate based on the PMP for the given catchment area was found to be 71.185m3/s in the 15-minute storm duration. As per the 1% AEP hydrology models, the XP RAFTS layout and hydrograph used for TUFLOW can be found under Appendix E.

Peak flood levels fronting the site were found to vary between RL 23.10m AHD to 23.50m AHD on the opposite side of Vines Drive. Although floodwater can enter the grounds of the boarding accommodation, the peak flood water level within this area remains at a maximum of RL 23.00m AHD and does not cause inundation of the finished floor levels.

Based on the PMF flood modelling of overland flow generated by the local catchment it is clear that the governing flooding mechanism for the PMF event will be the overtopping of banks due to riverine flooding of the Hawkesbury River which is recorded to be approximately RL26.40m AHD in the Hawkesbury Floodplain Risk Management Study & Plan December 2012 by Bewsher.

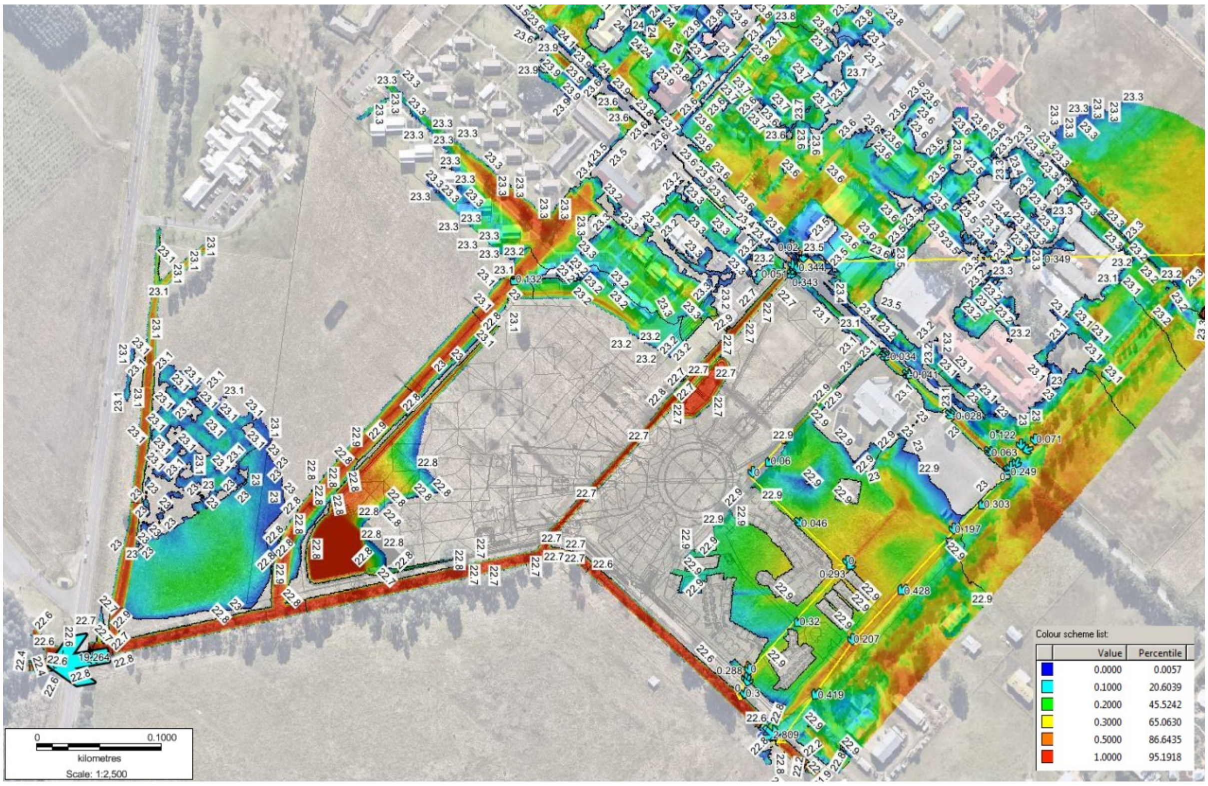


Figure 15 - PMF Depths of Inundation & Contours - Overland Flow (s02_010)

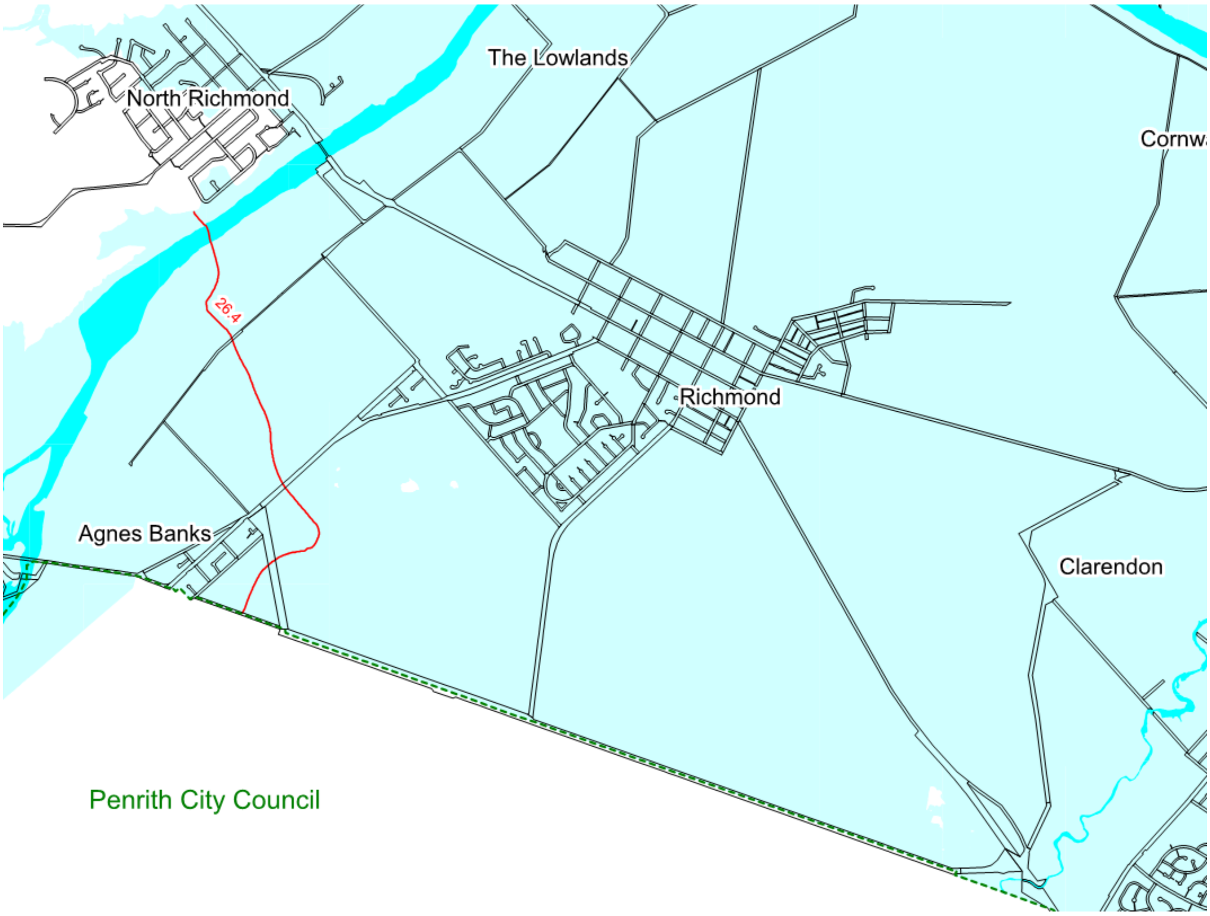


Figure 16 - PMF Extent & Contours - Riverine Flooding of the Hawkesbury (Bewsher 2012)

11.11 Sensitivity Analysis – Increased Rainfall (s02_012 & s02_013)

11.11.1 Increase in Rainfall

TTW have undertaken a sensitivity analysis on the effect of increases in rainfall on peak flood water levels. The procedure for estimating the percentage increase on rainfall is documented in Australian Rainfall and Runoff 2016: Book 1, Chapter 6 – Climate Change Considerations.

The assumptions made for the calculation of increases in rainfall include:

- An effective service life or planning horizon in excess of 20 years (50 years min; 2070).
- Given the purpose and nature of the school and consequence of failure a medium to high consequence and risk category was selected.
- Representative Concentration Pathways (RCPs) for greenhouse gas concentration levels of 4.5 and 8.5 were adopted.

Based on the process outlined in ARR 2016 the Global Climate Model (GCM) cases for the RCP8.5 greenhouse gas concentration level was the critical case. Based on a 1.5 degree to 3.0 degree increase in surface temperature, a sensitivity analysis of 12% increase in rainfall is recommended by following this procedure.

Further to the above, the climate change projections builder provided by the CSIRO and Bureau of Meteorology, Climate Change in Australia was also used to generate an approximate increase in surface temperature of 3.64 degrees. As a result, a 20% increase in rainfall was also undertaken to anticipate the worst-case scenario for the RCP8.5 case.

11.11.2 Results

Equivalent depths were achieved by applying the increase in rainfall percentages to the existing rainfall data for the 1% AEP storm event in DRAINS. The corresponding hydrographs for the 12% and 20% increase in rainfall events were then updated to the SA polygons for hydraulic analysis in TUFLOW. To ascertain the effect of the change in rainfall on peak flows five (5) points of interest were created within the model:

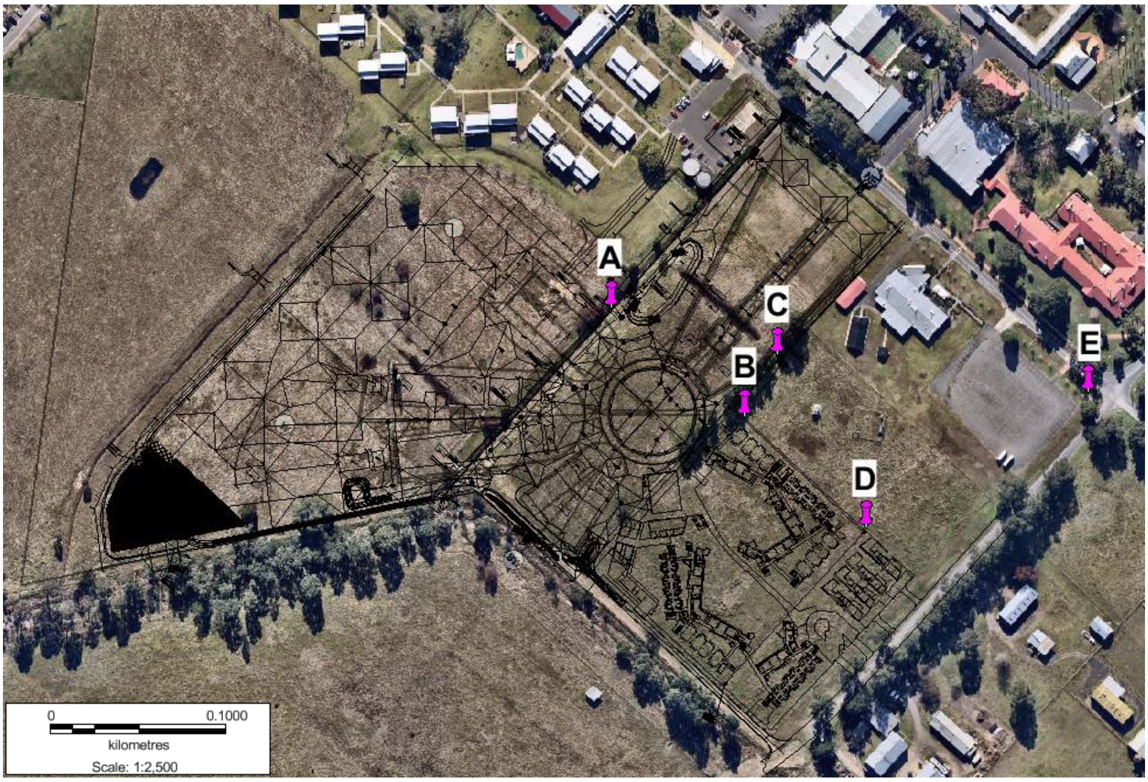


Figure 17 – Location of Comparison Points

Results of the TUFLOW sensitivity analysis on an increase in rainfall are provided in the following figures.

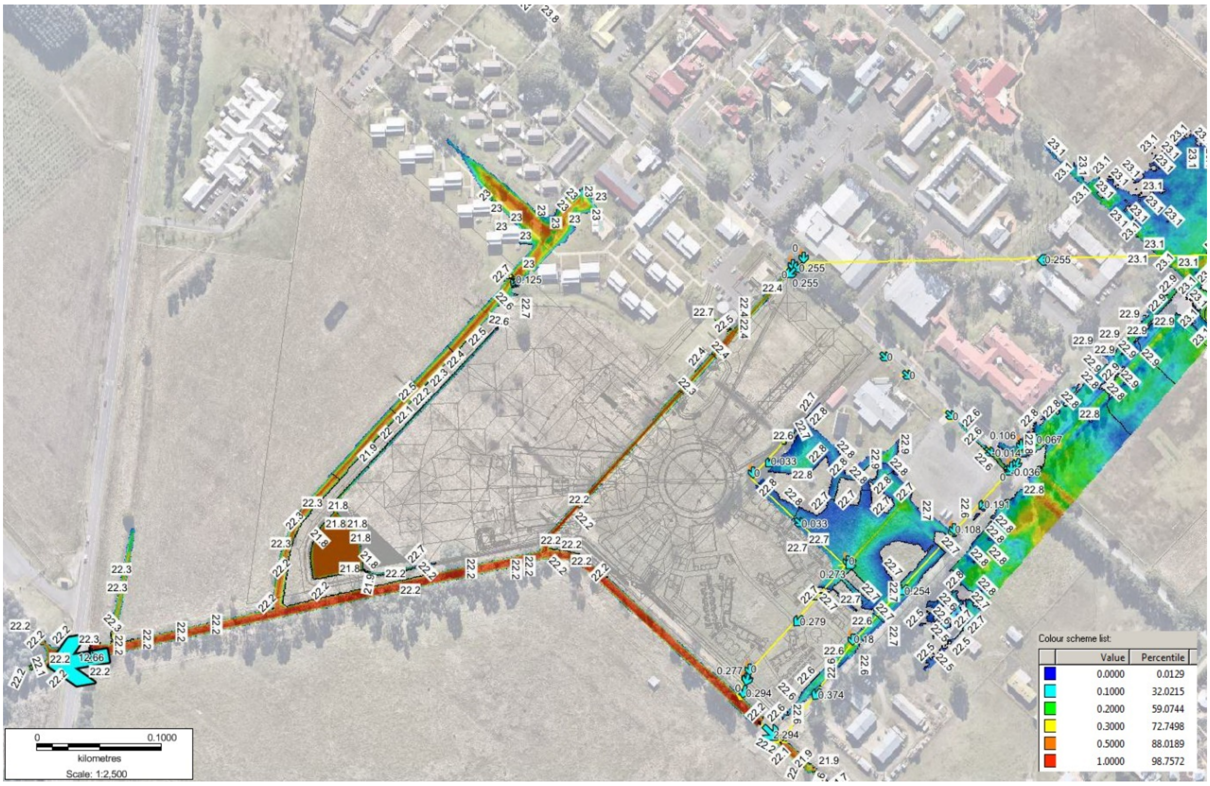


Figure 18 - 12% Increase in Rainfall - Depths and Contours (s02_012)

Figure 19 - 20% Increase in Rainfall - Depths and Contours (s02_013)

The following table compares the peak flow and flood levels from the mapping results at the key locations in comparison to the base 1% AEP modelling case (s02_011).

