Industrial Estate at Lot 210 DP1174939 (Stage 3), Tomago

Stormwater Management Plan

Northbank Enterprise Hub

1918-02-B8, 22 April 2024

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1 Introduction

1.1 BACKGROUND

Northbank Enterprise Hub Pty Ltd (NEH) proposes to develop Lot 210 (DP1174939) located adjacent to Tomago Road, Tomago (NSW) into an industrial estate (the proposed development) to be known as Tomago Estate. Figure 1.1 shows the location of the proposed development. The proposed development has an area of 50.13 ha and will consist of entirely of industrial lots with associated access roads and drainage reserves. The site drains to the Hunter River North Arm.

The proposed development represents Stage 3 of an existing conditional Project Approval granted by the NSW Department of Planning and Environment (DPE) (MP07_0086) as well as an existing conditional EPBC Approval (2007/3343) granted by the federal government. Both approvals cover the development of the existing Stage 1 (the WesTrac facility located on Lot 212 DP1174939) and the future Stage 2 (Lot 211 DP1174939) and Stage 3 (Lot 210 DP1174939). A Stormwater Management Plan was completed for Stage 1 (ADW Johnson, 2010), approved by NSW DPE and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW). The EPBC Approval area extends for 17 ha into Lot 1001 DP1127780. Annual reporting of water quality and water level data, observations and compliances has been completed for both approvals for over 10 years.

NEH currently has approval for partial filling within the development site (referred to as Stage 3.1A). However, further assessment is required to develop the entire development site as part of the conditions of approval.

WRM Water & Environment Pty Ltd (WRM) was requested by NEH to prepare a Stormwater Management Plan (SMP) for the proposed development of Stage 3. The WesTrac Facility (Stage 1 - Lot 212 DP1174939) has been fully developed. Stormwater management for the neighbouring Lot 211 DP1174939 (Stage 2) will be prepared separately and independently from Lot 210 (Stage 3) as it is a separate catchment.

This report presents the methodology and results of studies undertaken to determine appropriate surface water quality and quantity management measures for the proposed development of Stage 3. Proposed stormwater quantity and quality structures presented in this report were designed to demonstrate that the proposed development complies with the approval conditions attached to the EPBC Approval 2007/3343 and the Project Approval MP07_0086.

A separate Groundwater Management Plan (GMP) has been prepared by Douglas Partners Pty Ltd (DP) to address groundwater-specific requirements of the EPBC Approval 2007/3343. The GMP (DP, 2024) should be referred to for full details.

1.2 REPORT STRUCTURE

This report is structured as follows:

- Section 2 lists the attached conditions to the approval;
- Section 3 provides a description of the existing and proposed site characteristics;
- Section 4 describes the proposed development;
- Section 5 describes the estimation of discharges;
- Section 6 describes the water quantity management strategy for the site;
- Section 7 describes the water quality management strategy for the site;
- Section 8 describes the site water balance;
- Section 9 describes the erosion and sediment control plan;

- Section 10 provides an evaluation of risk;
- Section 11 presents the monitoring strategy;
- Section 12 presents a summary of findings; and
- Section 13 provides a list of references.

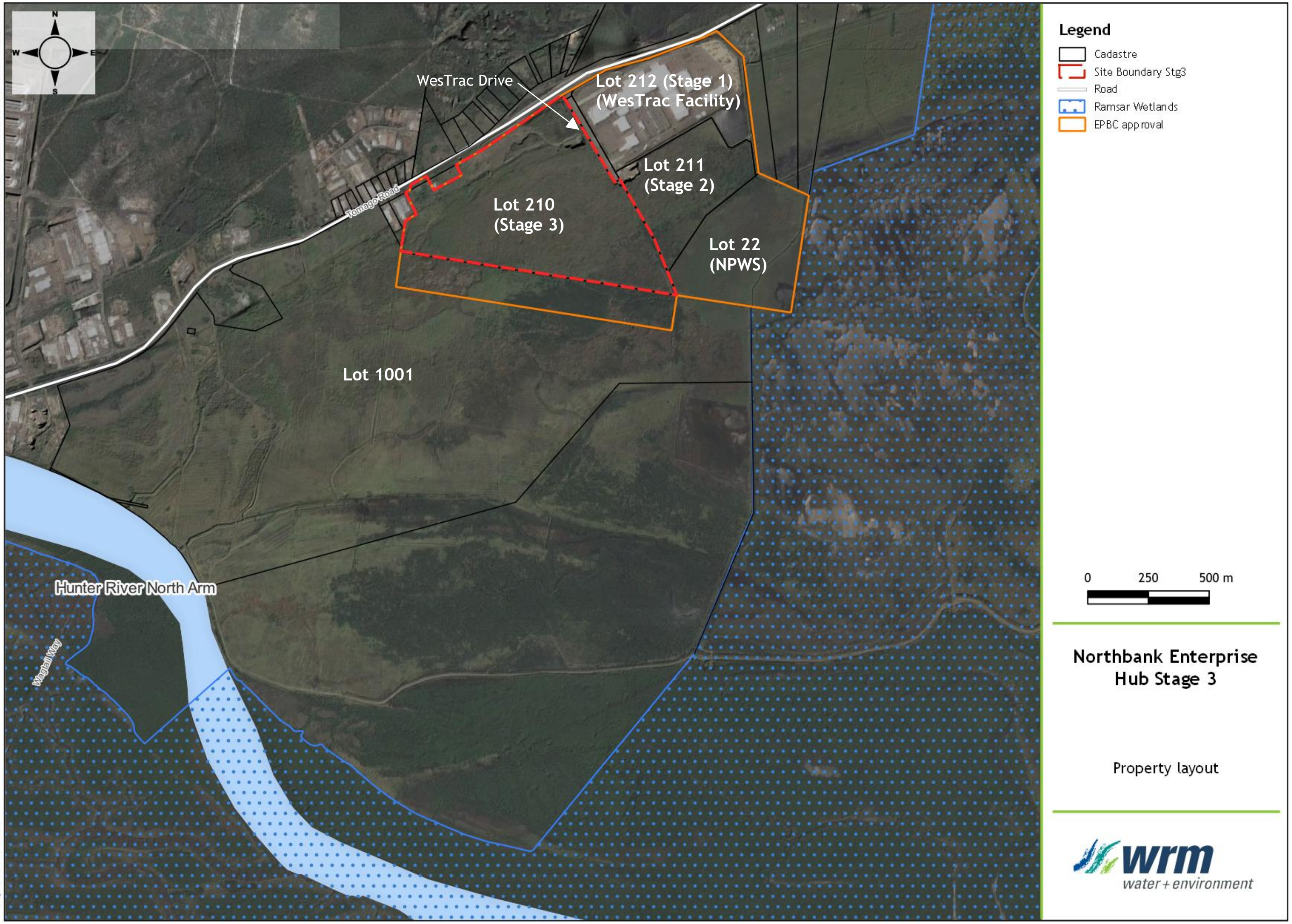

Figure 1.1 – Site locality

2 Stormwater management requirements

2.1 OVERVIEW

The proposed stormwater quantity and quality management strategy presented in this report was designed to demonstrate that the proposed development complies with conditions 2a-e and a-d of the EPBC Approval 2007/3343 (refer to Table 2.1), conditions 8,9,10 and 12 of the Project Approval MP07_0086 (refer to Table 2.2) as well as the draft statement of commitments attached to Project Approval MP07_0086 (refer to Table 2.3).

The following section lists the attached approval conditions and the section(s) of this report in which they are addressed.

2.2 EPBC APPROVAL 2007/3343

Table 2.1 lists the conditions associated with EPBC Approval 2007/3343. A Declaration of Accuracy has been provided in Appendix A. The Australian Government Department of Environment (now the DCCEEW) Environmental Management Plan Guidelines (DCCEEW, 2014) have been considered in the preparation of this report.

Table 2.1 – Conditions attached to EPBC Approval 2007/3343

Item no.		Report section	Demonstration of how this item is addressed in this report
2)	*In order to minimise potential significant impacts on the Hunter River Estuary Ramsar Wetland site, prior to any commencement of works for each stage the person taking the action must submit to the Minister for approval a stormwater and groundwater management plan for that stage. Works must not commence until the plan is approved by the Minister. The approved plan must be implemented and address the following matters:*		
a)	Documented industry best practice water sensitive design principles and practices;	Section 7.2	The proposed water quality management strategy for the development was developed in accordance with water quality objectives and assessment methodologies outlined in both local and state government guidelines listed in this section.
b)	A review of the environmental values and water quality objectives for the Hunter Estuary Wetlands Ramsar Site;	Sections 3.3, 7.2	This report acknowledged that the Ramsar Wetlands are recognised as a significant area of conservation for migratory birds (Sections 3.3). Section 3.3 of this report also summarises the biodiversity values of the Ramsar Wetlands according to the *Kooragang Ramsar Wetland Ecological Character Description* (Brereton and Taylor-Wood, 2010). Water quality objectives (WQOs) from DECC (2007) and HCCREMS (2007) relevant to wetland environments have been considered in this report (Section 7.2).
c)	Replication of natural surface and groundwater flows and water quality;	Section 6 [a]	Two detention basins will be constructed so that peak discharges from the developed site do not exceed pre-development peak discharges. Surface water outflows from the developed site will drain towards the Hunter River (via Lot 1001) generally as per existing conditions.
d)	Protection of the environmental values of receiving waters, including the Hunter Estuary Wetlands Ramsar Site;	Sections 6.4, 6.5, 7.4.5, 11	The development preserves the environmental values of the Ramsar Wetlands by directing surface water (freshwater) outflows towards the Hunter River (via Lot 1001) and further away from the Ramsar Wetlands (which is intended to be a predominantly tidal environment). Notwithstanding this, two combined wetland-detention basins will be constructed so that peak discharges from the developed site do not exceed pre-development peak discharges, and so that pollutant reduction targets for wetland environments are achieved. In the event of prolonged rainfalls that trigger releases of freshwater from the basins to Lot 1001, the extensive land area across the very flat Lot

Item no.		Report section	Demonstration of how this item is addressed in this report
			1001 provides significant retention and storage that is several times larger than the available storage in the Stage 3 area. The available topographical data indicates that the existing mapped drainage channels at Lot 1001 (refer to Figure 3.1) would direct ponded runoff at Lot 1001 to the west towards the Hunter River and not east towards the Ramsar Wetland The indicative locations for the outlets of the basins were selected such that the proposed drainage strategy for the development will conform with the approved drainage strategy for the proposed industrial subdivision at Lot 1001 (project approval MP10_0185). Specifically, outflows from the basins will be conveyed to the Hunter River via constructed open channels within the developed Lot 1001. Prior to development of Lot 1001, a Trigger Action Response Plan (TARP) will be implemented from the commencement of works at the development to define the minimum set of corrective actions required in response to unpredicted impacts to the receiving environment.
e)	The principle of continuous improvement;	Section 11	Baseline monitoring of stormwater and groundwater quality at the development site has been undertaken. Continuous monitoring of stormwater runoff quality from the development will be undertaken to review the baseline water quality parameters. An annual report will be prepared to record and analyse trends in stormwater quality, noting any exceedances of criteria (against the baseline values) and allowing for mitigation measures to be developed and implemented. Over 10 years of post-development water quality data, levels, observations during storms and monitoring from Stage 1 provides a base for understanding of the landscape and experience for managing Stage 3 stormwater. Management of Embankment vegetation, monitoring equipment selection which were all improved over time in Stage 1, can be implemented to improve Stage 3 from the outset.
	The plan must include but not be limited to the following elements:		
a)	The water treatment management practices and management practice treatment trains that will be used to achieve or exceed environmental performance targets as detailed in the final Redlake Enterprise Pty Ltd – Tomago Road, Tomago – Environmental Assessment Report dated 12 March 2008 “Concept Engineering, Servicing, Earthworks and Stormwater Management” Appendix F.	Section 7	The proposed water quality management strategy for the development (two constructed wetlands) ensures that the WQOs (i.e. the pollutant reduction targets) detailed in the 2007/2008 Redlake Enterprises’s Stormwater Management Plan are achieved.

Item no.		Report section	Demonstration of how this item is addressed in this report
b)	How attainment of water quality objectives for these receiving waters will be supported by the action	Section 7	Two constructed wetlands are proposed to treat stormwater runoff from the development. MUSIC modelling demonstrates that the proposed water quality management strategy exceeds the WQOs obtained from various sources, including the DECC (2007) and HCCREMS (2007) WQOs relevant to wetland environments.
c)	How monitoring activities will be undertaken to track environmental performance of the action; and	Sections 11	Monitoring of stormwater runoff quality from the development will be undertaken for at least three quarterly monitoring rounds to establish the baseline water quality parameters. Ongoing monitoring will be undertaken on a quarterly to yearly basis (depending on the parameter) to analyse trends and identify exceedances against the baseline. Water quality trigger values have been defined to prompt further investigation and/or develop mitigation measures (if required) in the event of an exceedance against the adopted criteria. A Trigger Action Response Plan will be implemented from the commencement of works to monitor the impacts of offsite discharges to the receiving environment and if necessary, implement mitigation measures.
d)	Groundwater and surface water monitoring must be undertaken pre, during and post development. This monitoring must continue until the Minister notifies that the construction and operation of this action is not impacting on the Hunter Estuary Wetlands Ramsar Site.	Section 11 [a]	Surface water and groundwater quality monitoring will be undertaken as described in Item 2(c) above. Annual report will continue to be prepared to record and analyse trends in stormwater quality, noting any exceedances of criteria (against the baseline values) and allowing for mitigation measures to be developed and implemented. Annual reporting will continue until further notification from the regulatory body.

[a] – Groundwater specific requirements are addressed in a separate Groundwater Management Plan prepared by Douglas Partners Pty Ltd (DP, 2024)

2.3 PROJECT APPROVAL MP07_0086

Table 2.2 – Conditions attached to Project Approval MP07_0086

Item no.		Report section
8)	*The Applicant must prepare and implement a Soil and Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:*	
a)	be submitted to the Planning Secretary for approval at least one month prior to the commencement of construction of Stage 1;	n/a
b)	be updated and submitted to the Planning Secretary for approval at least one month prior to the commencement of construction of Stages 2 and 3	n/a
c)	Be prepared in consultation with Council, HWC and OEH;	n/a
d)	Include: • A Ste Water Balance; • A Sediment and Erosion Control Plan; • An Acid Sulphate Soils Management Plan; • A Stormwater Management Scheme; and • A Groundwater Monitoring Program for Tomago sand beds; • A Wastewater Management Plan	Section 6, 7, 8, 9 [a]
9)	*The Site Water Balance must:*	
a)	Include details of: • sources and security of water supply; • water use/reuse on-site; • water management on-site; • reporting procedures;	Section 8
b)	Describe measures to minimise potable water use by the development and maximise reuse of rainwater harvested from the site; and	Section 8.3
c)	Be reviewed and recalculated each year in light of the most recent water monitoring data; and	Section 11
d)	compare measured surface water discharges and groundwater inflows, outflows and infiltration, relative to pre-development conditions.	Section 8.4.5 [a]
10)	*The Erosion and Sediment Control Plan must:*	
a)	be consistent with the requirements of Landcom's (2004) Managing Urban Stormwater: Soils and Construction	Section 9
b)	identify the activities on site that could cause soil erosion and generate sediment; and	Section 9
c)	describe what measures would be implemented to: • minimise soil erosion and the transport of sediment to downstream waters, including the location, function and capacity of any erosion and sediment control structures and; • maintain these structures over time;	Section 9
12)	*The Stormwater Management Scheme must:*	
a)	be prepared in consultation with Council and OEH;	n/a
b)	be prepared in accordance with DECC's Managing Urban Stormwater guidelines and HCCREMS Water Sensitive Urban Design Solutions for Catchments Above Wetlands;	Section 7.2

Item no.		Report section
c)	demonstrate that post development flows will not exceed predevelopment flows for a range of ARI from 1 year up to and including the 100 year ARI;	Section 6
d)	investigate alternative options to avoid discharges to the adjoining wetlands to the south of the site;	Section 6.5
e)	demonstrate that the existing stormwater drainage channels have capacity to accommodate post development flows under a range of tidal conditions;	Sections 6.2, 6.5
f)	demonstrate that the extended detention depth of the infiltration area allows vegetation growth and minimises groundwater mounding.	Section 7.5 [a]
g)	include provision for the drainage flow paths for culverts under Tomago Road through the site;	Section 4
h)	Includes details of the: • Stormwater detention (capacity and location); • Treatment and control infrastructure including pre-treatment for the infiltration area to reduce sediment and nutrient loads, the drainage design for the disposal of stormwater off-site and the method of controlled release from the site; and • Measures to monitor and maintain the stormwater treatment and control infrastructure; and	Sections 6, 7, 8
i)	Include a program to monitor stormwater quantity (including inflows, outflows and bypass flows) and quality (including but not limited to total suspended solids, total phosphorous and total nitrogen during operation of the development.	Section 11

[a] – Matters related to groundwater and acid sulphate soils were assessed separately by Douglas Partners Pty Ltd

Table 2.3 – Draft statement of commitments attached to Project Approval MP07_0086

Item no.		Report section
8.7	***Water quality***	
	Water quality measures will be installed in accordance with the report prepared by Asquith & de Witt. The water quality objective for the site was to determine a solution of 'no impact' to the downstream receiving waters. The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was established to verify the quantity of the runoff to the wetlands for 'no impact', post development. Reuse, a treatment train, gross pollutant trap, swale and constructed wetland was sized to meet the target objective verified with MUSIC. Water quality will be monitored, and a management plan, as detailed in the Flora & Fauna Report prepared by Eco biological, will be prepared to address the construction and operational phases. More specifically this management plan will include: • The nature and control of sediment run-off during the construction phase particularly as a result of an exceptional storm event; • The chemical content of the fill and of the groundwater seepage from that fill that would disperse into the wetlands over the long term; • The volume, path and content of stormwater discharging from the site during and after development; • The handling of hydrocarbon waste from the site during construction and operation stages; • Existing flow regime of subsurface and groundwater flow from the subject site into the wetlands; • At times of peak rainfall, sub-surface drainage through the fill is likely to discharge into the wetland – what will be the impact of the development on the quality of this water; • The current ecological character of the wetland in the immediate vicinity of the potential impact area; and • The impact of weed invasion during and after construction phase.	 Section 7.2 Sections 7, 9
	A monitoring plan will also be put in place to document the ongoing water quality status, measured against an established baseline.	Section 11
	All products stored on-site having the potential to contaminate stormwater in the event of spillage will also be contained within a bounded area to the requirements of DECC.	Building code requirement
	Stormwater controls	

Item no.		Report section
	Water quality control on site will be 2 proposed washpads. All vehicles and parts requiring washing will be taken to one of these, and no washing outside of these washpads will occur. WesTrac has standardised control over these facilities country wide at its existing operations.	Not applicable to Stage 3
	A Construction Management and Environmental Management Plan will be prepared to manage potential water quality issues and submitted as required prior to construction or commencement of ADW Johnson – separate cover Soil and Water Management Report for 6 WEPL Investments WesTrac facility at Tomago Road, Tomago NSW (Ref: 11886_Soil and Water Version D) Requirement Description Section reference/ Comment operations.	Addressed separately from this SMP
	The stormwater treatment train will be used for removal of the pollutants from the stormwater runoff prior to discharging to the wetlands downstream.	Section 7
	Gross Pollutant Traps will be installed at the entry to each of the constructed wetlands as a proprietary product for screening of heavy sediment and litter.	Section 7
	A large open channel swale drain has been designed into the development layout for street drainage, drainage of the intersection and secondary flows during major storm events. End of line treatment basins have been spread over the site to reduce the distances drainable for stormwater runoff.	Sections 4, 6, 7
	Basins have been located to have discharge outlets to the existing discharge points from the site along the southern boundary, post development.	Sections 4, 6, 7
	The site will be filled for development of the subdivision to a level that is flood free.	Sections 4
	Geotechnical approval will be obtained on the fill type and its properties prior to being used on the site. However, the preferred fill type is granular material with particles not greater than 100mm diameter. The fill will be pH neutral and will be screened for properties under the supervision of geotechnical engineers, prior to supply to the site. No ash will be used for filling.	Addressed separately from this SMP
	Soil and water management plan	
	The sediment basins have been designed for settlement of Type F soils. A higher criteria level of protection has been adopted for the design sizing of the sediment basins, reflecting the sensitivity of the receiving waters downstream. The 95th percentile, 5 day rainfall event has been selected as the standard for this site, which provides an increased capacity to capture runoff and minimised the potential risk of sediment laden water leaving the site and discharging to the wetlands.	Section 9
	Access is to be limited to the designated all weather roads, any truck exiting out of the site shall be thoroughly cleaned and limit the exportation of clay and sediment on public roads, and entry is prohibited on remaining land.	Section 9

Item no.		Report section
	Works shall be undertaken in the following construction sequence: 1) Install sediment fencing and cut drains to meet the requirements of the SWMP. Waste collection bins shall be installed adjacent to site office. 2) Construct stabilised site access in location nominated by the Contractor and in accordance with Port Stephens Council's requirements 3) Construct sediment basins for disturbed areas in accordance with the rate per hectare provided in the SWMP. Install risers and two pegs in the floor of the basin and have them marked to show the top of the sediment storage zone. Ensure the basin is cleared of sediment once the design capacity is reached. 4) Redirect clean water around the construction site. 5) Install sediment control protection measures at all natural and man-made drainage structures. Maintain until all the disturbed areas are stabilised. 6) Clear and strip the work areas in accordance with the Geotechnical advice provided. 7) Any disturbed areas, other than lot grading areas, shall immediately be covered with site topsoil within 7 days of clearing. Lot re-graded shall be covered with bitumen emulsion as specified. 8) Apply permanent stabilisation to site (landscaping).	Section 9.5

Sediment control conditions will include the following: • Proprietary sediment fencing shall be installed by the Contractor in accordance with their approved SWMP and elsewhere at the discretion of the site superintendent to contain sediment fractions as near as possible to their source. • Sediment removed from any trapping device shall be relocated where further pollution to down slope lands and waterways cannot occur. • Stockpiles shall be located by the Contractor in accordance with their approved SWMP and elsewhere at the discretion of the site superintendent. Where stockpiles are to be in place longer than 30 days they shall be stabilised by covering with mulch or with temporary vegetation. • 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 Contractor's approved SWMP. • Temporary sediment traps at pits shall be retained until after lands they are protecting are completely rehabilitated. • Dust suppression will be required for the control of airborne particles during construction. This will be via standard water cart usage during earthworks and pavement construction of the hardstand areas. Site maintenance requirements include the following: • 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.	Section 9.4
The site manager shall inspect the site at least weekly and shall: • Ensure that all drains are operating effectively and shall make any necessary repairs; • Remove any spilled material from area subject to runoff or concentrated flow; • Remove trapped sediment where the capacity of the trapping device falls below 60%; • Inspect the sediment basins after each rainfall even and/or weekly. 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;	Section 9.6

Item no.		Report section
	• Construct additional erosion and sediment control works as may be appropriate to ensure the protection of down slope lands and waterways; • Maintain erosion and sediment control measures in a fully functioning condition at all times until the site is rehabilitated; • Ensure that the revegetation scheme is adhered to and that the all grass covers are kept healthy, including watering and mowing; and • Remove temporary soil conservation structures as the last activity in the rehabilitation program.	
8.8	***Flow regime*** The proposed development will comply with the water balance prepared by Asquith & de Witt. The water balance model outcomes will be complied with and intend to provide the following:	Not applicable to Stage 3
	A water balance model including recycling, uses and quantities associated with the operation of the WesTrac facility, as a guide for WesTrac;	Not applicable to Stage 3
	An estimate for the rainwater storage requirements to ensure water security for the project;	Section 8.3
	An estimate of recharge to the HWC Special Area;	Not applicable to Stage 3
	An estimate of the quantity of runoff discharging to the wetlands downstream; and	Section 8
	An identification of the expected key risks to water management based on the outcomes of the water balance.	Section 8
8.9	***Water reuse*** The proposed development will comply with the water harvesting and recycling plan outlined in the report prepared by Asquith & de Witt. More specifically, the washpads proposed on site for the purpose of cleaning heavy vehicle equipment prior to workshop activities will be the primary water quality control on site. The process will involve using a biodegradable detergent which releases free oil after addition of an emulsion breaker for efficient oil separation and collection, together with a detergent stripping stage using a foam fractionator. The resultant treated water will be recycled through a filtration and sterilisation stage. A portion of treated water is removed from the circuit and sent for final treatment to the site sewage treatment plant.	Not applicable to Stage 3
	Water for washpad operations is derived from three (3) sources: Rainwater harvesting; Town water; and Recycled water.	Not applicable to Stage 3
	The resultant wastewater will be pumped to a settling tank after dosing with a primary flocculant. The primary flocculant dose breaks all emulsions and presents free oil and wastewater to the skid mounted oil/water separator. Oil/water separation is achieved using a heavy duty coalescing plate separator.	Not applicable to Stage 3

Item no.		Report section
	Wastewater produced by the separator is further treated by a foam fractionator.	
	The treated washpad wastewater will be recycled after surfactant removal. Recycled water undergoes further treatment using chlorination and sand filtration. The recycled water feeds a low pressure wash unit with inline UN sterilisation. The spent washwater drains to the solids sump at the start of processing for reuse.	Not applicable to Stage 3
8.10	***Soil erosion and sedimentation*** Erosion and sedimentation controls will be installed in accordance with the report prepared by Asquith & de Witt. More specifically, measures to be implemented during construction include:	Section 9
	Disturbance only of areas to be immediately worked on and regeneration of dust and erosion free surfaces - landscaping, concrete, bitumen sealing as soon as practical thereafter.	Section 9
	Provision of and continued maintenance of sediment fencing to low perimeter locations.	Section 9
	Provision of mesh and gravel or geotextile inlet filters.	Section 9
	Contract specifications requiring stabilised site access, low flow earth flow earth banks and wind erosion screens.	Section 9
	A construction programme that provides for the sediment basin to be constructed at the outset with all site runoff, where practical, piped or channelled to this basin for primary treatment/settlement before leaving the site via a mesh supported geotextile filter/riser before discharging to the wetlands.	Section 9
	Contract specifications requiring regular maintenance of all erosion and sediment control structures and devices for the full contract and maintenance period.	Section 9
	Furthermore, sediment control conditions will include the following: Proprietary sediment fencing shall be installed by the Contractor in accordance with their approved SWMP and elsewhere at the discretion of the site superintendent to contain sediment fractions as near as possible to their source. Sediment removed from any trapping device shall be relocated where further pollution to down slope lands and waterways cannot occur. Stockpiles shall be located by the Contractor in accordance with their approved SWMP and elsewhere at the discretion of the site superintendent. Where stockpiles are to be in place longer than 30 days they shall be stabilised by covering with mulch or with temporary vegetation. 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 Contractor's approved SWMP. Temporary sediment traps at pits shall be retained until after lands they are protecting are completely rehabilitated. Dust suppression will be required for the control of airborne particles during construction. This will be via standard water cart usage during earthworks and pavement construction of the hardstand areas.	Section 9

3 Existing site characteristics

3.1 SITE LOCALITY

Figure 1.1 and Figure 3.1 shows the location of the development site. The site is bounded by Tomago Road to the north, WesTrac Drive to the northeast, Lot 211 DP1174939 (Lot 211) to the southeast and Lot 1001 DP 1127780 (Lot 1001) to the south and west. Lot 1001 is also owned by NEH and approved by NSW DPE for business/industrial development (project approval MP10_0185).

