KFW
INFRASTRUCTURE PROFESSIONALS

PROJECT MANAGEMENT

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SEWER & WATER

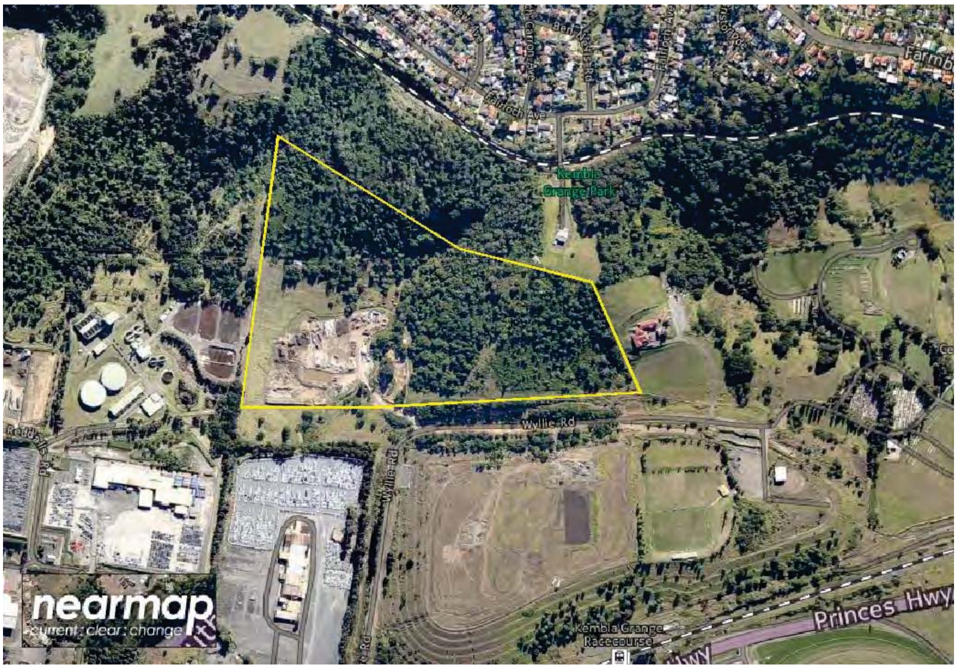
Flood Analysis Review

50 Wyllie Road

KEMBLA GRANGE

For Bi Corp Pty Ltd

WSUD and Flood Analysis Report



KF110816
10 June 2014

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1.0 INTRODUCTION

K.F. Williams & Associates Pty Ltd has been commissioned to undertake a Water Sensitive Urban Design Strategy and Flood Analysis for the construction materials recycling facility in Wyllie Road, Kembla Grange.

The WSUD Strategy has been undertaken in order to facilitate the development application assessment by Wollongong City Council.

In order to determine the stormwater detention storage requirements, the site was modeled using DRAINS. Site discharge was estimated for the site under pre-developed conditions and compared with estimated site discharge under post-developed conditions. Using runoff routing methods, the volume of detention storage was calculated to ensure that the post-development discharge was less than the pre-developed site discharge. A range of storm burst durations from 5 minutes to 6 hours were used for ARI of 100, 10 and 5 years.

In order to determine the water quality treatment requirement, the site was modeled using MUSIC#. Six minute rainfall data over the period 1963-2009 was used.

The purpose of the flood analysis is to provide an addendum to the 1D flood report prepared in August 2013 prepared by KFW.

A review of the effects of climate change has been performed by increasing the intensity of rainfall in the hydrological analysis. Predicted increases in rainfall have been applied in accordance with the Department of Environment and Climate Change document Practical Consideration of Climate Change (DECC 2007).

The critical hydrograph for the 100 year ARI flood was determined using WBNM and was compared to the previously determined peak discharge using the Probabilistic Rational Method using R.A.R.E.

The critical PMF hydrograph was generated using WBNM.

A 2D model of the site has been prepared using TUFLOW.

The 100 year ARI flood levels from the previous flood studies for the site have been reviewed.

Flood inundation maps have been created for the 100 year ARI flood, 100 year ARI flood with climate change and PMF for pre-development, post-development unblocked and post-development blocked scenarios.

2.0 BACKGROUND INFORMATION

The development site is Lot 10 DP 878167, Wyllie Road, Kembla Grange.

The location of the site is shown in Figure 2.1.

Lot 10 has a total area of 20,873 m^2.

The area of interest for this Development Application is the area in the immediate vicinity of operational area. The area of interest lies on either side of the existing watercourse.

The western precinct has an area of 4.299 ha.

The eastern precinct has an area of 0.371 ha.

The surrounding area is zoned IN2, IN3 and RE2.

The general site characteristics are:

- 2,230 m^2 of buildings
- 36,088 m^2 of recycled concrete pavement. This pavement will not present as 100% impervious and will allow infiltration,
- 4,662 m^2 of grass
- 3,428 m^3 water quality/reuse pond
- 3 x 100,000 rainwater tanks
- 1,953 m^3 detention pond (western precinct)
- 235 m^3 detention basin (eastern precinct)

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Locality Sketch

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3.0 PROPOSED DEVELOPMENT

The proposed development incorporates the following:

a. Extending the existing construction materials and recycling operational area.

b. Increasing the size of the water quality pond in order to harvest and store rainwater for reuse on site

c. Office and operational buildings

d. Green waste shredding

e. Equipment storage and fuel storage area.

f. Car parking.

The site has only one point of access/egress from Wyllie Road.

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4.0 WATER SENSITIVE URBAN DESIGN

4.1 SITE CATCHMENT CHARACTERISTICS

The site is well elevated and is well above the Mullet Creek / Lake Illawarra flood plain. The site is bisected by a watercourse. Other than the immediate area of the watercourse, the site can be classified as flood free.

Figure 4.1.1 presents the proposed development in the catchment context. The Mullet Creek Catchment has an area of 7,431 ha. The total site area is 21.6 ha. The site represents less than 0.3% of the Mullet Creek catchment.

The area covered by the proposed development is approximately 4.68 ha, which represents about 0.6% of the Mullet Creek catchment.

Figure 4.1.2 and Figure 4.1.3 show the 1% AEP flood level and PMF level as extracted from the Extension of Mullet Creek Flood Study (dec 2011).

It is clear from Figure 4.1.2 and Figure 4.1.3 that the site is not within the flood plain. It is noted that the flooding within the site is confined to and within the watercourse.

The site is clearly not within the floodplain. Excavation or filling on site will therefore have no impact on the flood characteristics within the Mullet Creek Floodplain.

The site and site buildings will offer safe refuge during a PMF.

Figure 4.1.4 shows the site sub catchments which have been analysed to determine the required OSD volume.

Catchment details are presented in Table 4.1.1 and Table 4.1.2 below.