Scenario	Peak Flow in CH01	Flood Level A	Flood Level B	Flood Level C	Flood Level D	Flood Level E
1% AEP base case (s02_011)	11.40m^3/s	22.29	22.84	22.67	22.71	22.62
1% AEP + 12% rainfall (s02_012)	13.20m^3/s	22.29	22.85	22.68	22.74	22.67
1% AEP + 20% rainfall (s02_013)	14.40m^3/s	22.39	22.86	22.88	22.75	22.73

Table 3 - Sensitivity Analysis

As expected, an increase in rainfall will result in an increase in flows and peak flood levels on the subject site. The flood levels in both the PMF and sensitivity analysis scenarios are still below the proposed finished floor level of the development. As such, floodwater generated by overland flow from the local catchment will be prevented from entering the development in all scenarios.

The hydrographs and peak flows generated in DRAINS/XP RAFTS as well as the TUFLOW flood maps showing depths of inundation and water surface contours can be found attached to this report under Appendix E and F respectively.

11.12 Flood Planning Levels

Flood planning levels were based on the nearest flood contour adjacent to each building to ensure that the habitable floors provide a level of freeboard.

Location	Post-Dev Flood Level s02_013 (mAHD)	Finished Floor Level (mAHD)	Min. Freeboard Provided (mm)
Building 01	RL 22.90 overland RL 22.50 in channel	**FFL 23.60**	500mm 500mm
Building 02	RL 22.40 in channel	**FFL 23.60**	500mm
Building 03	RL 22.40 in channel	**FFL 23.60**	500mm
Building 04	RL 22.40 in channel	**FFL 23.60**	500mm
Building 05	RL 22.90 overland	**FFL 23.60**	500mm
Boarding Accommodation	RL 22.90 overland	**FFL 23.40 (min)**	500mm

Table 17 - Flood Planning Levels

11.13 Emergency Evacuation Plan

A site emergency evacuation plan detailing the flood inundation, mitigation measures as well as the proposed relocation of people to a safe location should be developed and implemented by operations and management. The staff employed at the new development will be required to be trained for typical emergency situations such as fires. In addition to this generalised training the management of a flood event can also be incorporated into the responsibility of staff members. It is recommended that an emergency evacuation plan be developed based on the PMF flood behaviour and address the following items:

- The training and action required for the management of a flood event including the deployment of any flood mitigation measures and relocation of persons.
- Similarly, to fire wardens, flood wardens can be appointed and made responsible for managing the evacuation procedures. Flood evacuation drills can also be scheduled to ensure all persons are aware of the correct procedure.
- The maintenance and operation schedules of any alarm and warning systems implemented. E.g. a ball float alarm system can in installed within the lower lying pits which would then sound and activate alarms and any flood mitigation measures.
- Locations of the appropriate flood warning signage.

The emergency evacuation plan is proposed to be developed as a separate document and will act as a supplement to this civil engineering report. The plan will consider existing regional flood evacuation plans and how a site-specific strategy can be implemented.

11.14 Other Requirements

All structures are to have flood compatible building components at or below the flood planning level (100-year level plus freeboard). It should be noted that the structural engineering design shall certify that all building materials used within flood affected areas are able to withstand the forces of flood water including buoyancy and debris impact loads.

11.15 Flood Risk Assessment Recommendations:

The key strategies to be adopted for the development include the following:

- Freeboard is to be provided through setting the habitable floor levels as outlined in Section 11.11. A minimum of 500mm freeboard is provided above the 1% AEP flood levels.
- The development shall incorporate the flood mitigation measures outlined in Section 11.6.
- Due to the increased velocity depth product and associated hazard within the open and shotcrete channel it is recommended that this area be fenced off to prevent access in order to ensure the safety of students, staff and the general public.
- Maintenance access for the shotcrete channel underneath the proposed buildings shall be provided through chambers with lockable bolt down type sealed lids.
- The building shall be constructed from flood compatible materials and designed to withstand flood pressure and impacts from debris carried in flood waters.
- The design shall also be certified by a structural engineer engaged on the development.
- An emergency evacuation strategy based on the probable maximum flood shall be developed as a supplement to this civil engineering report.

12.0 Conclusions

The proposed development has the potential to lead to significant adverse changes in water quantity and quality leaving the site if a water sensitive urban design management strategy is not adopted during the design and development stage of the project. The measures outlined in this report extend beyond the traditional civil works management measures to consider the overall impact of all construction related activities on the surrounding man-made and natural environments. Best practices must encompass the effects of flooding, water quality and maintenance of these items to develop an appropriate water management strategy to ensure that development occurs in an ecologically sustainable way.

Prepared by
TAYLOR THOMSON WHITTING (NSW) PTY LTD

WILLIAM WEBB

Civil Engineer

Authorised By
TAYLOR THOMSON WHITTING (NSW) PTY LTD

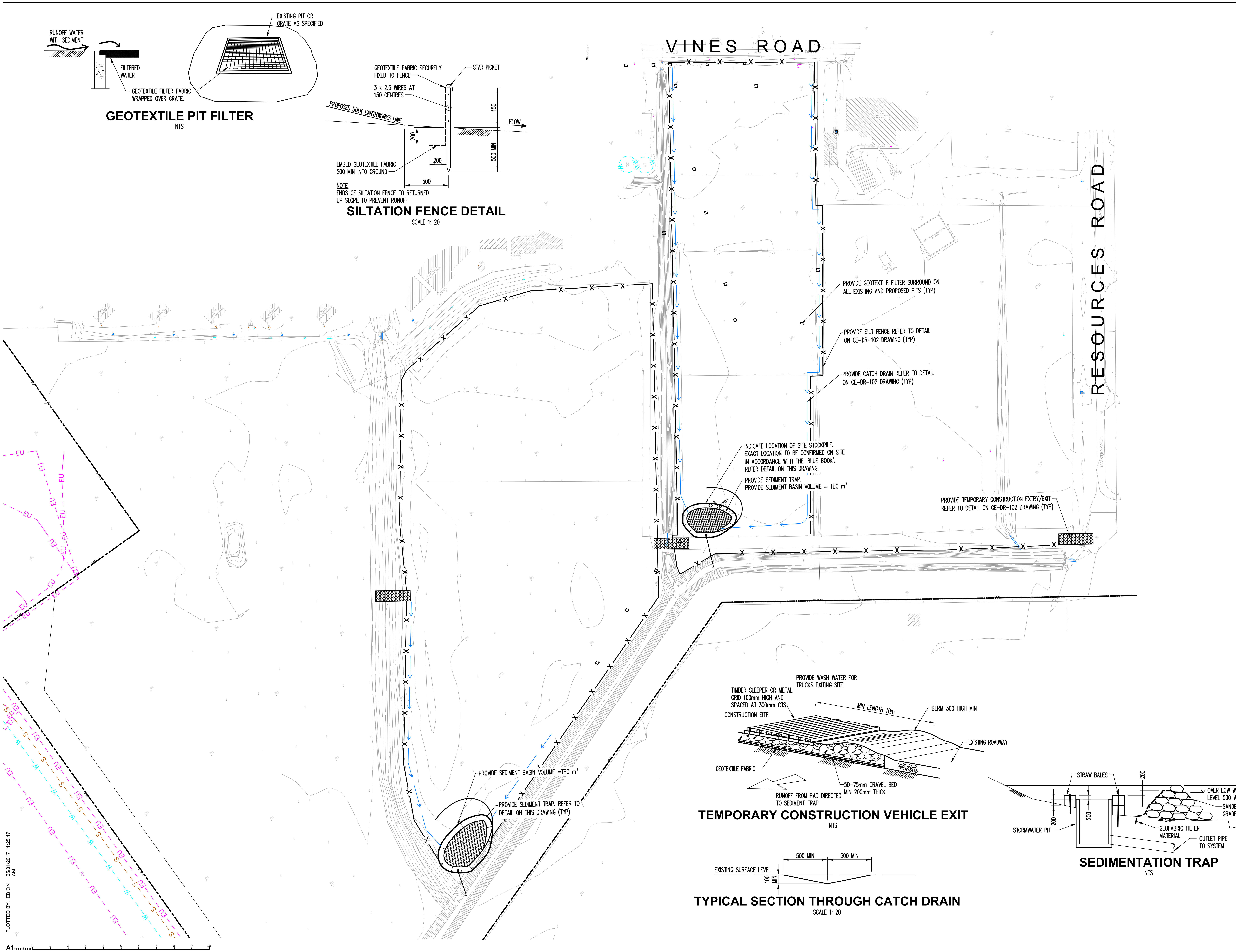
PAUL YANNOULATOS

Technical Director

P:\2016\1611\161108\Reports\TTW\171103 Civil Engineering Report - Rev D.docx

Appendix A

Sedimentation and Erosion Control Plan



EROSION AND SEDIMENT CONTROL NOTES

1. All work shall be generally carried out in accordance with
   (A) Local authority requirements,
   (B) EPA – Pollution control manual for urban stormwater,
   (C) LANDCOM NSW – Managing Urban Stormwater: Soils and Construction ("Blue Book").
2. Erosion and sediment control **drawings and notes are** provided for the whole of the works. Should the Contractor stage these works then the design may be required to be modified. Variation to these details may require approval by the relevant authorities. The erosion and sediment control **plan** shall be implemented and adopted to meet the varying situations as work on site progresses.
3. Maintain all erosion and sediment control devices to the satisfaction of the superintendent and the local authority.
4. When stormwater pits are constructed prevent site runoff entering the pits unless silt fences are erected around pits.
5. Minimise the area of site being disturbed at any one time.
6. Protect all stockpiles of materials from scour and erosion. Do not stockpile loose material in roadways, near drainage pits or in watercourses.
7. All soil and water control measures are to be put back in place at the end of each working day, and modified to best suit site conditions.
8. Control water from upstream of the site such that it does not enter the disturbed site.
9. All construction vehicles shall enter and exit the site via the temporary construction entry/exit.
10. All vehicles leaving the site shall be cleaned and inspected before leaving.
11. Maintain all stormwater pipes and pits clear of debris and sediment. Inspect stormwater system and clean out after each storm event.
12. Clean out all erosion and sediment control devices after each storm event.

SEQUENCE OF WORKS

1. Prior to commencement of excavation the following soil management devices must be installed.

1.1. Construct silt fences below the site and across all potential runoff sites.

1.2. Construct temporary construction entry/exit and divert runoff to suitable control systems.

1.3. Construct measures to divert upstream flows into existing stormwater system.

1.4. Construct sedimentation traps/basin including outlet control and overflow.

1.5. Construct turf lined swales.

1.6. Provide sandbag sediment traps upstream of existing pits.

2. Construct geotextile filter pit surround around all proposed pits as they are constructed.
3. On completion of pavement provide sand bag kerb inlet sediment traps around pits.
4. Provide and maintain a strip of turf on both sides of all roads after the construction of kerbs.

WATER QUALITY TESTING REQUIREMENTS

Prior to discharge of site stormwater, groundwater and seepage water into council's stormwater system, contractors must undertake water quality tests in conjunction with a suitably qualified environment consultant outlining the following:

- Compliance with the criteria of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)
- If required subject to the environmental consultants advice, provide remedial measures to improve the quality of water that is to be discharged into Councils storm water drainage system.This should include comments from a suitably qualified environmental consultant confirming the suitability of these remedial measures to manage the water discharged from the site into Councils storm water drainage system. Outlining the proposed, ongoing monitoring, contingency plans and validation program that will be in place to continually monitor the quality of water discharged from this site. This should outline the frequency of water quality testing that will be undertaken by a suitably qualified environmental consultant.

