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Flooding & Drainage Assessment

for

Speers Point Quarry LES

Report Transmittal

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Executive Summary

Northrop Consulting Engineers have undertaken a Hydrology, Flooding, Drainage and Water Resources Investigation for inclusion in the Speers Point Quarry Local Environmental Study (LES). This investigation included a review of several factors, including flooding, detention, water quality and water management practices. Several strategies have been presented as part of this investigation for the purposes of examining the feasibility of re-zoning.

Flood extents for the 1 in 20yr ARI, 1 in 100yr ARI and PMF; and flood hydraulic and risk categories have been determined in accordance with the NSW Floodplain Development Guidelines. The majority of the flow onsite is categorised as “Floodway” with a “high” risk category. Despite this, urban development will not be prevented on the subject site, however consideration to lot layout and finished floor levels should be given to minimise risk to property and life.

Detention and water quality requirements have been considered in accordance with Lake Macquarie City Council DCP No.1. Both these items are feasible, with an approximation of a possible detention solution included. Water management issues for construction as well as for watercourse rehabilitation have also been outlined.

Through a review of all the factors considered in this report, it is considered that the subject site is suitable for re-zoning to facilitate urban and conservation development objectives from a flooding and drainage perspective.

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1 Introduction

Northrop Consulting Engineers were engaged by RPS to undertake a Hydrology, Flooding, Drainage and Water Resources Investigation for inclusion in the Speers Point Quarry Local Environmental Study (LES). This LES is to be submitted as part of a proposal to rezone land occupied by the former quarry to facilitate urban development and conservation.

1.1 Aim

The objective of this investigation was to determine the suitability of the proposed rezoning from a water management perspective. This involves the potential impact of flooding, as well as the effect of any future development on water quality and quantity both within and downstream of the site.

A range of potential issues have been investigated and possible alternatives evaluated. The discussion contained in this report is intended to be for a rezoning application only, and is not to be interpreted as detailed design solutions.

The recommendations contained herein have been determined in accordance and with consideration to the following planning instruments and documents;

- Lake Macquarie City Council's (LMCC) Development Control Plans (DCP)
- LMCC Lifestyle 2020 Strategy
- LMCC Lake Macquarie Sea Level Rise Preparedness Adaptation Policy
- LMCC Local Area Plans for surrounding areas
- NSW Government Floodplain Development Manual
- NSW Government Floodplain Risk Management Guideline – Practical Consideration of Climate Change
- Australian and New Zealand Environment and Conservation Council - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).

1.2 Site Characteristics

The site consists of Lot 21 DP 790637, Lot 1 DP 557315, Lot 1 DP 210440, Lot 1 DP 321254, and Lot 1 and 2 DP 105845 and has hereafter been referred to as "the subject site". The majority is zoned 7(2) and 4(1) with a small pocket in the western corner zoned 1(1). It is the former site of the Speers Point Quarry with extraction of rock ceasing in 2007.

The subject site shows significant evidence of its former use, with two large pits exhibiting a high level of erosion and very little re-vegetation. The north-western portion of the site is grassed with sparse vegetation, whilst the eastern and southern portions of the site are categorized by steep slopes and dense wooded vegetation.

Elevations on the subject site vary significantly from 26m AHD on the western side to 158m AHD in the east with large ridges separating the main catchments. A description of the catchments and watercourses is provided later in this report.

2 Flooding and Drainage

2.1 Objectives

The objective of undertaking a flooding assessment was to determine the effect of flooding on the subject site, as well as the effect of possible future development on downstream drainage paths. Specifically, the effects of the following cases were investigated;

- Runoff from upstream catchments.
- Flooding in Lake Macquarie.
- Flooding from watercourses traversing the subject site.
- Sea level rise and climate change.

This was undertaken through a catchment analysis and the use of computer modelling software XP-RAFTS and HEC-RAS. The results of this investigation are discussed below.

2.2 Catchments

The subject site comprised of several discreet catchments, whose boundaries reflected those of the site fairly well. A diagram of these catchments is included overleaf in Figure 1 and they are described briefly below in Table 1.

Catchment	Size *Ha*	Description
A	55.9	"Catchment A" is by far the largest catchment and contains the remnants of the sites former use as a quarry. For the purpose of this investigation, it has been broken into several sub-catchments in order to separate the largely undisturbed upper portion of the catchment from the quarry excavations downstream. Sub-catchments "A3-A6" are densely vegetated and contain a number of un-sealed tracks and ponds. "A1-A2" contains a mixture of undisturbed land and quarry workings known as Pit A. Vegetation for the undisturbed land appears similar to that observed upstream, whereas quarry workings were covered with coarse sediment and aggregate. Pit A appeared to drain to the catchment outlet; however Pit B is located in a depression and forms its own catchment, "A7". Several gullies form natural drainage paths which combine and discharge to the south-west.
B	11.7	"Catchment B" is located on the southern portion of the subject site and is separated from "Catchment A" by a large ridge running through the site. It is undisturbed and is covered by dense vegetation with some grassed areas. A gully forms a natural drainage path through the site which discharges to the south west.
C	9.5	"Catchment C" is separated by a ridge from Pit B and is located on the western side of the subject site. It is mostly grassed with some sparse vegetation. A natural overland flow path splits this catchment which discharges towards the south-west.

Catchment	Size *Ha*	Description
D	3.6	"Catchment D" is a small catchment on the north-western portion of the subject site near the existing concrete tank. It appears to be grassed and discharges to the north-west.
E	6.8	"Catchment E" forms part of the western boundary of the subject site and as such is adjacent to neighbouring residential properties. It slopes to the west and is grassed.

Table 1 - Description of catchment characteristics.