3.2 TOPOGRAPHY AND DRAINAGE CHARACTERISTICS

Figure 3.1 and Figure 3.2 shows the topography and existing regional drainage features in the vicinity of the development site. Based on LiDAR data obtained in 2014, the northern part of the development immediately adjacent to Tomago Road comprises a low sand dune formation with elevations of between 3.0 mAHD and 4.5 mAHD. LiDAR data shows that the vast majority of the development site comprises low-lying alluvial plains, with elevations of between 0.5 mAHD and 1.5 mAHD. The existing ground at the site slopes down to the southeast towards the southern site boundary. Most of the site is covered by tall and thick grasses.

Recent ground survey for an area at the northeast of the development site and adjacent to WesTrac Drive (shown in Figure 3.3) indicate that LiDAR ground levels along Tomago Road and WesTrac Drive are within 0.1 m of the surveyed ground levels. However, the surveyed ground levels within the grassed areas of the development site are on average approximately 0.5 m lower than what the LiDAR data is indicating, which is likely due to the thick grass cover. Therefore, LiDAR ground levels at the vast majority of the site is potentially about 0.5 m higher than actual ground levels subject to survey.

Runoff from the existing site (Stage 3) generally drains via sheet flow from Tomago Road towards the southern site boundary. There are a number of open channels (farm drains) that were previously excavated within and in the vicinity of the development site. An existing grassed swale along the western side of WesTrac Drive convey runoff from WesTrac Drive and parts of Tomago Road towards the southeastern corner of the site. Ground survey indicates a 0.6 m diameter pipe at the upstream end of the existing swale adjacent to WesTrac Drive, which is assumed to convey runoff from Tomago Road. Existing man-made open channels to the south of the site (within Lot 1001) convey runoff from the southern development site boundary across Lot 1001 to the Hunter River North Arm.

There is an existing drain which runs east along the southern boundary of Lot 22 from the southeastern corner of the development site (Stage 3) (refer to Figure 3.2). A culvert exists at the upstream (western) end of this drain, which in the past would have conveyed some runoff from the development site to the east (into Lot 22). However, site observations indicate that this culvert is fully blocked and would be unable to convey flow. In addition, the existing approval for Stage 3.1A included a commitment to capping off this blocked culvert permanently. As a result, runoff from the entire development site (Stage 3) drains south and not east via this existing drain.

The existing topography shown in Figure 3.1 and Figure 3.2 indicate that surface runoff from large areas to the north of Tomago Road and north of the development site would report to a topographical depression just north of Tomago Road and potentially drain across the road towards the development site. Site observations (summarised in Figure 3.4) indicate the presence of a 0.5 m diameter pipe just south of Graham Drive and underneath Tomago Road. However, a cross-drainage pipe across Graham Drive (downstream of the depression) could not be located. It was assumed that the 0.5 m diameter pipe downstream of Graham Drive connects to the 0.6 m diameter pipe at the northeastern corner of the development site.

The neighbouring WesTrac facility (Stage 1 – Lot 212) is a separate catchment from the development site (Stage 3). Runoff from Lot 212 (Stage 1, with a catchment area of approximately 23 ha), is captured in a constructed wetland at the southeastern corner of Lot 212. Runoff in excess of the wetland's capacity in Stage 1 would discharge to the south to Lot 22 (the National Parks and Wildlife Service (NPWS) Estate) and then into the North South Drain. Monitoring of discharges from Lot 212 (Stage 1) has been undertaken and documented by annual reporting for over 10 years to NSW DPE and DCCEEW.

A series of levees and flood control structures are in place along the Hunter River North Arm as part of the Hunter River Valley Flood Mitigation Scheme (refer to Figure 3.1). These structures have significantly changed the hydrology of the land behind the levee (including the development site). During floods and/or high tides, water from the Hunter River North Arm does not overtop the existing levee until flooding in the river reaches approximately 1.5 mAHD. According to the flood study undertaken for the Northbank Enterprise Hub and Industrial Park (BMT WBM, 2012), the levee would not be overtopped by the Hunter River during events up to and including 10% AEP event.

3.3 RAMSAR WETLANDS

The Hunter Wetlands National Park is located southeast of the site and includes wetlands of international importance (referred to as Ramsar wetlands). These wetlands are recognised as a significant area of conservation for migratory birds. The Ramsar wetlands also extend to areas to the south of the Hunter River North Arm.

According to the *Kooragang RAMSAR Wetland Ecological Character Description* (Brereton and Taylor-Wood, 2010), the Hunter Estuary Wetland Ramsar site has a range of biodiversity values and supports:

- A range of estuarine vegetation communities including intertidal sand and mud flats, saltmarsh, and freshwater/brackish wetlands which are important foraging and roosting habitat for migratory birds;
- Infauna in intertidal mudflat areas which provide food for migratory waders;
- Seventeen species of migratory shorebirds;
- More than 1% of the Australian population of red-necked avocet; and
- A high diversity of flora and fauna … including 38 bird species which are listed as migratory under the EPBC Act.

Figure 3.1 shows the extent of the Ramsar Wetlands in the vicinity of the development site. The existing "north-south drain" and its raised banks represent a physical barrier which prevent local catchment runoff from the existing site from draining east to the Ramsar wetlands.

3.4 TOMAGO SAND BEDS

3.4.1 General

The Tomago Sandbeds is an underground water source that runs parallel to the coast between Newcastle and Port Stephens, starting at Tomago and stretching northeast for 25 km towards Lemon Tree Passage (refer to Figure 3.5).

The development site (Stage 3) drains away from the Tomago Sandbeds. However, the area to the north of Tomago Road is part of the contributing catchment draining from the Tomago Sandbeds. The Tomago Sandbeds flow through the site as groundwater base flows generated by the high infiltration rates over the sandbeds.

Whist the Hunter Water Special Areas Zone ("Tomago Sandbeds" on Figure 3.5) is mapped as including the northeast corner of Stage 1, Hunter Water has previously clarified this as an overflow area rather than a drawdown catchment area. As such, no part of the development site (Stage 3) is regarded as the Tomago Sandbeds catchment.

3.4.2 Contribution of surface water flows to the development site (Stage 3)

Based on the presence of the 0.5 m diameter pipe just south of Graham Drive and underneath Tomago Road, it is possible that surface runoff from the areas to the north of Tomago Road (part of the Tomago Sandbeds catchment) potentially drains to the development site via the 0.6 m diameter pipe discharging to the roadside swale adjacent to WesTrac Drive. However, historical observations indicate that runoff in areas north of Tomago Road (and north of the development site) would generally infiltrate into the underground aquifer (the Tomago Sandbeds). As a result, the catchment to the north of Tomago Road historically has no significant contribution to the volume of surface runoff draining to the development site (Stage 3).

Due to significant rainfall during the major Hunter River flood event in July 2022, the Tomago Sandbeds was known to have filled up, resulting in significant ponding upstream (north) of the road up to a peak ponding level of approximately 3.5 mAHD. As a result, ponded water overflowed across Tomago Road just to the northeast of the WesTrac Facility (Lot 212). However, there was no road closure at this location immediately north of the development site during this time.

On the basis of the above, the external catchment to the north of Tomago Road (and north of the development site) potentially contributes groundwater flows, however it does not contribute significant surface runoff draining to the development site (Stage 3). Therefore, the extent of the external surface water catchment upstream of the development site would be limited parts of the intersection of Tomago Road and WesTrac Drive.

3.4.3 Contribution of groundwater flows to the development site (Stage 3)

Hunter Water have been recording groundwater level data for bore SK3520 located just northeast of the WesTrac Facility (Stage 1) since 1976, representing approximately 45 years of data to date. Based on this data, the long-term average groundwater table level between 1976 and 2022 is 1.96 mAHD. The minimum and maximum recorded groundwater levels during this period are 0.57 mAHD and 3.37 mAHD respectively.

Annual monitoring undertaken at the WesTrac Facility (Stage 1) over the past 10 years revealed that elevated groundwater levels in the Tomago Sandbeds generated above ground surface water flows that are identifiable as basin outflows from the Stage 1 wetland, observed long after a storm event. This occurs due to the interface between the sandy aquifer and the underlying clay layer daylighting at the Stage 1 site. Generally, groundwater reports as surface water at the Stage 1 wetland only during periods when the groundwater level at SK3520 is above the long-term average. When regional groundwater levels at this bore is below the long-term average, no groundwater-based surface flows would report to the Stage 1 wetland. This groundwater, regarded as base flows through the Stage 1 wetland, has previously been observed in the approximate range of 0.1 L/s to 3.0 L/s. However, these base flow rates are highly influenced by rainfall accumulation and starting water levels in the underground aquifer near the site.

Based on the 2022 Annual Report for the WesTrac Facility, it is estimated that during years with average rainfalls, groundwater inflows reporting to the WesTrac Facility's basin would range between 0 to 100 ML/year. The proximity of the development site (Stage 3) to the WesTrac Facility and the Tomago Sandbeds suggest that groundwater from the Tomago Sandbeds potentially report to the development site. For the purpose of the site water balance assessment (described in Section 8), it was assumed that groundwater from the Tomago Sandbeds would report as surface flow to the development site (Stage 3) at a maximum rate of 140 ML/yr during years with average rainfalls. This was calculated by factoring up the maximum groundwater flow estimate to Stage 1 in proportion to the length of site frontage along Tomago Road (just downstream of the Tomago Sandbeds catchment) perpendicular to the groundwater flow direction to the south.

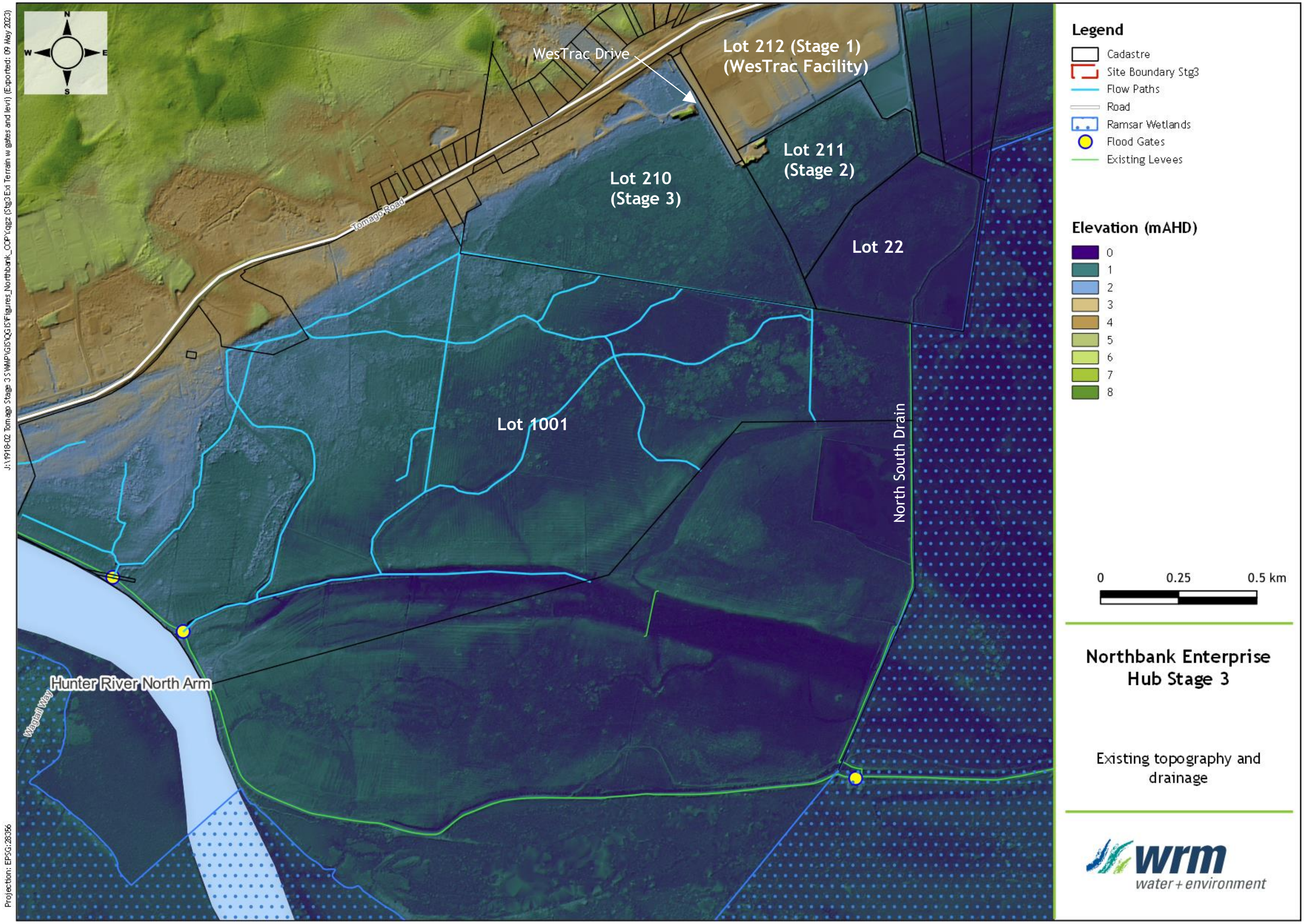

Figure 3.1 – Existing topography and regional drainage features

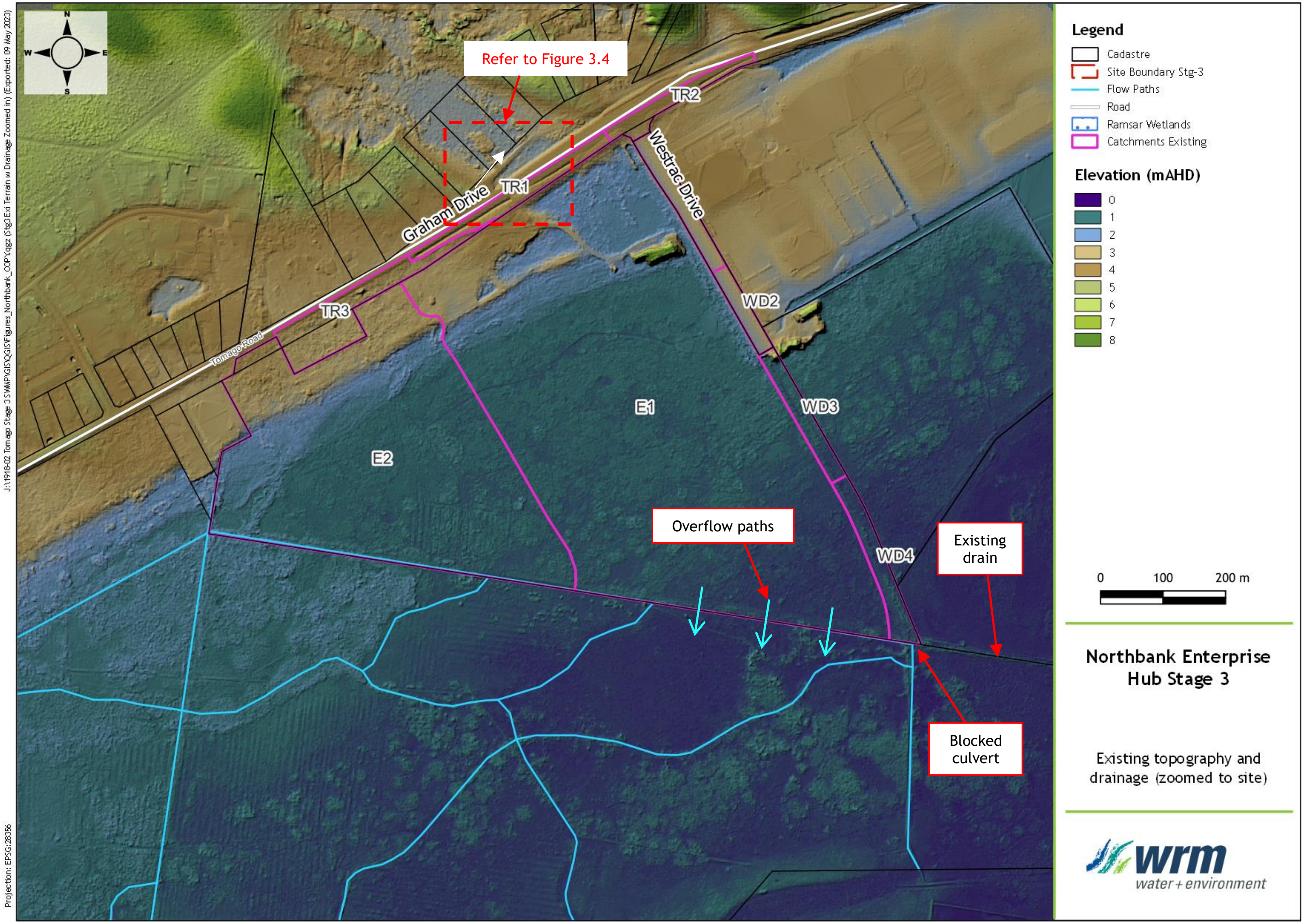

Figure 3.2 – Existing topography, local catchments and drainage features

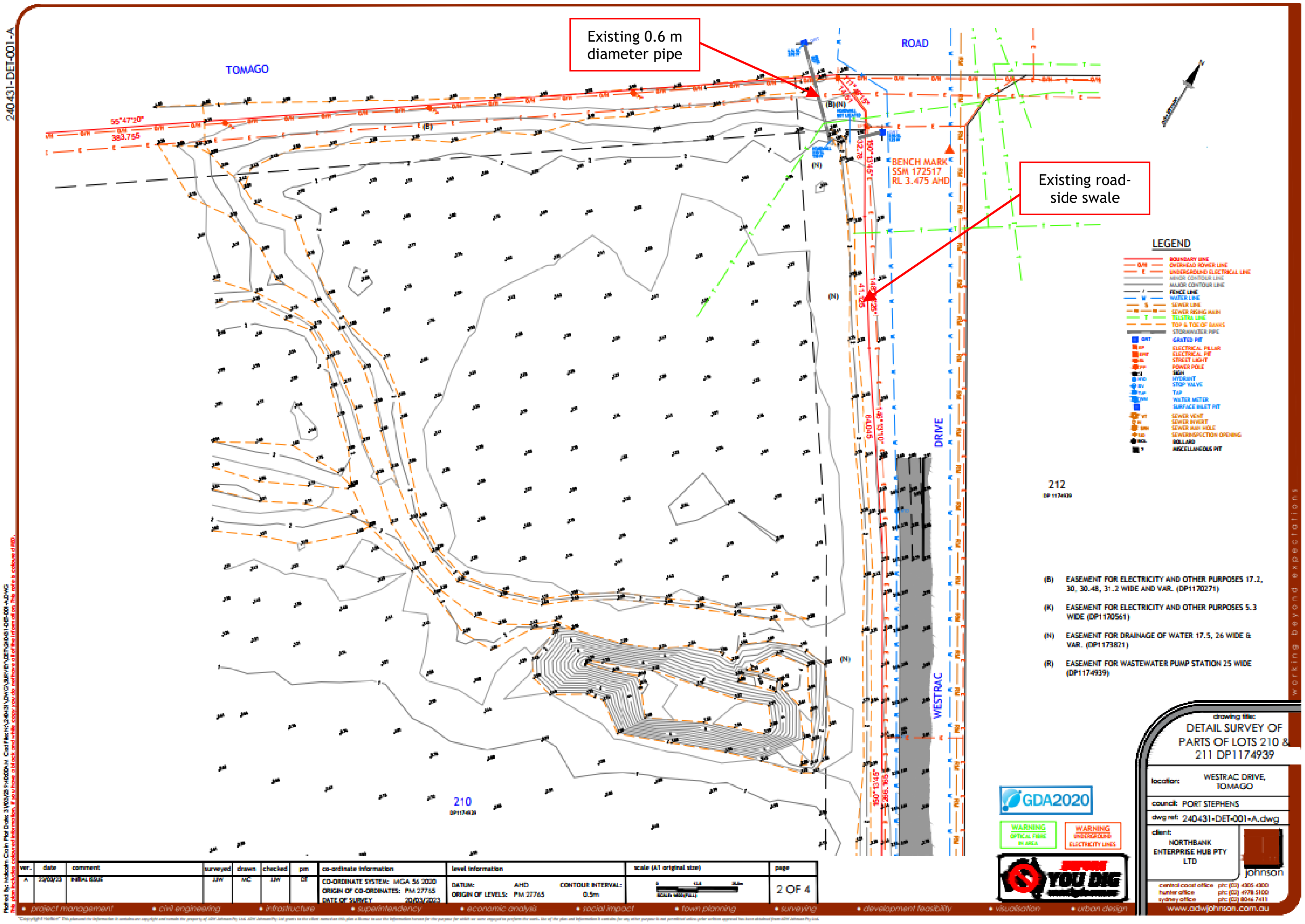

Figure 3.3 – Ground survey for the northeastern section of the development site adjacent to WesTrac Drive

Figure 3.4 – Site observations of drainage characteristics at Graham Drive and Tomago Road just north of the development site

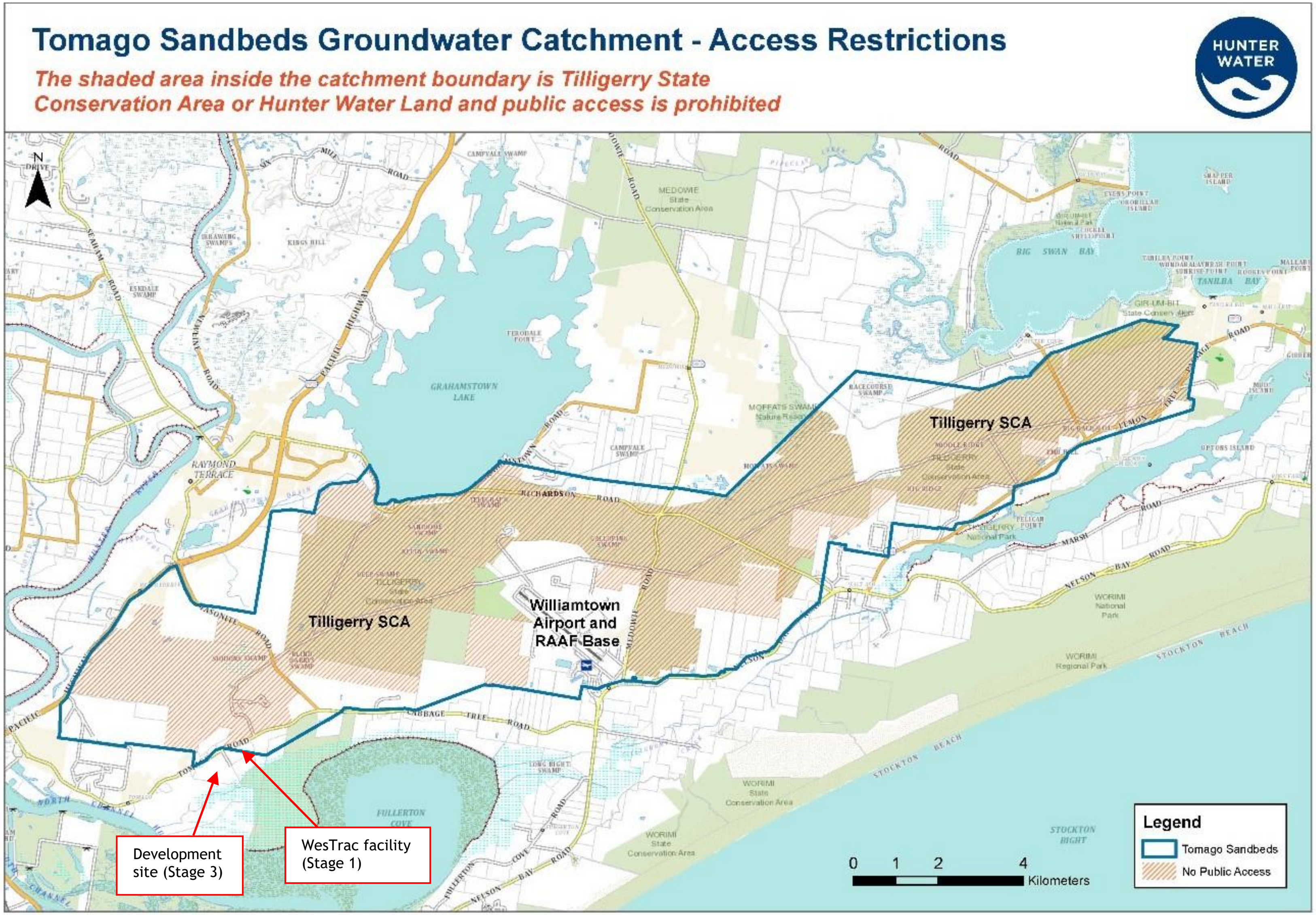

Figure 3.5 – Tomago Sandbeds groundwater catchment

4 Proposed development

4.1 OVERVIEW

It is proposed to develop the site for industrial use. Figure 4.1 shows the conceptual site layout and bulk earthworks plan. The proposed development will increase the imperviousness of the site from zero to approximately 90% impervious. The existing WesTrac Drive will be extended to the southeastern corner of the development site.