Table 4.1.1
Catchment Details

Area 1 (Eastern side of Creek)

Pre Development

Landuse	Area m^2	imperv %	L m	S m/m	tc min	Comments
Forest	30,893	0	325	0.10		
Grass/ cleared area	42,999	0	187	0.13	27.9	adopt t_c = 20
Roads / Buildings	0	n/a	-	-	-	
	73,892	0.0				

Post Development

Landuse	Area m^2	imperv %	L m	S m/m	tc min	Comments
Grass/cleared area	4,662	0	-	-	12	forest diverted from site Q_{100}=1,500 l/s
Roads/Buildings	38,337	80	-	-	5	Pavement is recycled crushed concrete
	42,999	71.3				

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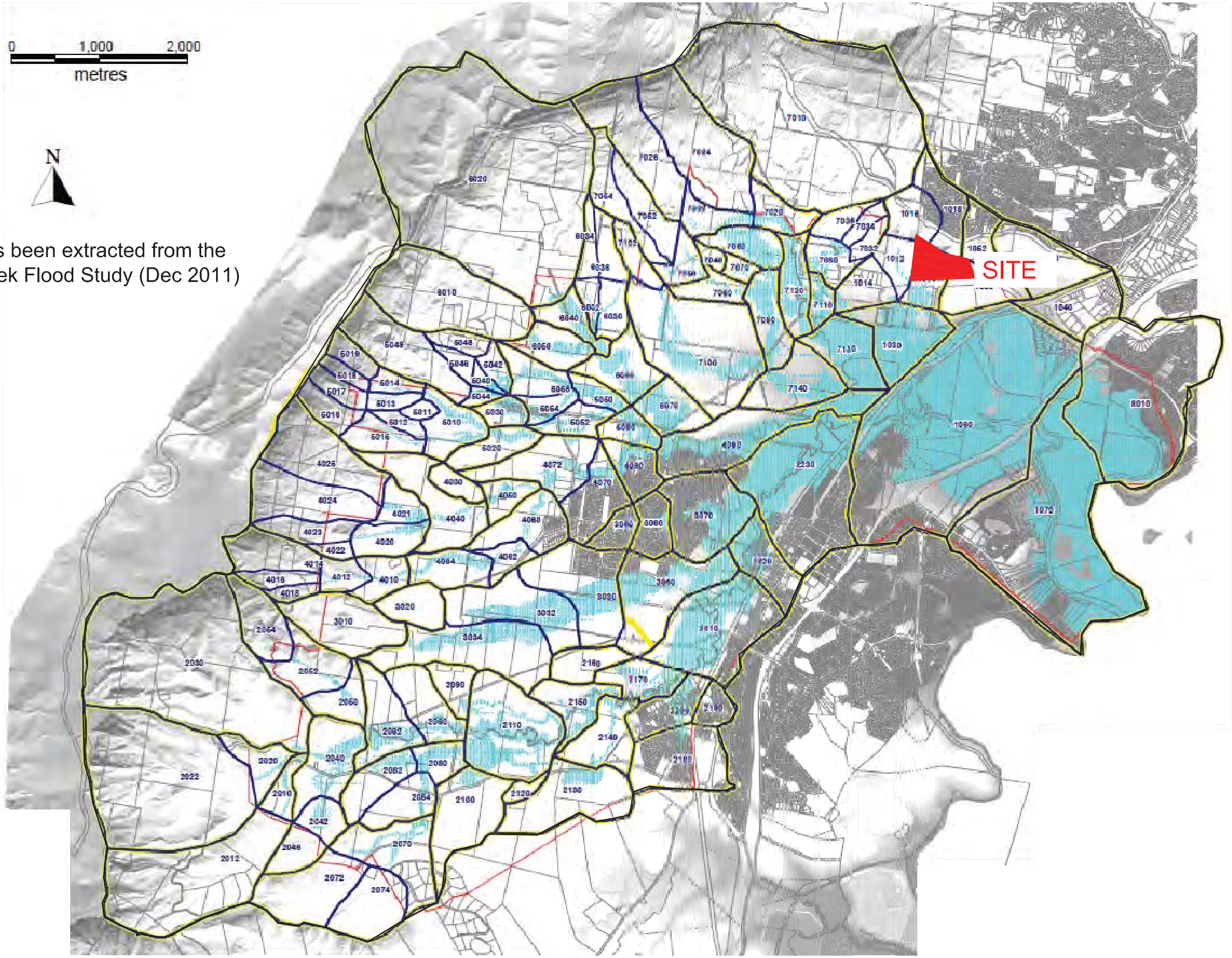

Flood information has been extracted from the Extension Mullet Creek Flood Study (Dec 2011)

Catchment Context

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1% AEP Flood Inundation Map

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PMF Flood Inundation Map

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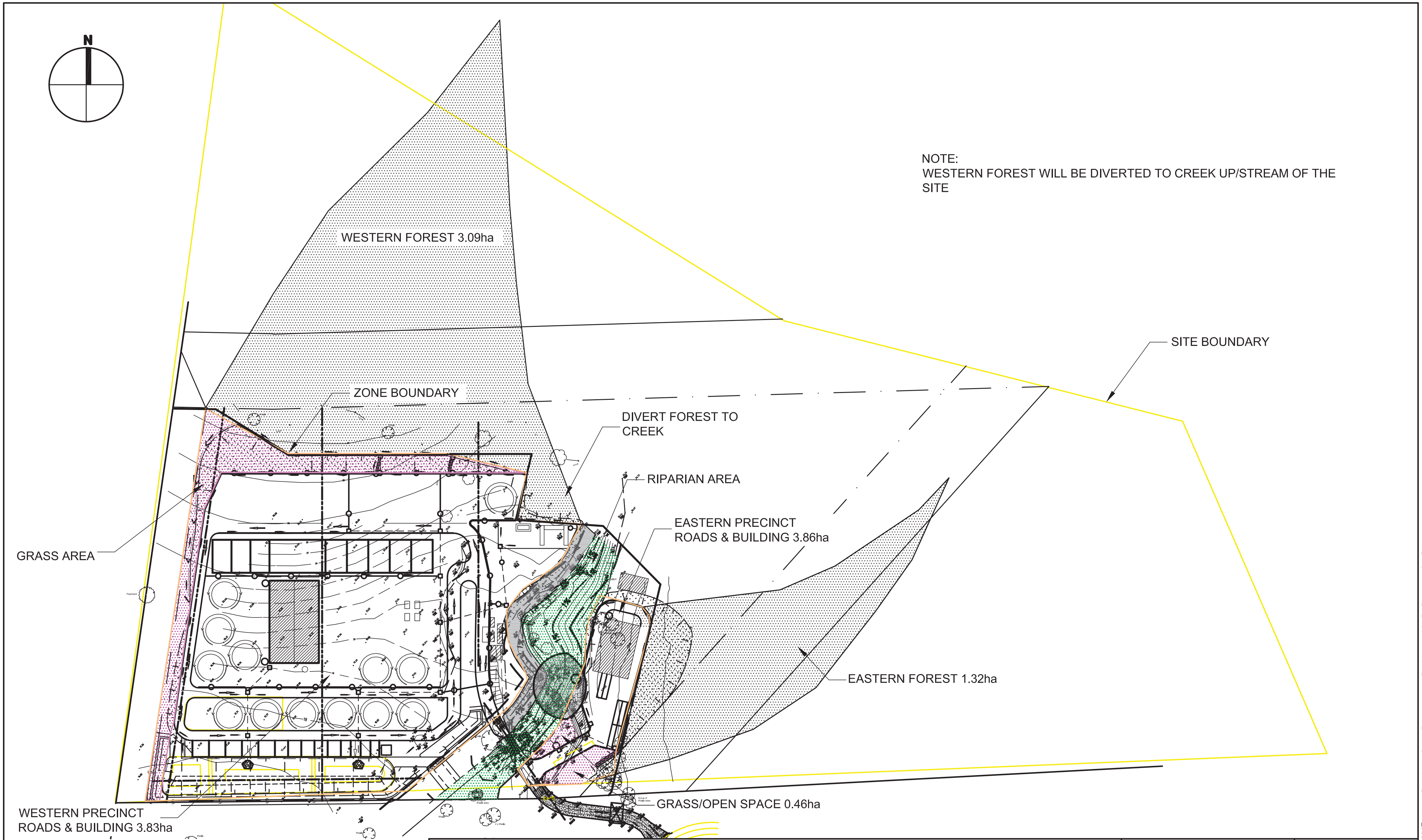