EROSION AND SEDIMENT CONTROL LEGEND

┬┬┬┬	Batter
—X—X—	Siltation fence
▭	Stormwater pit with Geotextile filter surround
← ←	Catch drain

0 10 20 30 40 50 60 70 80m

1:1000 A1 1:2000 A3

A1

CLIENT: NSW GOVERNMENT Education

PROJECT MANAGER: mace

CONSULTANT: TTW Taylor Thomson Whitting
612 9439 7288 | 48 Chandos Street St Leonards NSW 2065

PROJECT: HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY)

INTERNAL PROJECT No: 161108

DATE: 22/08/2017 11:25:17 AM

NORTH

DRAWING: EROSION & SEDIMENT CONTROL PLAN AND DETAILS SHEET 1

Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17
P2	ISSUE FOR APPROVAL	NB	AI	26.09.17

Scale : A1	Drawn	Authorised
1:1000	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE -	DR -	101	P2

Appendix B

Concept Stormwater Management Plan

PLOTTED BY: EB ON 25/01/2017 11:25:17 AM

CLIENT: NSW GOVERNMENT Education

PROJECT MANAGER: mace

CONSULTANT: TTW Taylor Thomson Whitting
612 9439 7288 | 48 Chandos Street St Leonards NSW 2065

PROJECT: HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY)

INTERNAL PROJECT No: 161108

DATE: 22/08/2017 11:25:17 AM

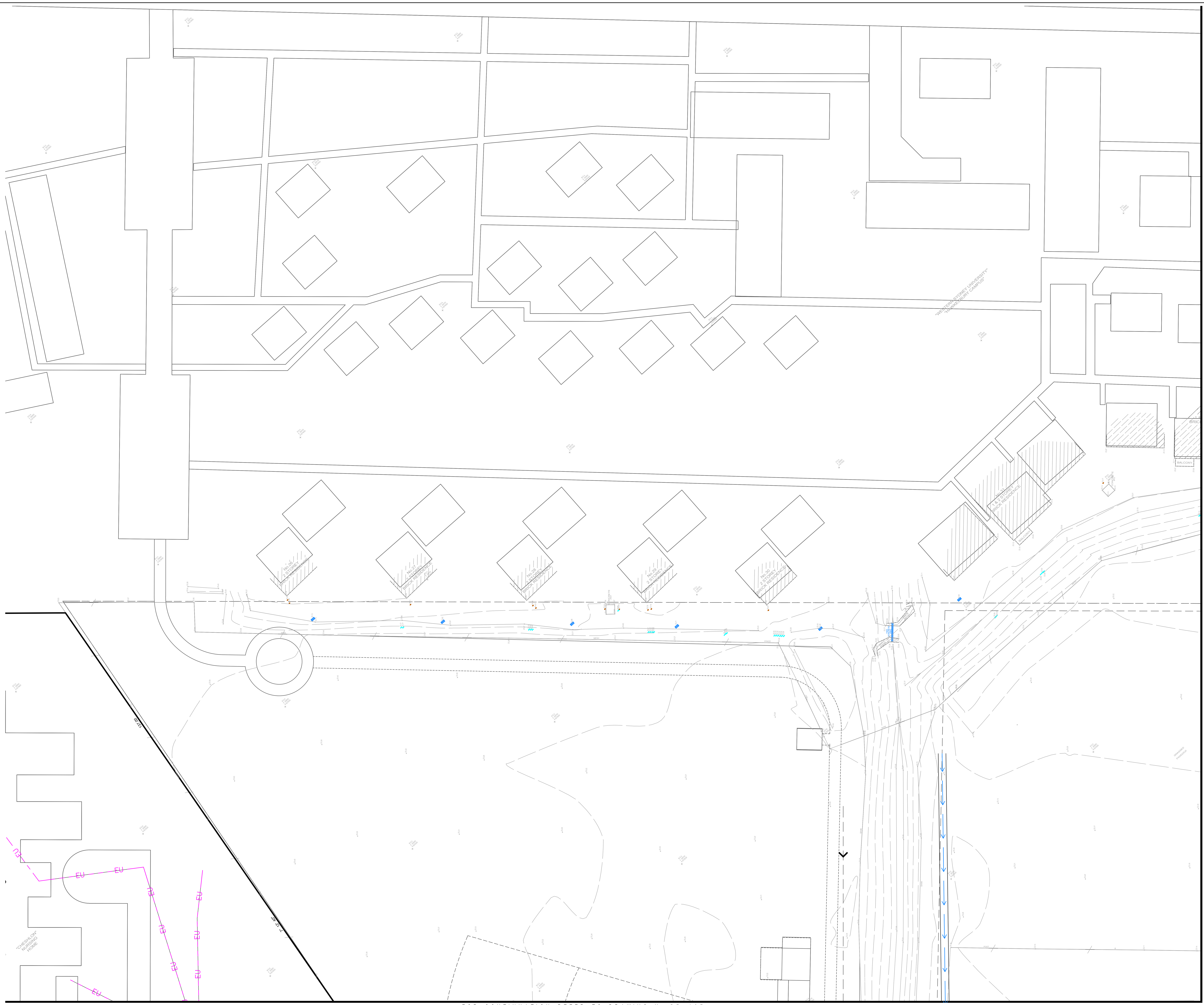
NORTH

DRAWING: OVERALL SITE WORKS PLAN

Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17
P2	ISSUE FOR APPROVAL	NB	AI	26.09.17

Scale : A1	Drawn	Authorised
1:1000	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE	- DR	- 102	P2



FOR CONTINUATION REFER TO DRAWING No.DR-104

FOR CONTINUATION REFER TO DRAWING No.DR-105

PLOTTED BY: EB ON 25/01/2017 11:25:17 AM

A1 0 1 2 3 4 5 6 7 8 9 10

CLIENT	PROJECT MANAGER	CONSULTANT	PROJECT	NORTH	DRAWING
NSW GOVERNMENT Education	mace	TTW Taylor Thomson Whitting 612 9439 7288 | 48 Chandos Street St Leonards NSW 2065	HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY)		SITEWORKS PLAN SHEET 1 OF 4

INTERNAL PROJECT No: 161108

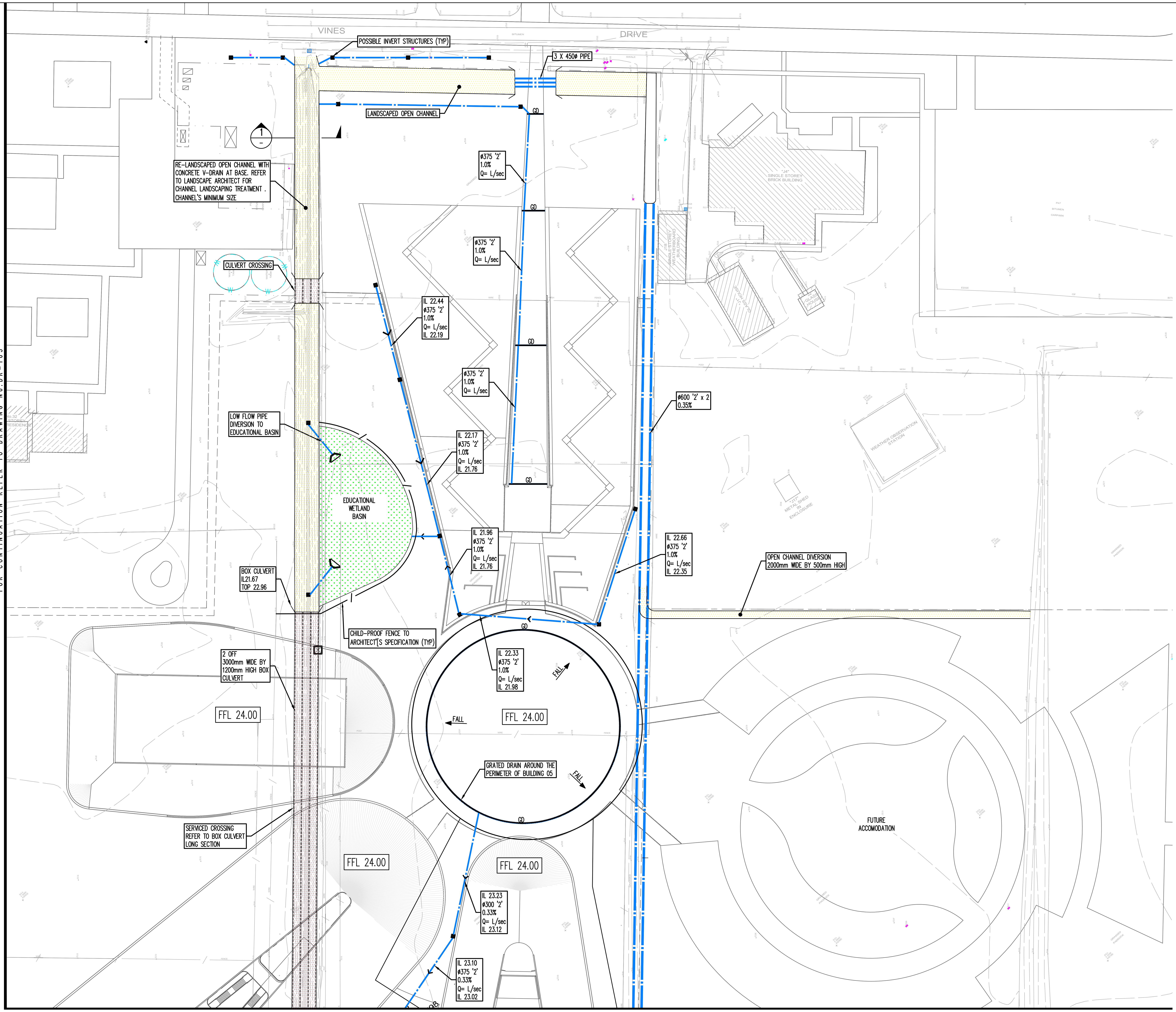
DATE: 22/08/2017 11:25:17 AM

© CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
mail@conradgargett.com.au ABN 49 325 121 350
DO NOT SCALE DRAWING & VERIFY ALL DIMENSIONS AND LEVELS ON SITE

Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17

Scale : A1	Drawn	Authorised
1:500	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE	- DR	- 103	P1



FOR CONTINUATION REFER TO DRAWING No.DR-103

FOR CONTINUATION REFER TO DRAWING No.DR-106

PLOTTED BY: EB ON 25/01/2017 11:25:17 AM

A1

CLIENT	PROJECT MANAGER	CONSULTANT	PROJECT	NORTH	DRAWING
NSW GOVERNMENT Education	mace	TTW Taylor Thomson Whitting 612 9439 7288 | 48 Chandos Street St Leonards NSW 2065	HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY)		SITEWORKS PLAN SHEET 2 OF 4

INTERNAL PROJECT No: 161108

DATE: 22/08/2017 11:25:17 AM

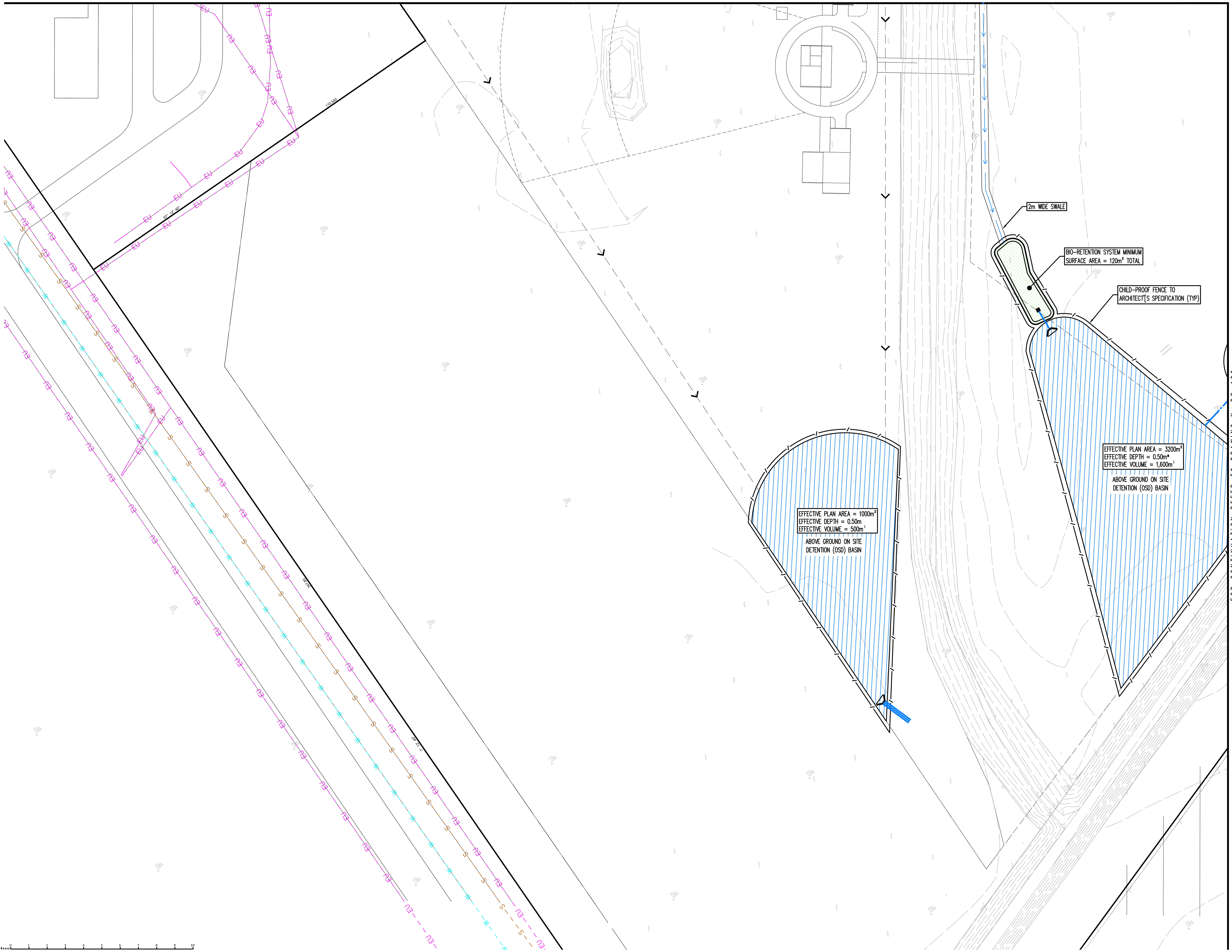
Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17
P2	ISSUE FOR APPROVAL	NB	AI	26.09.17

Scale : A1	Drawn	Authorised
1:500	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE	- DR	- 104	P2

This drawing is copyright and is the property of TAYLOR THOMSON WHITTING (NSW) Pty Ltd and must not be used without authorisation.