Stormwater quantity and quality management for the proposed development will require the construction of two combined wetland and detention basins located at the southeastern and southwestern corners of the development site.

4.2 DEVELOPED SITE CHARACTERISTICS

4.2.1 Bulk earthworks

The proposed industrial lots and internal roads will be constructed on fill. The proposed industrial lots will have a minimum finished level of 3.5 mAHD, which is based on the 1% AEP Hunter River peak flood level in the year 2100 plus 0.5 m freeboard. Based on Council's Flood Certificate (provided in Appendix B), the flood planning level for Lot 210 (Stage 3) is 3.5 mAHD. The finished levels of the lots will range from 3.5 mAHD to 4.0 mAHD. WesTrac Drive will be extended to the southeastern corner of the development site. Access to the developed site will be from the east via WesTrac Drive.

4.2.2 Proposed stormwater quantity management measures

Figure 4.1 shows the proposed drainage configuration for the fully developed site. The proposed water quantity management strategy for the proposed development is described below:

- Two combined wetland and detention basins will be constructed; one at the southeastern corner of the site (referred to as Basin 1) and one at the southwestern corner of the site (referred to as Basin 2), with a combined total surface area of 6.65 ha. Basins 1 and 2 will mitigate the impact of the proposed development on the total peak discharges at the boundary with Lot 1001.
- Three grassed open channels are proposed along the eastern site boundary (Channel 1), along the middle of the site (Channel 2) and at the western part of the site (Channel 3). Channels 1 and 2 will drain to Basin 1. Channel 3 will drain to Basin 2.
- The existing 0.6 m diameter pipe at the northeastern corner of the site (which conveys runoff from Tomago Road) would discharge into the proposed Channel 1, therefore maintaining cross drainage beneath Tomago Road.
- Basin 1 will capture runoff from approximately 67% of the developed site including developed subcatchments D1, D2, D3, D4, D5 and D6 and the Basin 1 footprint itself. Basin 1 will also capture and mitigate external runoff from parts of Tomago Road and WesTrac Drive (subcatchments TR1, TR2, WD1, WD2, WD3 and WD4) via Channel 1.
- Basin 2 will capture runoff from approximately 33% of the developed site including developed subcatchments D7, D8, D9 and D10 and the Basin 2 footprint itself. Basin 2 will also capture and mitigate external runoff from parts of Tomago Road (subcatchment TR3) via Channel 3.
- Runoff from subcatchments D1 and D2 will drain to Channel 1. Runoff from subcatchment D5 will drain to Channel 2. Runoff from subcatchment D4 will be piped to Channel 2. Runoff from subcatchments D3 and D6 will drain directly to Basin 1.

- Runoff from subcatchment D7 will be piped to Channel 3. Runoff from subcatchment D9 will be piped to Basin 2. Runoff from subcatchments D8 will drain to Channel 3. Runoff from subcatchment D10 will drain directly to Basin 2.

4.2.3 Proposed stormwater quality management measures

The proposed water quality management strategy for the proposed development is described below:

- Two wetlands will be constructed within Basins 1 and 2 to treat stormwater runoff from the proposed development as well as parts of Tomago Road and WesTrac Drive before discharging to Lot 1001. Basins 1 and 2 will be constructed above ground with minimal excavation.
- Vegetated Channels 1, 2 and 3 will also provide additional treatment of runoff from their upstream catchments.
- Gross pollutant traps (GPT) will be installed at the roadside stormwater inlet pits. Each industrial lot will have a GPT for primary stormwater treatment at source, prior to discharge to the trunk stormwater drainage system in the estate. A trash rack will also be installed at the inlets to Basins 1 and 2 (i.e. at the outlets of Channels 1, 2 and 3).
- Rainwater tanks will be installed at each of the future industrial lots, with a combined total volume equivalent to approximately 5 kL per 100 m^2 of roof area. Further details are provided in Section 8.3.
- Individual stages of development, such as Stage 3.1A, will have interim basin storages sized and constructed to meet the same design objectives and principles of the overall stormwater management plan.

4.2.4 Drainage from Lot 211 (Stage 2)

It was assumed that future development of Lot 211 (Stage 2), located adjacent and east of the development site (Stage 3), will likely include construction of a stormwater basin to manage stormwater quantity and quality from Lot 211. This basin would likely be located at the southwestern corner of Lot 211 (near the southeastern corner of Lot 210).

A drainage corridor will be provided for the drainage of stormwater outflows from Lot 211. Stormwater outflows from Lot 211 will be conveyed through this drainage corridor, bypassing the eastern edge of Basin 1 on Lot 210 and discharging to the south to Lot 1001.

Figure 4.1 – Proposed development site layout, bulk earthworks plan, developed catchments and drainage configuration

5 Discharge estimation

5.1 METHODOLOGY

The XP-RAFTS (Innovyze, 2018) hydrological model was used to estimate the 63% (1 in 1.58), 50% (1 in 2), 20% (1 in 5), 10% (1 in 10), 5% (1 in 20), 2% (1 in 50) and 1% (1 in 100) annual exceedance probability (AEP) design discharges at the development site under existing and developed conditions. Hydrology was undertaken based on the Australian Rainfall and Runoff 2019 (ARR 2019) guidelines.

Suitable historical rainfall and stream gauge data is not available to calibrate the XP-RAFTS model. As such, the model was validated against peak discharges estimated using the Rational Method.

The XP-RAFTS model was simulated for the above seven design event AEPs and for a range of storm durations up to 18 hours.

5.2 XP-RAFTS MODEL CONFIGURATION

5.2.1 Overview

The following two XP-RAFTS models were developed:

- An “existing conditions” model was developed to represent existing site conditions. This model consists of a total of 9 subcatchments ranging in size from 0.4 ha to 32 ha, including two subcatchments representing the development site itself and eight subcatchments representing external subcatchments (see Figure 3.2).
- A “developed conditions” model was developed to represent developed site conditions. This model consists of a total of 19 subcatchments ranging in size from 0.4 ha to 9.4 ha, including 12 subcatchments representing the development site itself and 7 subcatchments representing external subcatchments (see Figure 4.1).

5.2.2 XP-RAFTS model parameters

Both the existing and developed conditions XP-RAFTS models contain subcatchments that were assigned with either “undeveloped” or “developed” subcatchment parameters. “Undeveloped” catchment parameters were assigned to the vacant development site. Developed subcatchment parameters were assigned to existing roads, future roads and future industrial lots.

Table 5.1shows the adopted XP-RAFTS model parameters used in the XP-RAFTS model for undeveloped and developed catchments, including percentage impervious, catchment PERN “n”, initial losses (IL) and continuing losses (CL). IL’s and CL’s were configured based on the NSW Government Floodplain Risk Management Guide (OEH, 2019) using the following procedure:

- IL’s for undeveloped subcatchments were initially obtained from the Probability Neutral Burst Losses available from the ARR Datahub. The ARR Datahub provides a unique value of IL for every storm duration for every event. Therefore, for simplicity, IL’s were averaged and grouped for durations and AEPs with similar Probability Neutral Burst Losses.
- A CL of 1.1 mm/hr was adopted for undeveloped subcatchments, which was based on the default ARR data hub continuing loss of 2.7 mm/hr multiplied by a factor of 0.4 as per the OEH (2019) guideline.
- IL’s and CL’s for developed subcatchments were factored from the undeveloped subcatchment losses according to the increase in imperviousness.

Table 5.1 – Adopted XP-RAFTS model parameters

XP-RAFTS catchment and rainfall parameters	Design event AEP		
	63% - 50%	20% - 2%	1%
Undeveloped subcatchments			
% Impervious	0	0	0
PERN 'n'	0.05	0.05	0.05
Initial loss (mm)	8.8	7.0	3.4
Continuing loss (mm/hr)	1.1	1.1	1.1
Storage coefficient 'Bx'	1.0	1.0	1.0
Developed subcatchments			
% Impervious	90	90	90
PERN 'n'	0.045	0.045	0.045
Initial loss (mm)	0.9	0.7	0.3
Continuing loss (mm/hr)	0.1	0.1	0.1
Storage coefficient 'Bx'	1.0	1.0	1.0

5.2.3 XP-RAFTS model discharge validation

A Rational Method calculation was undertaken for the following representative catchments:

- A 32-ha catchment represented by subcatchment E1 in the existing conditions XP-RAFTS model (refer to Figure 3.2). Local subcatchment peak discharges from subcatchment E1 were compared against Rational Method peak discharges for subcatchment E1 to validate XP-RAFTS model parameters for undeveloped catchment conditions.
- A 13-ha catchment represented by the combined areas of subcatchments D4 and D5 in the developed conditions XP-RAFTS model (refer to Figure 4.1). Local subcatchment peak discharges from combined subcatchments D4 and D5 were compared against Rational Method peak discharges for combined subcatchments D4 and D5 to validate XP-RAFTS model parameters for developed catchment conditions.

The Rational Method calculations are presented in Appendix C.

Table 5.1 compares XP-RAFTS model predicted local subcatchment peak discharges at subcatchment E1 (for undeveloped catchment conditions) and just downstream of subcatchment D5 (for developed catchment conditions) against Rational Method peak discharges for these representative catchments. The XP-RAFTS validation results indicate the following:

- For undeveloped catchment conditions, the XP-RAFTS model peak discharges are generally within 20% of the Rational Method peak discharges for the 63% to 2% AEP events. The difference is within 6% for the 1% AEP event.
- For developed catchment conditions, the XP-RAFTS model peak discharges are generally within 5% of the Rational Method peak discharges for the 2% to 1% AEP events. The XP-RAFTS model overestimates peak discharges compared to the Rational Method for the 63% to 5% AEP events.
- For the 20% to 2% AEP events, the XP-RAFTS model overestimates the Rational Method peak discharges by similar magnitudes between undeveloped and developed conditions. For the 63%, 50% and 1% AEP events, the XP-RAFTS model underestimates peak discharges for undeveloped conditions while overestimating peak discharges for developed conditions compared to the Rational Method, which is considered conservative for the purpose of assessing the impact of the proposed development.

- Overall, the XP-RAFTS model is expected to produce reasonable estimates of peak discharges from the site using the adopted model parameters. The model is likely to be conservative with regards to the impact of the development on existing conditions peak discharges.

Table 5.2 – Comparison of XP-RAFTS and Rational Method peak discharges

Design event AEP	Peak discharge m³/s)					
	Undeveloped catchment (E1)			Developed catchment (D4+D5)		
	Rational Method	XP-RAFTS	Diff. (%)	Rational Method	XP-RAFTS	Diff. (%)
63%	0.40	0.34	-15%	1.24	1.96	58%
50%	0.50	0.43	-14%	1.54	2.27	47%
20%	0.86	1.01	18%	2.59	3.35	29%
10%	1.13	1.35	19%	3.41	4.23	24%
5%	1.44	1.75	21%	4.34	5.11	18%
2%	1.98	2.24	13%	5.93	6.27	6%
1%	2.41	2.27	-6%	7.24	7.34	1%

5.3 EXISTING CONDITIONS PEAK DISCHARGES

Table 5.3 shows the existing conditions design peak discharges at the southern site boundary with Lot 1001. In accordance with ARR 2019, the design peak discharges shown in Table 5.3 represent the mean peak discharge between the 10 design storms for the critical storm duration. The critical storm duration was estimated to be 9 hours for the 63% to 20% AEP events and 6 hours for the 10% to 1% AEP events.

Flows from the development site across to Lot 1001 would drain by sheet flow as there are no clearly defined channels where flows can concentrate within the development site. As such, the peak discharges shown in Table 5.3 represents the total peak discharge just downstream of Subcatchments E1 and E2 (refer to Figure 3.2). The peak discharges shown in Table 5.3 also include the discharges from external catchments including Tomago Road and WesTrac Drive. Note that flood storage has been ignored for this analysis.

Table 5.3 – XP-RAFTS model predicted existing conditions peak discharges at the southern lot boundary with Lot 1001

Design event AEP	Peak discharge (m^3/s)
63%	0.67
50%	0.84
20%	1.50
10%	2.11
5%	2.72
2%	3.47
1%	4.18

5.4 DEVELOPED CONDITIONS PEAK DISCHARGES

5.4.1 Impact of proposed development on peak discharges to Lot 1001

Table 5.4 compares the developed conditions design peak discharges against existing conditions peak discharges at the southern site boundary with Lot 1001 assuming no mitigation occurs. For developed catchment conditions, the critical storm duration for all events was estimated to be 45 minutes for the 63% to 20% AEP events, 30 minutes for the 10% and 5% AEP events and 15 minutes for the 2% and 1% AEP events.

Flows from the developed would be concentrated at the outlet of Basins 1 and 2. To compare the unmitigated impact of the proposed development, the developed conditions peak discharges reported in Table 5.4 represent the total combined peak discharge from the outlets of Basins 1 and 2. The model results show that increased imperviousness at the development site (unmitigated) would result in design peak discharges at the southern lot boundary with Lot 1001 increasing by between 2.6 to 5.3 times compared to existing conditions peak discharges.

Table 5.4 – Comparison of XP-RAFTS model predicted peak discharges at the southern lot boundary with Lot 1001 between existing and developed (unmitigated) conditions.

Design event AEP	Peak discharge (m^3/s)		Diff. (%)
	Existing conditions	Developed (unmitigated) conditions	
63%	0.67	4.18	526%
50%	0.84	4.84	479%
20%	1.50	7.13	375%
10%	2.11	8.90	321%
5%	2.72	10.67	292%
2%	3.47	13.03	275%
1%	4.18	15.15	262%

[a] – Peak discharges are reported for the critical storm duration only

5.4.2 Stormwater detention requirements

The results of XP-RAFTS hydrologic modelling indicate that without appropriate mitigation measures, the proposed development would increase design peak discharges at the southern lot boundary with Lot 1001 by between 2.7 to 5.4 times compared to existing conditions peak discharges. Therefore, stormwater detention is proposed to ensure that developed conditions peak discharges do not exceed those generated under existing catchment conditions. The proposed detention basins are described briefly in Section 4.2.3 and are modelled and reported on in detail in Section 6.

6 Water quantity management

6.1 OVERVIEW

The XP-RAFTS model described in Section 5.2 was used to design the stormwater detention requirements within Basins 1 and 2. Basins 1 and 2 are combined wetland-detention basin structures. The design of the water quality management component of Basins 1 and 2 are described in Section 7.

Design discharges obtained from the XP-RAFTS model were also used to size the proposed channels and culverts that convey runoff from the development site to Basins 1 and 2.

6.2 CONFIGURATION OF PROPOSED CHANNELS AND CULVERTS

6.2.1 Open channels

The HEC-RAS model was used to size the proposed Channels 1, 2 and 3. These open channels were sized to convey the 1% AEP design discharge without overflowing into the adjacent industrial lots and internal roads. Table 6.1 provides the key design characteristics of the proposed open channels. The sizing of these channels has accounted for elevated tailwater levels in Basin 1 and Basin 2 corresponding to the critical storm duration in each channel.

The proposed open channels were designed with a longitudinal gradient of 0.12%, which is consistent with the adopted longitudinal gradient of the existing constructed drains at the neighbouring WesTrac facility. Due to the extremely flat topography of the site, it would not be feasible to construct these drains with Council's preferred minimum grade of 0.5%.

Table 6.1 – Design characteristics of proposed open channels

Description	Open channel		
	Channel 1	Channel 2	Channel 3
Channel geometry			
Base width (m)	5.0	8.0	5.0
Batter slope	1V:4H	1V:4H	1V:4H
Longitudinal grade (%)	0.12	0.12	0.12
Upstream invert (mAHD)	1.33	0.82	1.22
Downstream invert (mAHD)	0.50	0.50	1.00
Hydraulic characteristics			
Design discharge (1% AEP) (m^3/s)	5.04	7.34	2.53
Peak 1% AEP flow depth (m)	0.83 - 1.08	0.99 - 1.13	0.71 - 0.75
Peak 1% AEP velocity (m/s)	0.34 - 0.56	0.52 - 0.62	0.42 - 0.45

6.2.2 Culvert crossings

There are four proposed culvert crossings at the internal roads and/or access driveways within the proposed development, including two crossings along Channel 1, one crossing at Channel 2 and one crossing at Channel 3. Figure 4.1 shows the locations of these crossings.

The HEC-RAS models used to size the drains were also used to size the proposed culverts at the four crossings. These culverts were sized to convey the 1% AEP peak discharge without overtopping of the road. Table 6.2 provides the key design characteristics of the proposed culverts. The sizing of these culverts has accounted for elevated tailwater levels in Basin 1 and Basin 2 corresponding to the critical storm duration at each channel.

Table 6.2 – Design characteristics of proposed culverts

Description	Open channel			
	Crossing 1	Crossing 2	Crossing 3	Crossing 4
Geometry				
Culvert type	RCBC	RCBC	RCBC	RCBC
Width (m)	1.20	1.20	1.20	1.20
Height (m)	0.75	0.90	0.90	0.75
No. of barrels	4	4	5	4
Upstream IL (mAHD)	1.04	0.57	0.62	1.03
Downstream IL (mAHD)	1.00	0.54	0.59	1.00
Hydraulic characteristics				
Design discharge (1% AEP) (m^3/s)	3.13	5.04	7.34	2.53
Peak velocity (1% AEP) (m/s)	0.87	1.17	1.36	0.73

6.3 DETENTION BASIN CONFIGURATION

Figure 6.1 shows a conceptual cross section of the detention basins. The basins will be used for both water quality and stormwater detention. A description of the detention storage component is given below.

6.3.1 Basin 1

Figure 6.2 shows the location of the proposed Basins 1 its associated catchment. The configuration and specifications of Basin 1 are shown in Figure 6.2 and Table 6.3 respectively. The adopted storage curve for Basin 1 is provided in Appendix D.

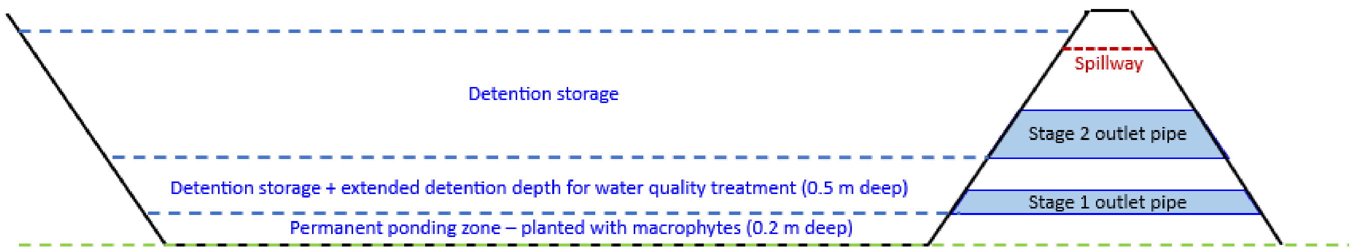

Figure 6.1 – Conceptual cross section of the combined wetland-detention basin (not to scale)

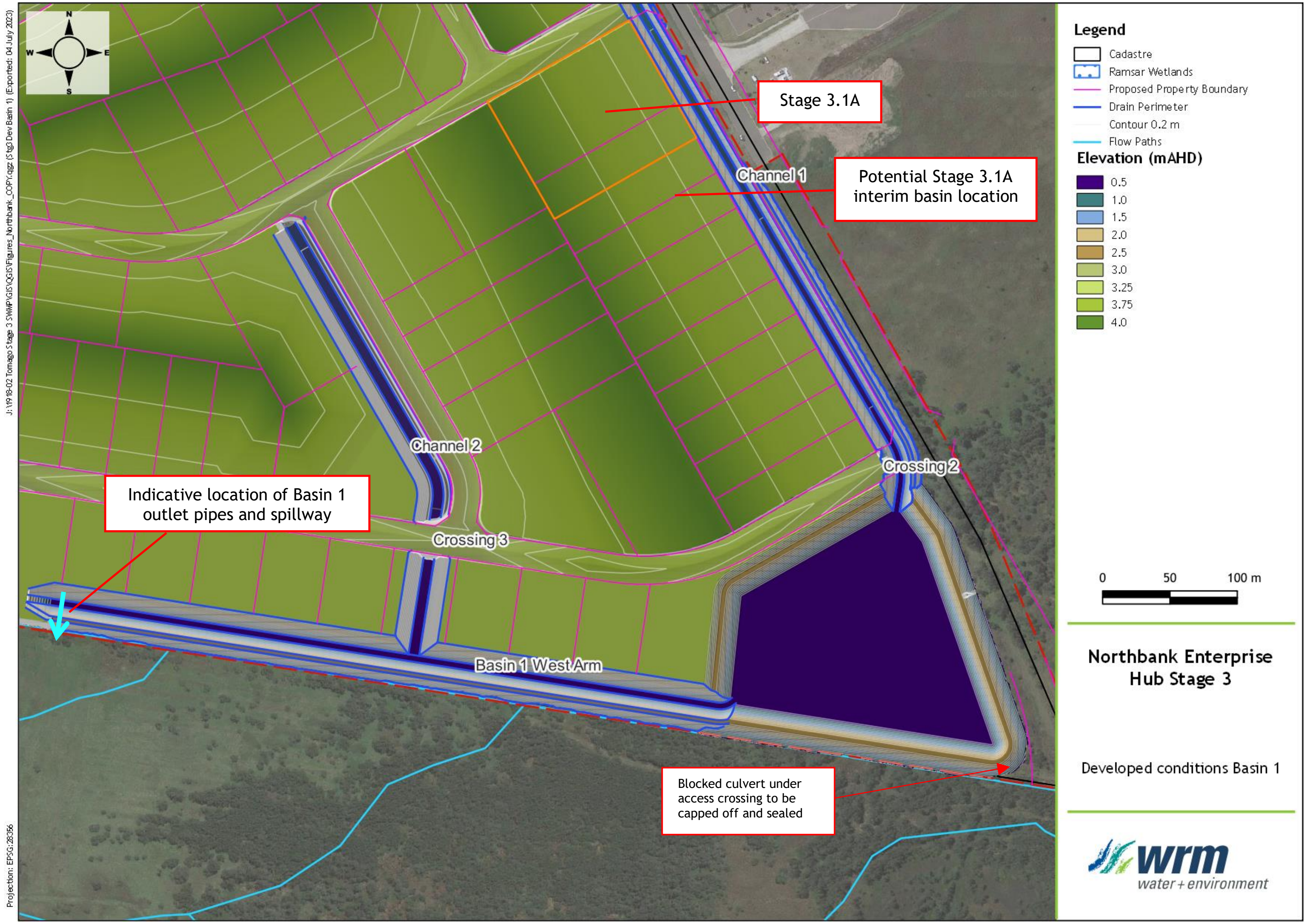

Figure 6.2 – Basin 1 layout

Table 6.3 – Basin 1 specifications

Basin 1 characteristics	
General	
Invert (basin floor) [a]	0.5 mAHD
Initial water level [b]	0.7 mAHD
Surface area at full supply level (FSL)	35,122 m^2
Hydraulics	
Peak water level (5% AEP) [c]	1.95 mAHD
Peak water level (1% AEP) [c]	2.26 mAHD
Peak detention volume (1% AEP) [c]	52,655 m^3
Outlet pipes (multi-staged)	
Stage 1	1 x 0.225 m diameter RCP Invert = 0.7 mAHD
Stage 2	4 x 0.450 m diameter RCP Invert = 1.2 mAHD
Spillway	
Width	10.0 m
Invert	2.05 mAHD
Volume below spillway	45,190 m^3
Embankments	
Embankment crest level	2.5 mAHD
Internal batters (main basin)	1V:6H
External batters (main basin)	1V:6H
Internal batters (western arm)	1V:4H
External batters (western arm)	1V:4H

[a] - Based on the minimum LiDAR elevation within the basin footprint (this will need to be confirmed by ground survey).

[b] - The bottom 0.2 m of the basin is the permanent ponding zone for the wetland macrophytes (refer to proposed wetland design in Section 7).

[c] - This value is associated with the representative design storm (closest to the mean) for the critical duration only and is not the maximum between all simulated storms for the critical duration.

6.3.2 Basin 2

Figure 4.1 shows the location of the proposed Basins 2 its associated catchment. The configuration and specifications of Basin 2 are shown in Figure 6.3 and Table 6.4 respectively. The adopted storage curve for Basin 2 is provided in Appendix D.