Sub Catchment Arrangement

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Table 4.1.2
Catchment Details

Area 2 (Western side of Creek)

Pre Development

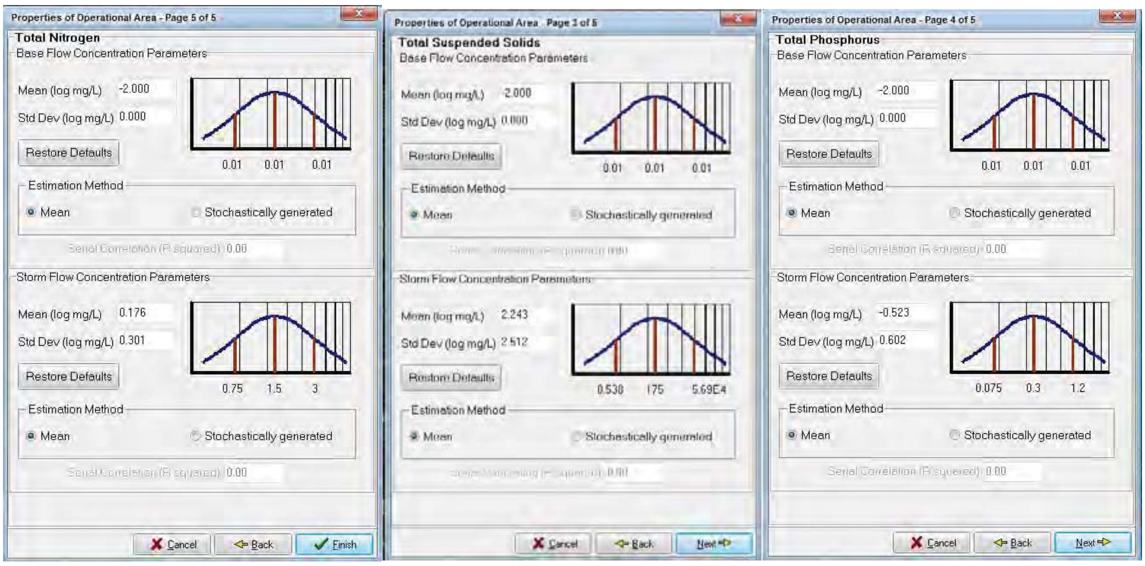
Landuse	Area m^2	imperv %	L m	S m/m	tc min	Comments
forest	13,206	0	260	0.1	15	
Grass/ cleared area	3,777	0	-	-	-	
	16,983	0				

Post Development

Landuse	Area m^2	imperv %	L m	S m/m	tc min	Comments
forest	13,206	0	260	0.1	15	
Grass/cleared area	754	0	-	-	-	
Roads/Buildings	3,023	100	-	-	5	
	16,983	20				

Pollutant concentrations for storm flod were derived from Australian Runoff Quality for an industrial landuse. Base flow will not be a significant contribution to runoff from the site and base flow pollutant concentrations will be close to zero.

Table 4.1.3
Poulltant Parameters



4.2 WSUD OBJECTIVES, CONSTRAINTS AND OPPORTUNITIES

Wollongong City Council DCP 2009 outlines the following WSUD objectives:

a. To sustainable integrate natural systems with urban development.

b. To integrate stormwater drainage treatments into the landscape.

c. To ensure water sensitive urban design treatment measures are incorporated in new developments taking into account stormwater management and floodplain management issues.

d. To improve the potential for urban run-off reuse.

e. To minimize the volume of stormwater run-off.

f. To protect the quality of water run-off from urban development.

g. To reduce run-off and peak flows from urban developments by local detention basins and minimizing impervious areas, wherever practicable.

h. To preserve, restore and enhance riparian corridors as natural systems.

i. To minimize the drainage infrastructure cost of development.

The site has the following constraints:

- Proximity to existing industrial development,
- Hillside catchment surrounded by existing development which limits the available discharge points.
- The requirement to maintain the ‘pre-developed’ site discharge.

The site offers the following opportunities:

- Opportunity for rainwater harvesting and use for on-site use such as washing equipment, dust suppression and toilet flushing. A combination of 100,000 litre rainwater tanks and a permanent pool will be used.
- Opportunity to use shallow subsoil drainage to enhance rainwater harvesting.
- Opportunity to use recycled crushed concrete for road pavement and hardstand areas. Recycled crushed concrete will propose infiltration.
- Opportunity to use batter drains to intercept runoff from forested RE2 zone and direct this runoff to the watercourse to eliminate the potential for clean water to be contaminated and reduce the load on SQIDs.

4.3 WSUD MEASURES

The proposed development will incorporate the following WSUD measures.

<u>Measure 1 – Rainwater Capture and Use</u>

Up to three 100,000 litre rainwater tanks will be installed to collect roof water from the larger buildings (workshop and processing shed). The rainwater captured may be used for toilet flushing, dust suppression and equipment washing.

Rainwater from the 100,000 litre tanks can be plumbed into toilets and decanted to the site water tanker for dust suppression. Captured water may be used in the crusher to maintain moisture content and reduce dust.

In addition to three rainwater tanks, a permanent pool will be constructed. The permanent pool will have a storage volume of 3,248 m^3. The permanent pool is the last 'carriage' in the 'treatment train' and will provide opportunity to use the capture water for dust suppression.

The daily dry weather demand for dust suppression and other site operations is in the order of 40,000 litres/day.

The stormwater system will be designed to divert discharge equal to 25% of the 1 in 1 year flow into the permanent pool.

The results from modeling water reuse in MUSIC[#] (1963-2009) indicate that reuse demand will be met as follows:

a. Rainwater tanks: meets 82% of demand (500 l/day from each tank site)

b. Permanent pond: meets 75% of demand (40,000 l/day)

WSUD Objectives met:
(d) Urban runoff reuse
(e) Minimise volume of stormwater runoff
(g) Reduce runoff peak flows
(i) Minimise drainage infrastructure cost

Measure 2 – Infiltration
Infiltration will be encouraged by:

- Use of recycled crushed concrete in road pavements and hardstand areas. Recycled crushed concrete is about 80% impervious and will thus promote a limited amount of infiltration and reduce the volume of surface runoff.

WSUD Objectives met:
(e) Minimise volume of stormwater runoff
(f) Protect quality of water runoff
(g) Reduce runoff peak flows
(h) To preserve, restore and enhance riparian corridors as natural systems by contributing to base flow.

Measure 3 – OSD Systems
Two OSD basins are proposed.

Basin #A will be constructed on the western side of the watercourse and will serve the largest part of the operational area within the site. The volume of Basin #A will be 1,953 m^2.

As shown in section 4.5 the peak discharge is maintained at or below the pre development discharge.

Basin #B will be constructed on the eastern side of the watercourse. The volume of Basin #B will be 235 m^2.

As shown in section 4.5 the peak discharge is maintained at or below the pre development discharge.

WSUD Objectives met:
(e) Minimise volume of stormwater runoff
(g) Reduce runoff peak flows
(i) Minimise drainage infrastructure cost

Measure 4 – Hydrocarbon Capture
Two Rocla downstream defenders will be installed in order to capture hydrocarbons (eg oils & grease). One DD1200 unit will be installed immediately upstream of Basin #B in order to treat runoff from the workshop and truck parking areas. The other DD1200 unit will be installed immediately downstream of the equipment storage area in order to treat runoff from the equipment storage area.

A Humeceptor will be installed immediately upstream of the permanent pool in order to remove hydrocarbons from the operational area. A control pit will be constructed to ensure that discharge up to and including 25% of the 1 in 1 year critical duration storm burst are routed through the Humeceptor.