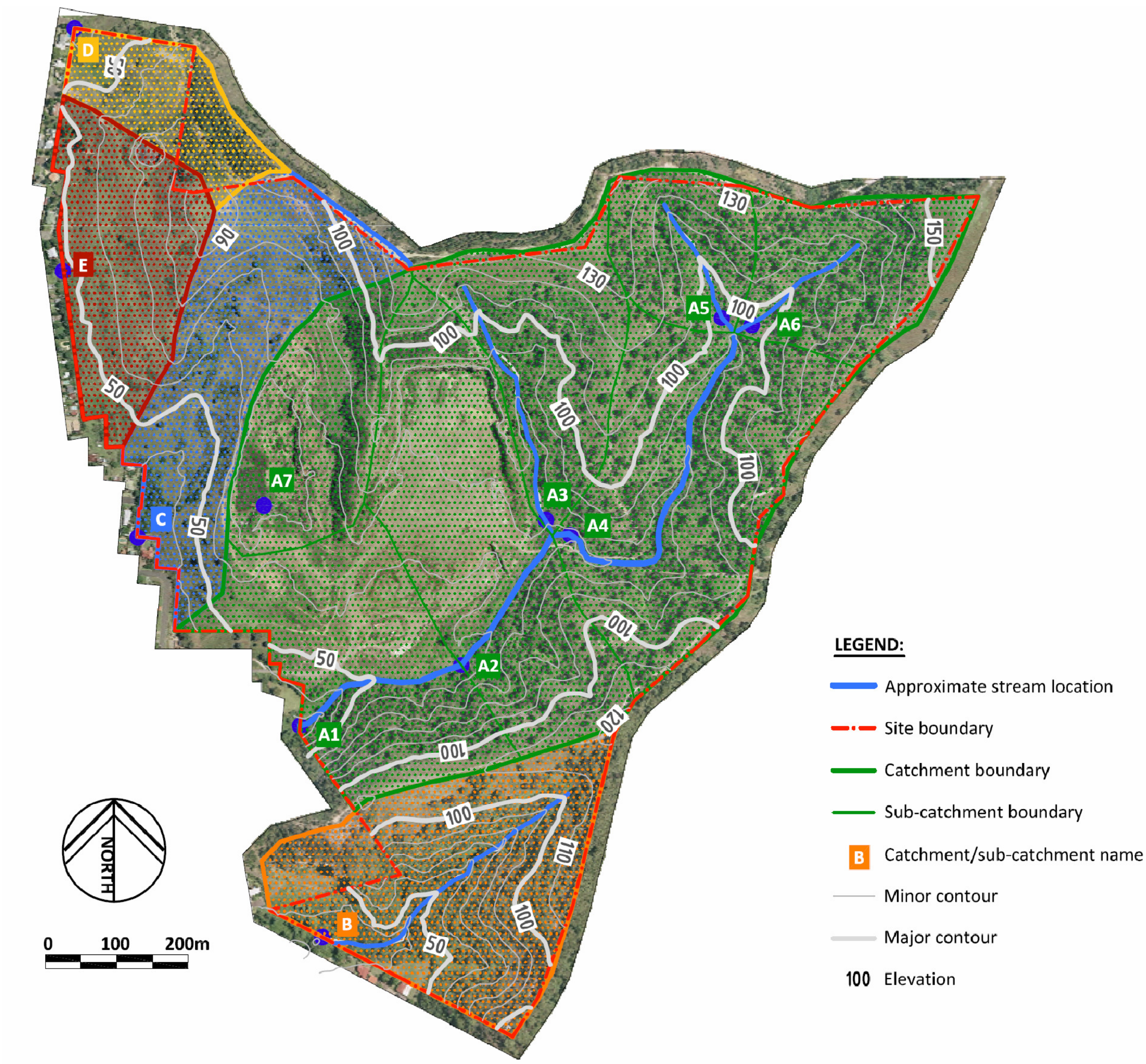

Figure 1 - Subject site showing catchments

2.3 Watercourses

A review of the 1:25,000 topographic maps available from the Department of Lands indicates the presence of several waterways on the subject site. A diagram of these is shown below in Figure 2.

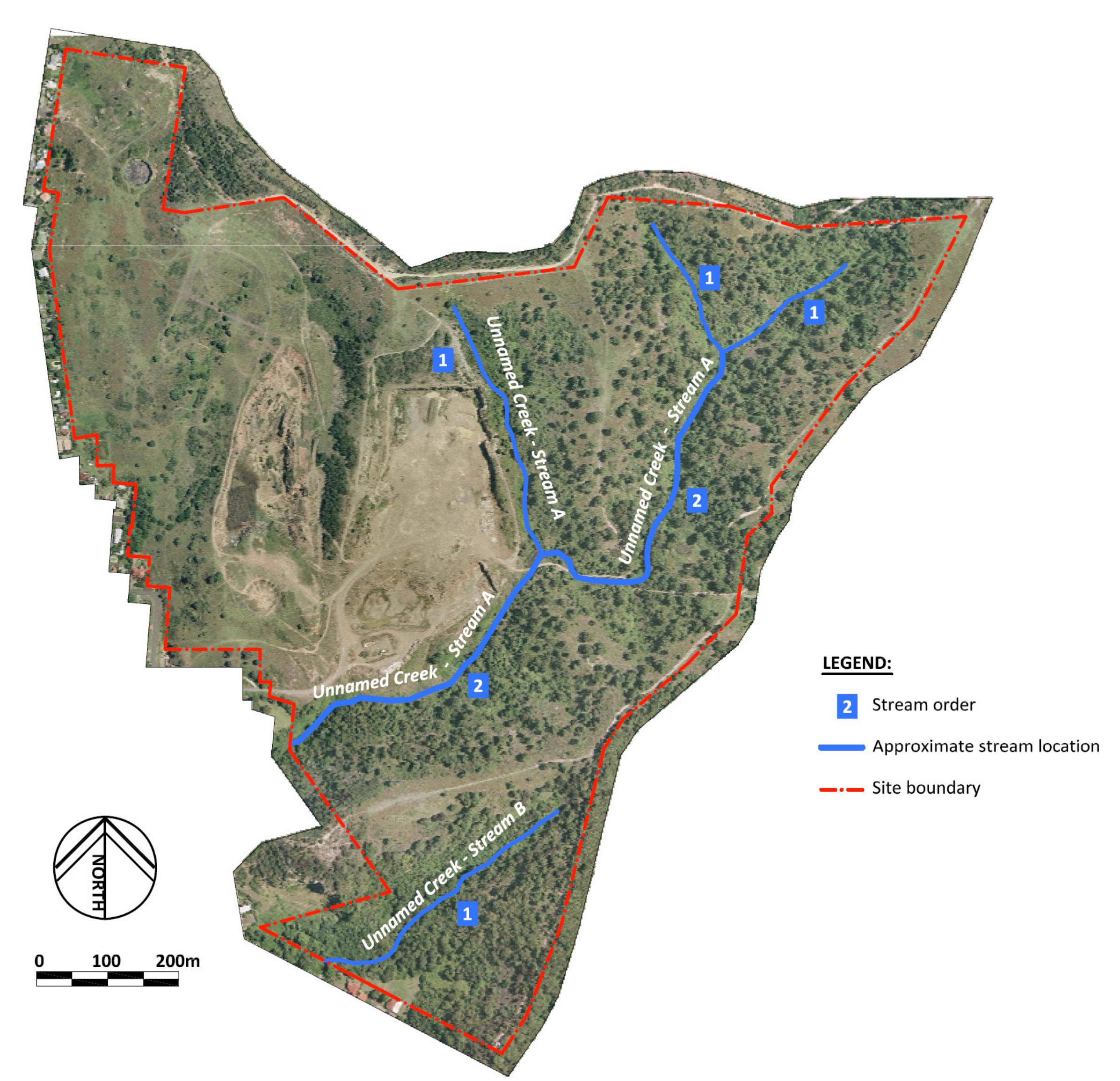

Figure 2 - Stream location and classification using the Strahler System

As shown, a small stream runs through "Catchment B" and several streams converge in "Catchment A". These streams have been categorised using the "Strahler System" as recommended by the former Department of Water and Energy in their "Government Agency Consultation Response". The Strahler system classifies watercourses from the upstream reaches of the catchment. Streams that form in these reaches are classified as first-order streams until they join with another first order stream in which case they become second order streams. A second order stream only becomes a third order stream when joined by another second order stream. This is reflected in Figure 2.

2.3.1 Unnamed Creek "Stream A"

Stream A forms on the upstream portions of the site, and several tributaries converge to form the major stream. This stream system captures water from most of the former quarry works. At this location, it diverges due to disturbance from quarry works and follows both a natural and disturbed route. This is shown below in Figure 3.

Figure 3 - Stream A at quarry showing natural flow path (L) and disturbed flow path (R)

2.3.2 Unnamed Creek "Stream B"

Stream B is located in an undisturbed catchment on the south of the site. It is highly vegetated and discharges to the south west. The highly vegetated nature of the site is evident in Figure 4

Figure 4 – Stream B showing dense vegetation

2.4 Flooding

2.4.1 Flooding from Upstream Catchments

As mentioned previously, the catchment boundaries reflect fairly accurately the boundaries of the site. Due to this topography, no other catchments drain through the site. Flooding from upstream catchments will not affect the subject site and was not considered further.