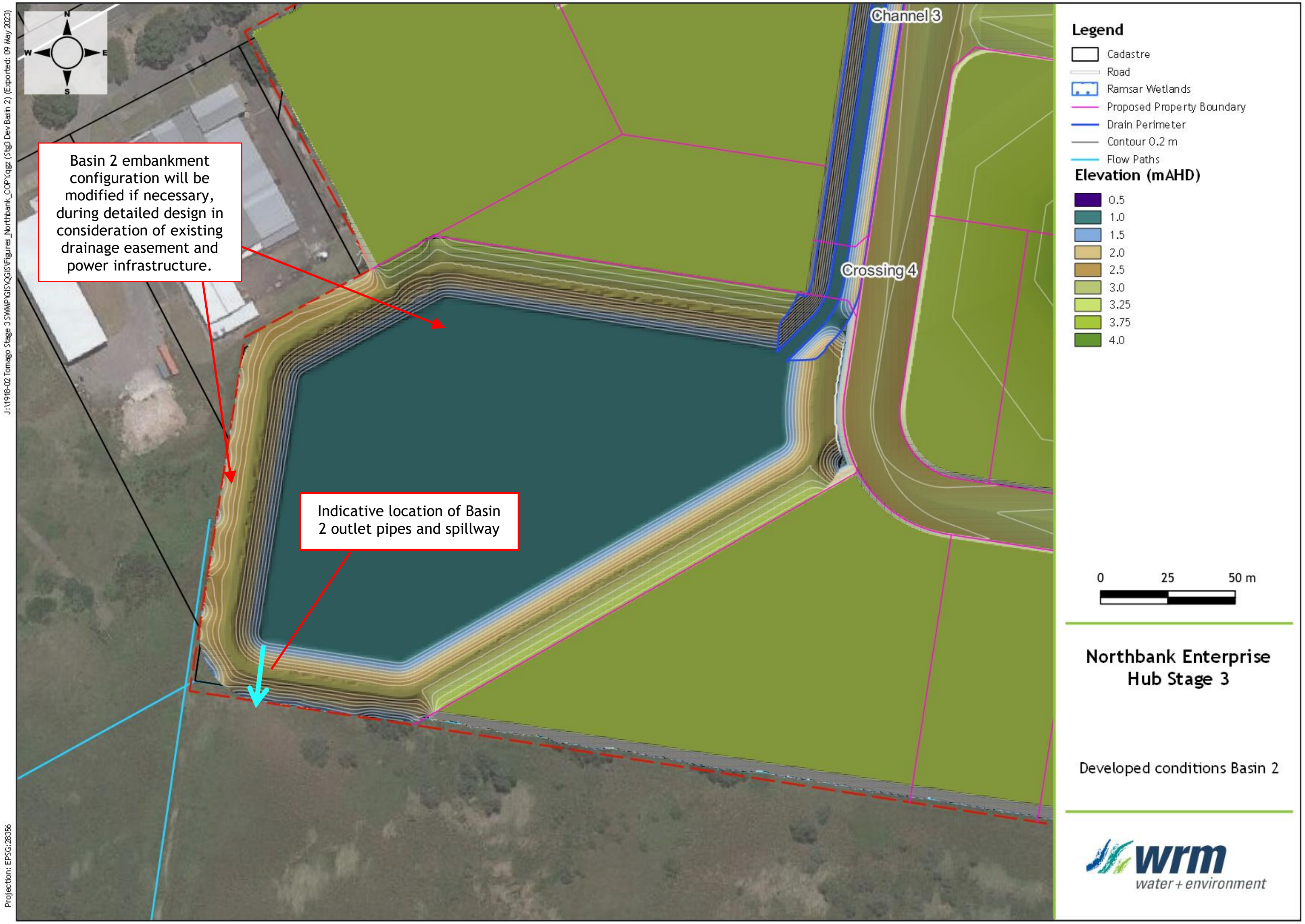

Figure 6.3 – Basin 2 layout

Table 6.4 – Basin 2 specifications

Basin 2 characteristics	
General	
Invert (basin floor) [a]	1.0 mAHD
Initial water level [b]	1.2 mAHD
Surface area at full supply level (FSL)	21,378 m^2
Hydraulics	
Peak water level (5% AEP) [c]	2.18 mAHD
Peak water level (1% AEP) [c]	2.39 mAHD
Peak detention volume (1% AEP) [c]	26,828 m^3
Outlet pipes (multi-staged)	
Stage 1	1 x 0.225 m diameter RCP Invert = 1.2 mAHD
Stage 2	3 x 0.450 m diameter RCP Invert = 1.7 mAHD
Spillway	
Width	5.0 m
Invert	2.30 mAHD
Volume below spillway	24,917 m^3
Embankments	
Embankment crest level	2.8 mAHD
Internal batters	1V:6H
External batters	1V:6H

[a] - Based on the minimum LiDAR elevation within the basin footprint (this will need to be confirmed by ground survey).

[b] - The bottom 0.2 m of the basin is the permanent ponding zone for the wetland macrophytes (refer to proposed wetland design in Section 7).

[c] - This value is associated with the representative design storm (closest to the mean) for the critical duration only and is not the maximum between all simulated storms for the critical duration.

6.4 IMPACT OF DETENTION BASINS ON DESIGN PEAK DISCHARGES

The impact of the proposed detention basins on design peak discharges at the southern site boundary with Lot 1001 was assessed using the XP-RAFTS model. Under existing conditions, there is no single point at which discharges from the site would be concentrated due to the flat topography of the site and the absence of well-defined flow paths. As such, developed conditions design peak discharges were compared against existing conditions peak discharges based on the total peak outflows from Basins 1 and 2. It was not feasible to compare pre- and post-development design peak discharges for the two individual basins in isolation. The comparison of design discharges is shown for the 63%, 50%, 20%, 10%, 5%, 2% and 1% AEP design events for the critical storm duration only.

Table 6.5 shows that the total peak discharges with the proposed detention basins in place are less than existing conditions peak discharges for the critical duration of all design events. For developed (mitigated) conditions, the critical storm durations for total outflows from the site were estimated to be 24 hours for the 63% and 50% AEP events, 9 hours for the 20% and 10% AEP events and 6 hours for the 5%, 2% and 1% AEP events. For comparison, the critical duration for existing conditions ranges from 6 to 9 hours between all modelled events, while the critical duration for developed (unmitigated) conditions ranges from 15 to 45 minutes between all events. Therefore, the timing of peak discharges from the fully developed site would generally be maintained closer to existing conditions with the proposed detention basins in place.

Table 6.5 – Comparison of XP-RAFTS model predicted peak discharges at the southern lot boundary with Lot 1001 between existing and developed (mitigated) conditions

Design event AEP	Peak discharge (m^3/s)		Diff. (%)
	Existing conditions	Developed (unmitigated) conditions	
63%	0.67	0.36	-46%
50%	0.84	0.46	-45%
20%	1.50	1.02	-32%
10%	2.11	1.50	-29%
5%	2.72	1.98	-27%
2%	3.47	2.77	-20%
1%	4.18	4.04	-3%

[a] - Peak discharges are reported for the critical storm duration only

6.5 DESIGN CONSIDERATIONS FOR THE BASIN OUTFLOW

The invert levels of the Stage 1 outflow pipes for Basins 1 and 2 are above the Mean High-Water Springs (MHWS) level of 0.69 mAHD in the Hunter River North Arm. However, there are existing levees and flood control structures (such as controlled and uncontrolled floodgates) that can prevent Hunter River water from flowing through the levee towards the development site during high tides and during floods. Therefore, in reality, it is likely that the locations of the Basin 1 and 2 outlets would not be affected by tidal influences for the majority of the time.

The indicative locations for the outlets of Basin 1 and 2 (refer to Figure 6.2 and Figure 6.3) were selected such that the proposed drainage strategy for the proposed development will conform with the approved drainage strategy for the proposed industrial subdivision at Lot 1001 (project approval MP10_0185) (shown in Figure 6.4). Specifically, outflows from Basin 1 would eventually drain to Channel 3 at Lot 1001, and outflows from Basin 2 would eventually drain to Channel 2, consistent with the previous estate wide stormwater strategy as approved under project approval MP10_0185.

The indicative location for the outlet of Basin 1 was also selected to discharge as far west as possible, therefore ensuring that all runoff from the fully developed site would drain southwest to the Hunter River and not east towards the Ramsar Wetlands. The culvert for this drainage direction which is currently blocked will be formally capped off.

Most discharge from the developed Stage 3 area will remain in Basins 1 & 2 with overflows ponding on Lot 1001. In the event of prolonged rainfalls that trigger releases of freshwater from the basin, the extensive land area across the very flat Lot 1001 provides significant retention and storage that is several times larger than the available storage in the Stage 3 area.

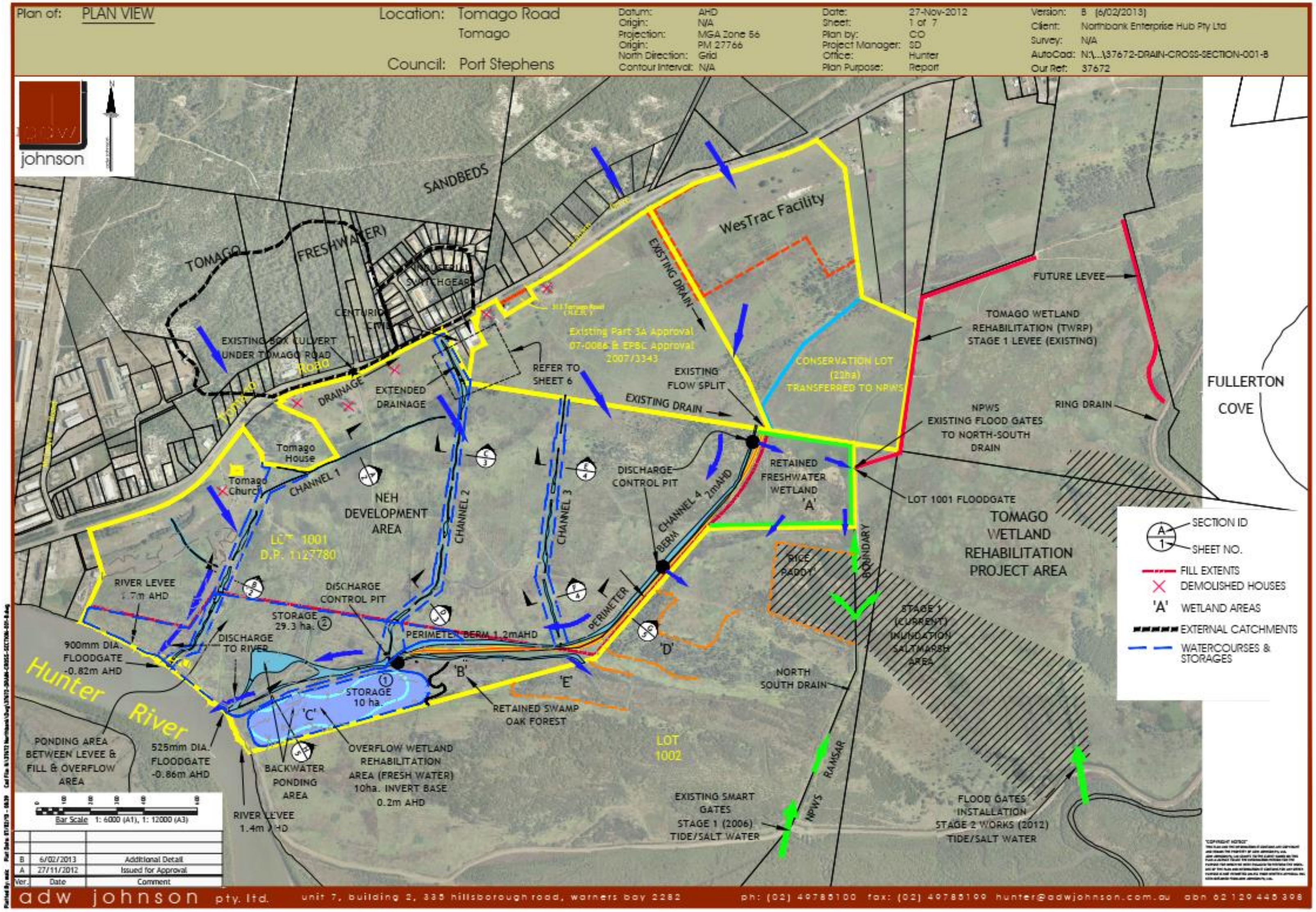

Figure 6.4 – Approved drainage strategy for proposed development at Lot 1001 (Project Approval MP10_0185)

7 Water quality management

7.1 OVERVIEW

The 'MUSIC' model for urban stormwater improvement conceptualisation (eWater, 2019) was used to assess the post-development site runoff from the proposed industrial lots as well as external catchments to determine the performance of the proposed stormwater treatment system.

The following sections describe the adopted water quality objectives (WQOs), the chosen treatment measures for the development site as well as the methodology and results of MUSIC modelling to assess the performance of the proposed stormwater treatment system. The following guidelines and/or previous assessments were considered for the water quality assessment:

- NSW Department of Environment and Climate Change's (DECC's) *Managing urban stormwater: environmental targets – Consultation Draft 2007* (DECC, 2007);
- HCCREMS' Water Sensitive Urban Design Solutions for Catchments above Wetlands (HCCREMS, 2007);
- Redlake Enterprises Pty Ltd's Volume 4 – Stormwater Management Report – Industrial Subdivision (Asquith & deWitt Pty Ltd, 2007);
- Port Stephens Council's (Council's) *Development Control Plan – General Provisions* (PSC, 2014);
- Council's *Development Design Specification – 0074 Stormwater Drainage (Design)* (PSC, 2022)
- Council's *Water Sensitive Development Strategy Guidelines* (BMT WBM, 2011);
- NSW Government's *NSW MUSIC Modelling Guidelines* (BMT, WBM, 2015); and
- Healthy Waterways Water by Design *MUSIC Modelling Guidelines – Consultation Draft November 2018* (HW, 2018).

7.2 WATER QUALITY OBJECTIVES

Table 7.1 compares load-based design objectives for site runoff in the operational phase of the development obtained from the above approvals and guidelines. The key pollutants that are generally of concern during the operational phase of the industrial development include litter, sediment and nutrients (nitrogen (N) and Phosphorous (P)). The WQOs shown in Table 7.1 indicate the pollutant reduction targets when comparing mitigated with unmitigated site annual pollutant loads. The proposed treatment train selected for the proposed development have been designed to meet the design WQOs for these key pollutants.

The EPBC Approval (2007/3343) conditions refer to the adopted WQOs previously set by the DECC (2007) (now NSW DPE). The Project Approval conditions MP07_0086 refer to the DECC (2007) and HCCREMS (2007) WQOs. As such, the proposed stormwater treatment strategy was designed to satisfy the DECC (2007) and HCCREMS (2007) as a minimum. However, Council's WQO's have also been considered in this assessment for comparison.

The DECC (2007) and HCCREMS (2007) WQOs are generally similar to the current Council WQOs set out in Council's DCP and in Council's *Water Sensitive Development Strategy Guidelines* (BMT, WBM, 2011) for sensitive catchments. It has been considered that the development site should be classified as a sensitive catchment due to the existing wetlands downstream of the site.

Table 7.1 – Water quality objectives

Water quality parameter	Percent reduction (%)			
	DECC (2007)	HCCREMS (2007)	PSC (2022) (outside drinking water catchment)	BMT WBM (2011) (sensitive catchment)
Gross pollutants	90	n/a	90	90
Total suspended solids (TSS)	85	80	90	85
Total Phosphorous (TP)	65	45	60	65
Total Nitrogen (TN)	45	45	45	50

n/a – not available

7.3 SELECTION OF TREATMENT TRAIN

A description of the proposed stormwater quality treatment measures is provided in Section 4.2.3. Figure 4.1 shows the locations of the proposed water quality treatment infrastructure.

Note that rainwater tanks are proposed to be installed at each of the future industrial lots, with a combined total volume of approximately 4 ML (4,000 m^3) over the entire estate (refer to Section 8.3). However, the final land use and layout of the industrial lots are unknown at this stage. As such, rainwater tanks were not included in the MUSIC model as part of the water quality treatment train. This approach is conservative for the purpose of satisfying the pollutant reduction targets.

7.4 WATER QUALITY MODELLING

7.4.1 Overview

Assessment of mitigated post-development site runoff water quality was undertaken using the MUSIC water quality model (eWater, 2018). The model was configured based on the MUSIC-Link template specific for Port Stephens Council. Using this approach, the default MUSIC node parameters including pollutant parameters are in line with the Council's preferred parameters. A review of the default MUSIC node including pollutant parameters indicate that they are generally consistent with those recommended in the *NSW MUSIC Modelling Guidelines* (BMT, WBM, 2015). Gross pollutants, suspended solids, total phosphorous and total nitrogen were estimated with the MUSIC model runoff generation parameters.

7.4.2 Rainfall and evapotranspiration

Rainfall in the MUSIC model was configured based on six-minute rainfall data for Williamtown RAAF (Station no. 061078) obtained from the Bureau of Meteorology (the Bureau). A rainfall period of ten years was used for all MUSIC modelling. The adopted period of analysis was 1 January 1998 to 31 December 2007. Evapotranspiration was also configured based on the estimates obtained from the Bureau. The default rainfall and evapotranspiration data form the Council-specific MUSIC model template were unchanged for the water quality assessment.

7.4.3 Source node parameters

The proposed development is considered to be large scale. As such, the proposed industrial lots were 'lumped' such that the source node used represents a number of lots with similar characteristics.

The MUSIC-Link template for Port Stephens Council contains default parameters for urban nodes, which are generally consistent with the recommended parameters in the BMT WBM (2015) guideline.

Table D.1 and Table D.2 in Appendix E show the adopted MUSIC rainfall-runoff parameters and source node pollutant concentration parameters, respectively.

Routing was not used in any drainage links.

7.4.4 Model configuration

A MUSIC model was developed for post-development site conditions with the chosen stormwater treatment trains. Figure D.1 Appendix E shows the MUSIC model configuration used to assess the mitigated post-development site runoff quality for the fully developed site. Table C.3 in Appendix E shows the adopted source node type, area and percentage impervious. The following is of note with regards to the MUSIC model configuration:

- Two constructed wetlands were included in the MUSIC model and referred to as Basins 1 and 2. These basins function as a combined wetland-detention basin, but only the water quality treatment component of the basins was modelled in MUSIC. Further details of the water quality treatment components of Basins 1 and 2 are provided in Section 7.5.
- Channels 1, 2 and 3 were modelled as vegetated swales and provide stormwater treatment for the following subcatchments:
  - Channel 1 treats runoff from developed subcatchments D1 and D2 as well as external runoff from Tomago Road (subcatchments TR1 and TR2) and WesTrac Drive (Subcatchments WD1, WD2 and WD3).
  - Channel 2 treats runoff from developed subcatchments D4 and D5.
  - Channel 3 treats runoff from developed subcatchments D7 and D8 as well as external runoff from Subcatchment TR3.

  Channels 1, 2 and 3 were sized to convey the 1% AEP design discharges as described in Section 6.2. As such, the size and configuration of these channels were not determined by water quality treatment requirements.
- SPEL Stormsack GPTs were incorporated into each developed subcatchment representing industrial lots.

7.4.5 Water quality modelling results

Table 7.2 shows the mean annual pollutant loads for gross pollutants, TSS, TN and TP for unmitigated and mitigated post-development conditions. The water quality modelling results have been reported based on the total outflow at the southern lot boundary (i.e. the combined outflow from Basins 1 and 2).

Table 7.2 – Comparison of mean annual pollutant loads between post-development unmitigated and mitigated conditions

Pollutant	Annual pollutant load (kg/year)		Percent reduction (%)	WQO percent reduction			
	Developed (unmitigated)	Developed (mitigated)		DECC (2007)	PSC (2022)	HCCREMS (2007)	BMT WBM (2011) (sensitive catchment)
Gross pollutants	115,000	0	100.0	90	90	n/a	90
Suspended solids	87,800	4,030	95.2	85	90	80	85
Total phosphorous	140	27	80.6	65	60	45	65
Total nitrogen	967	464	52.0	45	45	45	50

The water quality modelling results indicate that the percentage pollutant reduction achieved by the proposed treatment train exceeds all WQOs applicable to the development site, including those applicable to the wetland environments.

7.5 DESIGN CHARACTERISTICS OF THE PROPOSED WETLANDS

Table 7.3 provides the key design criteria for the proposed wetlands within Basins 1 and 2. A typical cross section is shown in Figure 6.1.

Table 7.3 – Key design characteristics of proposed wetlands in Basins 1 and 2

Description	Constructed wetland	
	Basin 1	Basin 2
Storage properties		
Surface area (m^2)	22,754	18,651
Extended detention depth (m)	0.5	0.5
Permanent pool volume (m^3)	4,259	3,468
Initial volume (m^3)	4,259	3,468
Exfiltration rate (mm/hr)	0.0	0.0
Evaporative loss as % of PET	125	125
Outlet properties		
Equivalent pipe diameter (mm)	225	225
Overflow weir width (m)	10.0	5.0
Notional detention time (hours)	37.9	31.1

7.6 IMPLEMENTATION OF TREATMENT TRAIN

The proposed treatment train for ultimate development will be installed during construction and will be ready for use when the development enters its operational phase. The two combined wetland-detention basins will initially function as sedimentation basins until the catchment is fully developed. An Erosion and Sediment Control Plan for the construction phase of the proposed development is provided in Section 9.

7.7 PROPOSED WATER QUALITY MONITORING STRATEGY

Details of the proposed monitoring and reporting of stormwater quality from the development site are provided in Section 11.

8 Site water balance

8.1 OVERVIEW

This section describes the site water balance for the proposed development, providing details of:

- sources and security of water supply;
- water use/re-use on-site;
- comparison of surface water discharges from the developed site compared to pre-development conditions; and
- reporting procedures.

8.2 SOURCES OF WATER SUPPLY

The sources of water supply and security for the proposed development are:

- water main from the Hunter Water Corporation's (Hunter Water's) regional water supply system (potable town water supply); and
- rainwater tank storage to be provided in the individual industrial lots to capture roof stormwater runoff and re-use for non-potable water uses such as irrigation of landscaped areas, toilet flushing and possibly showers and canteens.

8.3 PROPOSED WATER RE-USE STRATEGY

It is proposed that rainwater tanks will be provided at the individual industrial lots for stormwater capture and re-use. However, the future landuses at the proposed industrial lots are unknown at this stage of the development. Therefore, the proposed rainwater tank storage to be provided, as well as the operational water uses from the rainwater tanks cannot be determined accurately at this stage.

Notwithstanding the above, details the stormwater harvesting strategy adopted for the neighbouring WesTrac facility (Stage 1) obtained from the *Soil and Water Management Report for WesTrac Facility at Tomago Road, Tomago* (ADW Johnson, 2010), were used to derive the indicative rainwater tank volume requirement and the indicative rates of non-potable water use at the future industrial lots at the proposed development (Stage 3).

Based on the ADW Johnson (2010) report, roof water at the WesTrac facility is collected by a 2 ML (2,000 m^3) rainwater tank based on a total roof area of 4 ha (40,000 m^2), which is equivalent to approximately 5 kL per 100 m^2 of roof area. The estimated total non-potable water use including irrigation of landscaped areas is 15.5 ML/year. The estimated rainwater tank storage requirement and non-potable water use rates for the proposed development (Stage 3) was proportioned based on the relative difference in catchment area to the WesTrac facility.

Based on a total development site area of 50.1 ha, the estimated rainwater tank storage requirement and non-potable water use rates for the proposed development (Stage 3) are as follows:

- The total rainwater tank storage volume requirement is approximately 5 kL per 100 m^2 of roof area, to be apportioned between the future industrial lots.
- The total non-potable water use including irrigation of landscaped areas is approximately 31 ML/year.

The installation of a rainwater tank will be attached as a condition of development for the future industrial lots within Stage 3.

8.4 SITE WATER BALANCE

8.4.1 Overview

The MUSIC model described in Section 7 was used to estimate the surface water outflows from the development site under both pre-and post-development conditions. The MUSIC model was primarily used as a tool to assess the stormwater treatment performance of the proposed development as described in Section 7. The MUSIC model also calculates the volume of stormwater runoff generation from the site and accounts for the differences in catchment characteristics (such as soil storage capacities and evapotranspiration losses) between pre- and post-development conditions. Therefore, the MUSIC model is suitable for assessing impact of the proposed development on the volume of the surface water outflows from the development site compared to pre-development conditions.

8.4.2 Development of MUSIC model for pre-development conditions

The MUSIC model described in Section 7 is reflects mitigated developed conditions. To determine the volume of surface water outflows for pre-developed conditions, a pre-development conditions MUSIC model was developed by converting the MUSIC nodes for the proposed industrial lots into “forest” nodes (see Appendix E for the adopted MUSIC node rainfall-runoff parameters).

8.4.3 Meteorological conditions

The MUSIC model was configured to use rainfall data for Williamtown RAAF (Station no. 061078) for a 10-year period from 1 January 1998 to 31 December 2007. The average annual rainfall over this 10-year period is 1,125 mm. For comparison, the long-term average annual rainfall for this station (obtained from the Bureau’s statistics) is 1,132 mm (consistent with the MUSIC model) over a 72-year period between 1942 and 2023. Therefore, the rainfall data and simulation period adopted in the MUSIC model is considered appropriate.

The average annual evapotranspiration for the 10-year MUSIC model simulation period is approximately 1,394 mm.

8.4.4 External groundwater inflows

Based on flow monitoring data at the neighbouring WesTrac facility (described in Section 3.4.3), it is estimated that under average annual rainfall conditions, there is a potential for up to approximately 140 ML/year of groundwater inflow from the Tomago Sandbeds that could potentially report to the surface just downstream of the development site. This potential groundwater inflow volume has been included in the site water balance for both pre- and post-development conditions.

8.4.5 Site water balance

Table 8.1and Table 8.2 compare summaries of the site water balance for an average annual rainfall year between the existing and developed sites, respectively. The results indicate that the proposed development potentially increases freshwater discharge from the development site by approximately 194.7 ML based an average rainfall year.

Table 8.1 – Summary of site water balance for existing (pre-developed) conditions

Pre-development conditions	
Rainfall (mm/yr)	1125.5
Rainfall volume (ML/yr)	610.3
Catchment evapotranspiration loss (ML/yr)	431.0
Flow generated on-site (ML/yr)	179.3
External groundwater inflow (ML/yr)	140.0
Total outflow from site (ML/yr)	319.3

Table 8.2 – Summary of site water balance for developed conditions

Post-development conditions	
Rainfall (mm/yr)	1125.5
Rainfall volume (ML/yr)	610.3
Catchment evapotranspiration loss (ML/yr)	167.3
Flow generated on-site (ML/yr)	443.1
External groundwater inflow (ML/yr)	140.0
Evapotranspiration loss from wetlands (ML/yr)	70.0
Outflows from Basins 1	374.0
Total outflow from site (ML/yr)	514.0

8.4.6 Discussion on impact of increased freshwater discharges

Discharges from the developed site including from external catchments would be captured in the combined wetland-detention basins at the southern corners of the site (Basins 1 and 2). The outlet configuration of the proposed Basins 1 and 2 has been designed to discharge runoff to Lot 1001. Due to the existing topography of Lot 1001, discharges from the site would be stored on site and eventually conveyed west to the Hunter River. Surface water runoff from the site would not drain east to the Ramsar Wetlands under both pre- or post-development conditions. Therefore, the increase in freshwater discharges form the site would not have any impact on the hydrologic characteristics of the Ramsar Wetlands.

The storage and outlet configurations of Basins 1 and 2 were also designed to attenuate peak instantaneous flows from the developed site to below pre-development conditions peak flows (further details in Section 6). However, the proposed basin would not significantly reduce the volume of runoff other than through evapotranspiration from the basin surface. Although peak runoff volumes from the site would increase significantly post-development, the MUSIC model results (refer to Section 7.5) indicate that runoff retained in the proposed basins up to the extended detention depth would be discharged gradually via a 0.225 m low-flow outlet pipe in each basin, over a period of over 31 hours. Therefore, the proposed basins would provide some degree of mitigation to increased runoff volumes from the developed site.