WSUD Objectives met:
(e) Minimise volume of stormwater runoff
(g) Reduce runoff peak flows
(i) Minimise drainage infrastructure cost

4.4 WATER CONSERVATION

Water conservation targets will be met by using harvested rainwater on site.

4.5 STORMWATER MANAGEMENT

The development of the site will result in an overall increase in pervious area.

The OSD system proposed will maintain the post-developed site discharge at or below the pre-developed discharge.

The OSD system has been analysed using runoff routing methods in order to determine the volume of storage required to maintain site discharge to the pre-developed discharge.

The proposed OSD system will provide approximately 1,971 m^3 of detention storage.

Table 4.5.2 and 4.5.4 demonstrate that the proposed OSD system will reduce the post-developed site discharge such that the pre-developed discharge is not exceeded.

Table 4.5.1
Basin #A Details

Basin Characteristics	Volume m^3	Orifice dia mm	Outlet dia mm	Weir RL
	1,953	n/a	1 x 675	18.85

Table 4.5.2
Basin #A Performance Detail

Basin Outflow Details					
ARI yr	Q_{pre} l/s	Q_{post} l/s	Q_{basin}	Q_{total}	Comments
5	1,790	2,547	1,090	1,770	critical storm 2h – 20 l/s reduction
10	2,180	3,022	1,190	2,100	critical storm 2h – 80 l/s reduction
100	3,590	4,620	1,450	2,970	critical storm 2h – 620 l/s reduction

Table 4.5.3
Basin #B Details

Basin Characteristics	Volume m^3	Orifice dia mm	Outlet dia mm	Weir RL
	235	500	600	20.35

Table 4.5.4
Basin #B Performance Detail

Basin Outflow Details					
ARI yr	Q_{pre} l/s	Q_{post} l/s	Q_{basin}	Q_{total}	Comments
5	489	496	444	444	critical storm 2h – 45 l/s reduction
10	574	587	519	519	critical storm 2h – 55 l/s reduction
100	884	911	778	778	critical storm 2h – 106 l/s reduction

Output from DRAINS is presented in Appendix B.

It is evident from Table 4.5.2 and 4.5.4 that the two OSD Basins reduce the peak discharge from the site.

4.6 WATER QUALITY MANAGEMENT

The site was modeled using MUSIC#. Pollutant parameters were taken from Australian Runoff Quality (ARQ 2006). For the operational area of the site, parameters for 'Industrial" were used from ARQ 2006 Figures 3.2-3.4. For the forested area in the Eastern Precinct, parameters 'Forest' were used from Figures 3.2-3.4.

Rainfall data with 6 minute time step was obtained from the Port Kembla pluvio for the period 6 May 1963 – 31 July 2009.

The MUSIC# model is presented in Figure 4.6.1.

A summary of the MUSIC # modeling results area presented in the tables below.

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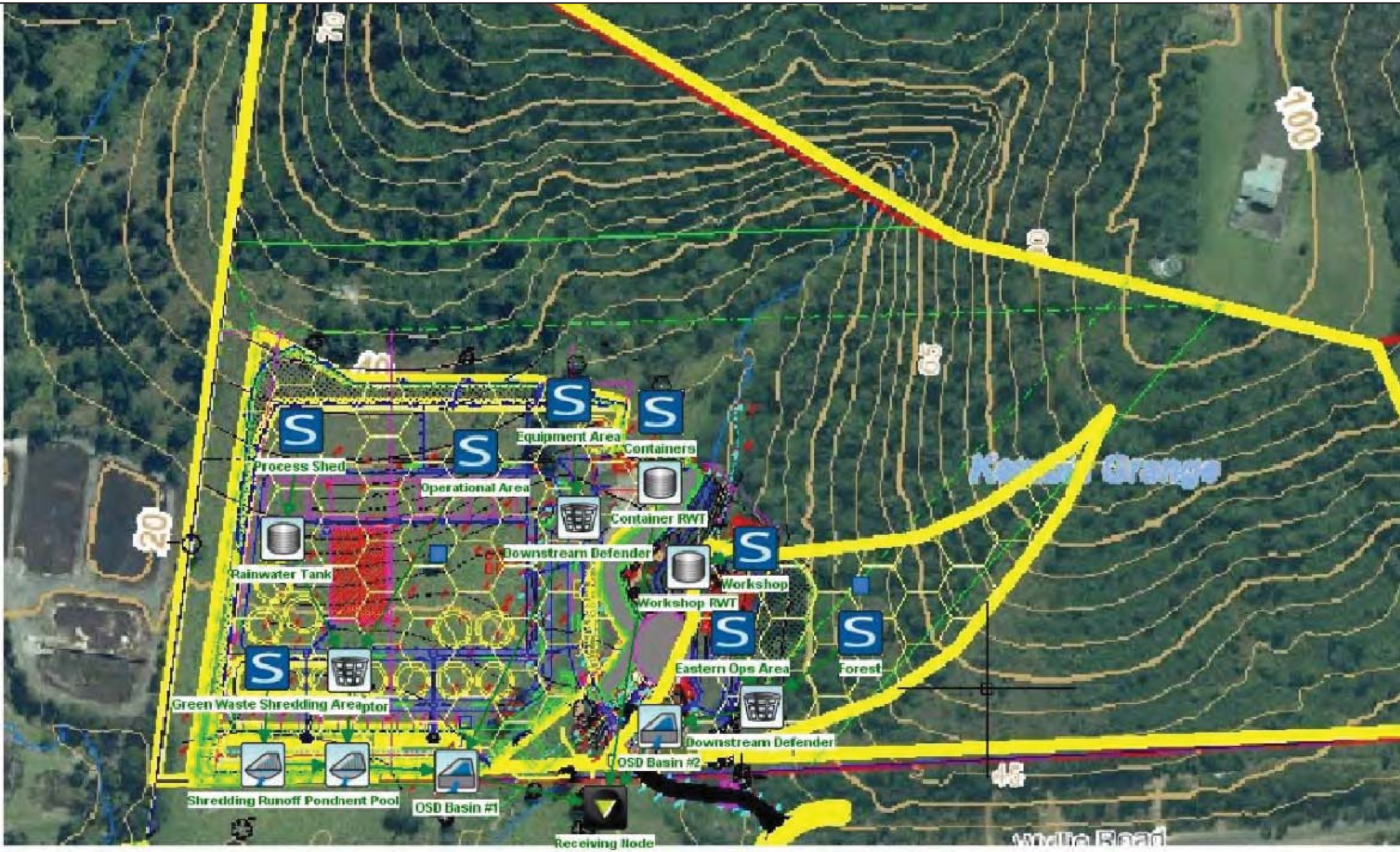

MUSIC Model Arrangement

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Table 4.6.1
Treatment Train Effectiveness

Treatment Train Effectiveness - Receiving Node

	Sources	Residual Load	% Reduction
Flow (ML/yr)	32.4	18.8	42.1
Total Suspended Solids (kg/yr)	5270	393	92.5
Total Phosphorus (kg/yr)	8.98	2.54	71.7
Total Nitrogen (kg/yr)	45.4	24	47
Gross Pollutants (kg/yr)	780	0	100

Council's pollutant load reduction requirements were conveyed in an email dated 17 July 2013. The load reductions required by Council are:

a. GP 90%
b. TSS 80%
c. TP 60%
d. TN 40%

It is evident from Table 4.6.1 that the WSUD components significantly reduce the export of TSS, TP, TN and gross pollutants from the site.