2.4.2 Flooding from Backwater Effects

The site is close to Lake Macquarie and as such the possibility of flooding from backwater was considered. The lowest outlet elevation is 26m AHD and the 1 in 100yr flood level for Lake Macquarie is currently 1.38m AHD. A lack of major control structures in the vicinity of the subject site means that flooding from backwater effects will not be an issue for any future development.

2.4.3 Peak Flows

Peak flows at sub-catchment boundaries have been estimated using XP-RAFTS. A schematic of the model used is shown below in Figure 5.

RAFTS can only have one outlet node which has been shown to join all the catchments as shown above. This is indicative only, and does not represent the direction of discharge from the subject site, or the location of convergence.

Sub-catchment data for the subject site was entered to reflect the specific characteristics of the land. This data included parameters such as roughness, size, slope and rainfall losses. Precipitation from the probable maximum event was estimated using the Bureau of Meteorology “Generalised Short Duration Method” and entered as custom storms into RAFTS. A number of storm durations and recurrence intervals have been considered and the peak discharges for each recurrence interval is presented below in Table 2.

2.4.4 Localised Flooding

Flooding will most likely be caused by runoff generated by localised catchments. In order to determine the extent of flooding, the hydraulic category, the velocity and hazard category of flow, a HEC-RAS model was compiled. Peak flows estimated above for the various recurrence intervals were used in this model.

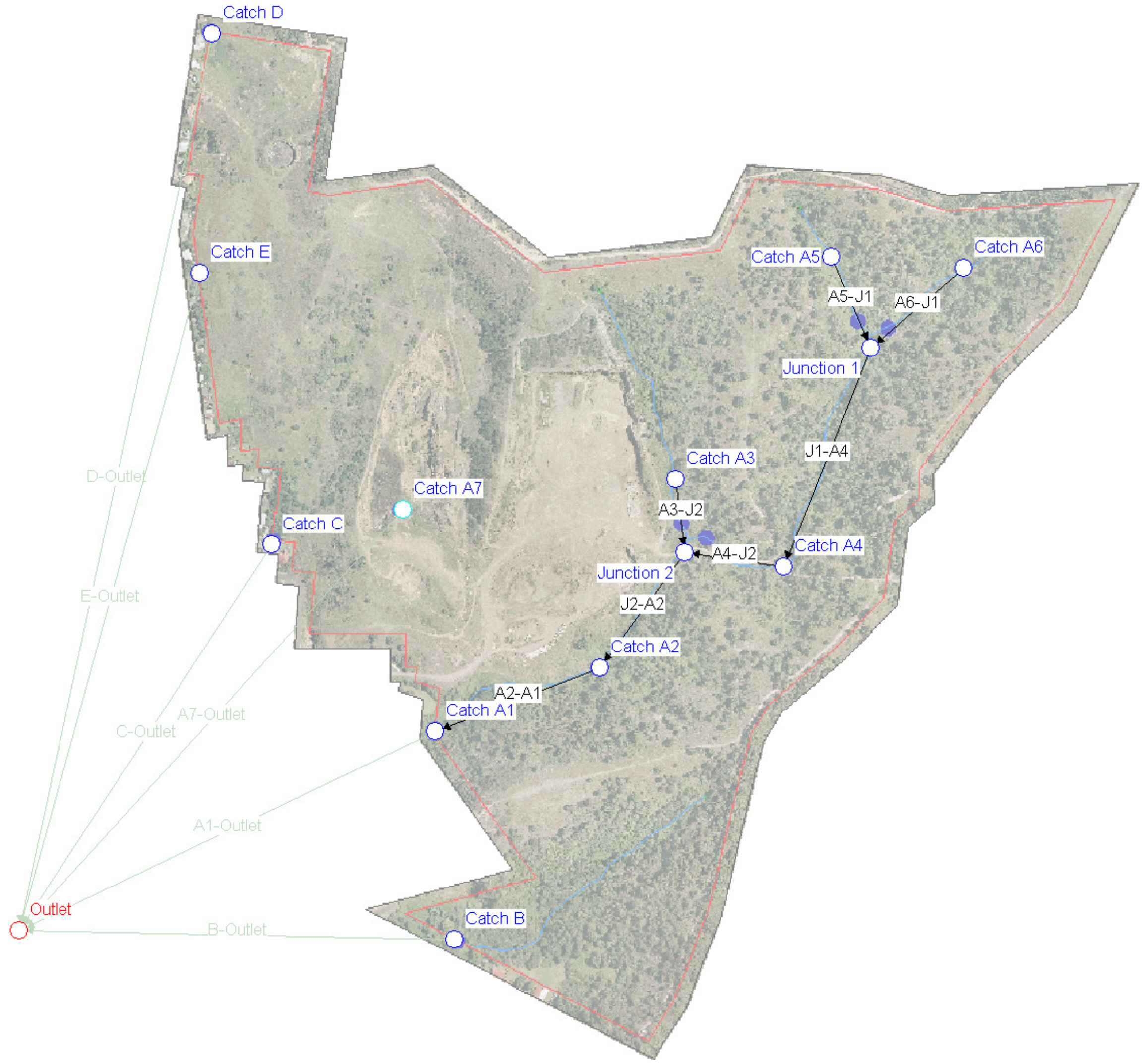

Figure 5 - XP-Rafts model used to calculate stream and catchment peak flow rates

Location	PMF m^3/s	1 in 100yr ARI m^3/s	1 in 50yr ARI m^3/s	1 in 20yr ARI m^3/s	1 in 5yr ARI m^3/s	1 in 1yr ARI m^3/s
A1	106.1	20.8	18.3	16.2	11.7	5.2
A2	85.5	16.0	14.1	12.5	8.9	3.9
A3	14.6	2.6	2.3	2.0	1.4	0.6
A4	44.5	8.0	7.0	6.1	4.4	1.8
A5	9.4	1.7	1.5	1.3	1.0	0.4
A6	13.0	2.3	2.0	1.8	1.3	0.6
A7	15.2	2.9	2.6	2.3	1.6	0.8
B	31.2	6.2	5.6	5.2	3.6	1.9
C	25.4	5.1	4.5	4.2	3.0	1.6
D	9.6	1.9	1.7	1.5	1.1	0.5
E	19.0	3.8	3.3	3.2	2.4	1.3

Table 2 - Flow rates at nominated points along the stream and from respective catchments

Flood Extents

Flood extents estimated for the 20yr, 100yr and PMF are shown below in Figure 6. A high value for Manning's roughness has been assumed in this model to represent the thick and overgrown state of the creek system.

Whilst the upstream section of stream A is overgrown and thick, adjacent to the quarry it has been significantly disturbed and modified. As outlined in LMCC DCP No.1 – Part 4.20 East Munibung Hill Area Plan, it is anticipated that this section would likely be modified and/or re-vegetated as part of any development to satisfy Council's intent for a "rehabilitation corridor". This reshaping would significantly alter flood behaviour and extent in this area and require further analysis; however it is considered a feasible option and would likely increase the amenity of the area.