FOR CONTINUATION REFER TO DRAWING No.DR-103



FOR CONTINUATION REFER TO DRAWING No.DR-106

PLOTTED BY: EB ON 25/01/2017 11:25:17 AM

A1 0 1 2 3 4 5 6 7 8 9 10

CLIENT	PROJECT MANAGER	CONSULTANT	PROJECT	NORTH	DRAWING
NSW GOVERNMENT Education	mace	TTW Taylor Thomson Whitting 612 9439 7288 | 48 Chandos Street St Leonards NSW 2065	HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY)		SITEWORKS PLAN SHEET 3 OF 4

INTERNAL PROJECT No: 161108

DATE: 22/08/2017 11:25:17 AM

© CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
mail@conradgargett.com.au ABN 49 325 121 350
DO NOT SCALE DRAWING & VERIFY ALL DIMENSIONS AND LEVELS ON SITE

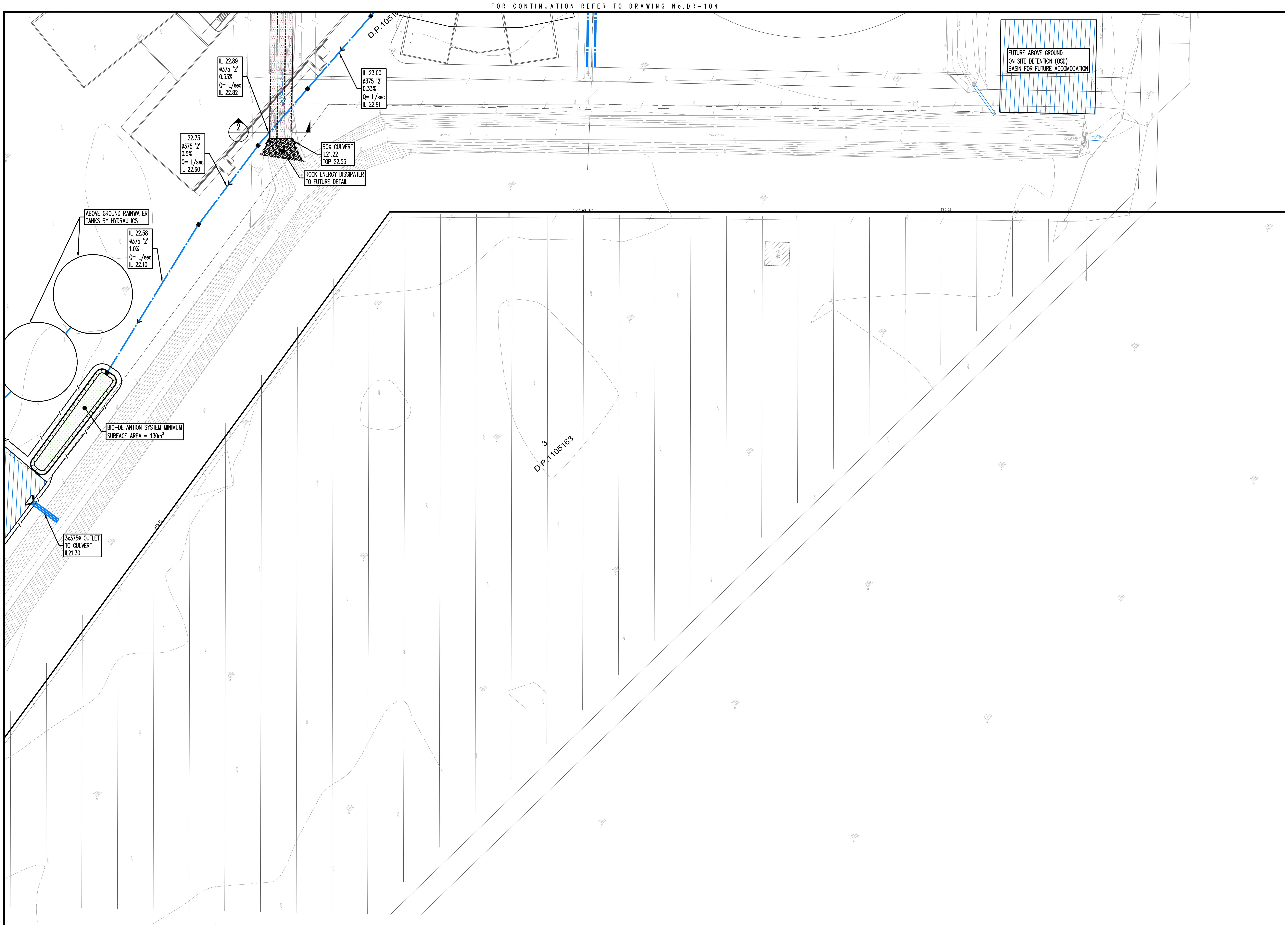
Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17
P2	ISSUE FOR CO-ORDINATION	NB	AI	26.09.17

Scale : A1	Drawn	Authorised
1:500	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE	- DR	- 105	P1

FOR CONTINUATION REFER TO DRAWING No.DR-104

FOR CONTINUATION REFER TO DRAWING No.DR-105



PLOTTED BY: EB ON 25/01/2017 11:25:17 AM

A1 0 1 2 3 4 5 6 7 8 9 10

CLIENT	PROJECT MANAGER	CONSULTANT	PROJECT	NORTH	DRAWING
NSW GOVERNMENT Education	mace	TTW Taylor Thomson Whitting 612 9439 7288 | 48 Chandos Street St Leonards NSW 2065	HURLSTONE AGRICULTURAL HIGH SCHOOL (HAWKESBURY) INTERNAL PROJECT No: 161108 DATE: 22/08/2017 11:25:17 AM © CONRAD GARGETT ANCHER MORTLOCK WOOLLEY mail@conradgargett.com.au ABN 49 325 121 350 DO NOT SCALE DRAWING & VERIFY ALL DIMENSIONS AND LEVELS ON SITE		SITEWORKS PLAN SHEET 4 OF 4

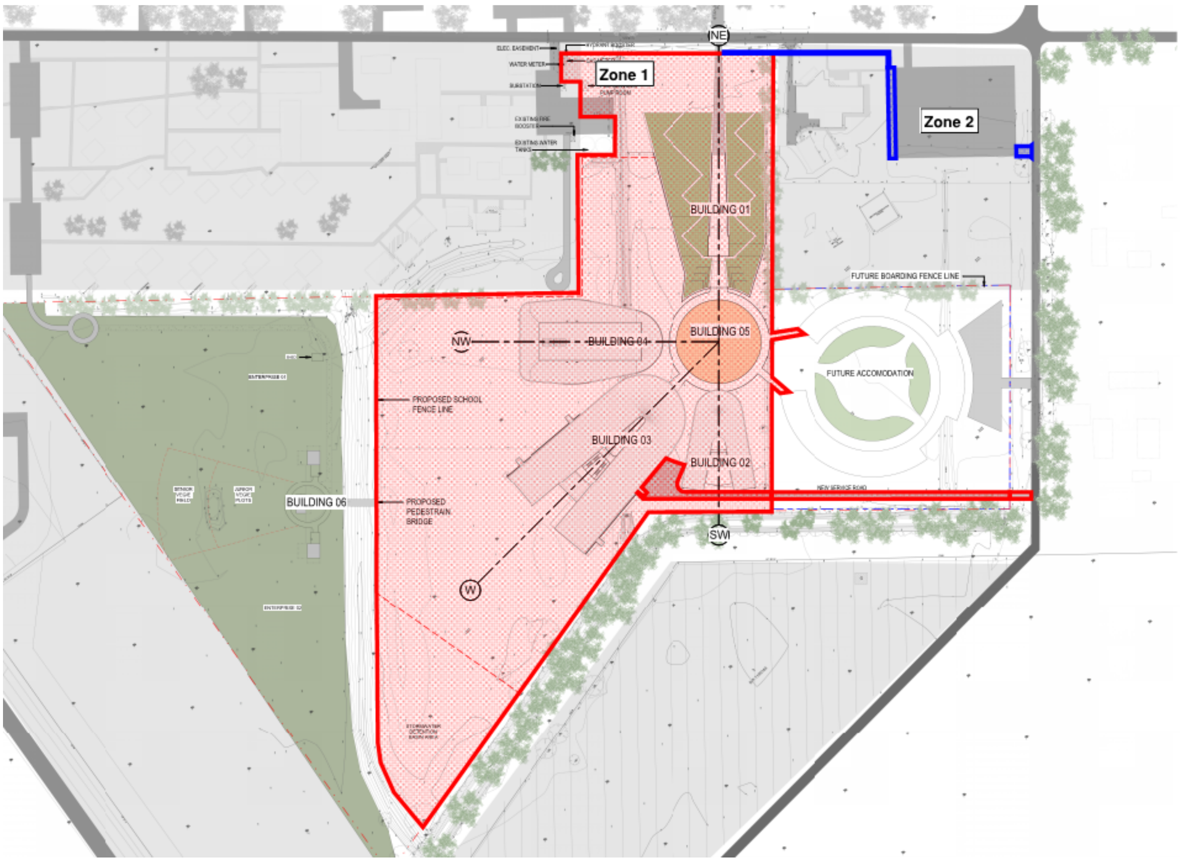
Rev	Description	Eng	Draft	Date
P1	ISSUE FOR CO-ORDINATION	NB	JH	12.09.17
P2	ISSUE FOR APPROVAL	NB	AI	26.09.17