Reuse of the rainwater harvested in the rainwater tanks and permanent pool lead to a reduction in runoff from the site during storm events.

It is clear that Council's pollutant reduction targets can be met.

Table 4.6.2
Mean Daily Load - TN

Daily Mean Statistics - Receiving Node (Daily Values)

- Flow (cubic metres/sec)
- TSS Concentration (mg/L)
- Log [TSS] (mg/L)
- TP Concentration (mg/L)
- Log [TP] (mg/L)
- TN Concentration (mg/L) (selected)
- Log [TN] (mg/L)
- TSS Load (kg/Day)
- TP Load (kg/Day)
- TN Load (kg/Day)
- Gross Pollutant Load (kg/Day)

	Inflow
mean	68.2E-3
standard deviation	0.422
median	0.00
maximum	17.6
minimum	0.00
10 percentile	0.00
90 percentile	90.4E-3

Table 4.6.3
Mean Daily Load – TP

Daily Mean Statistics - Receiving Node (Daily Values)

- Flow (cubic metres/sec)
- TSS Concentration (mg/L)
- Log [TSS] (mg/L)
- TP Concentration (mg/L) (selected)
- Log [TP] (mg/L)
- TN Concentration (mg/L)
- Log [TN] (mg/L)
- TSS Load (kg/Day)
- TP Load (kg/Day)
- TN Load (kg/Day)
- Gross Pollutant Load (kg/Day)

	Inflow
mean	40.7E-3
standard deviation	99.6E-3
median	0.00
maximum	1.30
minimum	0.00
10 percentile	0.00
90 percentile	0.142

It can be seen from Table 4.6.2 and Table 4.6.3 that mean daily TN & TP export concentration is low.

Table 4.6.4 indicates that 75% of the site water demand is met through the runoff harvested by the permanent pool.

Table 4.6.4
Water Balance Permanent Pool

Node Water Balance - Permanent Pool

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
Flow In	28.7	972.2	5.9	29.2	694.4
ET Loss	1.3	0.0	0.0	0.0	0.0
Infiltration Loss	0.0	0.0	0.0	0.0	0.0
Low Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
High Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
Pipe Out	6.6	133.6	0.9	8.6	0.0
Weir Out	9.5	214.1	1.4	11.6	0.0
Transfer Function Out	0.0	0.0	0.0	0.0	0.0
Reuse Supplied	10.8	223.2	1.5	16.1	0.0
Reuse Requested	14.4	0.0	0.0	0.0	0.0
% Reuse Demand Met	75.1	0.0	0.0	0.0	0.0
% Load Reduction	43.9	64.2	61.6	31.1	100.0

Decimal Places 1

Table 4.6.5 and Table 4.6.6 indicate that 82% of the site water demand is met through the runoff harvested by the rainwater tanks.

Table 4.6.5
Workshop Rainwater Tank

Node Water Balance - Workshop RWT

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
Flow In	0.5	0.0	0.0	0.0	12.8
ET Loss	0.0	0.0	0.0	0.0	0.0
Infiltration Loss	0.0	0.0	0.0	0.0	0.0
Low Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
High Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
Pipe Out	0.3	2.2	0.0	0.1	0.0
Weir Out	0.0	0.1	0.0	0.0	0.0
Transfer Function Out	0.0	0.0	0.0	0.0	0.0
Reuse Supplied	0.1	1.4	0.0	0.0	0.0
Reuse Requested	0.2	0.0	0.0	0.0	0.0
% Reuse Demand Met	81.5	0.0	0.0	0.0	0.0
% Load Reduction	28.8	-45326.2	-378.7	-1305.2	100.0

Decimal Places 1

Table 4.6.6
Processing Shed Rainwater Tanks

Node Water Balance - Rainwater Tank

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
Flow In	1.1	0.0	0.0	0.0	26.4
ET Loss	0.0	0.0	0.0	0.0	0.0
Infiltration Loss	0.0	0.0	0.0	0.0	0.0
Low Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
High Flow Bypass Out	0.0	0.0	0.0	0.0	0.0
Pipe Out	0.8	4.2	0.0	0.1	0.0
Weir Out	0.1	0.4	0.0	0.0	0.0
Transfer Function Out	0.0	0.0	0.0	0.0	0.0
Reuse Supplied	0.1	1.1	0.0	0.0	0.0
Reuse Requested	0.2	0.0	0.0	0.0	0.0
% Reuse Demand Met	82.7	0.0	0.0	0.0	0.0
% Load Reduction	14.3	-43818.1	-363.0	-960.0	100.0

Decimal Places 1

4.7 OPERATION AND MAINTENANCE

The proposed development will operate under a sole occupier/owner who will be responsible for the operation and maintenance of the development as a whole.

The draft Operation and Maintenance Plan for WSUD specific items is as follows:

Weekly Inspection / Maintenance

- Collect accumulated surface litter from the whole of the site. Dispose to garbage.
- Inspect surface inlet grates and grated drains and remove accumulated litter and dispose to garbage debris and silt and dispose to garbage.
- Particular attention is to be paid to the removal of debris from pit grates.
- Inspect recycled water pump system for serviceability.

Monthly Inspection / Maintenance and after every rainfall event > 25mm

- Inspect rainwater tank filters and inlet pipes. Remove accumulated litter and debris and dispose to garbage.
- Inspect permanent pool overflow pipe and screen. Remove accumulated debris as required.
- Inspect permanent pool control pit. Remove accumulated debris as required.
- Inspect OSD mesh screens.
  Remove accumulated litter and debris. Particular attention is to be paid to the removal of leaf litter and vegetation build up. Trim vegetation as required.
- Ensure rainwater tanks are drawing down.
- Inspect Downstream Defenders and Humeceptor.
  Remove accumulated oils/grease and dispose to accredited disposal site.
  Remove accumulated sediment and dispose to accredited disposal site.

Site Monthly Inspection / Maintenance

- Inspect and clean gutters of all buildings. Dispose of debris to garbage.
- Inspect rainwater tanks internally and externally for leaks and damage.
  Inspect tank filters and inlet pipes. Remove accumulated litter and debris and dispose to garbage.
- Inspect OSD basins internally and repair scour, trim vegetation.
- Inspect batter drains, repair scour, trim vegetation.
- Inspect OSD outlet screens and trim vegetation
- Inspect all stormwater pits and grates. Remove accumulated litter and debris and dispose to garbage. Replace damaged grates.
- Remove, clean and refit mesh screens from OSD outlets.
- Inspect Downstream Defender and Humeceptor.
  Remove accumulated oils/grease and dispose to accredited disposal site.
  Remove accumulated sediment and dispose to accredited disposal site.

5.0 FLOOD ANALYSIS

5.1 HYDROLOGICAL ANALYSIS

The critical burst 100 year ARI flood and PMF hydrographs were determined using WBNM.

The rainfall data for Kembla Grange was obtained from the Bureau of Meteorology and is presented below:

Intensity 2 year 1 hour	46.21 mm/hr
Intensity 2 year 12 hour	10.24 mm/hr
Intensity 2 year 72 hour	3.17 mm/hr
Intensity 50 year 1 hour	97.91 mm/hr
Intensity 50 year 12 hour	23.01 mm/hr
Intensity 50 year 72 hour	7.54 mm/hr
Geographical factor F2	4.28
Geographical factor F50	15.8
Regional Skewness factor G	0.00

The catchment has an area of 46.9 ha.

The catchment was determined to be 55% impervious.

The 90 minute storm burst was found to generate the greatest discharge for the 100 year ARI flood.

The 15 minute storm burst was found to generate the greatest discharge for the PMF.

The peak discharge for each ARI is summarized in Table 5.1.1.