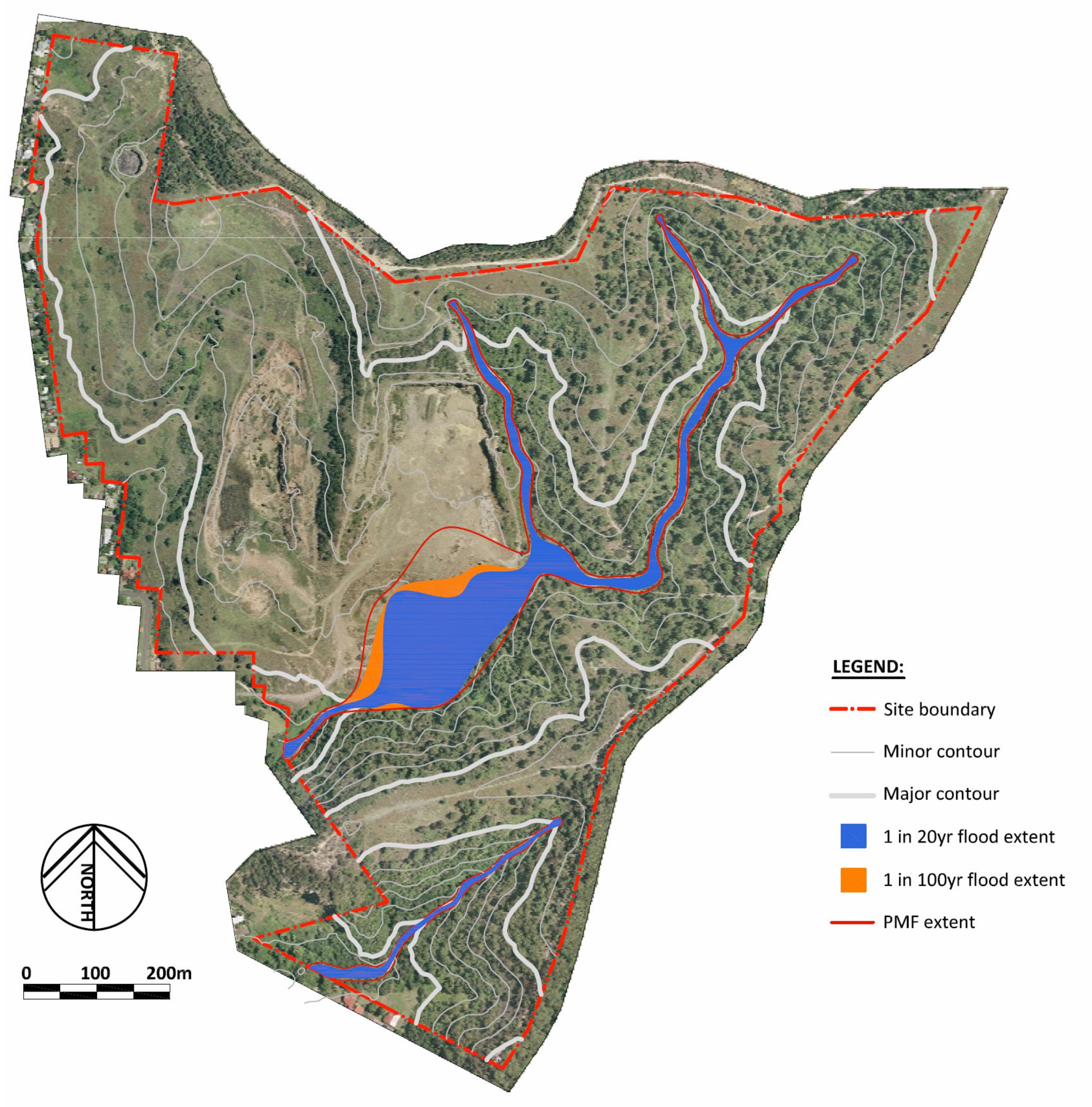

Figure 6 - Flood extents

Hydraulic and Hazard Categories

The N.S.W. Government's Floodplain Development Manual identifies hydraulic and hazard categories to help determine appropriate types of development within flood liable land. Hydraulic categories define the characteristics of flow dependent on how development will affect flood behaviour. Hazard categories define how flood flows are likely to affect development.

Three hydraulic categories, 'Floodways', 'Flood Storage' and 'Flood Fringe' are presented in the manual. Generally, floodways are aligned with the obvious natural channels and are those areas where a significant volume of water flows during floods. These areas, even if only partially blocked, are likely to cause a significant increase in flood levels and/or a significant redistribution of flood flows. Flood storage is those areas of a flood plain which provide temporary storage of flood waters during the passage of a flood. If the flood storage capacity is significantly reduced, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Flood fringe is the remaining area of flood affected land once floodways and flood storage areas have been defined.

Most of the runoff generated on the subject site is concentrated in a number of streams as outlined previously. In terms of hydraulic classification, this would result in the majority flow being "Floodway". A small portion in the PMF extent is classed as "Flood Fringe" where it breaks away from the 1 in 100yr ARI flood extent.

The manual defines two hazard categories to measure the possible adverse effects of flooding. These hazard categories are 'high hazard' and 'low hazard'. To define a hazard category consideration needs to be given to the threat to life, the potential for damage, the danger and difficulty of evacuating people and possessions and the extent of social disruption and loss of production caused by a flood. The process of evaluating a hazard category involves; firstly, evaluating the hazard based purely on hydraulic principles, and then refining the category based on other relevant factors. A table showing velocities at subcatchment outlets is shown below in Table 3.

Catchment	**PMF** m/s	**1 in 100yr ARI** m/s	**1 in 20yr ARI** m/s
A1	3.62	2.16	1.99
A2	0.75	1.38	0.32
A3	0.25	1.29	1.22
A4	1.92	1.71	1.61
A5	2.09	1.33	1.26
A6	2.21	1.75	1.45
B	2.52	1.74	1.66

Table 3- Velocities at catchment outlets

In order to determine whether flow is high hazard based on hydraulic principles, the manual gives guidance with respect to velocity and depth. All velocities over 2m/s and depths of over 1m are considered high risk, as well as moderate combinations of each. As shown, a significant portion of velocities are in the vicinity of 2m/s, and in other parts of the catchment are significantly more. Due to these conditions, the entire floodway has been determined to have a high hazard category.

Flooding from the streams is largely contained within the proposed riparian zones, expect for the aforementioned section in stream A. It is expected that these riparian zones will be maintained in accordance with best practice to preserve water quality and hydraulic characteristics.

Due to high velocities and depths, flow on the subject site is considered to be in the high hazard category. This will need to be taken into account when preparing a lot layout and determining land use in the vicinity of the watercourses for any future development.

2.4.5 Potential Increased Risk of Flooding

As a result of any potential development, the risk of localised flooding downstream is likely to increase. This arises due to increased peak flows from urbanisation of the catchments. It is considered that effective use of on-site detention to reduce post development flows to pre development rates will alleviate this issue as discussed later in this report.

2.4.6 Effect of Sea Level Rise and Climate Change

An increase in rainfall intensity and sea level rise due to climate change has been considered during the preparation of this report. It is likely that design rainfall intensities will change not only as a result of climate change, but as further information on rainfall estimation is released as part of Australian Rainfall and Runoff – 4th Edition (due 2012).

The former N.S.W Government Department of Environment and Climate Change “Floodplain Risk Management Guideline – Practical Consideration of Climate Change” recommends that a sensitivity analysis be conducted with an increase of 10%, 20% and 30% in peak rainfall “until more work is completed in relation to the climate change impacts on rainfall intensities”. This sensitivity analysis was not undertaken on this site due to the small impact likely on flood extents and levels. As shown in Figure 6, for an increase of over 500 percent (from 1in100yr ARI to PMF), the flood extent changes very little for the majority of the site.

As outlined in LMCC “Lake Macquarie Sea Level Rise Preparedness Adaptation Policy”, the water level in Lake Macquarie is also expected to rise from 1.38m AHD currently, to 2.47m AHD in 2100. As mentioned previously, the water level in the Lake is unlikely to have any impact of future development of the subject site and this is not expected to be affected by climate change.