Scale : A1	Drawn	Authorised
1:500	AI	PY

SCHOOL ID	BLDG ID	STAGE	DISCIPLINE	DOC TYPE	DRAWING No:	REV:
HASH	-00-	CO	-CE	- DR	- 106	P2

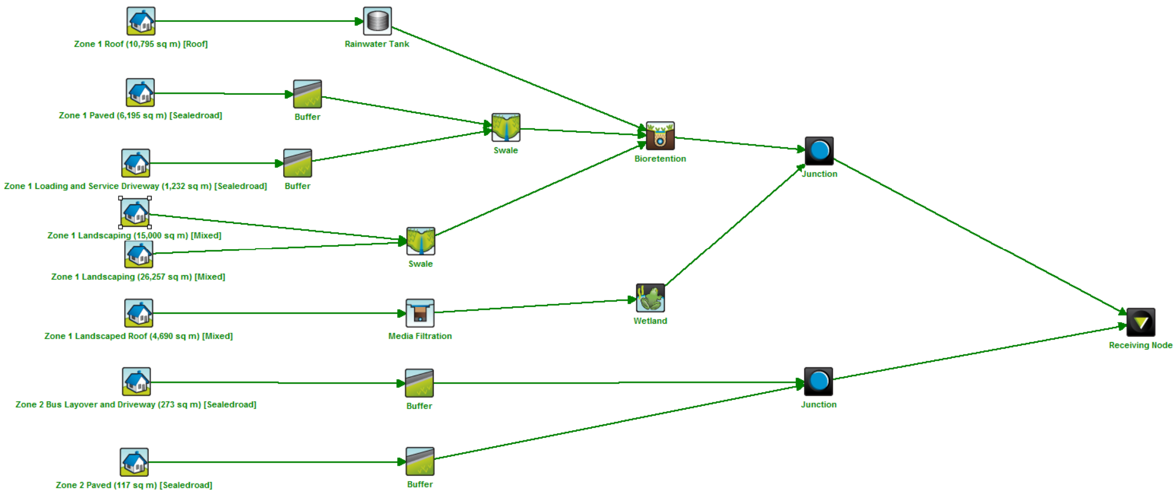
Appendix C

Music Catchment Plan



Appendix D

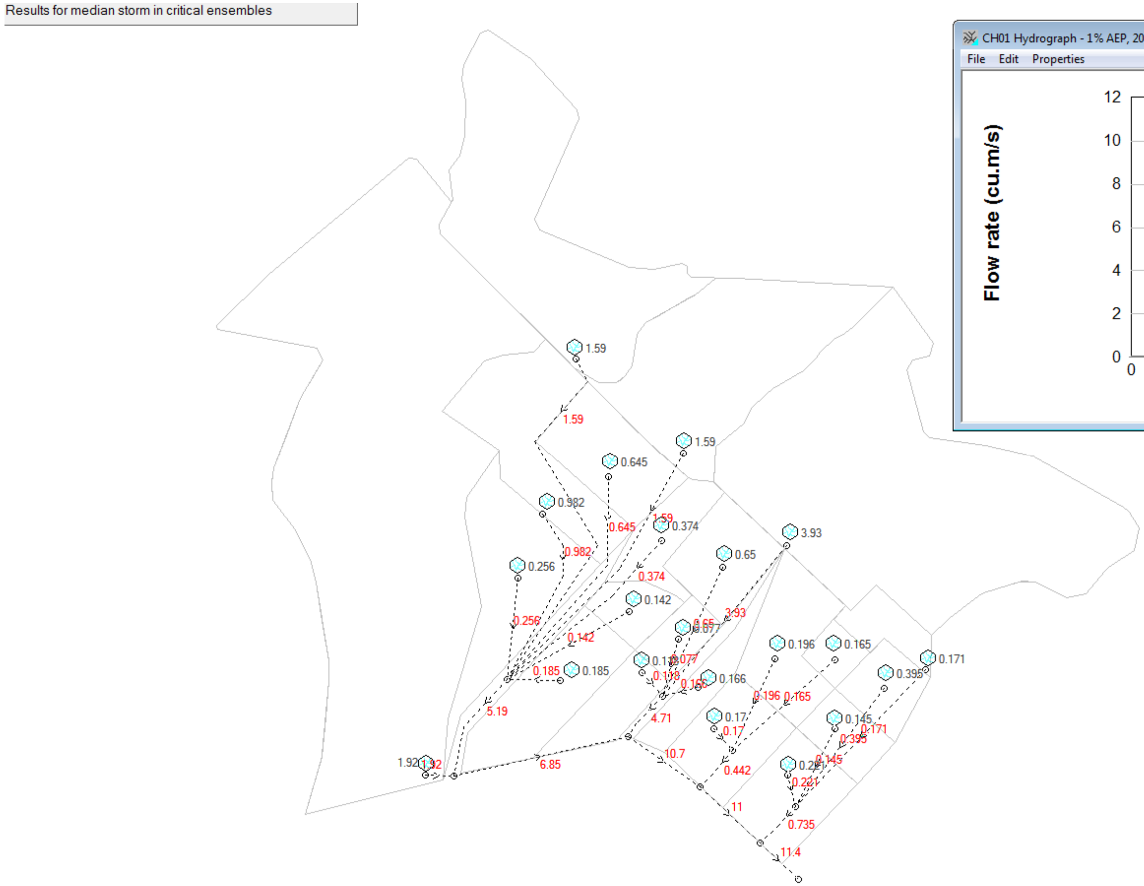
Music Model Layout

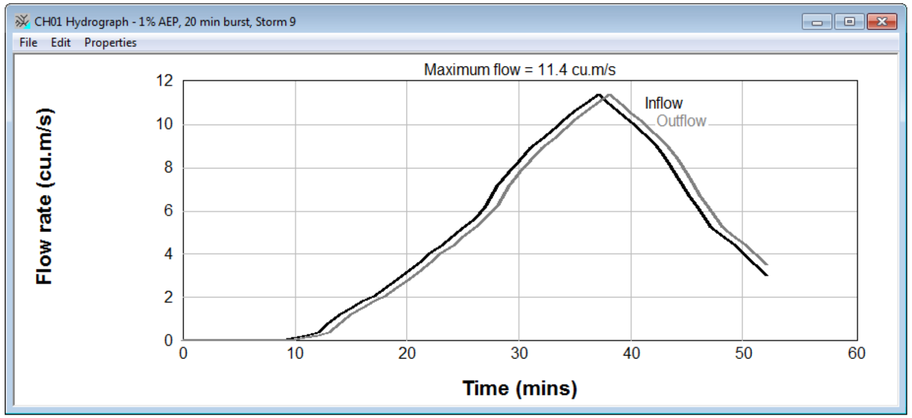


Appendix E

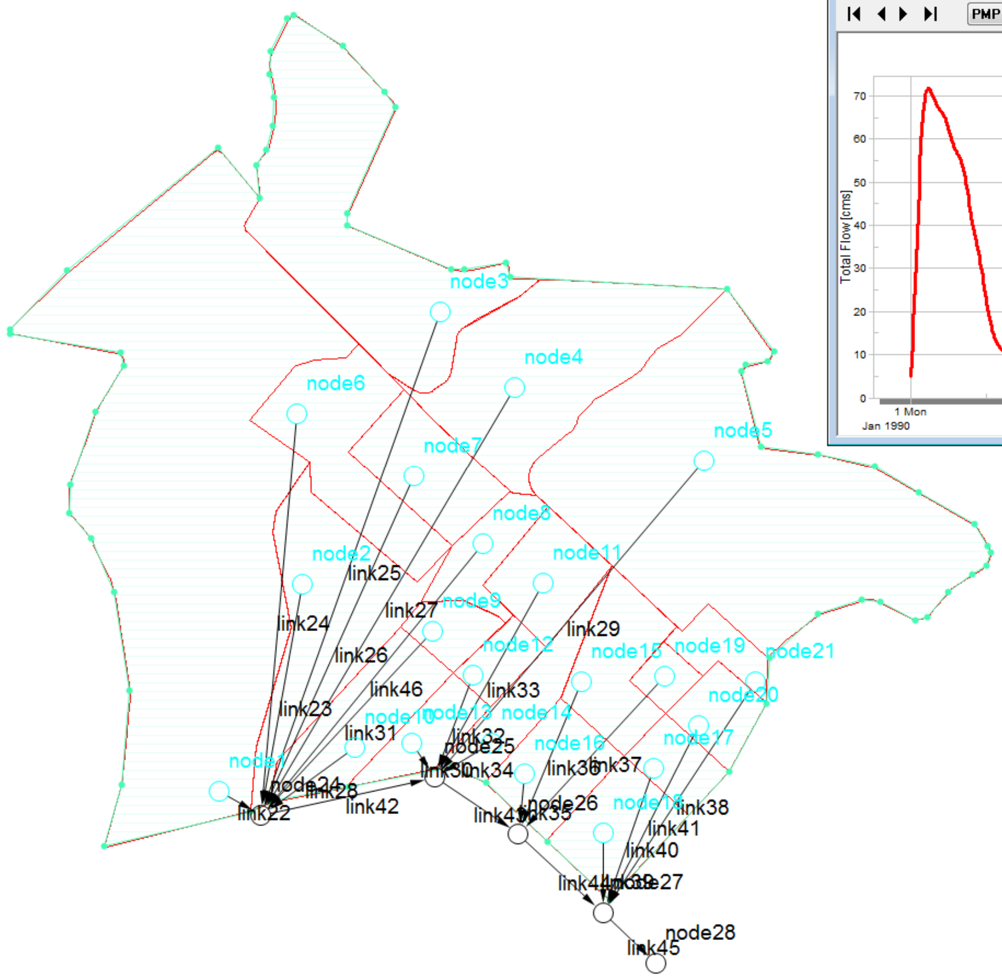
Hydrology Models

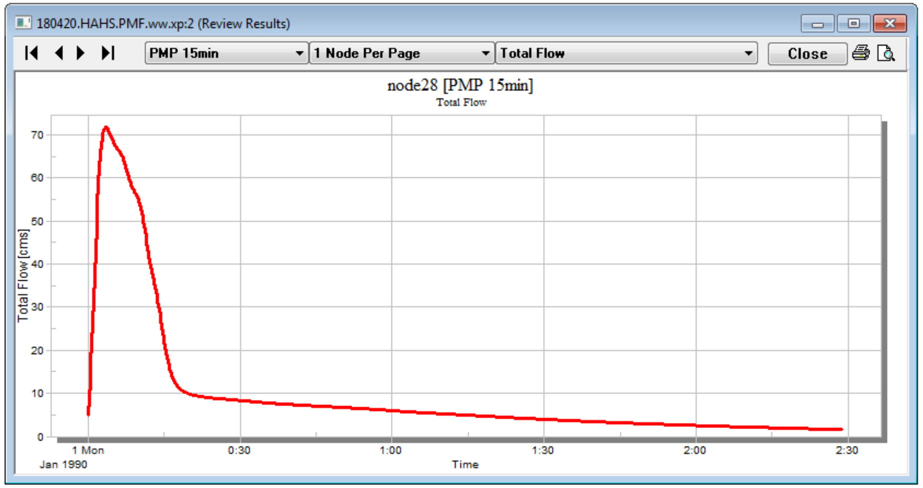
DRAINS – 1% AEP (s01_004 & s02_011)



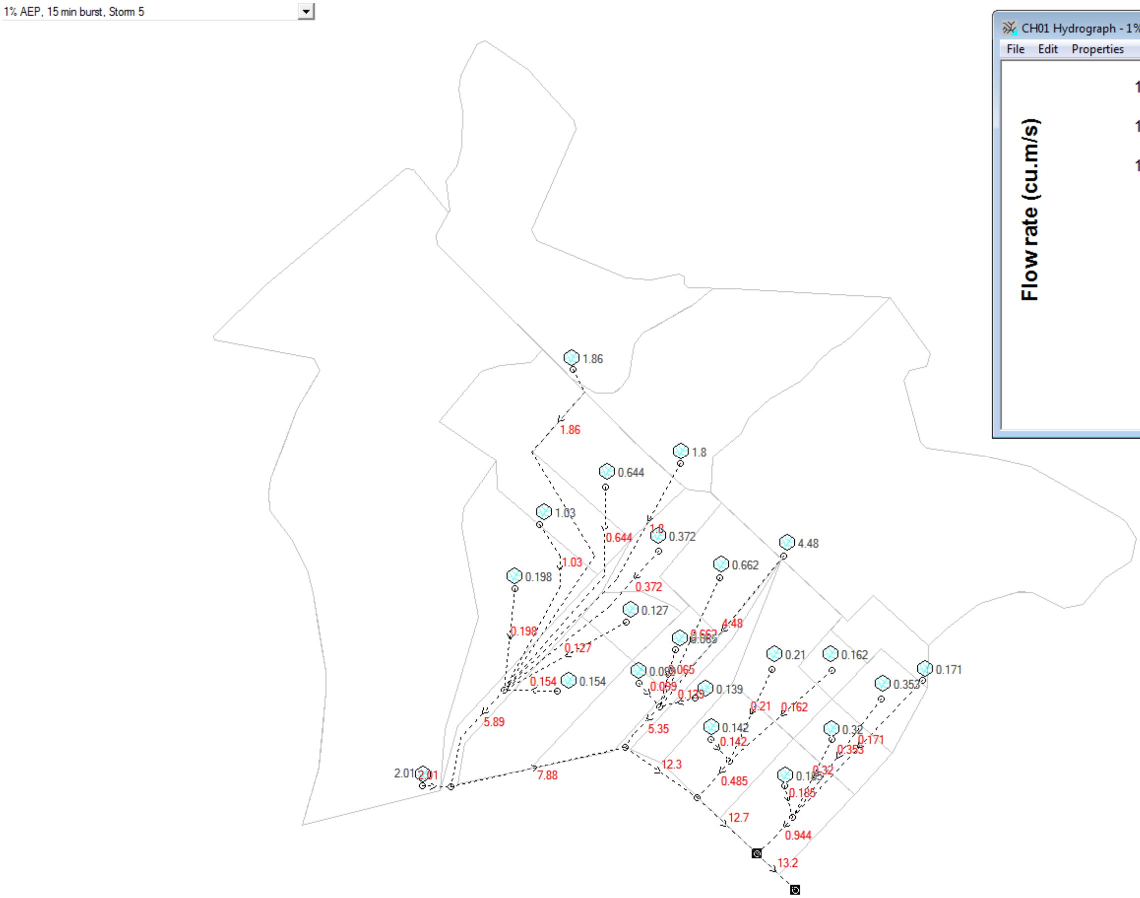


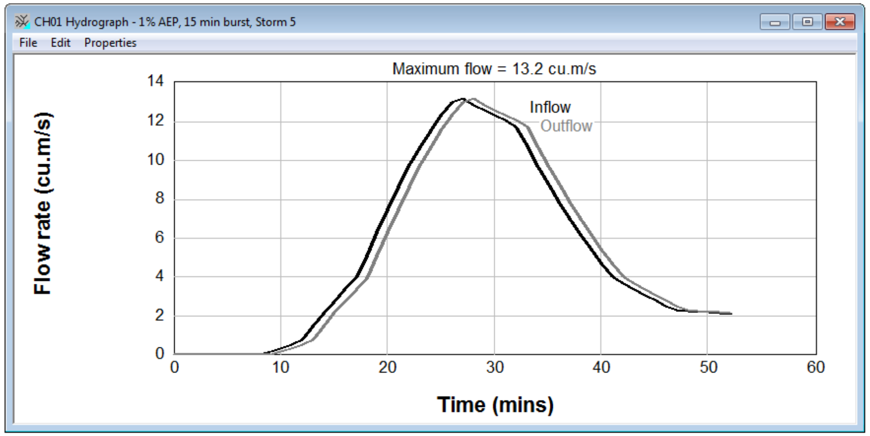
XP RAFTS – PMF (s02_010)



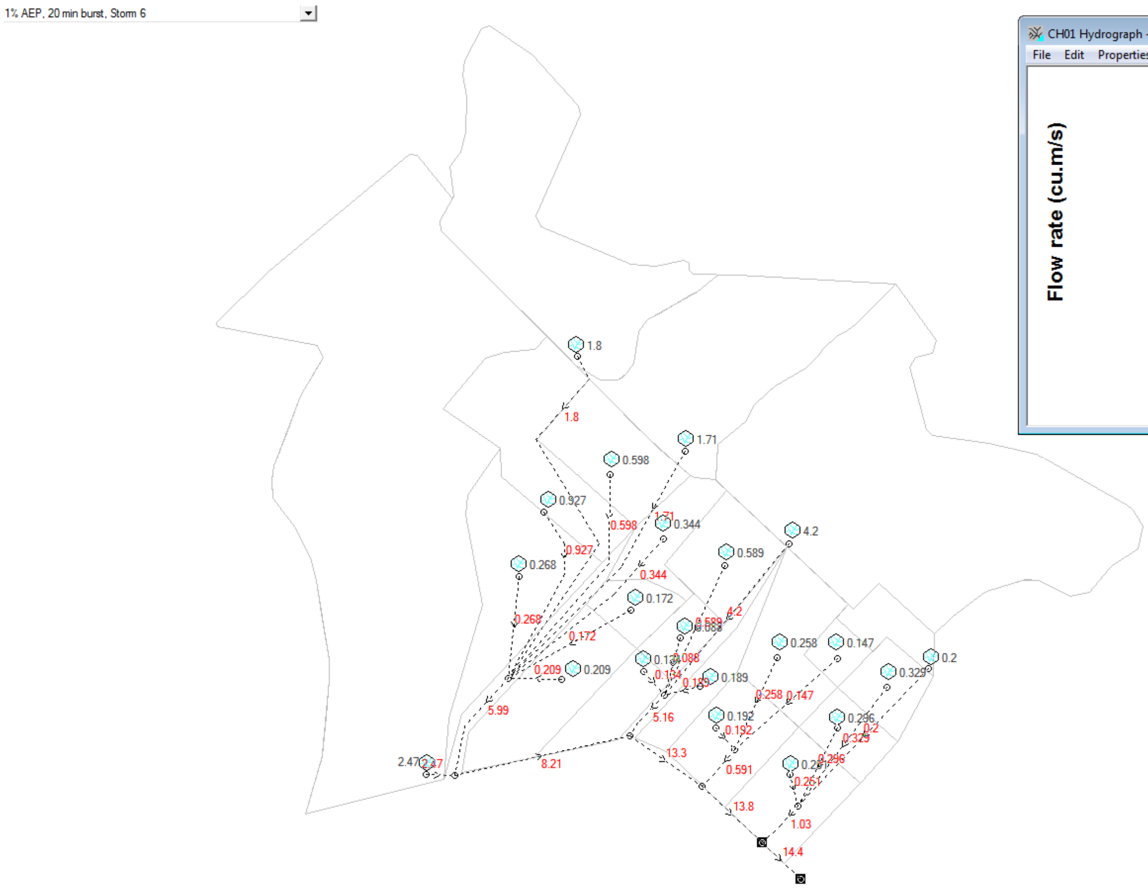


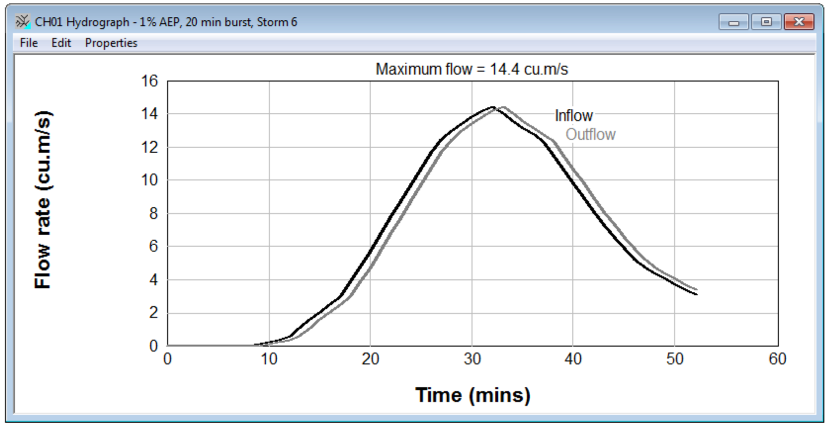
DRAINS – 1% AEP WITH 12% INCREASE RAINFALL (s02_012)