Table 5.1.1
Peak Discharge Summary

ARI	Critical Duration	Flow Rate (m^3/s)
100 year	90 min	23.45
100 year w/climate change	90 min	31.08
PMF	30 min	59.39

Hydrographs for the 100 year ARI flood, 100 year ARI flood with climate change and PMF are presented in Figure 5.1.1, Figure 5.1.2 and Figure 5.1.3. The time series data was used as the inflow boundary conditions for the hydraulic model.

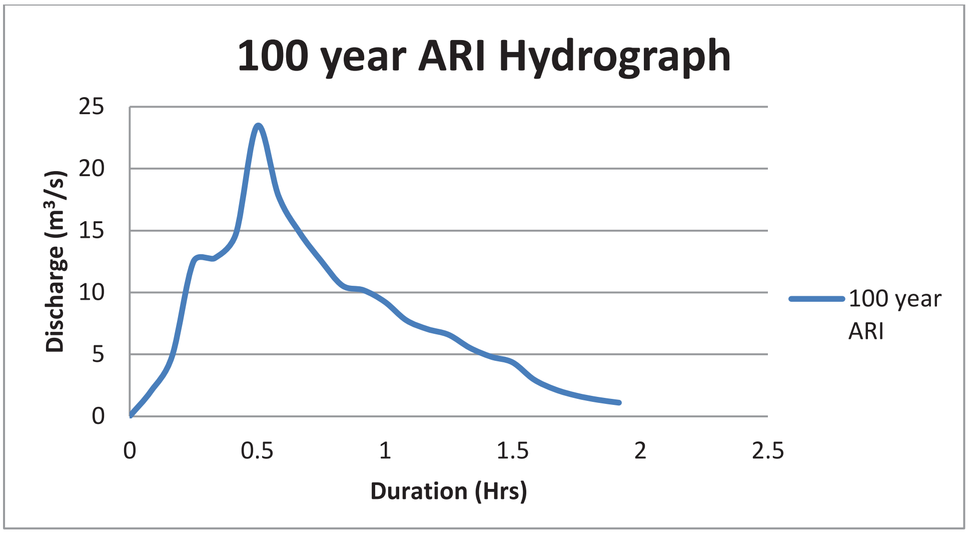

Figure 5.1.1
100 year ARI Hydrograph

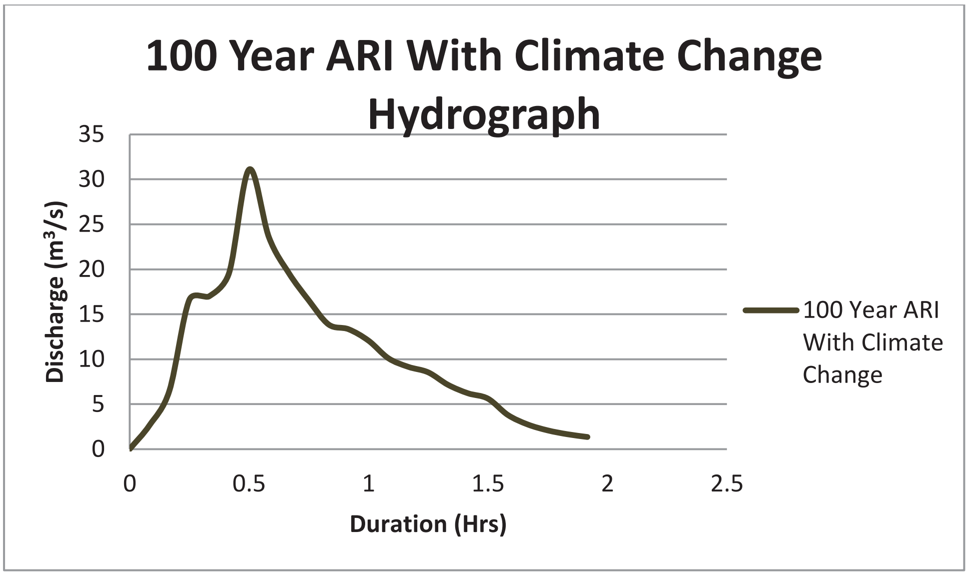

Figure 5.1.2
100 year ARI with Climate Change Hydrograph

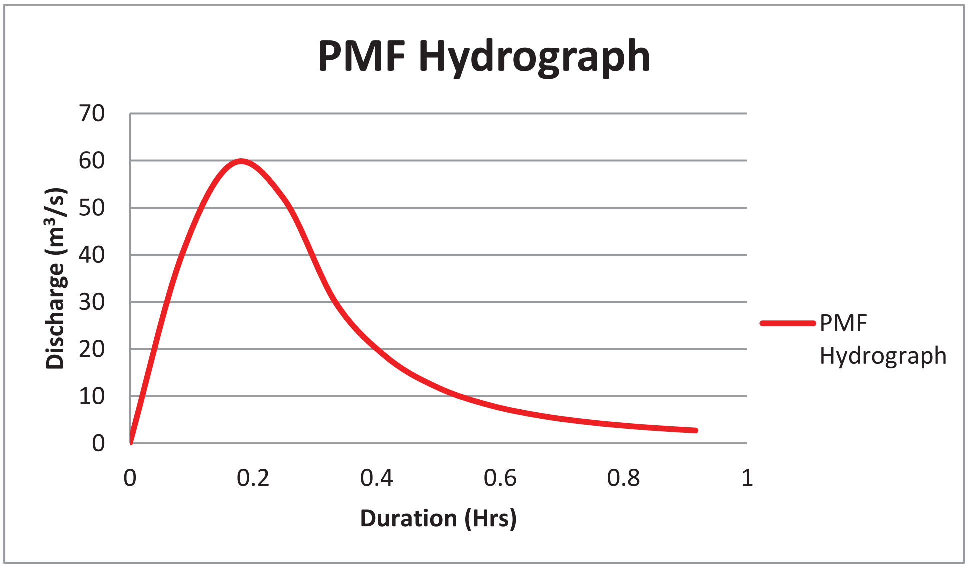

Figure 5.1.3
PMF Hydrograph

5.2 HYDRAULIC ANALYSIS

Hydraulic analysis was undertaken using a 2D hydraulic model with a dynamically linked 1D network. Modelling was undertaken using the numerical model TUFLOW.

5.2.1 Survey

A 3D model of the surface was generated using survey data.

The pre-development surface is shown in Figure 5.2.1. The boundary of the 2D domain is shown as a red line.

A 0.5m grid based on the 3D surface has been adopted for the pre-development scenarios of this study.