2.5 Water Quality

Water sampling was undertaken at two locations as shown in Figure 7 overleaf. The purpose of collecting this data was to assess the current quality of runoff exiting the site. Samples were collected on the 27th May 2010, corresponding to a 24 hour to 9am rainfall total of 22.2mm at Williamtown.

The results for these tests are summarised below in Table 4 and compared with the ANZECC 2000 Guidelines. The ANZECC 2000 guidelines don't provide guidelines as to the acceptable concentrations for all of the contaminants tested for, however the affected contaminants were generally equal to or below the measurable limits.

Therefore, the results indicate that the values were within the desirable range of the guidelines and hence the quality of water, given the limited testing regime, seems reasonable for the intended purpose.

	EQL	Units	Stream A Results	Stream B Results	ANZECC Trigger Value
Unfiltered Metals					
Arsenic	5	µg/L	<5	<5	50
Cadmium	0.5	µg/L	<0.5	<0.5	5
Chromium	5	µg/L	<5	<5	50
Copper	5	µg/L	<5	5	1000
Nickel	5	µg/L	12	13	100
Lead	5	µg/L	<5	<5	50
Zinc	5	µg/L	39	45	5000
Mercury	0.1	µg/L	<0.1	<0.1	1
pH	0.1	pH units	7.4	6.7	6.5-7.5
Ammonia (as N)	0.01	mg/L	<0.01	0.04	0.9
NO_X (as N)	0.1	mg/L	0.30	0.44	0.5
Total Phosphorus (as P)	0.01	mg/L	0.04	0.02	0.05
Total Organic Carbon (TOC)	5	mg/L	<5	15	-
Dissolved Oxygen (DO)	0.1	mg/L	9.6	8.3	>6.5
Total Dissolved Solids (TDS)	5	mg/L	340	302	1000
Total Suspended Solids (TSS)	5	mg/L	<5	<5	-
Biological Oxygen Demand (BOD)	2	mg/L	<2	<2	-

Source: LabMark Environmental Laboratories report E048416.
EQL: Estimated Quantification Limit.

Table 4 - Water quality results

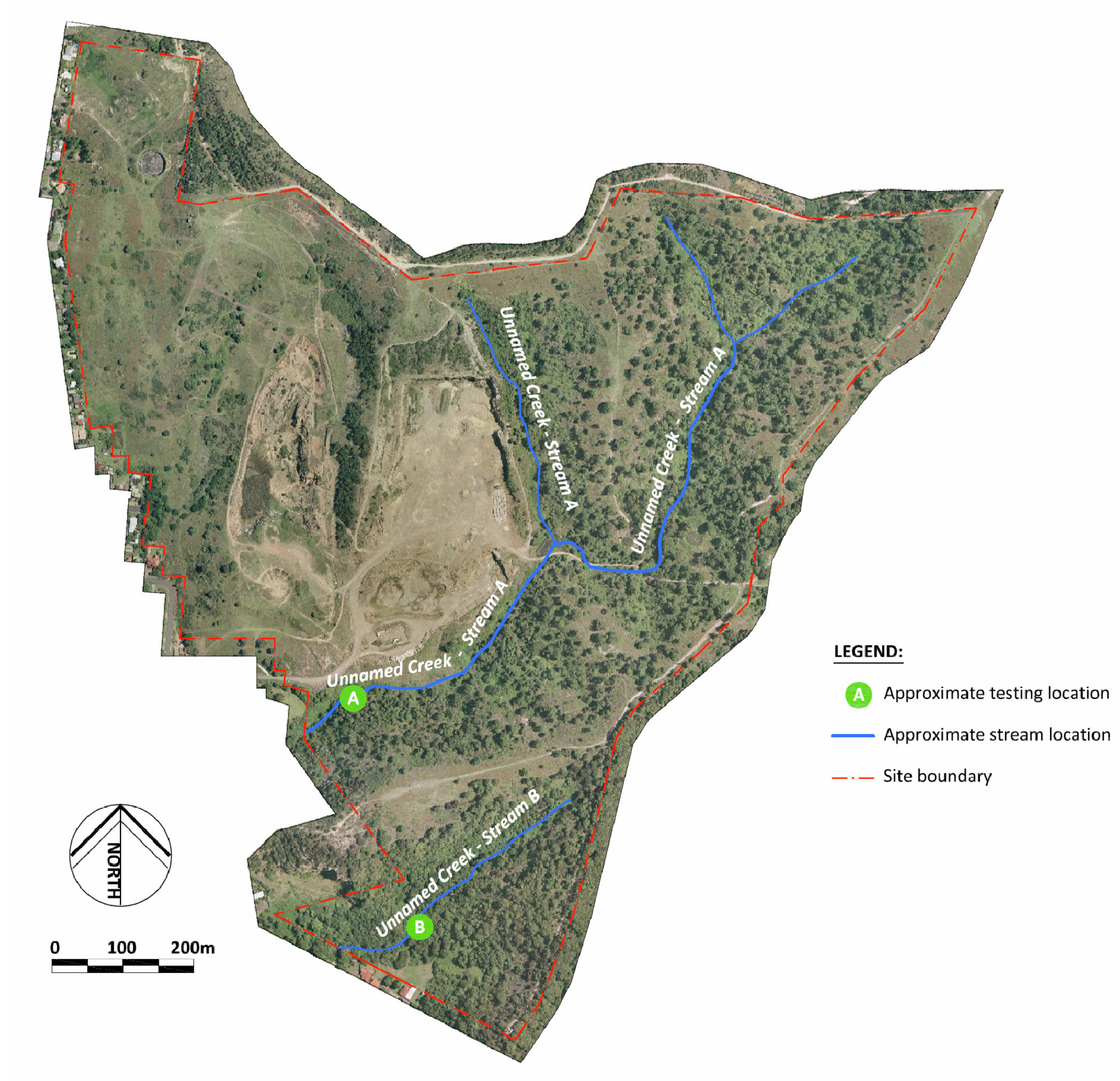

Figure 7 - Approximately water quality testing locations

3 Stormwater Management Strategy

3.1 Outline

This stormwater management strategy has been proposed in order to demonstrate that Council's policies and other statutory requirements are feasible on this site and to identify constraints that will affect any development.

3.2 Detention

Detention of water is designed to minimise the effect of increased peak flows from development on waterways downstream. This prevents damage such as erosion, destruction of vegetation and downstream flooding. Lake Macquarie City Council DCP No.1 – Section 2.5 nominates that;

> "Natural water bodies, waterways and vegetation are retained and protected from increased stormwater flows". (Clause P3.1)

> "For residential developments of more than 2 dwellings or lots and for all commercial and industrial developments on-site detention of stormwater will be required." (Clause P3.2)

Catchments within the subject site either contain a natural watercourse and/or have existing residential development downstream. Therefore, detention will be required for the site in order to achieve compliance with Council's policies.

For the purpose of this investigation, the provision of detention basins at a sub-catchment level and approximate size was explored using XP-RAFTS. Firstly, the model used to determine peak flows (see Section 2.4.1) was modified in order to estimate flows entering the stream from the individual sub-catchments. Sub-catchments were then urbanised assuming that land outside of the riparian zones was 70 percent impervious. Basins were added and sized to reduce the peak flow for the 1 in 5 and 1 in 100 year recurrence intervals back to pre-development flow rates. Experience would suggest that this method would have the same effect for most recurrence intervals. A plan showing approximate land grab is included in Figure 8 below.

This is not the only option for incorporating detention as part of any future development and should not be considered as such. Other options include detention as part of individual lots (such as "rain gardens" or water tanks) or a combination of "at-source" detention and regional basins.