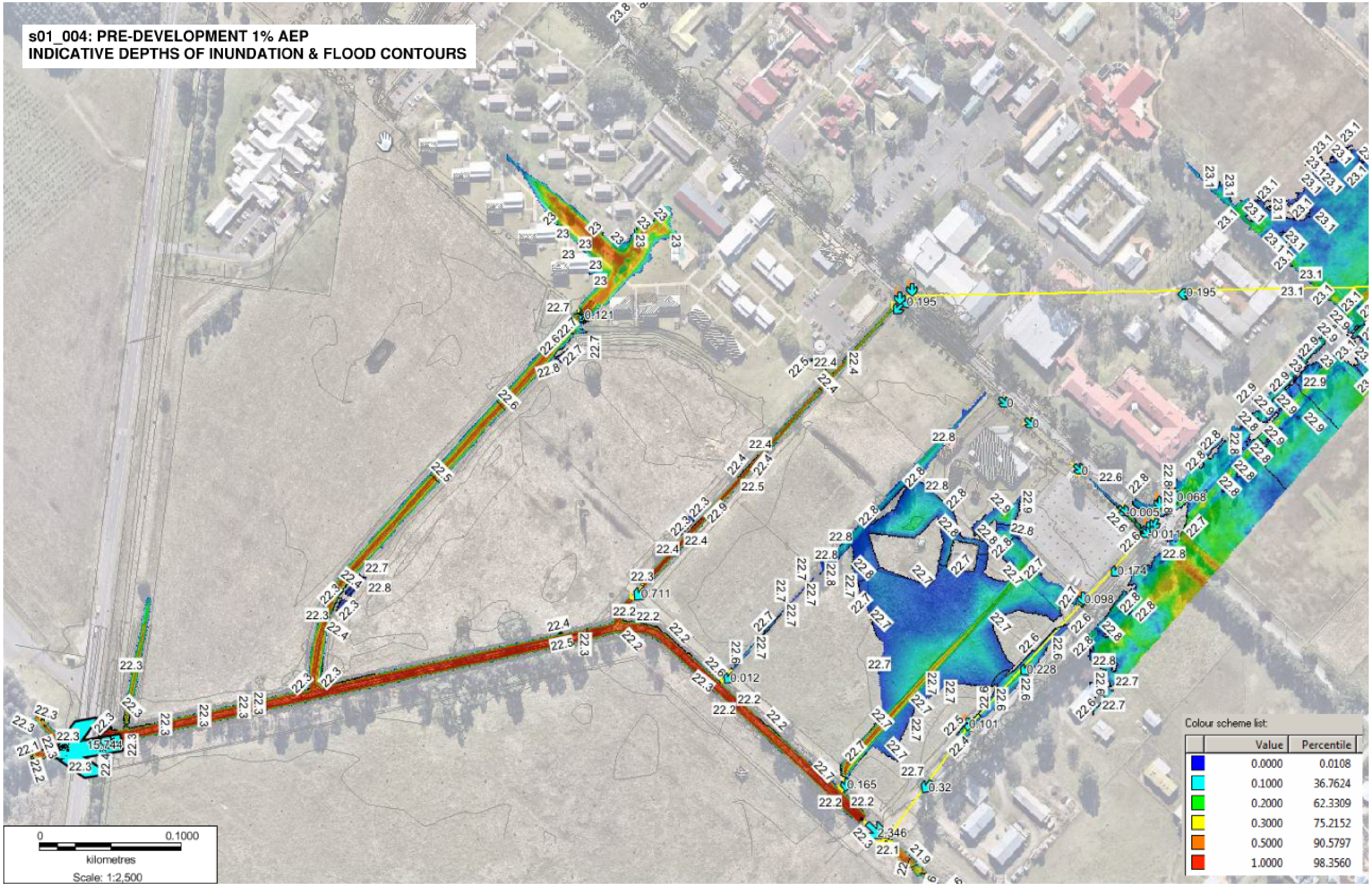
DRAINS – 1% AEP WITH 20% INCREASE RAINFALL (s02_013)