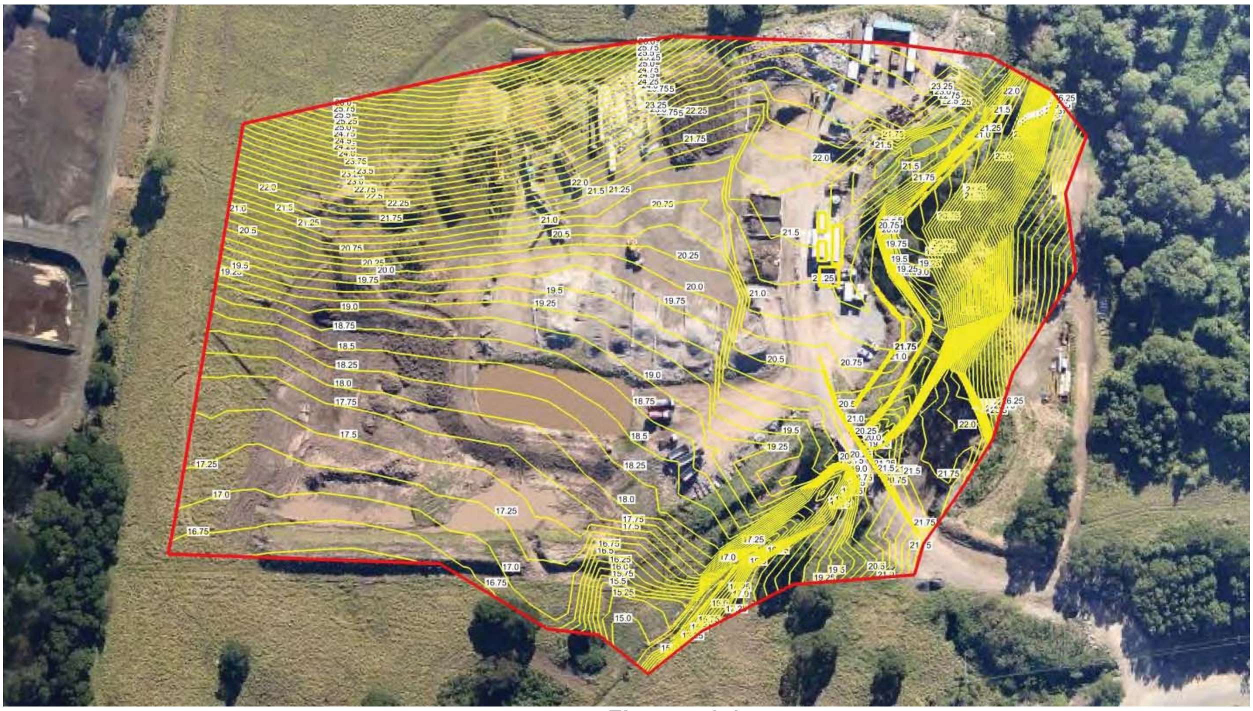

Figure 5.2.1
Pre-Developed Site Survey and Model Boundary

The post-development surface is shown in Figure 5.2.2. The boundary of the 2D domain is shown as a red line.

A 0.5m grid based on the 3D surface has been adopted for the post-development scenarios of this study.

Figure 5.2.2
Proposed Development Surface and Model Boundary

5.2.2 Roughness

Manning 'n' values allocated to each material type are presented in Table 5.2.1. Land not allocated to a material is given the default manning 'n' value.

Table 5.2.1
Mannings Roughness Values

ID	Coverage	Manning 'n' Value
1	Grass (Default)	0.035
2	Channel	0.045
3	Buildings & Storage Areas	0.080
4	Roadways	0.020

The model area has been divided into material types. Material allocations are presented in Figure 5.2.2. The 2D model extent is shown as a red line.

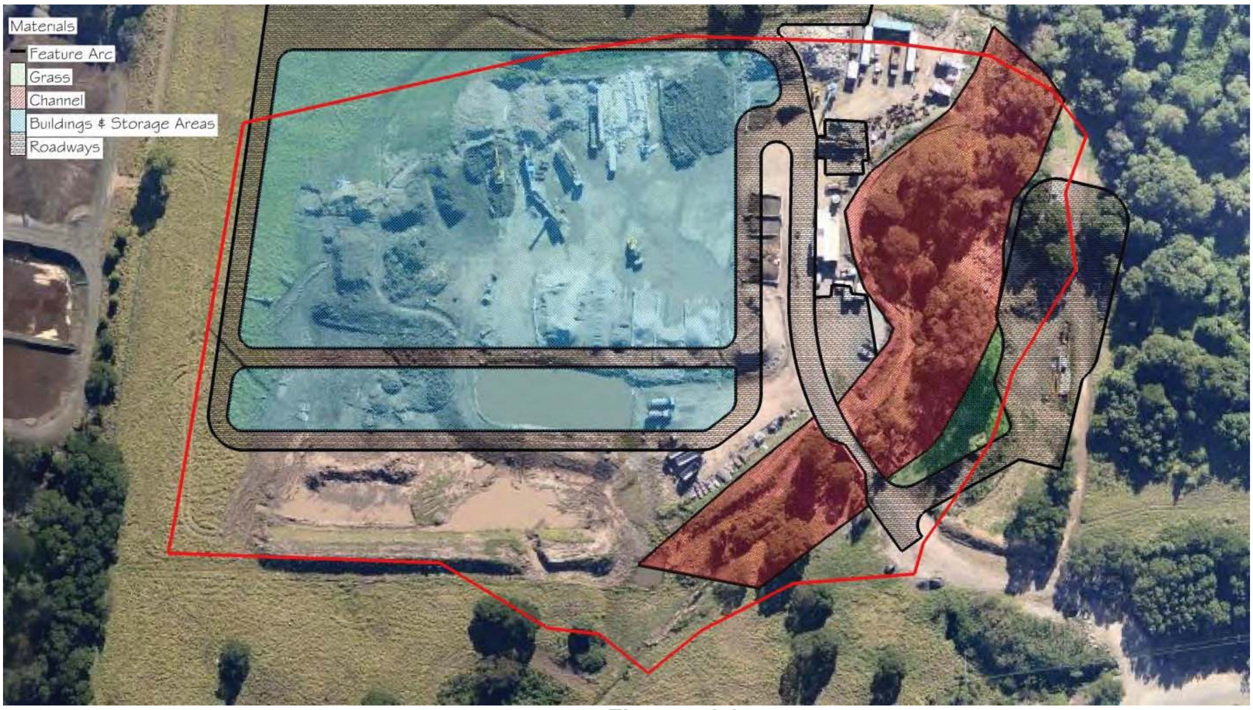

Figure 5.2.3
Material Coverage

There is a natural watercourse traversing the site. The watercourse is moderately vegetated upstream of the bridge. A mannings value of 0.045 has been adopted for the channel.

5.2.3 Boundary Conditions

Hydrographs shown in Figure 5.1.1, Figure 5.1.2 and Figure 5.1.3 have been used as a time series flow rate relationship at the upstream boundary.

The tail water boundary condition has been set as a water surface elevation to flow relationship based on a downstream water surface slope of 5%.

5.2.4 Simulations

Seven flood simulations representing different storms have been run in TUFLOW. These are presented in Table 5.2.2.

Table 5.2.2 – TUFLOW Simulations

Factor	Component
Conditions	Pre/Post-Unblocked/Post-Blocked
ARI	100yr/100yr with CC(Post-Blocked Only)/PMF

The pre-development model has been modeled using the layout of the previously approved development under DA2009/1153/A.

The post-development model differs from the pre-development model in the extent of bunding upstream of the bridge.

5.3 Results

The 2D hydraulic analysis shows the extent of flood inundation based on the survey data and critical 100 year ARI flood and PMF storm bursts.

Depths have been assessed at the locations of the cross sections used in the previous 1D analysis of the site to compared flood water levels.

5.3.1 Flood Maps

Flood inundation maps for the 100 year ARI and PMF showing depth, velocity and water level contours are attached as Appendix 3 to Appendix 5.

In the 100 year pre-development scenario, water will build up upstream of the bridge and overtop the northern bank. The water will run across the access way and re-enter the watercourse downstream of the bridge.

As previously discussed from the 1D analysis, the flood waters are contained within the channel for the 100 year unblocked scenario.

The 100 year ARI flood with blockage applied to the culvert will be contained within the watercourse as a result of the proposed development earthworks.

Access to the site is maintained in the 100 year blocked scenario as the vehicular access is not affected by flooding.

The 100 year blocked scenario maintains a safe access to the site.

The PMF overtops the banks of the channel upstream of the bridge in both the pre-development and post-development scenarios.