As demonstrated, detention can easily be incorporated on the subject site to satisfy the requirements of Lake Macquarie City Council's DCP No.1.

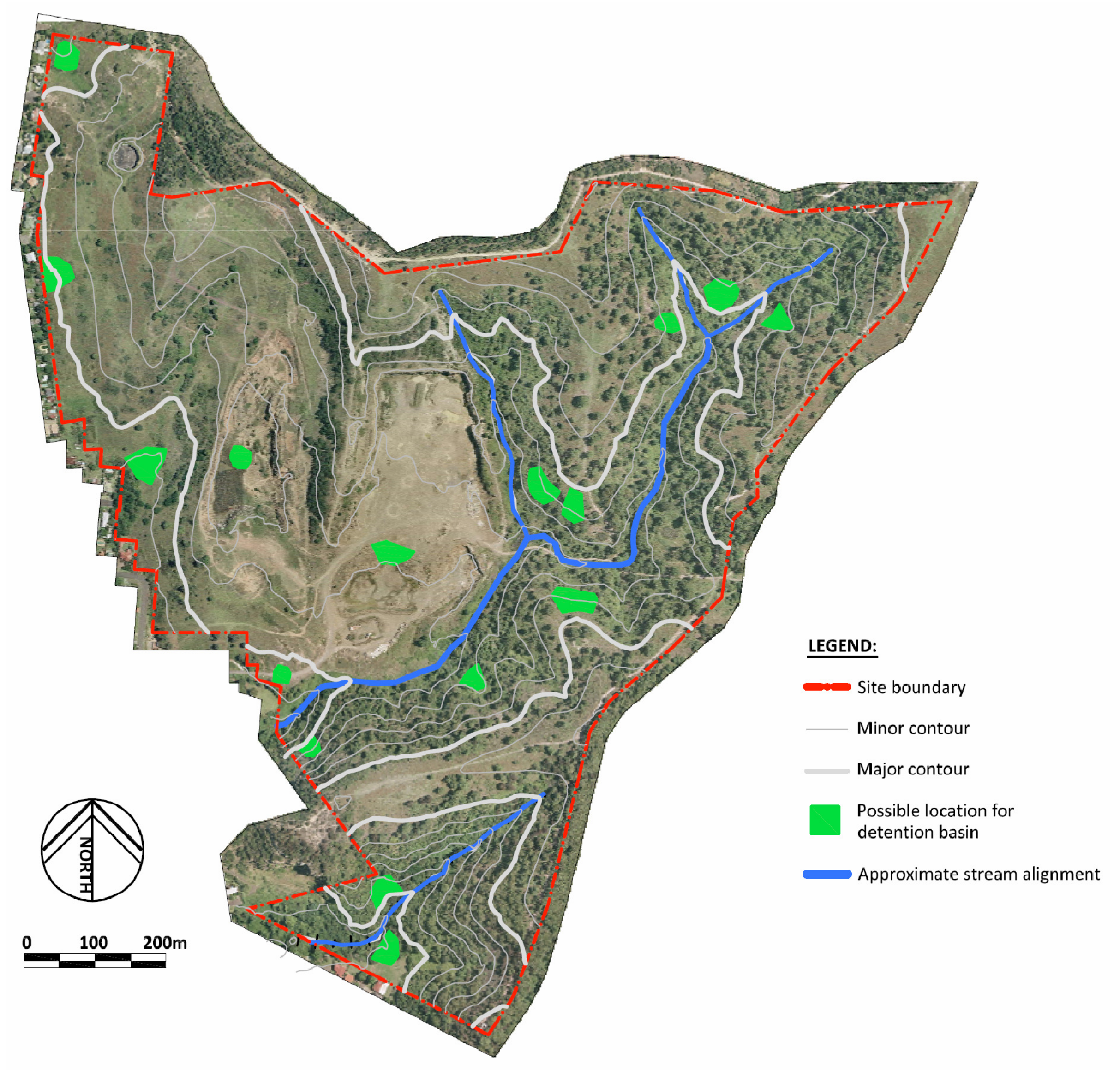

Figure 8 - Approximate size and location of detention basins

3.3 Water Quality

Currently the subject site is currently a mixture of disturbed and undisturbed land. In particular, the previous land use as a quarry is expected to have a high sediment load especially considering the lack of extensive re-vegetation and rehabilitation. Conversely, pollutant loads from the undisturbed areas upstream are expected to be relatively low. Lake Macquarie City Council DCP No.1 – Section 2.5 nominates that;

> "Stormwater discharge to surface and underground receiving waters during pre and post construction does not degrade the quality of receiving waters." (Clause P2.1)

> "The stormwater management system optimises the interception, retention and removal of water borne pollutants before their discharge to receiving waters." (Clause P2.2)

> "Point sources of pollution in the catchment are identified and their impacts minimised until they can be eliminated." (Clause P2.3)

> "The stormwater management system minimises the environmental impact of urban run-off on the quality of surface or ground receiving waters and on other aspects of the environment, such as ecologically valuable areas, ecological corridors and water bodies, waterways and wetlands." (Clause P2.4)

As a part of this investigation, the current land use and the effect of any development on pollutant loads generated from the subject site has been explored and discussed with reference to Council's policies.

In order to assess the pollutant loads and runoff volumes generated on the subject site, two MUSIC models were developed and compared. These were based on the current land use and future development based on the proposed urban development.

3.3.1 Pre-development

A pre development MUSIC model was created in order to reflect the current site characteristics. Nodes to represent the natural, undeveloped sub-catchments at the upper reaches of the site were separated from those catchments that have been affected by quarry activity. Grassed catchments adjacent to existing residential properties were also differentiated. Sydney Catchment Authority's "A Guide to the Use of MUSIC in Sydney's Drinking Water Catchments" was used in order to select pollutant loads for some of the pre-developed subject site. A synopsis of the pollutant loads adopted for all the sub-catchment is provided in Table 5.

Pollutant	Total Suspended Solids	Total Phosphorous	Total Nitrogen
Forest (A1N, A2N, A3, A4, A5, A6, B)			
Base (log mg/L)	0.90	-1.50	-0.14
Std Dev (log mg/L)	0.13	0.13	0.13
Storm (log mg/L)	1.90	-1.10	-0.08
Std Dev (log mg/L)	0.20	0.22	0.24
Rural Residential (C, D, E)			
Base (log mg/L)	1.15	-1.22	-0.05
Std Dev (log mg/L)	0.17	0.19	0.12
Storm (log mg/L)	1.95	-0.66	0.30
Std Dev (log mg/L)	0.32	0.25	0.19
Quarry (A1Q, A2Q, A7)			
Base (log mg/L)	1.20	-0.85	0.11
Std Dev (log mg/L)	0.17	0.19	0.12
Storm (log mg/L)	3.00	-0.30	0.34
Std Dev (log mg/L)	0.32	0.25	0.19

Table 5 - Pollutant concentration parameters for pre development model

This model was run with a 12-minute time step for 10 years worth of pluviograph rainfall data. The results for mean annual pollutant loads and flow volume are shown below.