8.5 MONITORING

Details of the proposed monitoring and reporting of stormwater quantities from the development site are provided in Section 11.

9 Erosion and sediment control

9.1 OVERVIEW

This section presents the Erosion and Sediment Control (ESC) strategy for the proposed development. It is intended to assist in the management, reduction and mitigation of erosion and consequent sediment transport at the development site. More detailed plans will be prepared for each stage of the development and be based on this strategy.

During construction of the proposed development, preventing unacceptable levels of sediments and contaminants from leaving the development site and entering the receiving surface water environment downstream is one of the most important functions of ESC. ESC measures are temporary and are required until the proposed industrial lots and roads are sealed and/or landscaped and revegetated.

As per Landcom's *Managing Urban Stormwater – Soils and Construction* (Landcom, 2004) guideline, this ESC Plan adopts the three cornerstones of ESC as follows:

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of diverted and surface water through the development site.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, non-dispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

For ESC to be effective, the following fundamentals are required:

- ensure ESC measures are designed and constructed effectively;
- minimise the duration and extent of soil exposure;
- promptly stabilise disturbed areas;
- maximise sediment retention on the site;
- control water movement through the site;
- minimise soil erosion wherever possible rather than applying down slope sediment controls;
- utilise existing topography and adopt construction practices that minimise soil erosion and sediment discharge from disturbed areas;
- integrate erosion and sediment control issues / measures into the planning phases of construction;
- choose the ESC technique to account for site conditions such as soil, weather and construction conditions;
- maintain all ESC measures in proper working order at all times; and
- monitor the site and adjust ESC practices to maintain the required performance standard.

9.2 POTENTIAL SOURCES OF EROSION

Construction at the development site may result in the alteration of existing surface water flow patterns by proposed activities and through diversion channels. Erosion may occur due to the following activities:

- topsoil and subsoil stockpiles;
- filling and excavation as part of bulk earthworks;
- cleared land ahead of construction activities;
- changes to catchments;
- runoff from the access road(s);
- vehicle and equipment movements; and
- disturbed areas not yet sealed and/or landscaped or revegetated.

9.3 EROSION AND SEDIMENT CONTROL MEASURES

9.3.1 General

ESC measures to be implemented during construction include:

- Disturbance is limited to areas to be immediately worked on and regeneration of dust and erosion free surfaces – landscaping, concrete, bitumen sealing as soon as practical thereafter.
- Provision of and continued maintenance of sediment fencing to low perimeter locations.
- Provision of mesh and gravel or geotextile inlet filters.
- Contract specifications requiring stabilised site access, low flow earth flow earth banks and wind erosion screens.
- A construction programme that provides for the sediment basin to be constructed at the outset with all site runoff, where practical, piped or channelled to this basin for primary treatment/settlement before leaving the site via a mesh supported geotextile filter/riser before discharging to the wetlands.
- Contract specifications requiring regular maintenance of all erosion and sediment control structures and devices for the full contract and maintenance period.

9.3.2 Primary sediment control measures

Primary control of sediment will be provided by two sediment basins which will be constructed within the footprints of Basins 1 and 2. The total minimum sediment basin volume has been determined based on the following design standards and methodology for a Type F sediment basin (Landcom, 2004):

- It was assumed that the proposed sediment basins will capture runoff and sediment from the entire site area of 49 ha.
- Total sediment basin volume = settling zone volume + sediment storage volume as shown in Figure 9.1. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event.
- The sediment basin settling zone volume was determined by adopting volumetric runoff coefficient (Cv) of 0.57 based on Group B soils, a 95th percentile 5-day duration rainfall of 77 mm, calculated using formula $R_{(Y\%, 5\text{-day})} = K1 * I_{(1yr, 120hr)} + K2$.
- The sediment storage volume was determined based on two months soil loss calculated using with RUSLE.

A summary of the sediment pond volume requirement is provided in Table 9.1. The detailed calculations are provided in Appendix F. The total required minimum sediment basin volume was calculated to be 21,651 m^3. This total sediment basin storage volume can be apportioned as appropriate between Basins 1 and 2 depending on the catchments draining to each basin during the construction phase of the development. Alternatively, this total sediment basin storage volume can also be apportioned to a number of smaller intermediate basins in conjunction with the staging of bulk earthworks.

Table 9.1 – Minimum total size requirement for the sediment basins

Catchment area	Settling volume (m^3)	Sediment storage volume (m^3)	Total volume (m^3)
48.6	21,322	329	21,651

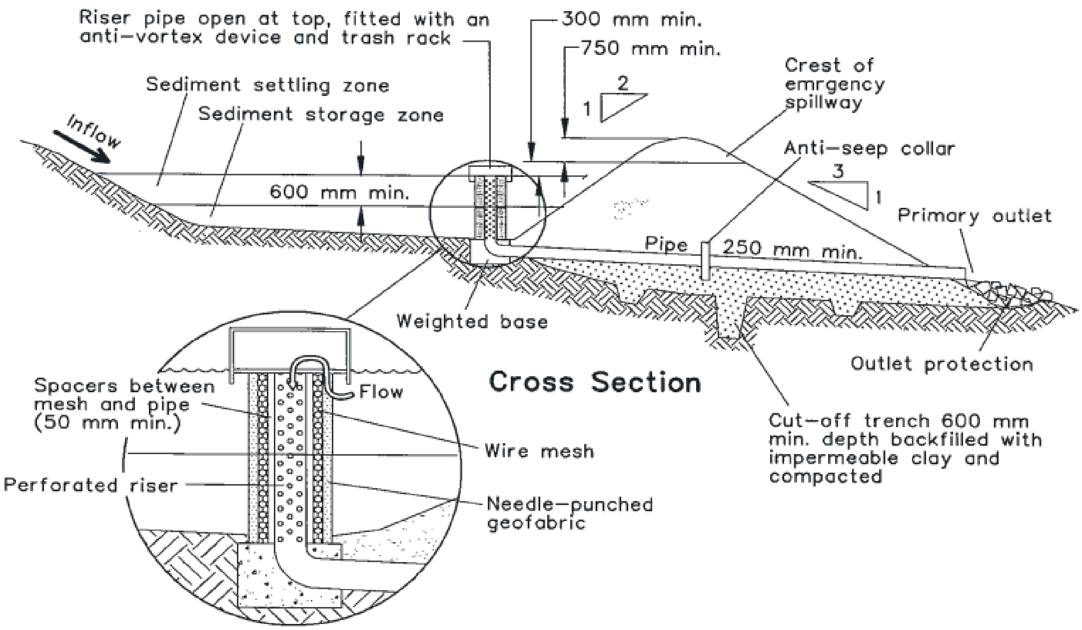

Figure 9.1 – Typical Type-F sediment basin cross section (Landcom, 2004)

9.3.3 Supplementary sediment control measures

Supplementary sediment controls are used in areas where the sediment producing catchment is small or the potential for producing sediment laden runoff is low. Supplementary sediment controls can be used in conjunction with the primary sediment control (i.e. to capture sediment before sediment-laden runoff reaches the sediment basins). A list of appropriate primary and secondary supplementary sediment control techniques is given in Table 9.2.

Table 9.2 – Summary of supplementary sediment control measures

Technique	Typical use
Check dam sediment trap	• Supplementary sediment trap in minor concentrated flow areas. • Trapping sediments in table drains and minor drainage lines. • Check dams may be constructed of rock, sandbags or compost filled socks.
Sediment fence	• Supplementary device for sheet flow from minor catchment areas. • Suitable for all soil types. • Require maintenance after every runoff event.

9.4 GENERAL RECOMMENDATIONS

The following general recommendations are adopted from Landcom (2004) to provide general guidelines that should be followed for correct implementation of sediment controls:

- Every opportunity should be taken to trap sediment within the site, and as close as practicable to its source.
- The potential safety risk of a proposed sediment trap to site workers and the public must be given appropriate consideration, especially those devices located within publicly accessible areas – Hazardous Structure assessments must be completed where necessary.
- All reasonable and practicable measures must be taken to prevent, or at least minimise, the release of sediment from the site.
- Suitable all-weather maintenance access must be provided to all sediment control devices.
- Materials, whether liquid or solid, removed from sediment control devices during maintenance or decommissioning, must be disposed of in a manner that does not cause ongoing soil erosion or environmental harm.
- Settled sediment must be removed from sediment basins when the volume of the sediment exceeds the designated sediment storage volume, or the design maximum sediment storage elevation.

Other considerations include:

- Proprietary sediment fencing shall be installed by the contractor at the discretion of the site superintendent to contain sediment fractions as near as possible to their source.
- Sediment removed from any trapping device shall be relocated where further pollution to down slope lands and waterways cannot occur.
- Stockpiles shall be located by the Contractor in accordance with their approved SWMP and elsewhere at the discretion of the site superintendent. Where stockpiles are to be in place longer than 30 days, they shall be stabilised by covering with mulch or with temporary vegetation.
- 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 Contractor’s approved SWMP.
- Temporary sediment traps at pits shall be retained until after lands they are protecting are completely rehabilitated.
- Dust suppression will be required for the control of airborne particles during construction. This will be via standard water cart usage during earthworks and pavement construction of the hardstand areas.

9.5 CONSTRUCTION SEQUENCE

Works will be undertaken in the following construction sequence:

1. Install sediment fencing and cut drains to meet the requirements of the SWMP. Waste collection bins shall be installed adjacent to site office.
2. Construct stabilised site access in location nominated by the Contractor and in accordance with Port Stephens Council’s requirements.
3. Construct sediment basins for disturbed areas in accordance with the rate per hectare provided in the SWMP. Install risers and two pegs in the floor of the basin and have them marked to show the top of the sediment storage zone. Ensure the basin is cleared of sediment once the design capacity is reached.
4. Redirect clean water around the construction site.

5. Install sediment control protection measures at all natural and man-made drainage structures. Maintain until all the disturbed areas are stabilised.
6. Clear and strip the work areas in accordance with the Geotechnical advice provided.
7. Any disturbed areas, other than lot grading areas, shall immediately be covered with site topsoil within 7 days of clearing. Lot re-graded shall be covered with bitumen emulsion as specified.
8. Apply permanent stabilisation to site (landscaping).

9.6 MONITORING AND MAINTENANCE

An effective monitoring program is recommended to assess the effectiveness of the ESC measures during construction. Maintenance and routine inspection options are:

- An inspection prior to expected rainfall events.
- An inspection post rainfall events.
- For sediment control structures (e.g. sediment dams), check for sediment deposition and the requirement for its removal.
- Waste bins 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.

The inspection and monitoring regime should collect and record the following key information:

- The previous condition of the infrastructure and any recommendations or works actioned since the last inspection;
- The current condition of the ESC infrastructure;
- The ESC controls currently in place, and their condition; and
- Recommendations on remedial measures or additional ESC controls.

The site manager shall inspect the site at least weekly and shall:

- Ensure that all drains are operating effectively and shall make any necessary repairs;
- Remove any spilled material from area subject to runoff or concentrated flow;
- Remove trapped sediment where the capacity of the trapping device falls below 60%;
- Inspect the sediment basins after each rainfall event and/or weekly. 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;
- Construct additional erosion or sediment control works as may be appropriate to ensure the sediment basins are the final measure, not the only measure;
- Maintain erosion and sediment control measures in a fully functioning condition at all times until the site is rehabilitated;
- Ensure that the revegetation scheme is adhered to and that grass covers are kept healthy, including watering and mowing; and
- Remove temporary soil conservation structures as the last activity in the rehabilitation program.

10 Risk evaluation

10.1 OVERVIEW

The development is adjacent to the Ramsar Wetlands, which is recognised as a matter of national environmental significant as defined by the EPBC Act. Hydrologic modelling (refer to Section 6) and water quality modelling (refer to Section 7) were undertaken to assess the potential impact of the development on the Ramsar Wetlands.

This section summarises the risk evaluation undertaken to qualitatively assess the potential environmental risks on the Ramsar Wetlands associated with the development, specifically the impacts on water quantity and quality. This risk evaluation was undertaken in accordance with the DCCEEW (2014) guideline and Australian Standard (AS) 31000:2009 (SA, 2009).

10.2 METHODOLOGY FOR ASSIGNING RISK RATING

The environmental risks associated with the development were identified as follows:

- Increased frequency and magnitude of inundation; and
- Contamination of surface water.

These environmental risks were given a rating in terms of likelihood and consequence using the criteria in Table 10.1 and Table 10.2. These ratings were then combined using the criteria in Table 10.3 to generate a risk rating of Low, Medium or High.

Table 10.1 – Qualitative measure of likelihood

Qualitative measure of likelihood (how likely is it that this event/issue will occur after control strategies have been put in place	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the development
Possible	Might occur during the life of the development
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances

Table 10.2 – Qualitative measure of consequence

Qualitative measure of consequences (what will be the consequence/result if this issue does occur rating)	
Minor	Minor incident of environmental damage that can be reversed
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts
High	Substantial instances of environmental damage that could be reversed with intensive efforts
Major	Major loss of environmental amenity and real danger of continuing
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage

Table 10.3 – Risk rating matrix

Likelihood	Consequence				
	Minor	Moderate	High	Major	Critical
Highly likely	Medium	High	High	Severe	Severe
Likely	Low	Medium	High	High	Severe
Possible	Low	Medium	Medium	High	Severe
Unlikely	Low	Low	Medium	High	High
Rare	Low	Low	Low	Medium	High

10.3 RISK EVALUATION

10.3.1 Risk of increased inundation at the Ramsar Wetlands

The environmental risk to the Ramsar Wetlands due to potential increases in surface water quantities from the development was determined in terms of consequence and likelihood, as summarised below:

- Consequence – The significant increase in site imperviousness associated with the development potentially increases surface water volume and discharges from the site, which in turn could increase the frequency and magnitude of inundation at the Ramsar Wetlands. The consequence of this on sensitive flora and fauna at the Ramsar Wetlands is potentially **High**.
- Likelihood – Two combined wetland-detention basins will be constructed to ensure non-worsening of peak discharges from the developed site (compared to pre-developed conditions) for all events up to 1% (1 in 100) AEP. In addition, outflows from the proposed basins will drain towards the Hunter River (via Lot 1001) and not towards the Ramsar Wetlands. Therefore, the likelihood of increased water quantities from the site affecting the Ramsar Wetlands is considered **Rare**.
- Risk – On the basis of High consequence and Rare likelihood, the risk of environmental harm to the Ramsar Wetlands due to increased frequency and magnitude of inundation is **Low**.

10.3.2 Risk of water contamination at Ramsar Wetlands

- Consequence – The significant change in land use associated with the development potentially increases surface water runoff pollutants from the site, which in turn could adversely affect sensitive flora and fauna at the Ramsar Wetlands. On this basis, the consequence is potentially **High**.
- Likelihood:
  - Two combined wetland-detention basins will be constructed to provide water quality treatment and to meet the WQOs set out by local and state governments including WQOs relevant to wetland environments. In addition, outflows from the proposed basins will drain towards the Hunter River and not towards the Ramsar Wetlands.
  - It is possible that during rare and extreme storm events, sufficient water could pond within the topographical depression downstream of the site causing some water to overflow to the Ramsar Wetlands. However, the likelihood of this occurring is rare and when this occurs the runoff will be diluted.
  - Therefore, the likelihood of surface water runoff from the development draining to the Ramsar Wetlands is considered **Rare**.

Risk – On the basis of High consequence and Rare likelihood, the risk of the development adversely impacting water quality at the Ramsar Wetlands **Low**.

11 Monitoring strategy

11.1 OVERVIEW

Surface water quality and quantity will be monitored at the outlets of Basins 1 and 2. In addition, a groundwater monitoring strategy has been developed, which is described in the GMP (DP, 2024) and in the following sections of this SMP. It is assumed that some of the groundwater monitoring results would be reasonably representative of surface water.

11.2 CONTINUOUS IMPROVEMENT AND DETAILED DESIGN

It is noted that the proposed development is at conceptual planning stages, and detailed design will be completed for each stage to achieve appropriate management strategies for groundwater, surface water and geotechnical considerations.

In addition to the requirements for on-going monitoring to achieve continuous improvement, detailed design will include the following:

- Details of fill materials, drainage blanket, and sizing of subsoil drains and possibly diversion trenches for the respective stage area;
- Geotechnical review of bulk fill, subject to identification of source materials;
- Confirm groundwater level ranges at specific locations based on historical data for determination of design invert levels for inflow and outflow points;
- Groundwater modelling of scenarios to confirm impacts can be mitigated;
- Continuing site wide integration of monitoring results for groundwater, surface water and geotechnical considerations as staging progresses;
- Monitoring equipment improvements to provide greater resolution for observing the water level responses to rainfall via equipment/technology which relay 'live' water levels.

In summary, detailed design of controls will be undertaken for respective stages to mitigate impacts and implement management strategies.

11.3 STANDARDS

Table 11.1 shows the standards that have been identified by DP (2024) for the groundwater management strategy.

Table 11.1 – Summary of monitoring network (DP, 2024)

Item	DECC (2007)
Groundwater monitoring well installation	• *Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2020).
Groundwater level and quality monitoring procedures	• Monitoring sampling, testing and assessment of groundwater shall be undertaken by appropriately qualified hydrogeologists or environmental scientists. • NEPC. (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [NEPM].* Australian Government Publishing Services Canberra: National Environment Protection Council. • Australian/New Zealand Standard (AS/NZS) 5667.1:1998 Water quality: sampling part 1 – guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; • AS/NZS 5667.4 Water quality: sampling guidance on sampling from lakes, natural and manmade; • AS/NZS 5667.6 Water quality: sampling guidance on sampling of rivers and streams; • AS/NZS 5667.11 Water quality: sampling guidance on sampling of groundwaters.
Laboratory testing	• Environment Protection Authority Approved methods for the sampling and analysis of water pollutants in NSW, 2022. • NATA accredited laboratory to test methods.
Review of groundwater quality, level and hydrogeological trends	• Appropriately qualified hydrogeologists or environmental scientists.

11.4 GROUNDWATER MONITORING NETWORK

DP (2024) noted that the groundwater quality should be monitored using a network of nine wells, comprising two existing wells and six new wells specifically for Lot 210/Stage 3 as shown on Figure 11.1 and Table 11.2. Well locations have been selected with consideration of upgradient, mid site and downgradient locations which would be suitable for long term monitoring (before and during construction). It is noted that access for personnel and machinery was notably limited by site vegetation and wet ground conditions at the downgradient locations.

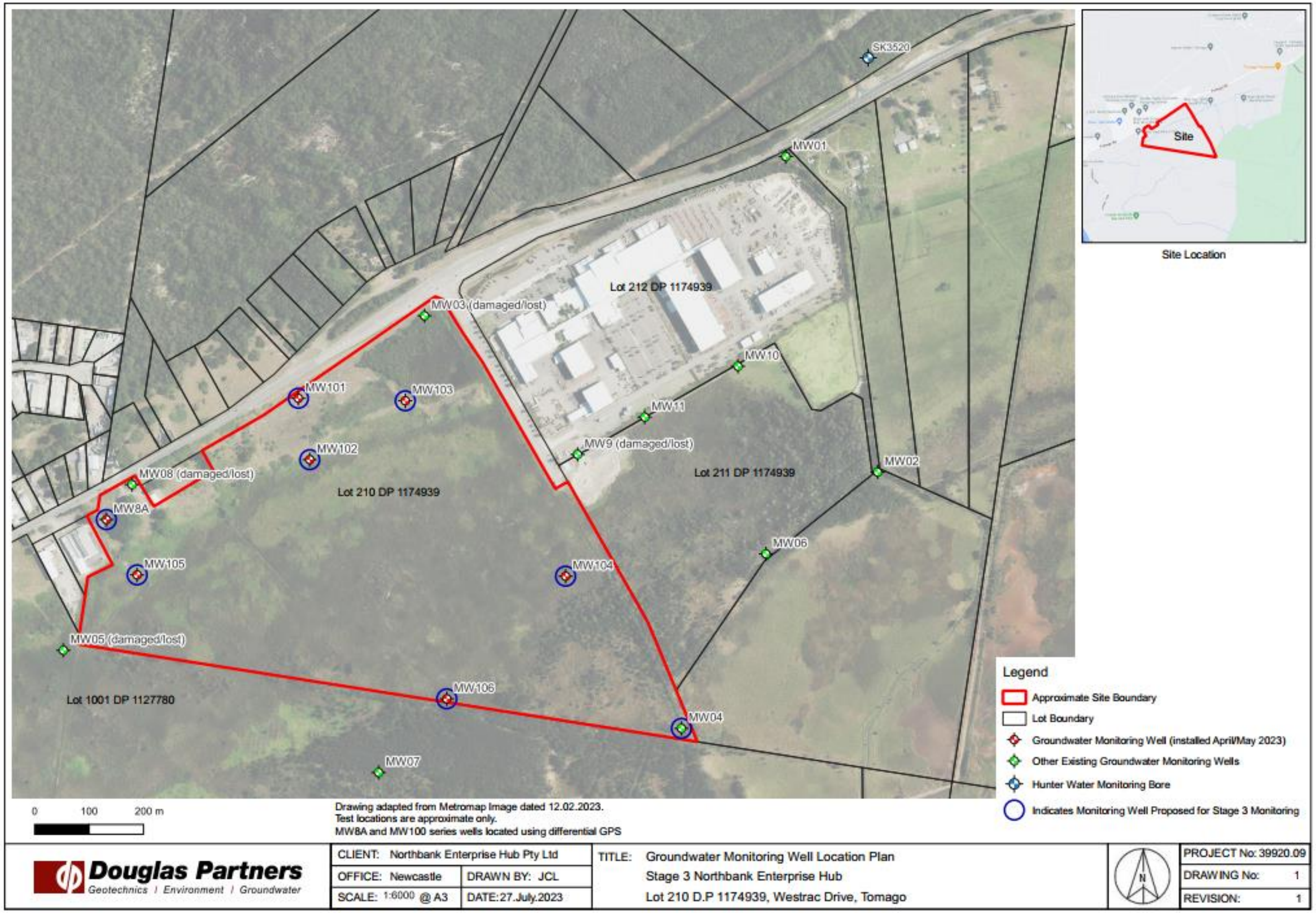

Figure 11.1 – Monitoring well location plan (source: DP (2024) – Drawing 1 in Appendix C)

Table 11.2 – Summary of Monitoring Network (DP, 2024)

Well ID	New/Existing	Location within site	Rationale
MW04	Existing	Southeastern corner Near southern boundary	Downgradient location Adjacent to future Basin 1
MW8A	New (replacement for MW8)	North-western corner Near northern boundary	Upgradient location Replacement / relocation of MW8 (damage and boundary adjustment)
MW101	New	Northwestern corner	Upgradient location
MW102	New	Central / northern part of the site	Downslope of elevated costal sand deposits
MW103	New	Northeastern corner	Accessible and suitable location for long term monitoring West and downgradient of proposed Stage 3.1 A fill area
MW104	New	Eastern portion	Mid site location Downgradient of proposed Stage 3.1 A fill area
MW105	New	Western corner	Accessible location on western part of site Downgradient of northern surface water flow path Near future western basin
MW106	New	Central/southern boundary	Downslope of future fill area and industrial lots Downslope / adjacent to surface water
MW107	New (to be installed)	Southern/southwestern boundary	Downslope of future fill area and industrial lots and western discharge area

The early installation of additional wells in Stage 3 and aim of upgradient locations is to further provide “background” water levels and quality with respect to groundwater flowing into the site. Similarly, downgradient locations provide water levels and quality for groundwater leaving the site. The wells near the initial Stage 3 fill area will allow for monitoring of groundwater responses and assist in detailed design of the remaining Stage 3 development.

The monitoring wells are screened to assess the upper water conditions in the unconfined aquifers.

Details of well logs, monitoring wells strata and installation depths are given in the GMP (DP, 2024).

11.5 WATER QUALITY PARAMETERS

DP (2024) noted that the parameters to be measured fall into three categories as shown in Table 11.3. The analytes comprise contaminants of concern based a typical suite of general water quality indicators and potential contaminants of concern considering future commercial/industrial use which has yet to be confirmed. The assessment criteria are shown on Tables G.1 and G.2 in Appendix G.

Table 11.3 – Water quality parameters

Category	Parameter
Category 1 Parameters (Field parameters)	• Temperature (T) • pH • Electrical Conductivity (EC) • Dissolved oxygen • Oxidation-reduction potential (ORP) • Turbidity

Category 2 Parameters (laboratory)	• Total Suspended Solids (TSS)
	• Cations
	  ○ Calcium (Ca)
	  ○ Potassium (K)
	  ○ Magnesium (Mg)
	  ○ Sodium (Na)
	  ○ Iron (Fe)
	• Anions
	  ○ Chloride (Cl)
	  ○ Sulphate (SO4)
	  ○ Ammonia (NH3)
	  ○ Bicarbonate (HCO3)
	  ○ Carbonate (CO3)
	  ○ Total alkalinity
	  ○ Nitrite (NO2)
	  ○ Nitrate (NO3)
	  ○ Total Kjeldahl Nitrogen (TKN)
	  ○ Total Phosphorous (PO4)
	  ○ Fluoride (F)
	• Heavy metals
	  ○ Aluminium (Al)
	  ○ Arsenic (As)
	  ○ Cadmium (Cd)
	  ○ Chromium (Cr)
	  ○ Copper (Cu)
	  ○ Iron (Fe)
	  ○ Lead (Pb)
	  ○ Manganese (Mn)
	  ○ Mercury (Hg)
	  ○ Molybdenum (Mo)
	  ○ Nickel (Ni)
	  ○ Zinc (Zn)

Category	Parameter
Category 3 Parameters (laboratory)	• Total recoverable hydrocarbons (TRH) • Polycyclic aromatic hydrocarbons (PAH) • Benzene, toluene, ethyl benzene, xylene (BTEX) • Polychlorinated biphenyl (PCB) • Phenols • Organochlorine pesticides (OCP) / organophosphorus pesticides (OPP) • Per- and polyfluoroalkyl substances (PFAS)

11.6 SAMPLING AND TESTING PROTOCOL

DP (2024) noted that sampling should be undertaken in accordance with standard industry practice, including:

- Purging of at least three bore volumes or until T, pH, EC, DO, ORP and turbidity readings are steady;
- Filtering and preservation of samples;
- Chain of custody documentation;
- Duplicate samples on at least 10% of samples or one per monitoring event; and
- Reporting (NSW EPA, 2020).