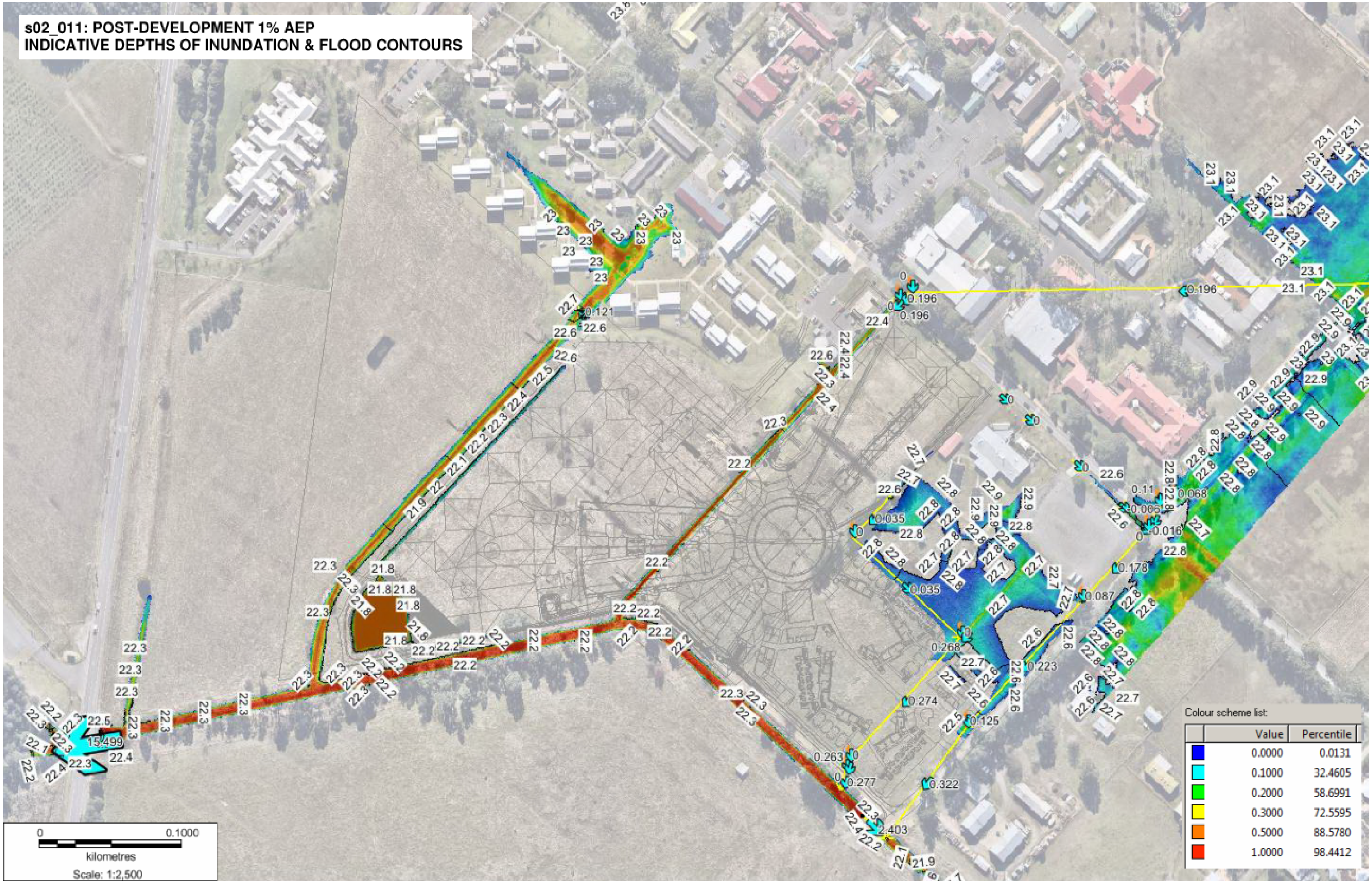


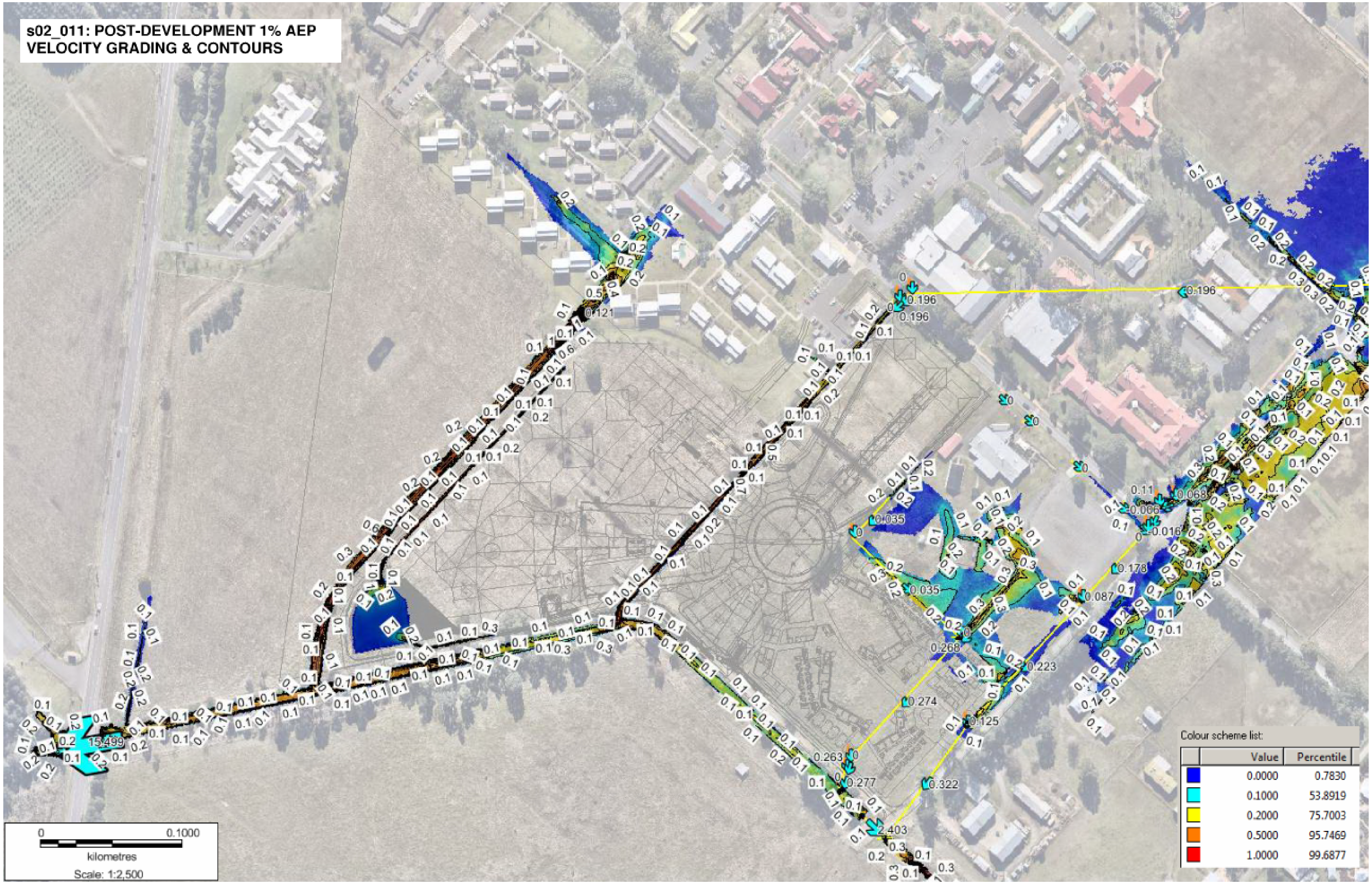


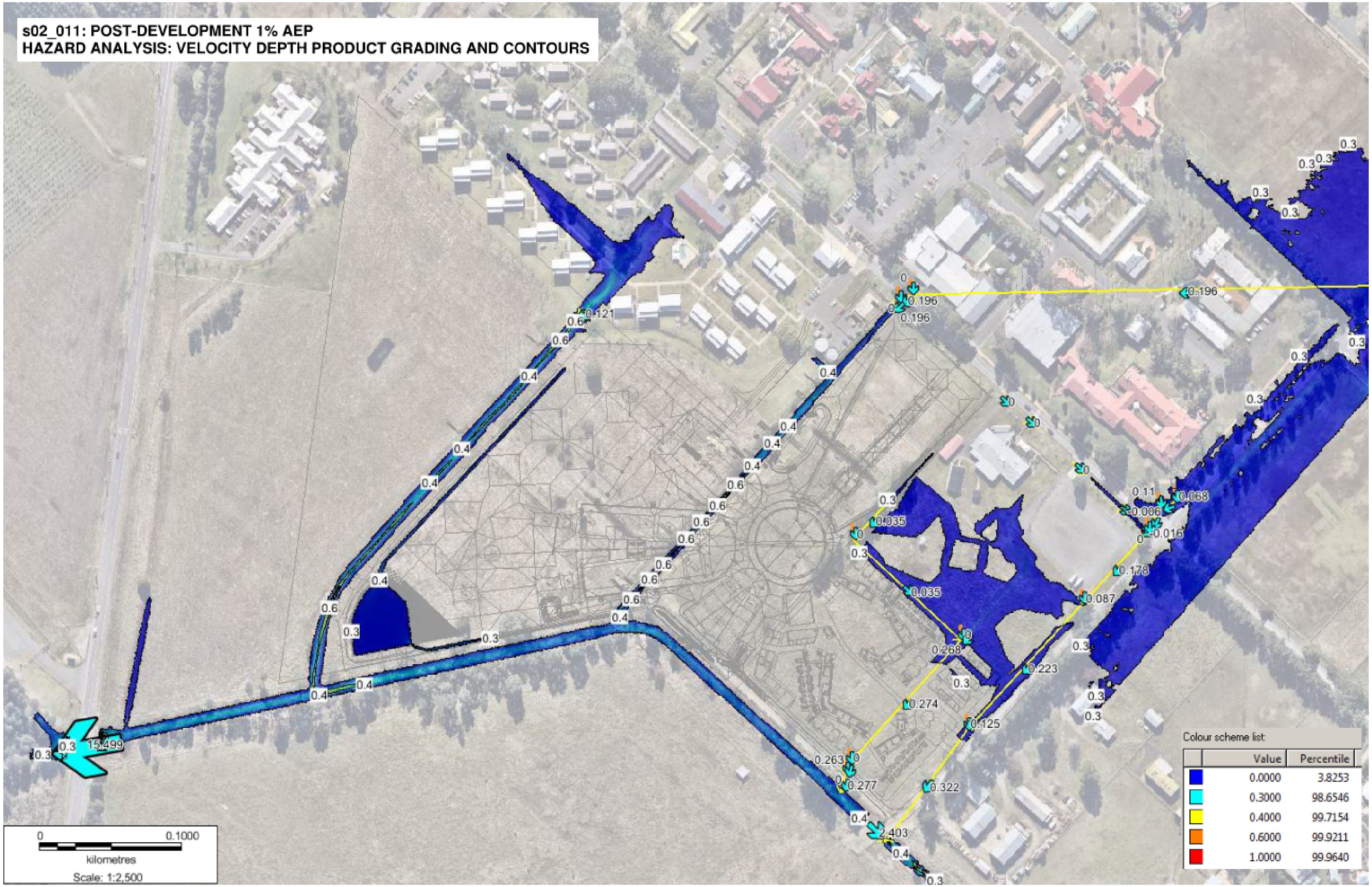
Appendix F

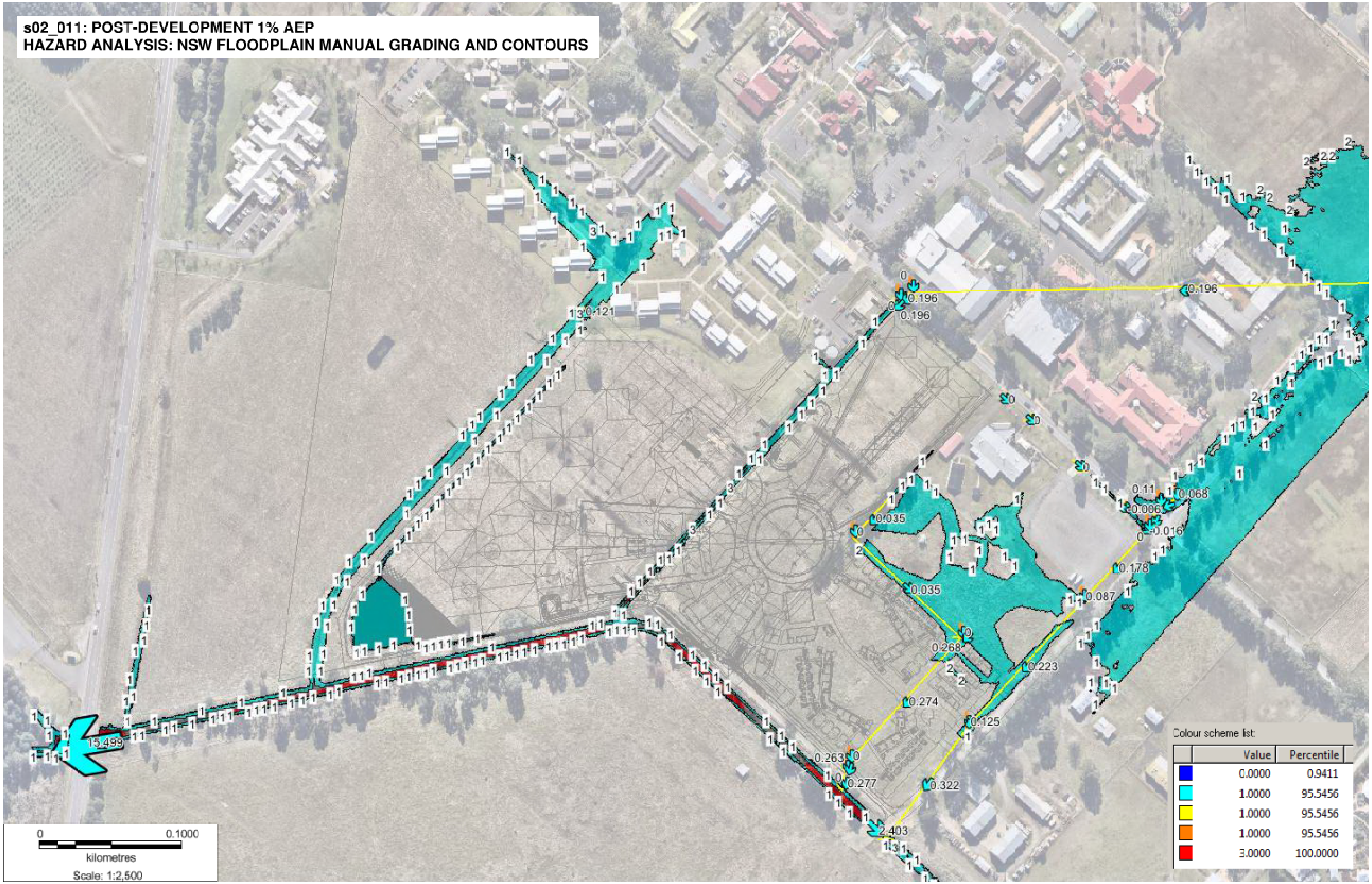
Hydraulic Modelling Results


s01_004: PRE-DEVELOPMENT 1% AEP
INDICATIVE DEPTHS OF INUNDATION & FLOOD CONTOURS
0
0.1000
kilometres
Scale: 1:2,500
Colour scheme list
Value
Percentile
0.0000 0.0108
0.1000 36.7624
0.2000 62.3309
0.3000 75.2152
0.5000 90.5797
1.0000 98.3560

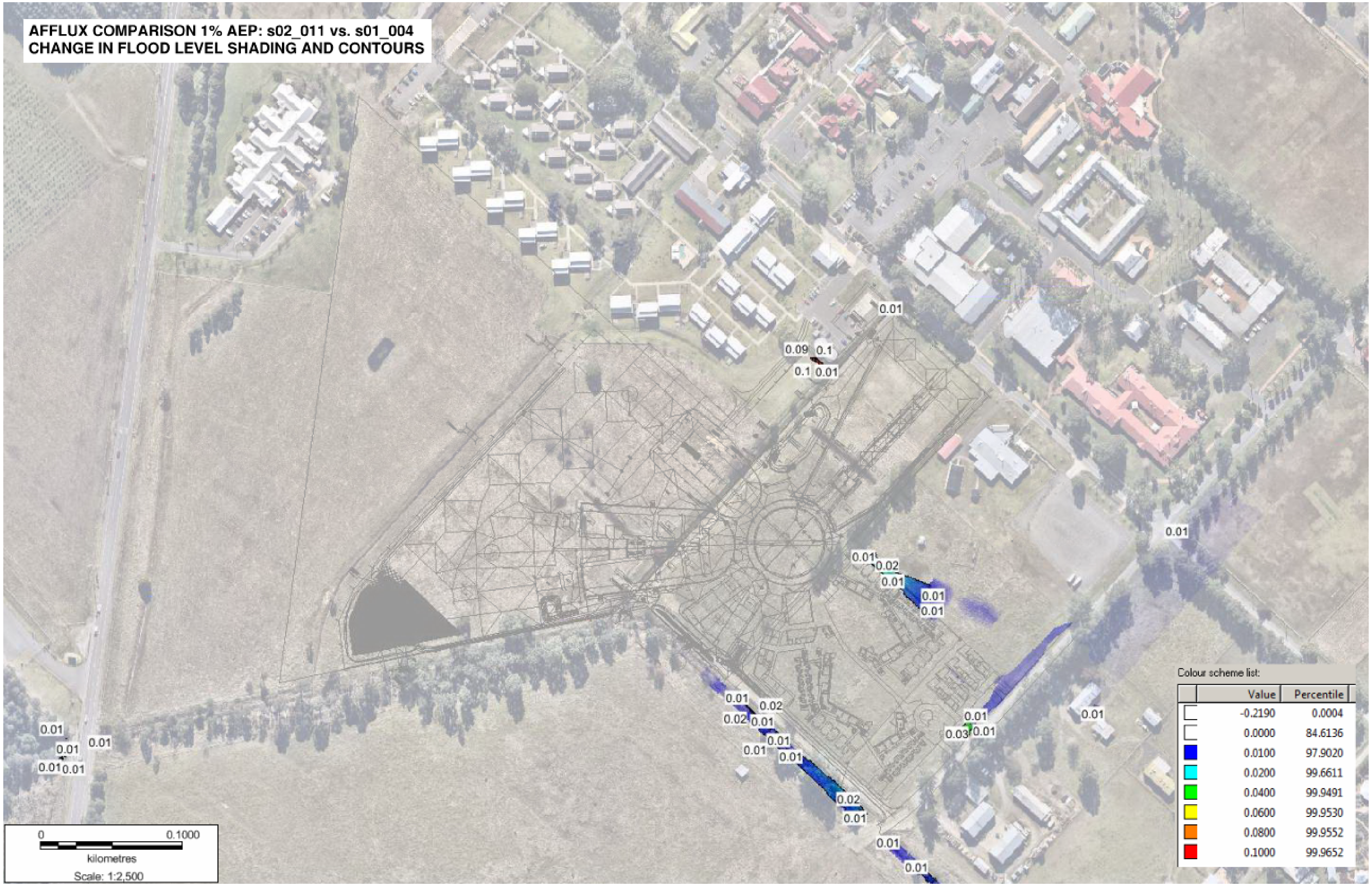

s02_011: POST-DEVELOPMENT 1% AEP
INDICATIVE DEPTHS OF INUNDATION & FLOOD CONTOURS
0
0.1000
kilometres
Scale: 1:2,500
Colour scheme list:
Value
Percentile
0.0000
0.0131
0.1000
32.4605
0.2000
58.6991
0.3000
72.5595
0.5000
88.5780
1.0000
98.4412

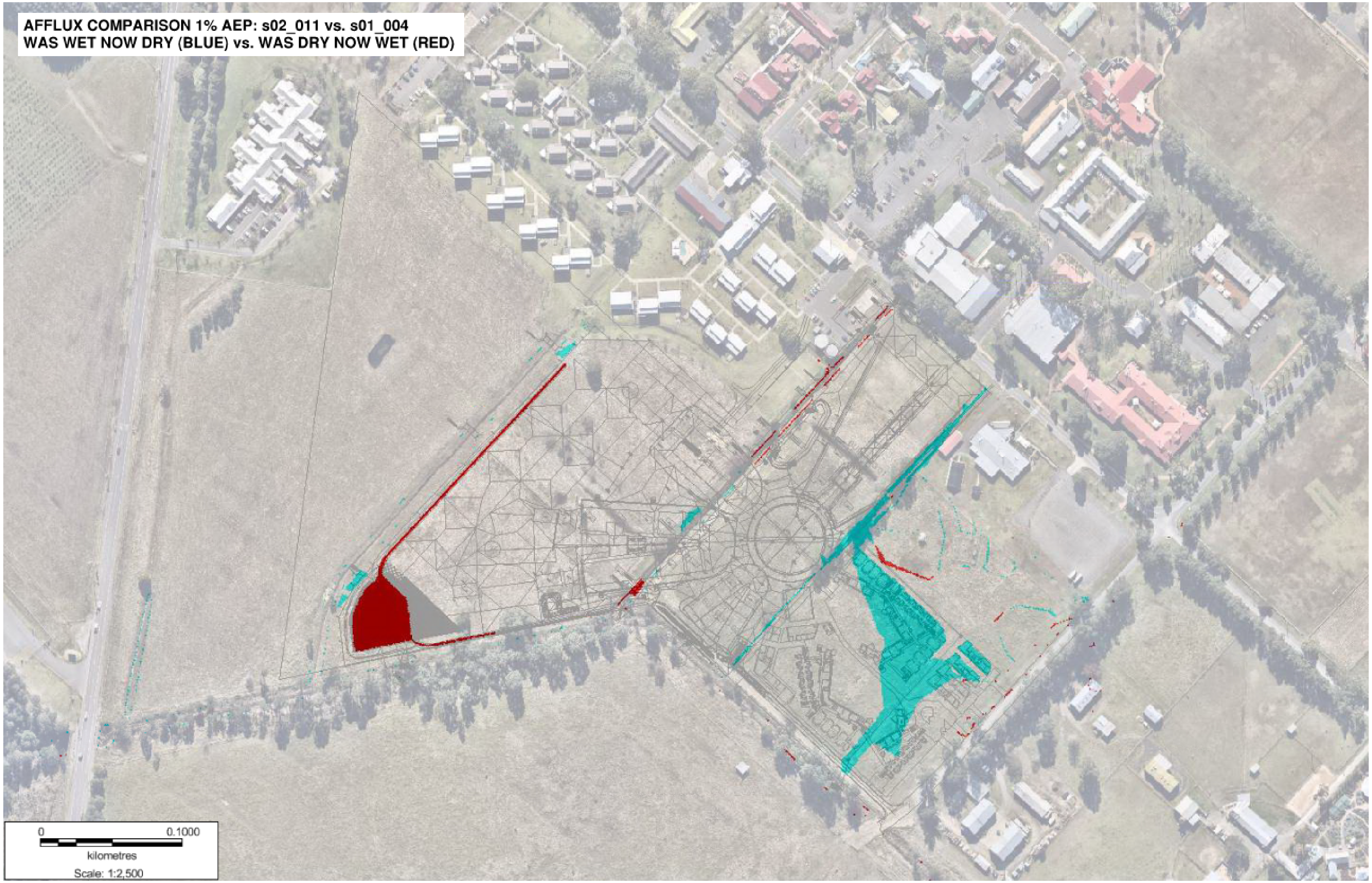

s02_011: POST-DEVELOPMENT 1% AEP
VELOCITY GRADING & CONTOURS
Colour scheme list:
Value Percentile
0.0000 0.7830
0.1000 53.8919
0.2000 75.7003
0.5000 95.7469
1.0000 99.6877
0 0.1000
kilometres
Scale: 1:2,500