Catchment	Flow (ML/yr)	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
A*	158.0	47900	27.70	193.00	92
A1N	14.2	626	0.83	12.20	91
A1Q	15.3	19100	8.73	36.50	111
A2N	13.4	479	0.70	11.10	0
A2Q	23.1	29900	13.50	54.30	168
A3	22.9	1020	1.36	19.90	147
A4	41.6	1840	2.46	34.90	267
A5	12.2	456	0.66	10.10	0
A6	17.6	643	0.94	14.70	0
A7	17.9	22000	10.10	41.90	130
B	39.9	1800	2.41	34.10	256
C	28.6	3260	7.15	60.80	207
D	11.0	1190	2.68	23.30	80
E	20.5	2280	5.10	43.50	149

Table 6 - MUSIC results for subject site predevelopment

**Note: "A" denotes a point at the site boundary and includes cumulative pollutant loads from sub-catchments A1-A6.*

3.3.2 Post-development

The pre-development MUSIC model was then modified in order to represent an urbanised catchment. It has been assumed that for any urban residential development, an impervious fraction of 70 percent can be expected. This has therefore been adopted during the urbanisation of the catchments, however riparian zones have been assumed to be entirely pervious. Urban nodes have been used in the development of this model and the pollutant loads are summarised below in Table 7.

Pollutant	Total Suspended Solids	Total Phosphorous	Total Nitrogen
Urban			
Base (log mg/L)	1.10	-0.82	0.32
Std Dev (log mg/L)	0.17	0.19	0.12
Storm (log mg/L)	2.20	-0.45	0.42
Std Dev (log mg/L)	0.32	0.25	0.19

Table 7 - Pollutant concentration parameters for post development model

Similarly, this model was run with a 12-minute time step for 10 years worth of pluviograph rainfall data. The results for mean annual pollutant loads and flow volume are shown below.

Catchment	Flow (ML/yr)	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
A	338.0	57700	122.00	913.00	1820
A1N	29.3	5300	11.40	83.30	846
A1Q	35.8	6610	14.10	101.00	1040
A2N	33.6	6400	13.30	95.20	965
A2Q	53.9	9970	21.00	151.00	1560
A3	44.4	7960	17.00	123.00	1290
A4	78.2	13800	29.70	217.00	2260
A5	25.8	4620	9.82	72.10	744
A6	39.2	7130	15.10	109.00	1130
A7	46.3	9090	18.90	132.00	1330
B	76.7	13600	29.40	213.00	2220
C	74.0	14000	28.90	209.00	2120
D	21.8	3770	8.19	60.10	622
E	53.5	10300	21.40	153.00	1530

Table 8 - MUSIC results for subject site post development

3.3.3 Comparison of Results and Operation of Development

A comparison showing percentage increase or decrease from pre to post development is shown below in Table 9.

Catchment	Flow (ML/yr)	Total Suspended Solids (kg/yr)	Total Phosphorus (kg/yr)	Total Nitrogen (kg/yr)	Gross Pollutants (kg/yr)
A	114	20	340	373	1885
A1N	106	747	1270	583	831
A1Q	134	-65	62	177	837
A2N	151	1236	1792	758	N/A
A2Q	133	-67	56	178	829
A3	94	680	1150	518	778
A4	88	650	1107	522	746
A5	111	913	1392	614	N/A
A6	123	1009	1503	641	N/A
A7	159	-59	87	215	923
B	92	656	1120	525	767
C	159	329	304	244	924
D	98	217	206	158	681
E	161	352	320	252	927

Table 9 - Comparison of MUSIC results

As expected, this shows a significant increase in pollutant loads for the developed scenario for all sub catchments except for suspended solids in those affected by the former quarry.

3.3.4 Urban Runoff Quality Control

Lake Macquarie City Council's "Stormwater Treatment Framework & Stormwater Quality Improvement Device Guidelines" are expected to be implemented in the design of any future development. Water sensitive urban design measures such as tanks, swales and constructed wetlands are recommended in this case. Alternatives such as proprietary water treatment devices could be considered to reduce the size of constructed wetlands or increase their efficiency; however they should not be considered as the only form of water quality control due to their expensive initial and ongoing cost.

Rainwater Tanks

Rainwater tanks on individual lots will perform as a primary treatment device and present several benefits including reduced potable demand as well as at-source control of roof water pollutants. Sediment and nutrients are removed from the stormwater stream thus increasing the efficiency of the treatment devices downstream.

Grass Lined/Vegetated Swales

Swales further filter stormwater and replicate natural concentration of water which is congruent to the objectives of a secondary treatment device. Sediment is deposited in the vegetation and some pollutants attach to soil particles and organic matter. The use of swales on the subject site depend on the layout employed, and would best be suited if aligned approximately parallel to the contours adjacent to roadways.

Constructed Wetlands

Constructed wetlands provide tertiary treatment for stormwater and can double as public open space. This has the potential to increase the amenity of the site and also provide treatment suitable to be released further downstream. In this case, extended detention can also be provided above the wetland to reduce peak flows back to pre development levels. In the interest of public safety, DCP No 1, Volume 2, Part 5 – Batter Slope Treatments and Fencing Guidelines for Constructed Wetlands and Detention Basins should be consulted when designing these devices.

Proprietary Devices

Proprietary devices such as gross pollutant traps, pit inserts or filtration technology may be considered to supplement the treatment train at various stages. This may have benefits in terms of reducing land occupied by water treatment devices; however they are not to be considered as a replacement. Generally, these devices are expensive to install and maintain and also can have reduced efficiency when not maintained adequately.

Pollutant loads on the subject site are likely to increase significantly as a result of development which could occur under the new zoning. Water quality treatment of runoff originating from this development would be an essential step in maintaining the health of Lake Macquarie. Through the implementation of appropriately sized water sensitive urban design features such as those described above, we believe that Lake Macquarie City Council's policies for water quality will be able to be met.

3.3.5 Construction Runoff Quality Control

Management of water quality during any construction activity on the subject site is to be undertaken in accordance with the recommendations outlined in Landcom's, "The Blue Book: Managing Urban Stormwater". This may include but not limited to; cut off swales on the high side of disturbed work, sediment fences, sediment basins, staked bales and stockpile erosion protection.

3.4 Riparian Zones and Watercourse Rehabilitation

Riparian zones perform important environmental functions and serve to preserve the amenity and function of the watercourse. Furthermore, as part of LMCC DCP No.1 Part 4.20 - East Munibung Hill Area Plan, a rehabilitation corridor is proposed along the approximate alignment of "Stream A". Therefore, it is assumed that as part of any development in the area, the watercourse, core riparian zone and vegetated buffer zone will be modified and maintained to satisfy environmental outcomes as well as public amenity.

Riparian zones and vegetated buffer zones have been included on the subject site as recommended by the former Department of Water and Energy in their "Government Agency Consultation Response". Width between banks has been adopted as four metres for first order streams, and ten metres for second order streams which has been chosen as the width to convey frequent rainfall events. This, along with riparian zones and vegetated buffer widths, are to be confirmed by the department at DA stage for any future development. The core riparian zone is then determined from this assumed top of bank location. Riparian zone widths are shown below in Table 10.

Stream Reach	Core Riparian Zone Width (m)	Vegetated Buffer Zone Width (m)
A6-J1, A5-J1, A3-J2, B	10	10
J1-A4, A4-J2, J2-A2, A2-A1	20	10

Table 10 - Widths of riparian zones

A diagram of these zones is shown below in Figure 9.

In order for riparian zones to be successful, effective maintenance should be undertaken. Details of any rehabilitation proposal and ongoing maintenance should be included as part of the development application. Consideration in the preparation of these documents should include;

- Removal of weeds and non-native vegetation.
- Definition of stream banks and paths
- Selection of appropriate vegetation as outlined in LMCC "Estuarine Creekbank Stabilisation and Rehabilitation Guidelines" and NSW Office of Water "Guidelines for Controlled Activities: Vegetation Management Plans".

Through proper design and management, the use of core riparian zones and vegetated buffers could improve the amenity of any future development and form part of a rehabilitation corridor in the Munibung Hill area.