Laboratory testing should be undertaken at a NATA-accredited chemical laboratory and Practical Quantification Limits (PQLs) should be no greater than half of the relevant criteria for each parameter.

11.7 BASELINE MONITORING (PRIOR TO CONSTRUCTION OF STAGE 3)

Monitoring water quality for Stage 1 and the broader area of Lot 210 has been undertaken since 2010, therefore, groundwater quality has in part been established relevant to Lot 210/Stage 3. Stage 3.1A is already approved by NSW DPE and NPWS and is located well within site boundaries and of small scale and therefore can be compared to baseline monitoring data.

Prior to commencement of further filling of Stage 3, beyond Stage 3.1A, a baseline monitoring program will be undertaken comprising:

- Quarterly groundwater quality sampling, including Category 1, 2 and 3 parameters (refer to Table 11.3); and
- Continuous groundwater level monitoring at hourly intervals using dataloggers in at least five of the monitoring wells and manual level measurements taken at the time of the water quality sampling events in every well.

The three Baseline 2 monitoring events were undertaken in September 2023, January 2024 and April 2024.

11.8 POST-BASELINE MONITORING (DURING AND AFTER CONSTRUCTION OF STAGE 3)

Following baseline monitoring (i.e. during and after construction of Stage 3), monitoring will continue on a 6 monthly basis. The exact number of wells and suite of analytes that need monitoring will be reviewed based on the outcome of the baseline monitoring program. Some initial advice is provided below.

Monitoring wells should be retained for as long as possible to assess for potential impacts, especially wells MW102 to MW104 which are located downgradient of initial fill areas. Monitoring wells in the northern and central areas of the site will be adjusted if required as staging of the development progresses. Reinstallation or replacement well at suitable long term monitoring locations will be at the advice of the environmental/hydrogeological consultant. Monitoring wells will be replaced as soon as practicable and within three months.

For example, post-baseline monitoring for Stage 3 could comprise the following:

- Monitoring of wells MW04, MW8A and MW101 to MW106 for as long as possible. Key / minimum monitoring wells to be retained long term are MW04, MW106, MW8-A and MW101;
- The monitoring well coverage will generally maintain upstream and downstream locations for development staging. The interval and frequency of well installations will be confirmed by an environmental/hydrogeological consultant as staging progresses;
- Water quality sampling for the following parameters:
  - Category 1 and 2 Parameters on a 6 monthly basis during and after construction;
  - Category 3 Parameters on a 12 monthly basis;
- Groundwater level gauging on a 3 monthly basis if not subject to automated datalogger monitoring.

11.9 MONITORING SUMMARY

The groundwater monitoring program developed by DP (2024) is summarised in Table 11.2 with the nominated monitoring wells shown on Figure 11.1.

Table 11.4 – Summary of monitoring program

Parameters	Baseline monitoring (Baseline 2) (Note 1)	During Stage 3 Construction
Wells to be Monitored	MW04, MW8A and MW101 to MW107 (all Stage 3 wells)	TBC (Note 2)
Water Levels	Continuous (dataloggers) 3 monthly (manual) (Note 3)	Continuous (dataloggers) 3 monthly (manual)
Category 1 and 2 Parameters	3 Monthly, min of 3 rounds	6 Monthly
Category 3 Parameters	3 Monthly, min of 3 rounds	12 Monthly
Reporting	On completion	12 Monthly
Monitoring Program Review	On Completion	3 Yearly

Notes:
1. Baseline 1 was conducted as part of Stage 1 development and GMP (2009)
2. Exact wells that will be monitoring during and after construction will be determined based on the outcome of the baseline monitoring program. As a Minimum, we recommend monitoring of MW04, MW106, MW107, MW8A and MW101 be continued in addition to new wells installed for the project (if required).
3. Hourly water level monitoring by datalogger in wells MW04, MW8A and MW101 to MW106, 3 monthly manual measurements in all wells.

The three Baseline 2 monitoring events were undertaken in September 2023, January 2024 and April 2024.

11.10 ASSESSMENT CRITERIA

11.10.1 Groundwater levels

DP (2024) noted that groundwater levels will fluctuate with variations in climatic conditions and therefore comparison will need to be made with the background fluctuations as well as with climatic conditions. The ongoing results of monitoring should be reviewed on an annual basis for variations in groundwater levels which are inconsistent with rainfall trends (measured at Williamtown Meteorological Station) and/or outside the range of measured background fluctuations.

11.10.2 Groundwater quality

Available groundwater quality data have been reviewed by DP (2024) to analyse baseline conditions and noticeable trends and to determine site-specific trigger levels. The trigger levels were based on the historical data set and the first of the Baseline 2 monitoring event undertaken in September 2023. The trigger levels will be updated following completion of the remaining Baseline 2 monitoring rounds (January 2024 and April 2024).

The ANZG (2018; 2023) guidelines recommend the use of site baseline data and relevant default guideline values (DGVs) to derive site-specific trigger levels, particularly where background concentrations naturally exceed DGVs. In this approach, the natural range of values for key indicators at reference sites is used to provide a suitable baseline for comparison against values derived from similar aquatic ecosystems' (ANZG, 2023). It is noted that adoption of site-specific data, where lower than the DGV, would be an overconservative approach and not reflect the level of protection required.

Trigger levels do not guarantee a level of protection, rather, are defined as the 'concentration recorded by monitoring which would trigger further investigation to assess the potential for adverse impact on groundwater quality from a site. Periodic exceedances of the groundwater quality Trigger Levels can be expected to occur, particularly where values are based on the $20^{th}/80^{th}$ percentile calculations from the baseline data.

It is proposed that different criteria be used for monitoring bores screened in the Tomago Sandbeds aquifer and those in the overlying clay soils given the difference in water chemistry and beneficial uses of the two groundwater systems.

Typically, the guidelines (ANZG 2018) recommend the 80^{th} percentile of the available baseline data be used as criterion for each analyte. For stressors that cause problems at low levels, it is recommended that the lower criterion be the 20^{th} percentile of the baseline data (i.e. pH which is expressed as an upper range by the 80^{th} percentile and lower range by the 20^{th} percentile to provide a trigger level range, commensurate with the generic ANZG pH criteria).

Statistical analysis of groundwater quality data was undertaken on available site monitoring data to determine the 80th percentile for each analyte to establish site specific upper trigger levels, and the 20th percentiles for analytes requiring lower trigger levels (Section 6.3).

The methodology used to select preliminary trigger levels in each groundwater system is described below. Proposed criteria for each analyte are provided in Table G.1 and G.2 in Appendix G.

The statistical analysis and associated trigger levels will be reviewed and refined:

- At the end of the Stage 3 baseline monitoring program in April 2024 (refer Section 11.7); and
- Regularly thereafter as additional water quality data become available.

It should be noted that the site-specific trigger levels for groundwater are not applicable to surface water quality. However, the applicable values for surface water are the ANZG (2018) 95% Freshwater protection criteria which are indicated in Tables G.1 and G.2 as 'Note A'.

11.10.2.1 Tomago Sandbeds Trigger Levels

DP (2024) noted that potential GDEs (GDE Atlas) in the Tomago Sandbeds are present upstream of the site. Risks of impacts from the project to these GDEs are currently considered to be low given their upstream location. However, the 95% freshwater species protection DGVs (ANZECC & ARMCANZ 2000) was considered to establish trigger criteria for bores in the Tomago Sandbeds aquifer. The Drinking Water Guidelines (NHMRC, 2021) have also been considered due to the proximity to drinking water supply bores in the Tomago Sandbeds aquifer. The guideline value for the most sensitive beneficial use should be adopted for each analyte (i.e. the lower of ANZECC & ARMCANZ 2000 and NHMRC, 2021).

It is recognised, however, that groundwater in the region can have background levels (e.g. dissolved metals attributed to historical mining activities) with concentrations higher than the guideline values. Analytes for which the background 80th percentile is higher than the guideline value for the most sensitive beneficial use have been assigned the 80th percentile background concentration as a trigger level. Otherwise, the guideline value for the most sensitive beneficial use has been adopted (i.e. the lower of ANZECC & ARMCANZ 2000 and NHMRC, 2021). Where no criteria or site-based data exists, the trigger level has been adopted as the laboratory limit of reporting (LOR).

The trigger level and basis for derivation of the value is highlighted in Table G.1 in Appendix G.

11.10.2.2 Clay Aquitard Trigger Levels

DP (2024) noted that due to the presence of the potential GDEs downgradient of the site, the 95% freshwater species protection DGVs (ANZECC & ARMCANZ 2000) have been considered to establish trigger criteria for bores in the clay aquitard. The adopted trigger levels for bores in the clay have been taken as the higher of the 80th percentile background concentrations and 95% freshwater species protection DGVs. Where no criteria or site based data exists, the trigger level has been adopted as the laboratory LOR.

The trigger level and basis for derivation of the value is highlighted in Table G.2 in Appendix G.

11.11 REPORTING REQUIREMENTS

An annual report should be prepared which shall include the following:

- Time and date of sampling;
- Sampling methods, including well purging records;
- Sample Chain of Custody Documentation;
- Results of QA/QC protocols;
- Laboratory test methods and LOR;
- Tabulated results of current round of testing;
- Plot of results over time to allow assessment of trends;
- Groundwater levels plotted against rainfall records;
- Comparison with groundwater quality trigger levels and assessment of trends in groundwater levels noting any exceedances of criteria; and
- Areas of recommended improvement or improvements to site practices such as to meet the object of continuous improvement and/or improve overall water quality targets.

11.12 CONTINGENCY MEASURES

11.12.1 Groundwater levels

If a consistent trend in variations in groundwater level are recorded, then the potential implications of the long-term variation should assess. The management strategy will depend on the nature of the groundwater variation and its expected effects as outlined in Sections 8 and 9 of the GMP (DP, 2024).

11.12.2 Groundwater quality

It is considered that the UCL95-mean values could be used to indicate when monitored values are above average background levels, prompting review and closer scrutiny if levels are consistently above average. Exceedance of the adopted trigger levels would prompt further sampling and testing. This procedure is summarised in Table 11.5.

Table 11.5 – Actions Prompted by Monitoring Results

Event	Action
Consecutive results exceed UCL95-mean value	Review trend in parameter(s) concerned and note in monitoring report.
Result exceeds trigger level	Review the significance of the exceedance against the adopted guideline value. Undertake additional round of sampling as soon as practicable and analysis for parameter(s) concerned. Temporarily increase monitoring frequency until results have returned to below the trigger levels
Three consecutive results exceed the trigger level	Notify the following government agencies within 7 days: • NSW DPE. Investigate possibility of a contaminant plume or adverse changes to the groundwater quality/flow regime and if necessary, implement appropriate actions to mitigate contamination.

11.13 TRIGGER ACTION RESPONSE PLAN

A Trigger Action Response Plan (TARP) has been developed to define the minimum set of corrective actions required in response to unpredicted impacts.

The TARP is included in Appendix H. The TARP defines different levels of impacts defined from 1 to 5. Level 1 applies to normal conditions (i.e. no noticeable impacts). Levels 2 to 5 refer to abnormal conditions with various degrees of impacts rated based on increased risk.

The TARP should be reviewed and updated at the end of the baseline monitoring period, following detailed design stages or as required.

11.14WATER MANAGEMENT STRATEGY AND PLAN REVIEW

A review of the SMP and GMP including the water quality and quantity monitoring program should be undertaken as follows:

- If there are additional monitoring requirements as a result of detailed design;
- Following completion of significant project work stages;
- Following significant environmental incidents;
- When improvements to performance have been recommended by the consultant in annual reports or as directed by the environmental authority;
- Every 3 years by a suitably qualified groundwater consultant to:

- Review land uses and potential contamination sources (given the development is staged and future use is unknown);
- Analyse trends in groundwater levels and quality;
- Assess effectiveness of existing monitoring program;
- Review trigger levels as additional baseline data are collected;
- Recommend any changes to provide an efficient and effective monitoring program.

Parameters which have been established to be of minimal concern from the results of monitoring may be dropped from the program and others may be added if warranted from changes to site use.

12 Summary

A Stormwater Management Plan (SMP) was prepared for the proposed industrial subdivision of Lot 210 (DP1174939), which is Stage 3 of NSW Project Approval MP07_0086 and federal government EPBC Approval (2007/3343). This SMP was prepared to address the conditions attached to both approvals.

Stormwater quantity and quality at the site will primarily be managed by constructing two combined wetland and detention basins (referred to as Basins 1 and 2) at the southwest and southeast corners of the development site, with a combined total surface area of 6.65 ha. Additional stormwater quality management measures to be implemented at the site include the construction of three grassed swales and the installation of GPTs at the industrial lots as well as the roadside stormwater gully pits.

The results of hydrologic modelling using XP-RAFTS show that the proposed stormwater detention components of Basins 1 and 2 and their associated outlet configurations would ensure that the total post-development peak discharge from the development site to Lot 1001 do not exceed pre-development conditions peak discharges.

The results of MUSIC water quality modelling show that the proposed wetland component of Basins 1 and 2 would ensure that the pollutant reduction targets from the development site are satisfied for gross pollutants (litter), total suspended solids, total phosphorous and total nitrogen.

Runoff from the development site under existing and developed conditions drain south to Lot 1001 and are conveyed by existing channels to the west towards the Hunter River under both pre- and post-development conditions. In addition, the existing “North South Drain” and its raised banks represent a physical barrier which prevent local catchment runoff from the development site (Stage 3) from draining east to the Ramsar wetlands. Therefore, any changes stormwater runoff quantities and quality from the development site would not result in any material impact on the Ramsar Wetlands.

A surface and groundwater water monitoring program will be implemented for the developed site and then reviewed on a three-yearly basis. A Trigger Action Response Plan will be implemented from the commencement of works.

13 References

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Appendix A - Declaration of accuracy

Re: Preparation of this Stormwater Management Plan for Stage 3 of EPBC Approval 2007/3343

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed ____________________

Full name (please print) Bryant Stokes

Organisation (please print) Northbank Enterprise Hub Pty Ltd

Date 22/04/2024

Appendix B - Port Stephens Council Flood Certificate

PORT STEPHENS COUNCIL

FLOOD CERTIFICATE

File No: PSC2013-05401
Issue date: 19-Aug-19
Property ID: 45555

Scott Day
Torque Projects Pty Limited
Newcastle NSW 2300

Certificate number: 83-2019-421-1

Property details: 2 Westrac Drive TOMAGO LOT: 210 DP: 1174939

Thank you for your recent flood enquiry regarding the above property. This certificate confirms that this property is located in a **flood prone** area. This is a "flood control lot" for the purposes of the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008.* This lot is part of a Declared Floodplain and **has** a levee or other structure on or adjacent to it, as part of the Hunter Valley Flood Mitigation Scheme, conditions and restrictions may apply see *Water Management Act 2000.*

Flood Planning Level	**3.5 metres AHD** (velocity = 0.9 m/s)	(This level defines the minimum floor level for habitable rooms and land that is subject to flood-related development controls (refer to Port Stephens LEP Section 7.3, Port Stephens DCP Section B5).
Highest Hazard Category	**High Hazard Floodway**	
Flood levels that may be useful are:		
Probable maximum flood level	6.0 metres AHD (velocity = 1.6 m/s)	(The highest flood level that could conceivably occur at this location. If required, onsite flood refuges are built at or above this level, refer to the Port Stephens Development Control Plan B5.2)
Surveyed floor level	3.38 metres AHD	(Council may have a floor level at the entrance to the residence on this site that was surveyed June 2013 as part of the preparation of a Floodplain Risk Management Study for this area.)
Current day 1% AEP flood level	2.2 m – 2.3 m AHD	(This level is useful for insurance purposes, refer to your insurance policy and the Insurance Contracts Regulation 1985 (Cwealth).)
Adaptable minimum floor level	3.4 metres AHD	(The 1% AEP flood level plus 0.5m, 50 years from now, refer to the Port Stephens Development Control Plan B5.2.)
Minimum onsite wastewater level	1.1 metres AHD	(The 5% AEP level 50 years from now, refer to the Port Stephens On-site Sewage Management Development Assessment Framework and AS/NZS 1547:2012 5.5 land application system design.)

Flooding extent on subject lot, categorised by hazard

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Flood Hazard Categories

- Flood Prone Land
- Flood Planning Level
- Low Hazard Flood Fringe area
- Low Hazard Flood Storage area
- Low Hazard Overland Flow Path area
- Low Hazard Floodway area
- High Hazard Flood Fringe area
- High Hazard Flood Storage area
- High Hazard Overland Flow Path area
- High Hazard Floodway area
- Flood Prone Land subject to further investigation

Information derived from Port Stephens Council 2017, *Williamtown / Salt Ash Floodplain Risk Management Study & Plan*, BMT WBM, Newcastle.

PORT STEPHENS COUNCIL

116 Adelaide Street Raymond Terrace NSW 2324 | PO Box 42 Raymond Terrace NSW 2324 | **Phone:** 02 4980 0255 **Email:** council@portstephens.nsw.gov.au | www.portstephens.nsw.gov.au **ABN** 16 744 377 876

Appendix C - Rational Method calculations

Table C.1: Rational Method calculation for existing catchment condition

Catchment:	**Subcatchment E1**

Catchment area and coefficient of runoff	
Catchment Area (ha)	32.00
C_{10}	0.35

Overland flow travel time (Friend's Equ)	
Horton's 'n'	0.060
Length (m)	200
Slope (m/m)	0.0015
Overland flow travel time (mins)	54.8

Channel characteristics	
Channel length (m)	620
Channel slope (m/m)	0.0015
Manning's 'n'	0.050
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.010

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	Channel Velocity[a] (m/s)	Channel Travel Time (mins)	t_c[b] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.28	0.14	71.87	126.64	16.1	0.40
1.44	50	0.85	0.30	0.15	67.66	122.43	19.0	0.50
4.48	20	0.95	0.33	0.18	58.88	113.66	29.0	0.86
10	10	1.00	0.35	0.19	54.80	109.57	36.4	1.13
20	5	1.05	0.37	0.20	51.50	106.27	44.2	1.44
50	2	1.15	0.40	0.22	47.48	102.25	55.4	1.98
100	1	1.20	0.42	0.23	45.20	99.97	64.5	2.41

a - Channel velocity calculated using Mannings's equation

b - Time of Concentration (t_c) = Overland Flow Travel Time + Channel Travel Time

Table C.2: Rational Method calculation for developed catchment condition

Catchment:	Combined subcatchments D4 + D5

Catchment area and coefficient of runoff	
Catchment Area (ha)	13.20
C_{10}	0.90

Standard inlet time	
Standard inlet time (mins)	12.0

Channel characteristics	
Channel length (m)	230
Channel slope (m/m)	0.0012
Manning's 'n'	0.045
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.250

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	Channel Velocity[a] (m/s)	Channel Travel Time (mins)	t_c[b] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.72	0.33	11.66	23.66	46.8	1.24
1.44	50	0.85	0.77	0.36	10.79	22.79	54.9	1.54
4.48	20	0.95	0.86	0.42	9.06	21.06	82.5	2.59
10	10	1.00	0.90	0.46	8.27	20.27	103.2	3.41
20	5	1.05	0.95	0.50	7.65	19.65	125.1	4.34
50	2	1.15	1.04	0.55	6.92	18.92	156.3	5.93
100	1	1.20	1.08	0.59	6.51	18.51	182.9	7.24

a - Channel velocity calculated using Mannings's equation

b - Time of Concentration (t_c) = Overland Flow Travel Time + Channel Travel Time

Appendix D - Basin storage curves

Table D.1 - Basin 1 stage-storage relationship

Stage (mAHD)	Volume (m^3) [a]
0.5	0
0.6	2,366
0.7	4,807
0.8	7,322
0.9	9,913
1.0	12,578
1.1	15,319
1.2	18,136
1.3	21,029
1.4	23,998
1.5	27,044
1.6	30,167
1.7	33,368
1.8	36,645
1.9	40,001
2.0	43,435
2.1	46,947
2.2	50,538
2.3	54,208
2.4	57,957
2.5	61,786

[a] - Includes the storage within the Basin 1 West Arm

Table D.2 - Basin 2 stage-storage relationship

Stage (mAHD)	Volume (m^3)
1.0	0
1.1	1,718
1.2	3,468
1.3	5,250
1.4	7,066
1.5	8,914
1.6	10,796
1.7	12,711
1.8	14,660
1.9	16,643
2.0	18,660
2.1	20,711
2.2	22,797
2.3	24,917
2.4	27,073
2.5	29,263
2.6	31,489
2.7	33,751
2.8	36,048

Appendix E - MUSIC model configuration

Table E.1 – MUSIC rainfall-runoff parameters (MUSIC-link default parameters)

Parameter	Urban (pervious)	Forest (pervious)
Rainfall Threshold (mm)	1.4	1.0
Soil Capacity (mm)	120	120
Initial Storage (%)	30	25
Field Capacity (mm)	40	80
Infiltration Capacity Coefficient a	150	200
Infiltration Capacity Coefficient b	3.5	1.0
Initial Depth (mm)	10	10
Daily Recharge Rate (%)	90	25
Daily Drainage Rate (%)	5	5
Daily Deep Seepage Rate (%)	0	0

Table E.2 – MUSIC base and storm flow pollutant concentrations

Land use type for MUSIC source nodes	Parameter	Total Suspended Solids (Log_{10} mg/L)		Total Phosphorous (Log_{10} mg/L)		Total Nitrogen (Log_{10} mg/L)	
		Base flow	Storm flow	Base flow	Storm flow	Base flow	Storm flow
Industrial	Mean	1.20	2.15	-0.85	-0.60	0.11	0.30
	Std Deviation	0.17	0.32	0.19	0.25	0.12	0.19
Forest	Mean	0.78	1.60	-1.22	0.13	-0.52	-0.05
	Std Deviation	0.13	0.20	0.13	0.25	0.13	0.24

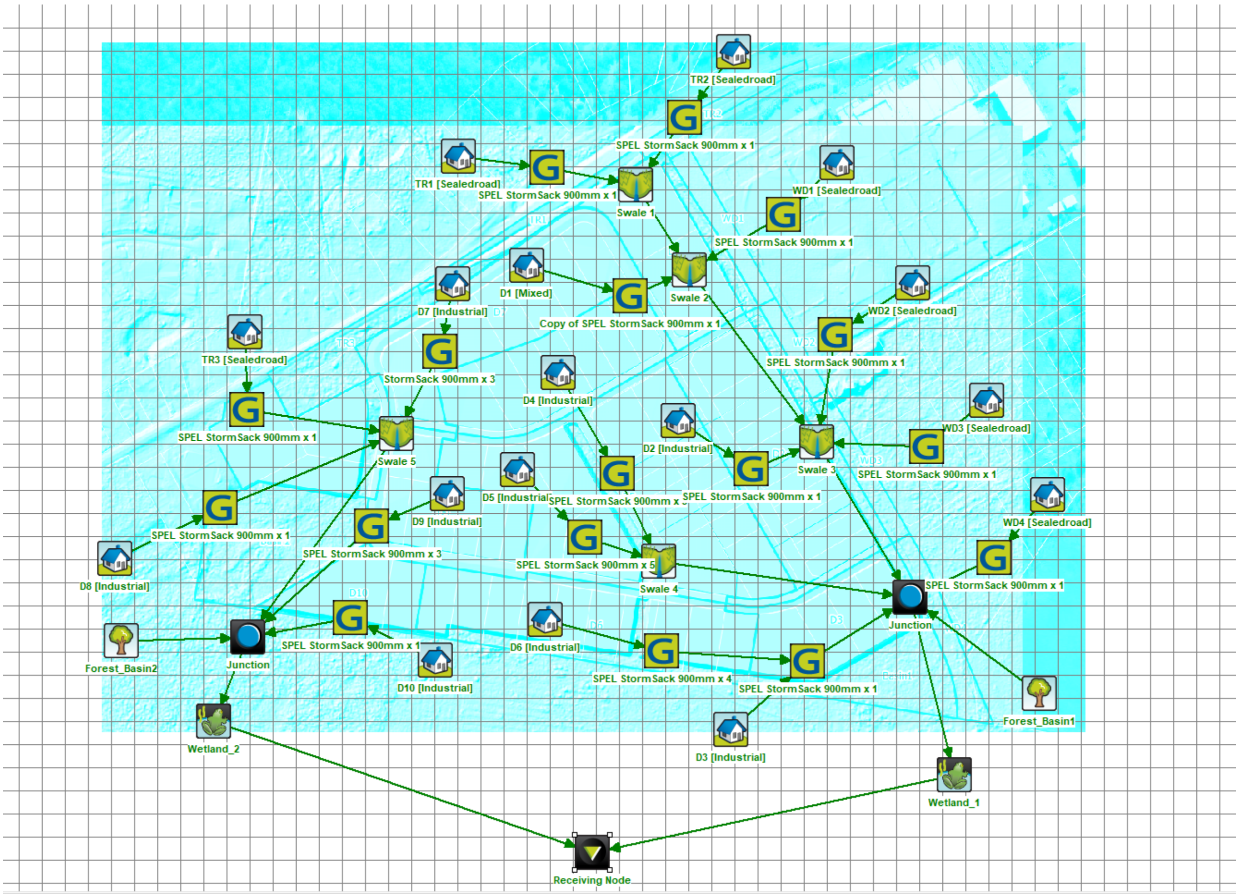


Figure E.1 – MUSIC model configuration (developed mitigated conditions)

Table E.3 – Source node parameters

Source node ID	Source node type	Area (ha)	% impervious
D1	Urban	3.30	90
D2	Urban	6.05	90
D3	Urban	0.73	90
D4	Urban	3.77	90
D5	Urban	9.43	90
D6	Urban	5.34	90
D7	Urban	5.00	90
D8	Urban	3.10	90
D9	Urban	3.25	90
D10	Urban	1.77	90
Basin1	Forest	3.75	0
Basin2	Forest	3.13	0
TR1	Urban	0.83	90
TR2	Urban	0.60	90
TR3	Urban	1.56	90
WD1	Urban	0.69	90
WD2	Urban	0.39	90
WD3	Urban	0.66	90
WD4	Urban	0.86	90