Parts of the access road and internal road network experience a high hydraulic hazard during the PMF.

The northern portion of the site is flood free for the PMF.

The equipment area, indoor processing shed and green waste shredding area are all above the PMF level. Workers who may be on site can seek refuge in these locations until the PMF subsides.

A minor part of the stockpile area is affected by the PMF when blockage is applied to the bridge culverts. The part of the stockpile area that is affected will contain crushed concrete. As the velocity of water within the vicinity of the stockpile is negligible, the stockpiled concrete will not be affected by the PMF and will not be conveyed into the adjacent watercourse.

It is noted that operations on site are weather dependent and it is unlikely the site will be occupied during extreme weather and lead up there to.

5.3.2 Flood Levels

Flood levels were taken for the 100 year ARI flood at the locations presented in Attachment 1. The flood levels are shown in Table 5.3.1.

Table 5.3.1 – Flood Study Comparison (Unblocked)

Section	Flood Study Results Comparison			Comment
	100yr ARI			
	KFW 2009	KFW 2013	KFW 2014	
1	22.79	22.78	22.45	
2	21.11	20.83	21.44	
3	20.21	20.96	20.98	
4	20.22	20.75	20.77	
5	20.01	20.74	20.76	U/S of brdg
6	19.30	18.86	18.72	D/S of brdg

These flood levels have been used to compare the results from the TUFLOW model to the previously determined flood levels using HECRAS.

5.3.3 Sensitivity Analysis

A sensitivity analysis has been performed to determine the effects climate change could have on flooding within the site in the 100 year ARI flood.

The rainfall data used to determine the critical 100 year ARI hydrograph has been increased by 30%, in accordance with the Practical Consideration of Climate Change (DECC 2007), to determine what impact this has on flood levels.

The accessway will be affected by flooding as a result of climate change. The water will overtop the roadway from the western bank upstream of the bridge and flow across the accessway. The velocity and depth of water is such that it is a low hydraulic hazard. Vehicles and pedestrians will maintain safe access to and from the site.

Table 5.3.2 presents the increase in flood water surface levels at different locations as a result of possible climate change effects.

Table 5.3.2 –Effects due to Climate Change on Flood Water Surface Levels

Section	100 year ARI Flood Level (Blocked) (m AHD)	100 year ARI Flood Level with Climate Change (Blocked) (m AHD)
1	22.45	22.62
2	21.35	21.73
3	21.39	21.75
4	21.32	21.67
5	21.32	21.67
6	19.22	19.27
7	17.56	17.67

5.4 REVIEW AND DISCUSSION

This flood study has reviewed the 100 year ARI flood water surface levels through use of a 2D model with a dynamically linked 1D network. The results have been compared to the previous 1D modelling of the site.

The PMF has been analysed for pre-development, post-development unblocked and post-development blocked scenarios.

Impacts on flooding due to climate change have been assessed in accordance with Practical Consideration of Climate Change (DECC 2007).

5.4.1 Flood Study Differences

There were some differences between this 2D flood study, the 2013 1D flood study and the 2009 flood study for the site.

Table 4.1 presents the differences between flood studies.

This flood study has applied a 2D analysis with a dynamically linked 1D network. This report is an addendum to the 1D HECRAS model produced in 2013 for the site.

This 2D model more accurately represented the flooding regime within the site as it is uses a digital terrain model. The 1D HECRAS model was based on 7 cross sections through the site.

The 2D model calculates water levels and velocities based on the number of cells provided. This 2D model was set up using a 0.5 m cells. As a result of the finite nature of the 2D model, the water levels are represented more accurately than that in the 1D model previously produced.

5.4.2 Comparison with Council's Mullet Creek Extension Flood Study

The extent of the 100 year ARI flood and PMF have been compared to flood maps produced for Council's Mullet Creek Extension Flood Study (Bewsher 2011).

The Mullet Creek Extension Flood Study is based off a coarse survey grid and is a regional model of flood inundation for Mullet Creek and its tributaries.

Notwithstanding, the flood mapping produced as part of this flood study is generally in accordance with the Mullet Creek Extension Flood Study flood mapping. This flood study is based off finer survey data and is a more realistic plot of the critical 100 year ARI flood.

Similarly, the PMF results presented in this flood analysis are generally in accordance with the PMF results presented in the Mullet Creek Extension Flood Study.

5.4.2 PMF

The PMF affects the south eastern portion of the site.

The operational area affected by the PMF represents approximately 22% of the site. A relatively narrow section adjacent to the water course is subject to a high hydraulic hazard. The remainder of the site affect by the PMF is a low hydraulic hazard. Refer to Appendix 5 for VxD maps.

Part of stockpile area is inundated during the PMF event. The part of the stockpile that is affected by the PMF is to be used to store concrete and bricks. The velocity of the PMF is insufficient to affect the stock pile and convey parts of the stockpile downstream. This velocity of the flood water is in the order of 0.25 m/s to 0.5 m/s within the area of the stockpile.

The site provides opportunity for safe refuge and shelter on site well away from PMF affected areas.

Operations on site are weather dependent. It is therefore highly unlikely that employees or other persons will be on site during a PMF. Safe refuge on site is a satisfactory option.

The site management plan should ensure that in the event of extreme rainfall all mobile plant and equipment are stored outside the PMF area.

5.4.3 Climate Change

The climate change assessment was performed in accordance with Practical Consideration of Climate Change (DECC 2007) in order to assess the possible impacts on flood levels as a results of climate change by 2070.

The analysis showed that increasing the rainfall intensity by up to 30% caused the flood level to overtop the channel to the north of the bridge. The overtopping results in minor localised flooding that does not affect the operation of the site nor isolate the site from main roads.

The localised section of the access road that floods experiences a VxD of less than 0.4 m^2/s and is safe for pedestrians and vehicles to cross.

The development will not be affected by possible future climate change increases in rainfall intensity.

6.0 CONCLUSION

This report has covered both Water Sensitive Urban Design and flood analysis of the proposed development on the Wyllie Road site.

The proposed WSUD sufficiently meets the required pollution reduction targets through implementation of the proposed WSUD devices.

The proposed OSD reduces the post-development site peak discharge to below pre-development levels.

The addendum flood study had been undertaken in accordance with Australian Rainfall and Runoff and the NSW Flood Development Manual.

The 2D analysis supports the flood levels previously determined using a 1D approach.

Flood inundation maps for the 100 year ARI and PMF presented in Appendix 3 to Appendix 5 indicate that the stockpile areas are not inundated during the 100 year ARI flood.

Climate change has been determined to have insignificant effects on the overall peak water surface elevation during the 100 year ARI flood.

The proposed development minimises the extent of flooding during a 100 year ARI flood when the bridge remains unblocked.

There is a minor increase in flood levels when the bridge has a blockage applied to it in accordance with WCC DCP 2009 Ch E14. The afflux is negligible and will not affect upstream or downstream properties.

The site has safe access during the 100 year ARI flood in both unblocked and blocked scenarios.

The proposed development will result in lower flood levels on downstream properties during the PMF as a result of additional site storage resulting from the earthworks of the proposed development.

The site provides the opportunity for safe refuge for employees during the PMF.

The PMF will not result in hazardous materials being washed from the site.

The proposed development is not adversely affected by flooding up to and including the 100 year ARI as flooding is contained within the existing watercourse in the culvert unblocked condition.

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Appendices:
Appendix A – Flood Inundation Maps - Depth
Appendix B – Flood Inundation Maps - Velocity
Appendix C – Flood Inundation Maps - Velocity x Depth

APPENDIX 1

Concept Plans