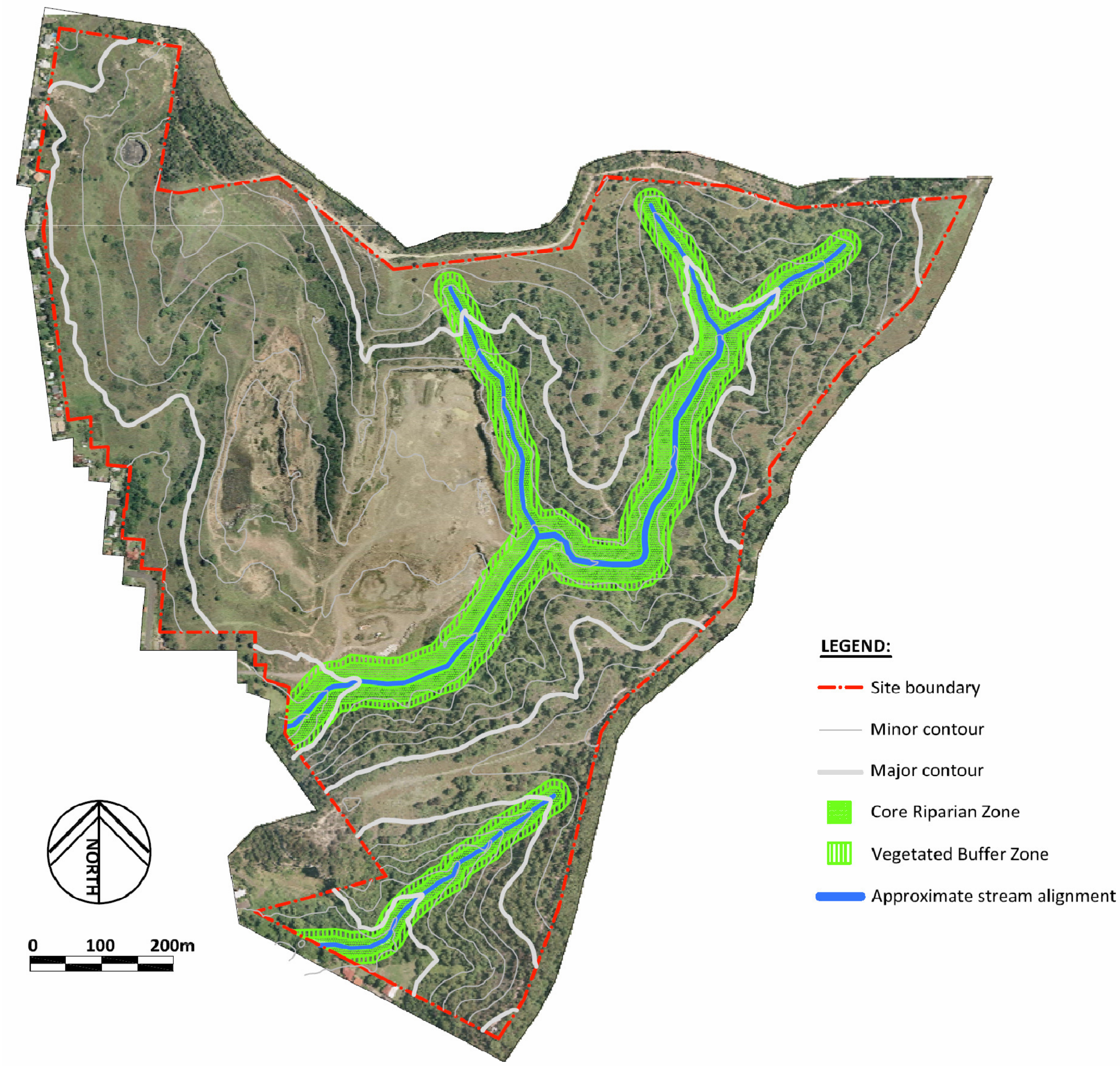

Figure 9 - Riparian zones and vegetated buffers

4 Discussion and Recommendations

4.1 Flooding

As deduced earlier, the subject site will likely be susceptible to localised flooding generated by concentrated runoff. For the purposes of this investigation, the existing topography has been examined and adopted using observations gathered from site. The flood extent does not prohibit urban development or conservation objectives stipulated; however choice of vegetation and creek remodelling will need to be considered further.

As part of rehabilitation objectives stated for the subject site, it is anticipated that creek modification will form part of the proposed development. It is advised that this process consider the high velocity expected and flora selected appropriately as well as additional modelling undertaken to determine the revised extent and account for any further information relating to rainfall intensity and climate change.

4.2 Water Management

Any future development should enact a water management plan that accounts for detention, water quality and the maintenance of riparian corridors.

Detention can be provided in several ways on-site, including the use of regional detention basins or through “at source” measures such as tanks or rain gardens. It is not the purpose of this report to provide a design solution to this problem, but simply to state that these measures will achieve the desired outcome of attenuating peak discharge. When selecting an approach, consideration should be given to proposed lot layouts, land use and topography to determine the suitability or efficacy of a solution with respect to Council policies.

Water quality treatment should be provided on-site to meet Council’s requirements. It is proposed that this be achieved through the use of water sensitive urban design features such as rainwater tanks, grassed swales and constructed wetlands. Due to the steep nature of many portions of the site, the lot layout will largely determine the suitability of these devices. Proprietary devices could also be considered to supplement the treatment train at various locations.

It is expected that riparian corridors and vegetated buffer zones will be required as part of any future development. This would be in line with the intent of the East Munibung Hill Area Plan which documents a rehabilitation corridor running through the subject site. It is recommended that vegetation within this zone be appropriately selected and maintained in accordance with industry best practice. Reference documents may include LMCC “Estuarine Creekbank Stabilisation Rehabilitation Guidelines” and the former NSW Department of Water and Energy “Guidelines for Controlled Activities – Vegetation Management Plan”.

Through compliance with LMCC DCP No 1 and associated guidelines and the implementation of water sensitive urban design features, the subject site should be able to accommodate urban and conservation land uses from a flooding and stormwater perspective.

5 Conclusion

Based on a review of several factors, including flooding, detention, water quality and water management practices; it is considered that the subject site is suitable for re-zoning to facilitate urban and conservation development objectives from a flooding and drainage perspective. Several strategies have been presented as part of this investigation for the purposes of examining the feasibility of re-zoning. These are by no means detailed design solutions and any future development should consider the latest information regarding water management and urban flooding estimation and design accordingly.

6 References

Australian and New Zealand Environment and Conservation Council (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000);

Lake Macquarie City Council Lifestyle 2020 Strategy;

Lake Macquarie City Council (1999) Stormwater Management Plan;

Lake Macquarie City Council (2003) DCP No.1 – Volume 2 – Engineering Guidelines – Stormwater Treatment Framework and Stormwater Quality Improvement Device Guidelines;

Lake Macquarie City Council (2004) Lake Macquarie Local Environmental Plan 2004;

Lake Macquarie City Council (2006) DCP No.1 – Volume 1 – Guidelines - Water Cycle Management Guidelines;

New South Wales Government (2001) Floodplain Development Manual: the management of flood liable land

New South Wales Government Department of Environment and Climate Change (2007) Floodplain Risk Management Guideline – Practical Consideration of Climate Change;

The Institute of Engineers, Australia (1987) Australian Rainfall and Runoff - A Guide to Flood Estimation;

Webb, McKeown & Associates Pty. Ltd. (2000) Lake Macquarie Floodplain Management Study;

Webb, McKeown & Associates Pty. Ltd. (2001) Lake Macquarie Floodplain Management Plan.