Appendix F - Sediment basin sizing

Table F.1 – Calculation of required total minimum sediment basin storage volume

Description	Value
Basin type	F
Catchment area (ha)	48.6
Settling zone	
Runoff coefficient (C_v)	0.57
95th %ile, 5-day rainfall event (mm)	77.0
Settling zone volume (m^3)	21,322
Sediment storage zone	
Rainfall erosivity factor, R	2,500
Soil erodibility factor, K	0.059
Slope length gradient factor, LS	0.27
Erosion control practice factor, P	1.30
Cover factor, C	1.0
Sediment storage zone volume (m^3)	329
Total storage required (sediment + settling zones)	
Total storage required (m^3)	21,651

Appendix G - Water quality assessment criteria

Table G.1 – Groundwater Quality Assessment Criteria for bores in the Tomago Sandbeds (i.e. MW8A, MW101, MW102, MW103, MW105)

Parameter	Unit	Ecological Guidelines (Note A)	Human Health Guidelines (Note A)	Most Sensitive Beneficial Use (i.e. lower of ANZG or DWG)	Background Quality (Note E)		Laboratory LOR	Adopted trigger Level
		ANZG (2018) 95% Freshwater protection criteria (Note A)	Drinking Water Guidelines (Note B)	Corresponding Guideline	UCL_{95}-mean	80^{th} Percentile		Higher of Most Sensitive Beneficial Use Criteria and 80^{th} Percentile of Background Quality (or LOR where applicable)
Physio chemical parameters								
pH	pH units	pH 6.5-8.5	NC	ANZG (2018)	5.89	5.17 (P20) - 6.38 (P80)	0.1	5.2 - 8.5
Electrical Conductivity	µS/cm	NC	NC	NC	357	529	1	529
Dissolved oxygen	mg/L	NC	NC	NC	11.3	9.62	0.1	-
Total suspended solids	mg/L	NC	0.6	NHMRC (2021)	253	251	1	-
Anions and non-metallic inorganics								
Chloride (Cl)	mg/L	NC	250	NHMRC (2021)	47	57	1	250
Sulphate (SO_4^{2-})	mg/L	NC	500	NHMRC (2021)	15	23	1	500
Fluoride	mg/L	NC	1.5	NHMRC (2021)	0.1	0.1	0.1	1.5
Hydroxide Alkalinity	mg/L	NC	NC	NC	1	1	5	1
Carbonate (CO_3^{2-})	mg/L	NC	NC	NC	6	5	5	5
Bicarbonate (HCO_3^-)	mg/L	NC	NC	NC	56	37	5	37
Total Alkalinity	mg/L	NC	NC	NC	25	32	5	32
Nutrients								
Ammonia (NH_3) as N	mg/L	0.9	0.5	NHMRC (2021)	0.4	0.5	0.005	0.5
Nitrite + Nitrate as N	mg/L	NC	NC	NC	0.07	0.04	0.05	0.04
Nitrite as N	mg/L	NC	3	NHMRC (2021)	0.2	0.1	0.05	3
Nitrate as N	mg/L	0.7	50	ANZG (2018)	0.014	0.02	0.005	0.7
Total Kjeldahl Nitrogen as N	mg/L	NC	NC	NC	0.85	1.1	0.1	1.1
Total Phosphorus	mg/L	0.025	NC	ANZG (2018)	0.14	0.086	0.05	0.086
Cations								
Calcium	mg/L	NC	NC	NC	12	13	0.5	13
Magnesium	mg/L	NC	NC	NC	5	6	0.5	6
Potassium	mg/L	NC	NC	NC	3	4	0.5	4
Sodium	mg/L	NC	180	NHMRC (2021)	45	66	0.5	180
Total / dissolved metals								
Aluminium	mg/L	**0.055 (pH>6.5) (M) 0.0008 pH <6.5 (L)**	0.2 (C)	ANZG (2018)	NR	NR	0.01	0.055 (pH>6.5) 0.0008 (pH <6.5)
Arsenic	mg/L	0.013	0.01	NHMRC (2021)	0.002	0.002	0.001	0.01
Cadmium	mg/L	0.0002	0.002	ANZG (2018)	0.0001	0.0001	0.0001	0.0002
Chromium	mg/L	0.001	0.05	ANZG (2018)	0.002	0.002	0.001	0.002
Copper	mg/L	0.0014	2	ANZG (2018)	0.001	0.001	0.001	0.001
Iron	mg/L	0.7	0.3 (C)	NHMRC (2021)	0.6	0.8	0.01	0.8
Manganese	mg/L	1.9	0.5	NHMRC (2021)	0.07	0.07	0.01	0.50
Molybdenum	mg/L	NC	0.05	NHMRC (2021)	0.001	0.001	0.001	0.05
Nickel	mg/L	0.011	0.02	ANZG (2018)	0.001	0.001	0.001	0.011
Lead	mg/L	0.0034	0.01	ANZG (2018)	0.001	0.001	0.001	0.0034
Zinc	mg/L	0.008	3	ANZG (2018)	0.007	0.010	0.001	0.01
Mercury	mg/L	**0.00006**	1	ANZG (2018)	0.0001	0.0001	0.00005	0.0001
Total Recoverable Hydrocarbons (Note D)								
C6 - C10 Fraction	mg/L	NC	NC	NC	<LOR	<LOR	0.01	0.01
C6 - C10 Fraction minus BTEX (F1)	mg/L	NC	NC	NC	<LOR	<LOR	0.01	0.01
>C10 - C16 Fraction	mg/L	NC	NC	NC	<LOR	<LOR	0.05	0.05
>C16 - C34 Fraction	mg/L	NC	NC	NC	<LOR	<LOR	0.1	0.1
>C34 - C40 Fraction	mg/L	NC	NC	NC	<LOR	<LOR	0.1	0.1
>C10 - C40 Fraction (sum)	mg/L	LOR	NC	NC	<LOR	<LOR	0.1	0.1
>C10 - C16 Fraction minus Naphthalene (F2)	mg/L	NC	NC	NC	<LOR	<LOR	0.05	0.05
Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene (BTEXN)								
Benzene	mg/L	0.95	0.001	NHMRC (2021)	<LOR	<LOR	0.001	0.001
Toluene	mg/L	*0.18*	0.8	ANZG (2018)	0.0009	0.0011	0.001	0.18
m- & p-Xylene	mg/L	*0.08*	0.3	ANZG (2018)	<LOR	<LOR	0.001	0.08
ortho-Xylene	mg/L	0.075	NC	ANZG (2018)	<LOR	<LOR	0.002	0.075
Total xylenes	mg/L	NC	0.6	NHMRC (2021)	<LOR	<LOR	0.002	0.6
Naphthalene	mg/L	0.0016	NC	ANZG (2018)	<LOR	<LOR	0.001	0.0016
Polycyclic Aromatic Hydrocarbons (PAH)								
Naphthalene	mg/L	0.0016	NC	ANZG (2018)	<LOR	<LOR	0.0001	0.0016
Phenanthrene	mg/L	**0.0006**	NC	ANZG (2018)	<LOR	<LOR	0.0001	0.0006
Anthracene	mg/L	***0.00001***	NC	ANZG (2018)	<LOR	<LOR	0.0001	0.00001
Fluoranthene	mg/L	***0.001***	NC	ANZG (2018)	<LOR	<LOR	0.0001	0.001
Benzo(a)pyrene	mg/L	***0.0001***	0.00001	NHMRC (2021)	<LOR	<LOR	0.0001	0.00001
Phenols								

Parameter	Unit	Ecological Guidelines (Note A)	Human Health Guidelines (Note A)	Most Sensitive Beneficial Use (i.e. lower of ANZG or DWG)	Background Quality (Note E)		Laboratory LOR	Adopted trigger Level
		ANZG (2018) 95% Freshwater protection criteria (Note A)	Drinking Water Guidelines (Note B)	Corresponding Guideline	UCL_{95}-mean	80th Percentile		Higher of Most Sensitive Beneficial Use Criteria and 80th Percentile of Background Quality (or LOR where applicable)
Total Phenol	mg/L	0.32	NC	ANZG (2018)	0.1610	0.0125	0.001	0.32
2-Chlorophenol	mg/L	0.34	0.3	NHMRC (2021)	<LOR	<LOR	0.001	0.30
2-Methylphenol	mg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
3- & 4-Methylphenol	mg/L	NC	NC	NC	<LOR	<LOR	0.002	0.002
2-Nitrophenol	mg/L	0.002	NC	ANZG (2018)	<LOR	<LOR	0.001	0.002
2.4-Dimethylpheno	mg/L	0.002	NC	ANZG (2018)	<LOR	<LOR	0.001	0.002
2.4-Dichlorophenol	mg/L	0.12	0.2	ANZG (2018)	<LOR	<LOR	0.001	0.12
2.6-Dichlorophenol	mg/L	0.034	NC	ANZG (2018)	<LOR	<LOR	0.001	0.034
4-Chloro-3-methylphenol	mg/L	NC	NC	NC	<LOR	<LOR	0.005	0.005
2.4.6-Trichlorophenol	mg/L	0.003	0.02	ANZG (2018)	<LOR	<LOR	0.001	0.003
2.4.5-Trichlorophenol	mg/L	0.00005	NC	ANZG (2018)	<LOR	<LOR	0.001	0.00005
Pentachlorophenol	mg/L	0.0036	0.01	ANZG (2018)	<LOR	<LOR	0.005	0.0036
Organophosphorous Pesticides (OPP)								
Dichlorvos	µg/L	NC	5	NHMRC (2021)	<LOR	<LOR	0.00005	5
Dimethoate	µg/L	0.15	7	ANZG (2018)	<LOR	<LOR	0.0001	0.15
Diazinon	µg/L	0.01	4	ANZG (2018)	<LOR	<LOR	0.00001	0.01
Chlorpyrifos-methyl	µg/L	NC	NC	NC	<LOR	<LOR	0.00005	0.00005
Parathion-methyl	µg/L	NC	0.7	NHMRC (2021)	<LOR	<LOR	0.00005	0.7
Malathion	µg/L	0.05	70	ANZG (2018)	<LOR	<LOR	0.00005	0.05
Fenthion	µg/L	NC	7	NHMRC (2021)	<LOR	<LOR	0.00005	7
Chlorpyrifos	µg/L	0.01	10	ANZG (2018)	<LOR	<LOR	0.00005	0.01
Parathion	µg/L	0.004	20	ANZG (2018)	<LOR	<LOR	0.000004	0.004
Chlorfenvinphos	µg/L	NC	2	NHMRC (2021)	<LOR	<LOR	0.000009	2
Bromophos-ethyl	µg/L	NC	NC	NC	<LOR	<LOR	0.00005	0.00005
Fenamiphos	µg/L	NC	0.5	NHMRC (2021)	<LOR	<LOR	0.00005	0.5
Ethion	µg/L	NC	4	NHMRC (2021)	<LOR	<LOR	0.00005	4
Azinphos Methyl	µg/L	**0.01**	30	ANZG (2018)	<LOR	<LOR	0.0002	0.01
Organochlorine Pesticides (OCP)								
alpha-BHC	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Hexachlorobenzene (HCB)	µg/L	***0.05***	NC	ANZG (2018)	<LOR	<LOR	0.001	0.05
beta-BHC	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
gamma-BHC	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
delta-BHC	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Heptachlor	µg/L	***0.01***	0.3	ANZG (2018)	<LOR	<LOR	0.001	0.01
Aldrin	µg/L	*0.001*	NC	ANZG (2018)	<LOR	<LOR	0.001	0.001
Heptachlor epoxide	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
trans-Chlordane	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
alpha-Endosulfan	µg/L	*0.0002*	NC	ANZG (2018)	<LOR	<LOR	0.002	0.0002
cis-Chlordane	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Dieldrin	µg/L	*0.01*	NC	ANZG (2018)	<LOR	<LOR	0.001	0.01
4.4`-DDE	µg/L	*0.03*	NC	ANZG (2018)	<LOR	<LOR	0.001	0.03
Endrin	µg/L	**0.01**	NC	ANZG (2018)	<LOR	<LOR	0.001	0.01
beta-Endosulfan	µg/L	*0.007*	NC	ANZG (2018)	<LOR	<LOR	0.002	0.007
4.4`-DDD	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Endrin aldehyde	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Endosulfan sulfate	µg/L	**0.03**	20	ANZG (2018)	<LOR	<LOR	0.001	0.03
4.4`-DDT	µg/L	0.006	9	ANZG (2018)	<LOR	<LOR	0.001	0.006
Methoxychlor	µg/L	0.005	300	ANZG (2018)	<LOR	<LOR	0.001	0.005
Total chlordane	µg/L	**0.03**	0.2	ANZG (2018)	<LOR	<LOR	0.001	0.03
Sum of DDD + DDE + DDT	µg/L	NC	NC	NC	<LOR	<LOR	0.001	0.001
Sum of Aldrin + Dieldrin	µg/L	NC	0.3	NHMRC (2021)	<LOR	<LOR	0.001	0.3
Polychlorinated Biphenyls (PCB)								
Aroclor 1016	µg/L	*0.001*	NC	ANZG (2018)	<LOR	<LOR	0.00001	0.001
Aroclor 1221	µg/L	*1*	NC	ANZG (2018)	<LOR	<LOR	0.00001	1
Aroclor 1232	µg/L	*0.3*	NC	ANZG (2018)	<LOR	<LOR	0.00001	0.3
Aroclor 1242	µg/L	***0.3***	NC	ANZG (2018)	<LOR	<LOR	0.00001	0.3
Aroclor 1248	µg/L	*0.03*	NC	ANZG (2018)	<LOR	<LOR	0.00001	0.03
Aroclor 1254	µg/L	***0.01***	NC	ANZG (2018)	<LOR	<LOR	0.00001	0.01
Aroclor 160	µg/L	*25*	NC	ANZG (2018)	<LOR	<LOR	0.00001	25
Per- and polyfluoroalkyl substances (PFAS)								
Perfluorooctanesulfonic acid (PFOS)	µg/L	0.00023	NC	ANZG (2018)	-	-	0.001	0.00023
Perfluorooctanoic acid (PFOA)	µg/L	19	0.56	NHMRC (2021)	-	-	0.001	0.56
Sum of PFHxS and PFOS	µg/L	NC	0.07	NHMRC (2021)	-	-	0.001	0.07

Notes:

A - Guidelines values can be applied to surface water quality.
B - ANZG (2018) suggest use of ANZECC & ARMCANZ (2000) DGVs
C - NHMRC Australian Drinking Water Guidelines, 2011
D - TRH only detected in the first sample of some bores, could be attributed to residual drilling fluids
E – Background data is expressed as <LOR as the LOR at times has varied between monitoring events in the indicative range of +/- one order of magnitude. Higher LORs were mostly associated with historical data. With improvements in laboratory techniques, more consistent LORs are routinely achieved.
DGV - Default guideline value
LOR - Limit of reporting
NC - No current criteria
NHMRC arsenic guidelines are based on total arsenic
Guidelines for chromium are based on Cr (VI)
Total Phenolics guideline based on Phenol
Guidelines for mercury are based on inorganic mercury.
NHMRC guideline for TSS are based on TDS in the absence of a TSS value.
NHMRC guidelines for mercury are based on total mercury.
Default trigger values for TP and TN are for NSW & Vic. east flowing coastal rivers for slightly disturbed ecosystems (ANZECC 2000)
Guidelines in *italics* are low level reliability guidelines
Guidelines in **bold** indicates the 99% protection level should be adopted for slightly-moderately disturbed ecosystems protection level due to potential for bioaccumulation or acute toxicity to particular species PFAS criteria based for human health based on HEPA (2020)

Table G.2 – Groundwater Quality Assessment Criteria for bores in the clay aquitard (i.e. MW4, MW104, MW106, MW107)

Parameter	Unit	Ecological Guidelines (Note A)	Background Quality (Note E)		Laboratory LOR	Adopted trigger Level
		ANZG (2018) 95% Freshwater protection criteria (Note A)	UCL_{95}-mean	80^{th} Percentile		Higher of DGVs and 80^{th} Percentile of Background Quality
Physio chemical parameters						
pH	pH units	pH 6.5-8.5	7.12	6.56 (P20) - 7.38 (P80)	0.1	6.5 - 7.4
Electrical Conductivity	(µS/cm)	NC	17100	24500	1	24500
Dissolved oxygen	mg/L	NC	25	5.77	0.1	-
Total suspended solids	mg/L	NC	-	-	1	-
Anions and non-metallic inorganics						
Chloride (Cl)	mg/L	NC	6200	8560	1	8560
Sulphate (SO_4^{2-})	mg/L	NC	2540	3690	1	3690
Fluoride	mg/L	NC	0.6	0.7	0.1	0.7
Hydroxide Alkalinity	mg/L	NC	1	1	5	1
Carbonate (CO_3^{2-})	mg/L	NC	290	18	5	18
Bicarbonate (HCO_3^-)	mg/L	NC	609	808	5	808
Total Alkalinity	mg/L	NC	798	949	5	949
Nutrients						
Ammonia (NH_3) as N	mg/L	0.9	8.7	2.0	0.005	2.0
Nitrite + Nitrate as N	mg/L	NC	0.12	0.07	0.05	0.07
Nitrite as N	mg/L	NC	0.02	0.03	0.05	0.03
Nitrate as N	mg/L	0.7	0.08	0.04	0.005	0.7
Total Kjeldahl Nitrogen as N	mg/L	NC	6.6	4.6	0.1	4.6
Total Phosphorus	mg/L	0.025	1.4	2.1	0.05	2.1
Cations						
Calcium	mg/L	NC	349	478	0.5	478
Magnesium	mg/L	NC	684	977	0.5	977
Potassium	mg/L	NC	147	208	0.5	208
Sodium	mg/L	NC	3760	5310	0.5	5310
Total / dissolved metals						
Aluminium	mg/L	**0.055 (pH>6.5) (M) 0.0008 pH <6.5 (L)**	NR	NR	0.01	0.055 (pH>6.5) 0.0008 (pH <6.5)
Arsenic	mg/L	0.013	0.017	0.009	0.001	0.013
Cadmium	mg/L	0.0002	0.0001	0.0001	0.0001	0.0002
Chromium	mg/L	0.001	0.005	0.004	0.001	0.004
Copper	mg/L	0.0014	0.007	0.005	0.001	0.005
Iron	mg/L	0.7	60.8	55.2	0.01	55.2
Manganese	mg/L	1.9	7.25	10.10	0.01	10.10
Molybdenum	mg/L	NC	0.004	0.003	0.001	0.003
Nickel	mg/L	0.011	0.021	0.011	0.001	0.011
Lead	mg/L	0.0034	0.002	0.002	0.001	0.0034
Zinc	mg/L	0.008	1.14	0.14	0.001	0.14
Mercury	mg/L	**0.00006**	<LOR	<LOR	0.00005	0.00006
Total Recoverable Hydrocarbons (Note C)						
C6 - C10 Fraction	mg/L	NC	0.018	0.018	0.01	0.01
C6 - C10 Fraction minus BTEX (F1)	mg/L	NC	0.013	0.017	0.01	0.01
>C10 - C16 Fraction	mg/L	NC	0.14	0.12	0.05	0.05
>C16 - C34 Fraction	mg/L	NC	0.21	0.17	0.1	0.1
>C34 - C40 Fraction	mg/L	NC	0.09	0.12	0.1	0.1
>C10 - C40 Fraction (sum)	mg/L	LOR	0.28	0.19	0.1	0.1
>C10 - C16 Fraction minus Naphthalene (F2)	mg/L	NC	0.17	0.14	0.05	0.05
Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene (BTEXN)						
Benzene	mg/L	0.95	<LOR	<LOR	0.001	0.95
Toluene	mg/L	*0.18*	0.003	0.003	0.001	0.18
m- & p-Xylene	mg/L	*0.08*	<LOR	<LOR	0.001	0.08
ortho-Xylene	mg/L	0.075	<LOR	<LOR	0.002	0.075
Total xylenes	mg/L	NC	<LOR	<LOR	0.002	0.002
Naphthalene	mg/L	0.0016	<LOR	<LOR	0.001	0.0016
Polycyclic Aromatic Hydrocarbons (PAH)						
Naphthalene	mg/L	0.0016	<LOR	<LOR	0.0001	0.0016
Phenanthrene	mg/L	**0.0006**	<LOR	<LOR	0.0001	0.0006
Anthracene	mg/L	***0.00001***	<LOR	<LOR	0.0001	0.0000
Fluoranthene	mg/L	***0.001***	<LOR	<LOR	0.0001	0.0010
Benzo(a)pyrene	mg/L	***0.0001***	<LOR	<LOR	0.0001	0.0001
Phenols						
Total Phenol	mg/L	0.32	0.0198	0.0044	0.001	0.32
2-Chlorophenol	mg/L	0.34	<LOR	<LOR	0.001	0.34
2-Methylphenol	mg/L	NC	<LOR	<LOR	0.001	0.001

Parameter	Unit	Ecological Guidelines (Note A)	Background Quality (Note E)		Laboratory LOR	Adopted trigger Level
		ANZG (2018) 95% Freshwater protection criteria (Note A)	UCL_{95}-mean	80th Percentile		Higher of DGVs and 80th Percentile of Background Quality
3- & 4-Methylphenol	mg/L	NC	0.039	0.006	0.002	0.002
2-Nitrophenol	mg/L	0.002	<LOR	<LOR	0.001	0.002
2.4-Dimethylpheno	mg/L	0.002	<LOR	<LOR	0.001	0.002
2.4-Dichlorophenol	mg/L	0.12	<LOR	<LOR	0.001	0.12
2.6-Dichlorophenol	mg/L	0.034	<LOR	<LOR	0.001	0.034
4-Chloro-3-methylphenol	mg/L	NC	<LOR	<LOR	0.005	LOR
2.4.6-Trichlorophenol	mg/L	0.003	<LOR	<LOR	0.001	0.003
2.4.5-Trichlorophenol	mg/L	0.00005	<LOR	<LOR	0.001	0.00005
Pentachlorophenol	mg/L	0.0036	<LOR	<LOR	0.005	0.0036
Organophosphorous Pesticides (OPP)						
Dichlorvos	µg/L	NC	<LOR	<LOR	0.00005	0.00005
Dimethoate	µg/L	0.15	<LOR	<LOR	0.0001	0.15
Diazinon	µg/L	0.01	<LOR	<LOR	0.00001	0.01
Chlorpyrifos-methyl	µg/L	NC	<LOR	<LOR	0.00005	0.00005
Parathion-methyl	µg/L	NC	<LOR	<LOR	0.00005	0.00005
Malathion	µg/L	0.05	<LOR	<LOR	0.00005	0.05
Fenthion	µg/L	NC	<LOR	<LOR	0.00005	0.00005
Chlorpyrifos	µg/L	0.01	<LOR	<LOR	0.00005	0.01
Parathion	µg/L	0.004	<LOR	<LOR	0.000004	0.004
Chlorfenvinphos	µg/L	NC	<LOR	<LOR	0.000009	0.000009
Bromophos-ethyl	µg/L	NC	<LOR	<LOR	0.00005	0.00005
Fenamiphos	µg/L	NC	<LOR	<LOR	0.00005	0.00005
0.00005Ethion	µg/L	NC	<LOR	<LOR	0.00005	0.000009
Azinphos Methyl	µg/L	**0.01**	<LOR	<LOR	0.0002	0.01
Organochlorine Pesticides (OCP)						
alpha-BHC	µg/L	NC	<LOR	<LOR	0.001	0.001
Hexachlorobenzene (HCB)	µg/L	***0.05***	<LOR	<LOR	0.001	0.05
beta-BHC	µg/L	NC	<LOR	<LOR	0.001	0.001
gamma-BHC	µg/L	NC	<LOR	<LOR	0.001	0.001
delta-BHC	µg/L	NC	<LOR	<LOR	0.001	0.001
Heptachlor	µg/L	***0.01***	<LOR	<LOR	0.001	0.01
Aldrin	µg/L	*0.001*	<LOR	<LOR	0.001	0.001
Heptachlor epoxide	µg/L	NC	<LOR	<LOR	0.001	0.001
trans-Chlordane	µg/L	NC	<LOR	<LOR	0.001	0.001
alpha-Endosulfan	µg/L	*0.0002*	<LOR	<LOR	0.002	0.0002
cis-Chlordane	µg/L	NC	<LOR	<LOR	0.001	0.001
Dieldrin	µg/L	*0.01*	<LOR	<LOR	0.001	0.01
4.4`-DDE	µg/L	*0.03*	<LOR	<LOR	0.001	0.03
Endrin	µg/L	**0.01**	<LOR	<LOR	0.001	0.01
beta-Endosulfan	µg/L	*0.007*	<LOR	<LOR	0.002	0.007
4.4`-DDD	µg/L	NC	<LOR	<LOR	0.001	0.001
Endrin aldehyde	µg/L	NC	<LOR	<LOR	0.001	0.001
Endosulfan sulfate	µg/L	**0.03**	<LOR	<LOR	0.001	0.03
4.4`-DDT	µg/L	0.006	<LOR	<LOR	0.001	0.006
Methoxychlor	µg/L	0.005	<LOR	<LOR	0.001	0.005
Total chlordae	µg/L	**0.03**	<LOR	<LOR	0.001	0.03
Sum of DDD + DDE + DDT	µg/L	NC	<LOR	<LOR	0.001	0.001
Sum of Aldrin + Dieldrin	µg/L	NC	<LOR	<LOR	0.001	0.001
Polychlorinated Biphenyls (PCB)						
Aroclor 1016	µg/L	*0.001*	<LOR	<LOR	0.00001	0.001
Aroclor 1221	µg/L	*1*	<LOR	<LOR	0.00001	1
Aroclor 1232	µg/L	*0.3*	<LOR	<LOR	0.00001	0.3
Aroclor 1242	µg/L	***0.3***	<LOR	<LOR	0.00001	0.3
Aroclor 1248	µg/L	*0.03*	<LOR	<LOR	0.00001	0.03
Aroclor 1254	µg/L	***0.01***	<LOR	<LOR	0.00001	0.01
Aroclor 160	µg/L	*25*	<LOR	<LOR	0.00001	25
Per- and polyfluoroalkyl substances (PFAS)						
Perfluorooctanesulfonic acid (PFOS)	µg/L	0.00023	-	-	0.001	0.00023
Perfluorooctanoic acid (PFOA)	µg/L	19	-	-	0.001	19
Sum of PFHxS and PFOS	µg/L	NC	-	-	0.001	0.001

Notes:

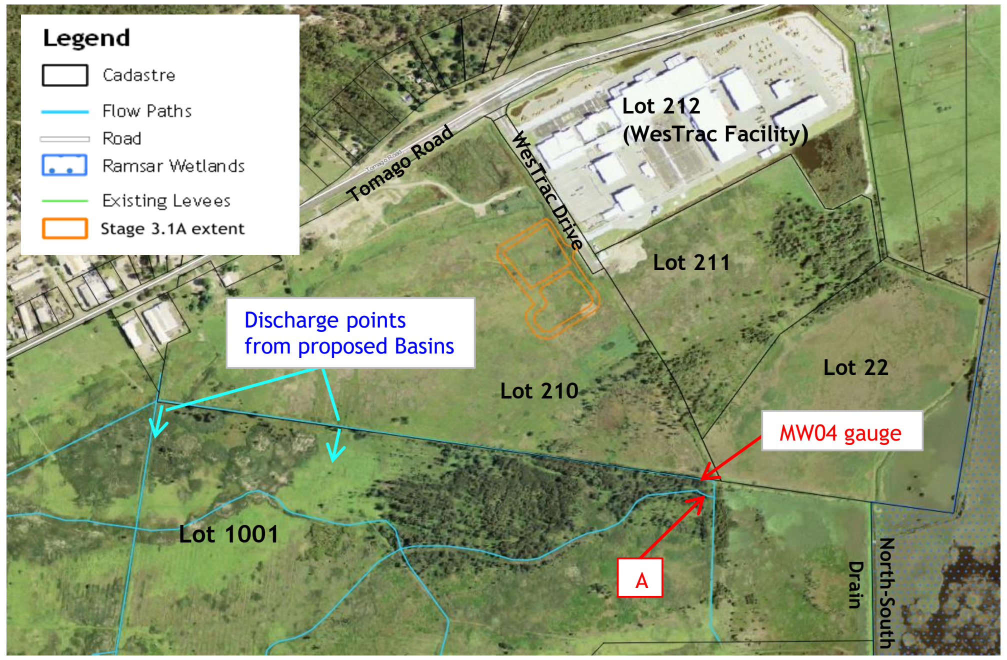
A Guidelines values can be applied to surface water quality.
B ANZG (2018) suggest use of ANZECC & ARMCANZ (2000) DGVs
C TRH only detected in the first sample of some bores, could be attributed to residual drilling fluids
E Background data is expressed as <LOR as the LOR at times has varied between monitoring events in the indicative range of +/- one order of magnitude. Higher LORs were mostly associated with historical data. With improvements in laboratory techniques, more consistent LORs are routinely achieved.
LOR Limit of reporting
NC No current criteria
DGV Default guideline value
DVGs for TP and TN are for NSW & Vic. east flowing coastal rivers for slightly disturbed ecosystems (ANZECC & ARMCANZ 2000).