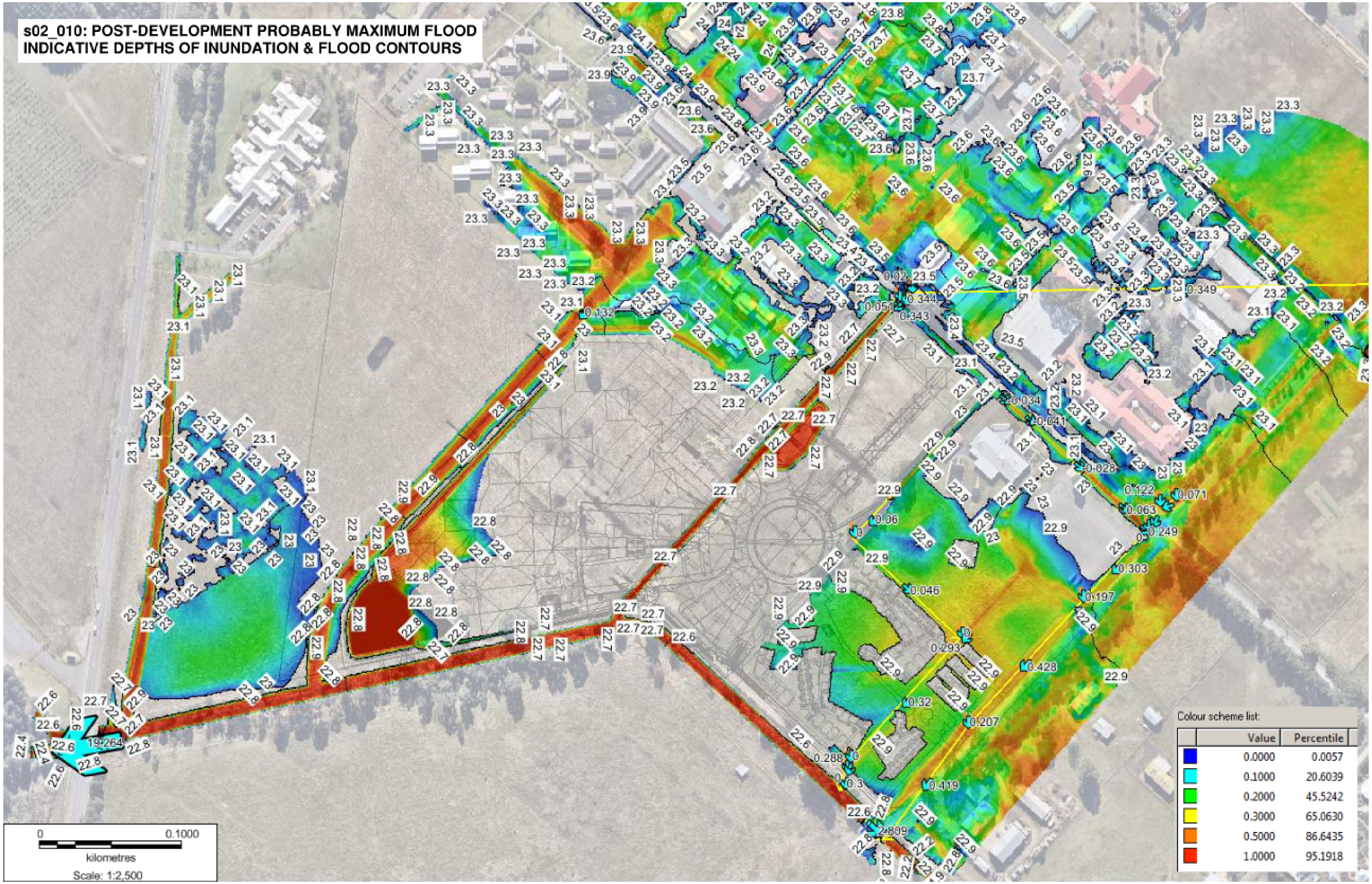

s02_011: POST-DEVELOPMENT 1% AEP
HAZARD ANALYSIS: VELOCITY DEPTH PRODUCT GRADING AND CONTOURS
Colour scheme list
Value Percentile
0.0000 3.8253
0.3000 98.6546
0.4000 99.7154
0.6000 99.9211
1.0000 99.9640
0 0.1000
kilometres
Scale: 1:2,500

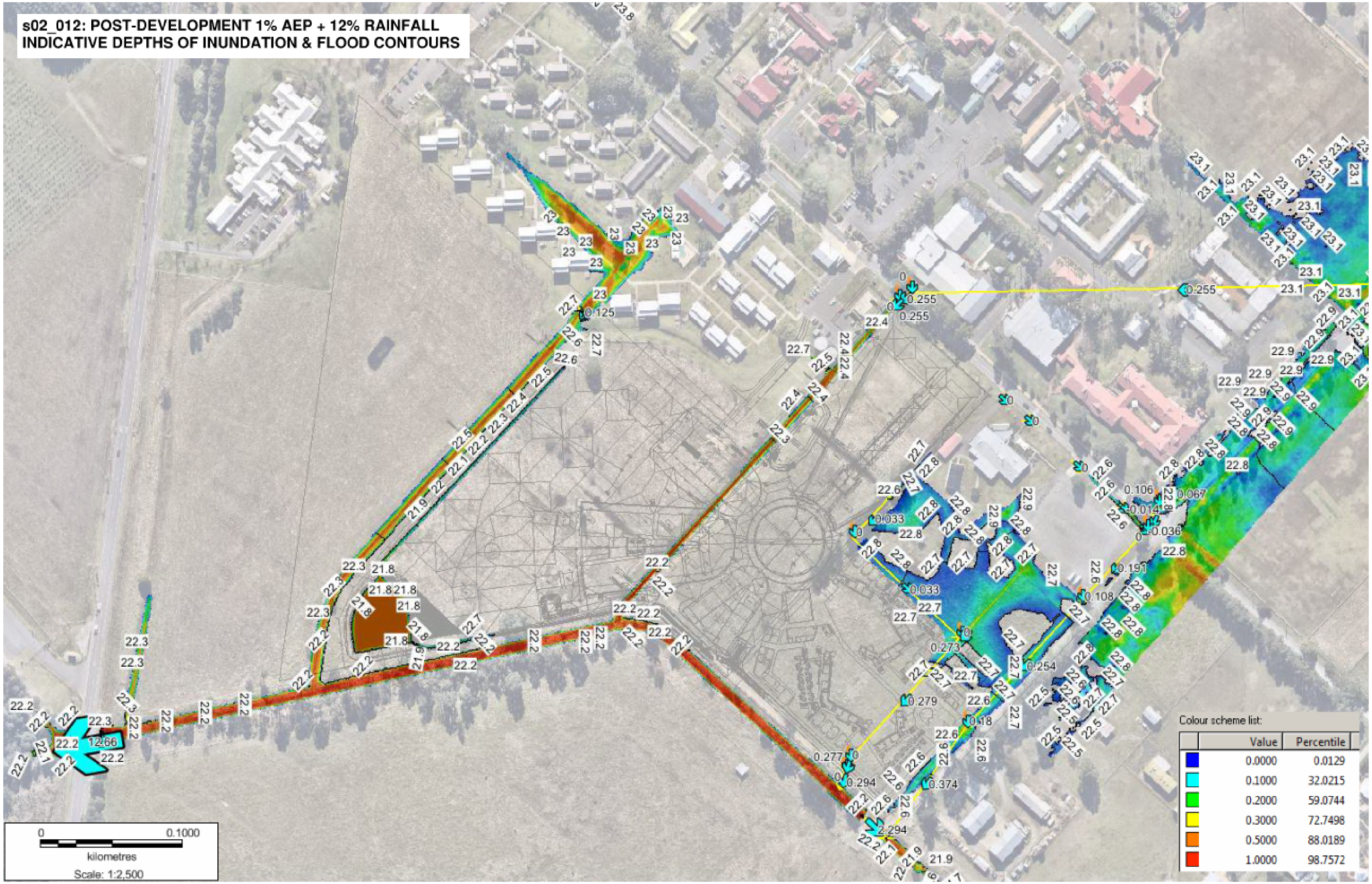


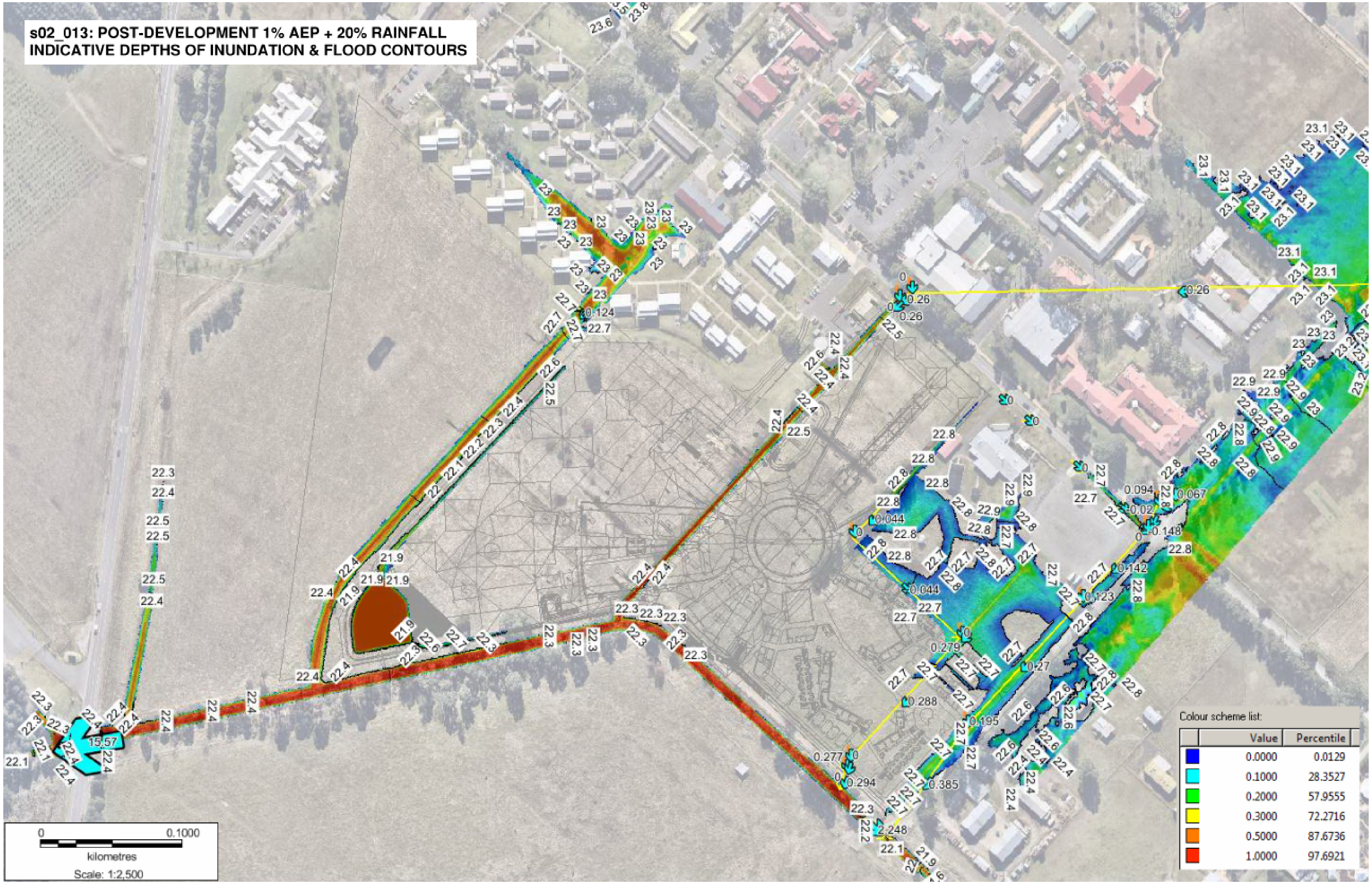
Value	Percentile
0.0000	0.9411
1.0000	95.5456
1.0000	95.5456
1.0000	95.5456
3.0000	100.0000


AFFLUX COMPARISON 1% AEP: s02_011 vs. s01_004
CHANGE IN FLOOD LEVEL SHADING AND CONTOURS
Colour scheme list:
Value
Percentile
-0.2190
0.0004
0.0000
84.6136
0.0100
97.9020
0.0200
99.6611
0.0400
99.9491
0.0600
99.9530
0.0800
99.9552
0.1000
99.9652
0
0.1000
kilometres
Scale: 1:2,500


AFFLUX COMPARISON 1% AEP: s02_011 vs. s01_004
WAS WET NOW DRY (BLUE) vs. WAS DRY NOW WET (RED)
0
0.1000
kilometres
Scale: 1:2,500


s02_010: POST-DEVELOPMENT PROBABLY MAXIMUM FLOOD
INDICATIVE DEPTHS OF INUNDATION & FLOOD CONTOURS
0
0.1000
kilometres
Scale: 1:2,500
Colour scheme list:
Value Percentile
0.0000 0.0057
0.1000 20.6039
0.2000 45.5242
0.3000 65.0630
0.5000 86.6435
1.0000 95.1918


s02_012: POST-DEVELOPMENT 1% AEP + 12% RAINFALL
INDICATIVE DEPTHS OF INUNDATION & FLOOD CONTOURS
0
0.1000
kilometres
Scale: 1:2,500
Colour scheme list:
Value Percentile
0.0000 0.0129
0.1000 32.0215
0.2000 59.0744
0.3000 72.7498
0.5000 88.0189
1.0000 98.7572


s02_013: POST-DEVELOPMENT 1% AEP + 20% RAINFALL
INDICATIVE DEPTHS OF INUNDATION & FLOOD CONTOURS
0
0.1000
kilometres
Scale: 1:2,500
Colour scheme list:
Value | Percentile
0.0000 | 0.0129
0.1000 | 28.3527
0.2000 | 57.9555
0.3000 | 72.2716
0.5000 | 87.6736
1.0000 | 97.6921