Guidelines for chromium are based on Cr (VI)
Guidelines for mercury are based on inorganic mercury.
Total Phenolics guideline based on Phenol
Guidelines in *italics* are low level reliability guidelines
Guidelines in **bold** indicates the 99% protection level should be adopted for slightly-moderately disturbed ecosystems protection level due to potential for bioaccumulation or acute toxicity to particular species
PFAS criteria based for human health based on HEPA (2020)

Appendix H - Trigger Action Response Plan

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Locality and drainage map



Estate Layout Plan

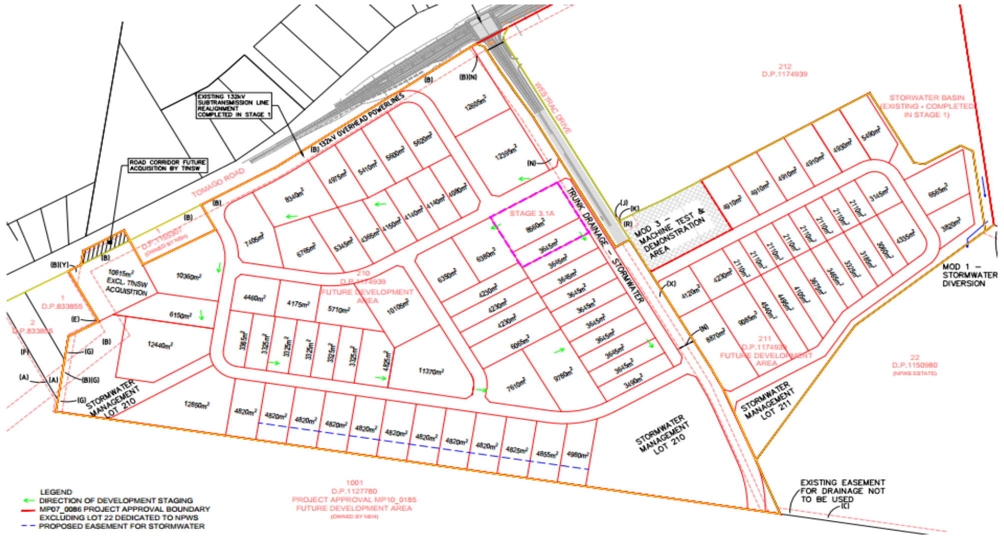


Photo of Location "A"

Purpose of this TARP (TARP #1)

TARP #1 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of the Project due to changes in groundwater quality and quanity downstream of the Project (i.e. the potential impact to the environmental receptors).

Commitments and monitoring

1) The following will be undertaken prior to the commencement of Stage 3 works:
- Existing drains will be cleared as per the drain clearing plan (refer to Figure 1 on Page 4).
- Assessment of water level data at MW04 and the downstream data provided by NPWS to establish baseline water level trends.
- Monitoring of observation areas to establish baseline site conditions (refer to Figure 2 on Page 5 for potential observation areas).
- Installation of live water level monitoring device at MW04 (telemetry).

2) The following will be undertaken during the first 3 months from the commencement of Stage 3 works:
- Continued monitoring and assessment of water level data at MW04 to establish baseline water level trends.
- Continued site observations on the ground and/or by drone.
- Continued observations of the cleared drains for integrity and function.

3) The following will be assessed and reported to NPWS every 6 months from the commencement of Stage 3 works:
- Observation area monitoring results.
- Water level monitoring results at MW04.
- Observations on the integrity and function of the cleared drains.

TARP

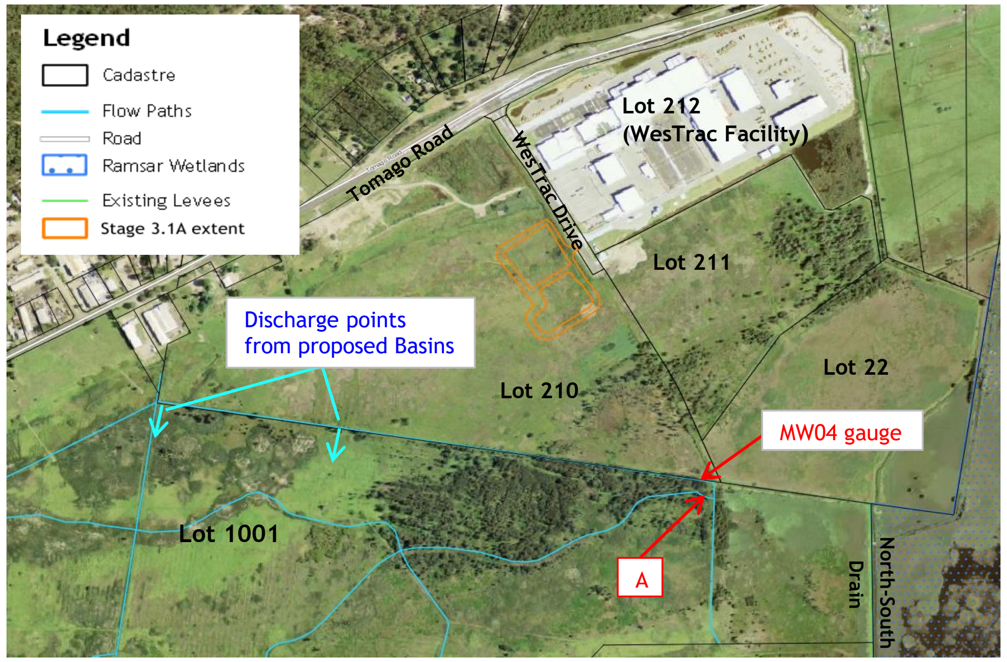
Level	Trigger (see note [a])	Action	Response
Level 1 (Normal)	• Trend in peak water levels at MW04 is not adversely increased compared to the baseline.	• Continue to monitor water level at MW04 and NPWS Floodgate.	• No further response required.
Level 2 (Mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS drains. • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 1 - Undertake capping of the existing culvert at the southeastern corner of Lot 210 (refer to Figure 2 on Page 5).
Level 3 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline. • Level 3 trigger applies if: ○ Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS drains. • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 2 - Grade fill layer for runoff control across Lot 210 towards the south and southwestern boundaries of Lot 210 to direct runoff to Lot 1001 DP1127780, including berms to control runoff from any interim basins within Lot 210 (refer to Figure 3 on Page 6).
Level 4 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline. • Level 4 trigger applies if: ○ Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger; and ○ Graded fill layer across Lot 210 is in place in response to Level 3 trigger.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS drains. • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate.	• Response 3 - Undertake additional drain clearing along the existing drainage easement further south within Lot 1001 to reinstate the drains from Lot 210 to the more deeply incised drains within Lot 1001 (refer to Figure 4 on Page 7).
Level 5 (Additional mitigation measures required)	• Trend in peak water levels at MW04 is adversely increased compared to the baseline. • Level 5 trigger applies if: ○ Culvert at the southeastern corner of Lot 210 has been capped in response to Level 2 trigger; ○ Graded fill layer across Lot 210 is in place in response to Level 3 trigger; and ○ Additional drain clearing on Lot 1001 has been undertaken in response to Level 4 trigger.	• Inspect the integrity of the cleared drains and undertake remediation if required. • Check NPWS drains. • Check the recorded data at MW04 and confirm the increase in peak water level trend. • Continue to monitor water level at MW04 and NPWS Floodgate. • Review the observation area monitoring results and assess any correlations with the recorded water level data at MW04.	• Initiate an investigation on the reasons for increased water levels at MW04 and develop additional mitigation measures for further catchment diversions to the Hunter River.

[a] - The criteria for what would be considered an "adverse increase" in peak water level trends will be confirmed based on analysis of recorded water level data to date. This criteria will be reviewed on a quarterly basis and updated if required as additional monitoring data becomes available.

Page 1 of 8

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Locality and drainage map



Estate Layout Plan

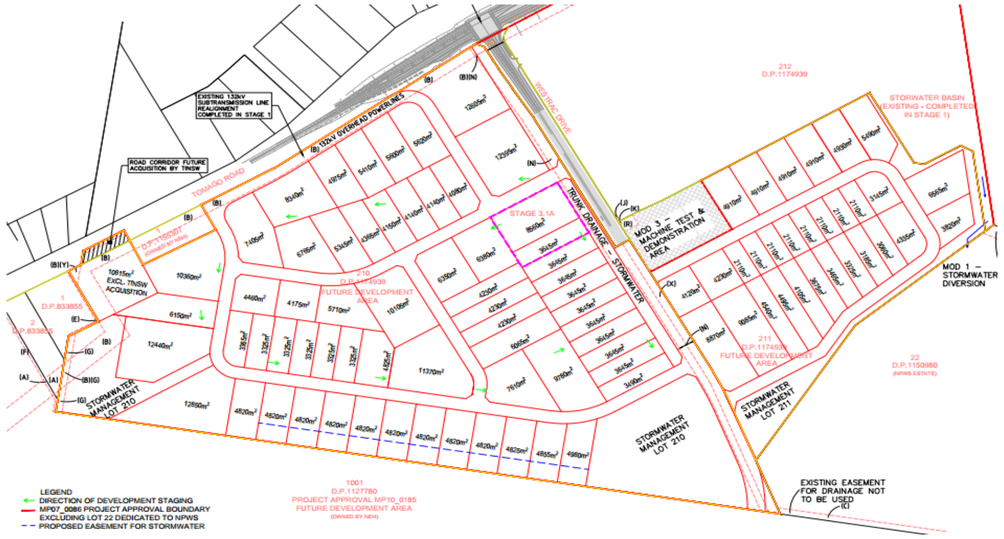


Photo of Location "A"

Purpose of this TARP (TARP #2)

TARP #2 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of the Project on the drinking water supply (Hunter Water Corporation) due to changes in groundwater quantity in the Tomago Sandbeds.

Commitments and monitoring

1) The following will be undertaken prior to the commencement of Stage 3 works:
- Installation of live water level monitoring device at MW101 and SK3520 (refer to Figure 5 on Page 8 for monitoring locations).
- Assessment of baseline conditions at MW101 screened in the Tomago Sandbeds and located near the upstream boundary of the site.
- Collection and review of monitoring data collected at the HWC bore (SK3520) screened in the Tomago Sandbeds and located about 1 km northeast of the project to assess baseline conditions at this location.

2) The following will be undertaken during the first 3 months from the commencement of Stage 3 works:
- Continued monitoring and assessment of water level data at MW101 and SK3520 to establish baseline water level trends.

3) The following will be assessed and reported to NPWS every 6 months from the commencement of Stage 3 works:
- Review of water level monitoring results at both MW101 and SK3520.

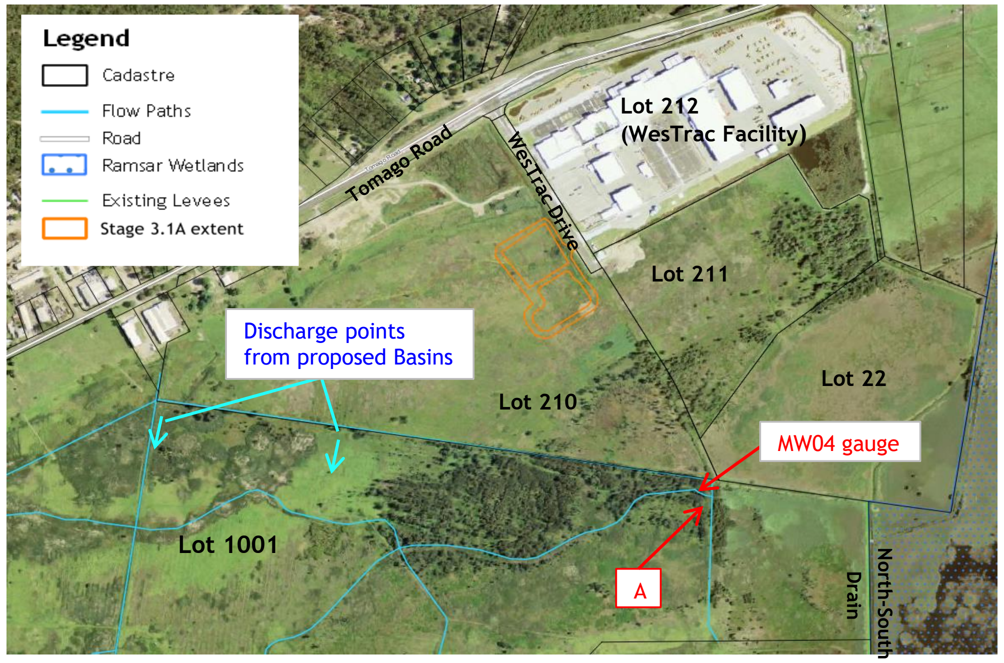
MW101 and SK3520 are both screened in the Tomago Sandbeds. The purpose of monitoring both MW101 located within the site and SK3520 located outside of the site is to assess whether any observed trends are attributable to the project or to regional stressors.

TARP

Level	Trigger	Action	Response
Level 1	• Groundwater levels at MW101 are within the baseline range; and • any noticeable trends are attributed to external stressors (e.g. climate, pumping).	• Continue to monitor as planned.	• No response required.
Level 2	• Groundwater levels at MW101 are outside baseline range; and • trends can be noticed that are not obviously attributable to external stressors.	• Review recorded data at SK3520 to check if trend is general. If so, trend would be considered not attributable to the project.	• Response 1 - investigate possible causes for the change.
Level 3	• Groundwater levels at MW101 are outside baseline range; • trends can be noticed that are not attributable to external stressors; • similar change is not observed at SK3520.	• If increase in water level (mounding): review drainage requirements in northern part of the site. • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 2 (if mounding): installation of a drain at the northern boundary of the project to divert any runoff to Lot 210 (stormwater management basin area). • Response 2 (if drawdown): control and reduce inflows in excavation areas, discharge clean surplus water to the northern part of the site (on the sand beds) for infiltration and recharge.
Level 4	• Same as above; and • Response 2 was implemented but trends are still observed.	• Review performance of measures implemented as part of Response 2. • If increase in water level (mounding): review drainage system in northern part of the site. • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 3 (if mounding): additional drain to divert water to Lot 210 (stormwater management basin area). • Response 3 (if drawdown): increased control to reduce inflows in excavation areas, discharge clean surplus water to the northern part of the site (on the sand beds) for infiltration and recharge.
Level 5	• Same as above; and • Response 3 was implemented but trends are still observed.	• Review performance of measures implemented as part of Response 3. • If increase in water level (mounding): review drainage system in northern part of the site • If decrease in water level (drawdown): review groundwater inflows in excavations.	• Response 4 - Stop work, initiate detailed investigations to understand the cause(s) of the changes in water levels, develop additional mitigation measures.

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Locality and drainage map



Estate Layout Plan

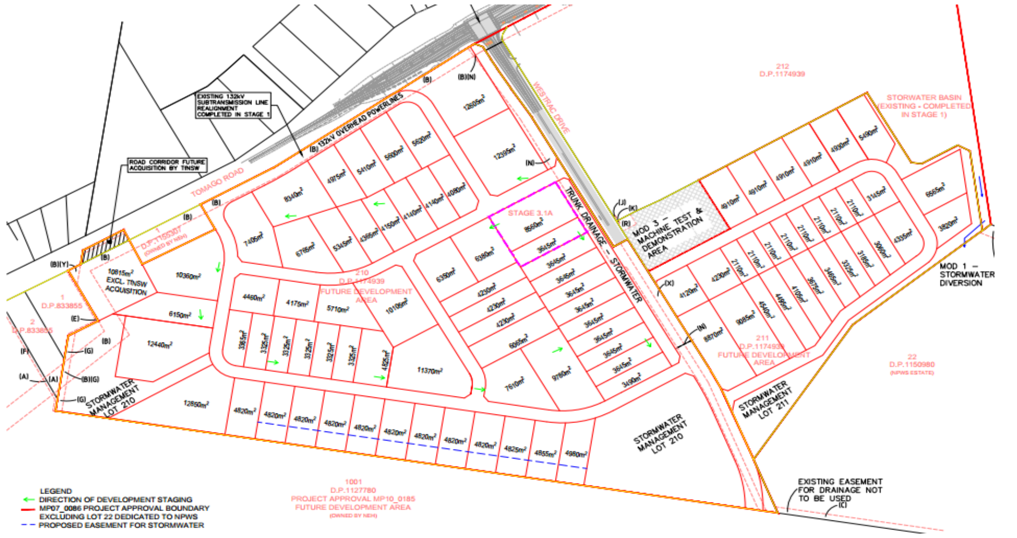


Photo of Location "A"

Purpose of this TARP (TARP #3)

TARP #3 describes the adopted triggers, proposed actions and responses to identify and mitigate the potential impacts of contamination/changes in groundwater and/or surface water quality as a result of the Project.

Commitments and monitoring

Monitoring of water quality will be implemented as outlined in the groundwater and surface water management plans.

TARP

Level	Trigger	Action	Response
Level 1	• Groundwater quality is within baseline range; and • any noticeable trends are attributed to external stressors (e.g. climate, pumping).	• Continue to monitor as planned.	• No response required.
Level 2	• Single exceedance for any one analyte and bore; or • Any noticeable trends / changes in water quality.	• Review water quality data for all analytes. • Organise additional monitoring rounds to confirm the exceedances / change in water quality	• Response 1 - keep monitoring water quality and assessing trends.
Level 3	• Three consecutive results exceeding trigger levels for any one bore and analyte.	• Advise and seek advice from DPE Water. • Review water quality data for all analytes. • Organise additional monitoring rounds to confirm the exceedances / change in water quality.	• Response 2 - investigate possible causes for the change.
Level 4	• Exceedances continue and cannot be attributed to external factors.	• Collect water quality data outside of the project area (e.g. at monitoring locations at other projects). • Compare site-specific data to those collected from surrounding areas. • If change in water quality appears to be caused by the project, advise relevant authorities, adjacent water users and conduct detailed investigations to plan for remediation.	• Response 3 (If change in water quality appears to be caused by the project) - Prepare remediation plan based on results of investigations. • Response 3 (if change is regional and not caused by project) - review and update trigger values.
Level 5	• Response 3 (if change is regional and not caused by project) - review and update trigger values; and • More analytes exceed their trigger levels.	• Review performance of measures implemented as part of Response 3.	• Response 4 - Stop work, develop additional remediation measures if consultation with experts.

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 1: Drain clearing plan (for TARP#1 on Page 1)

Page 4 of 8

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago
Figure 2: Response 1 (for TARP#1 on Page 1) - Capping of the existing culvert at the southeastern corner of Lot 210	

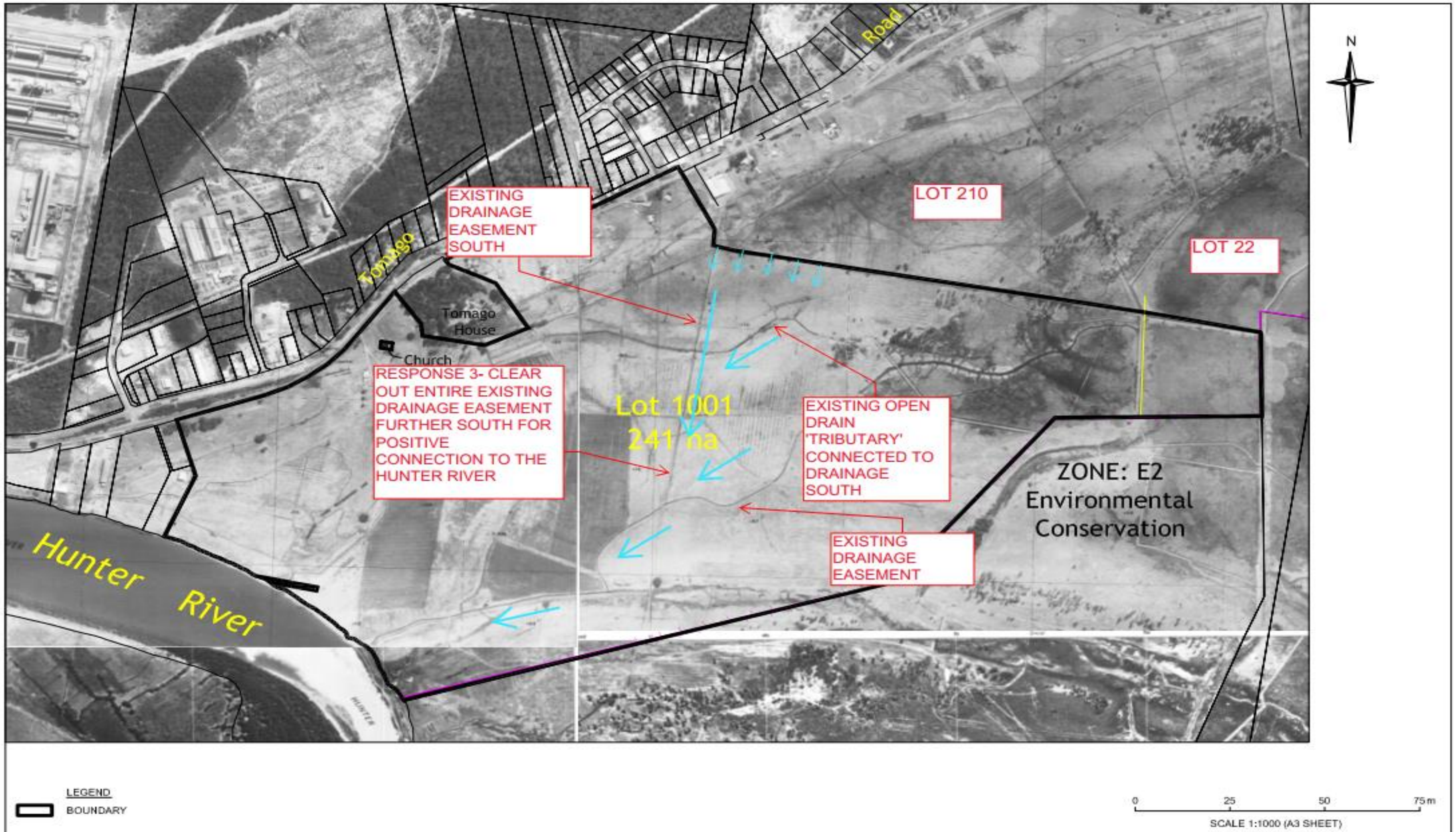
	Page 5 of 8

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago
Figure 3: Response 2 (for TARP#1 on Page 1) - Extent of proposed initial fill layer, graded towards the south and southwestern boundaries of Lot 210	

	Page 6 of 8

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 4: Response 3 (for TARP#1 on Page 1) - Additional drain clearing along the existing drainage easement at Lot 1001



DRAWING ADAPTED FROM PLAN SUPPLIED BY CLIENT, REF 37672 VERSION A DATED 22/3/10, AND 1986 ORTHOPHOTOS

Douglas Partners Geotechnics Environment Groundwater	Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Campbelltown, Townsville, Cairns, Wollongong, Darwin	TITLE: 1986 ORTHOPHOTO OVERLAY PROPOSED NORTH BANK ENTERPRISES PARK LOT 1001, DP1127780 TOMAGO ROAD, TOMAGO	CLIENT: ADW JOHNSON PTY LTD DRAWN BY: PLH | SCALE: 1:1000 APPROVED BY:	REF:P:\49608\DRAWINGS\49608 DRAWING 2 PROJECT No: 49608 | OFFICE: NEWCASTLE DATE: | DRAWING No: 2

Worksheet title:	Trigger Action and Response Plan (TARP) for Industrial Estate at Lot 210 DP1174939, Tomago

Figure 5: Groundwater monitoring well location plan