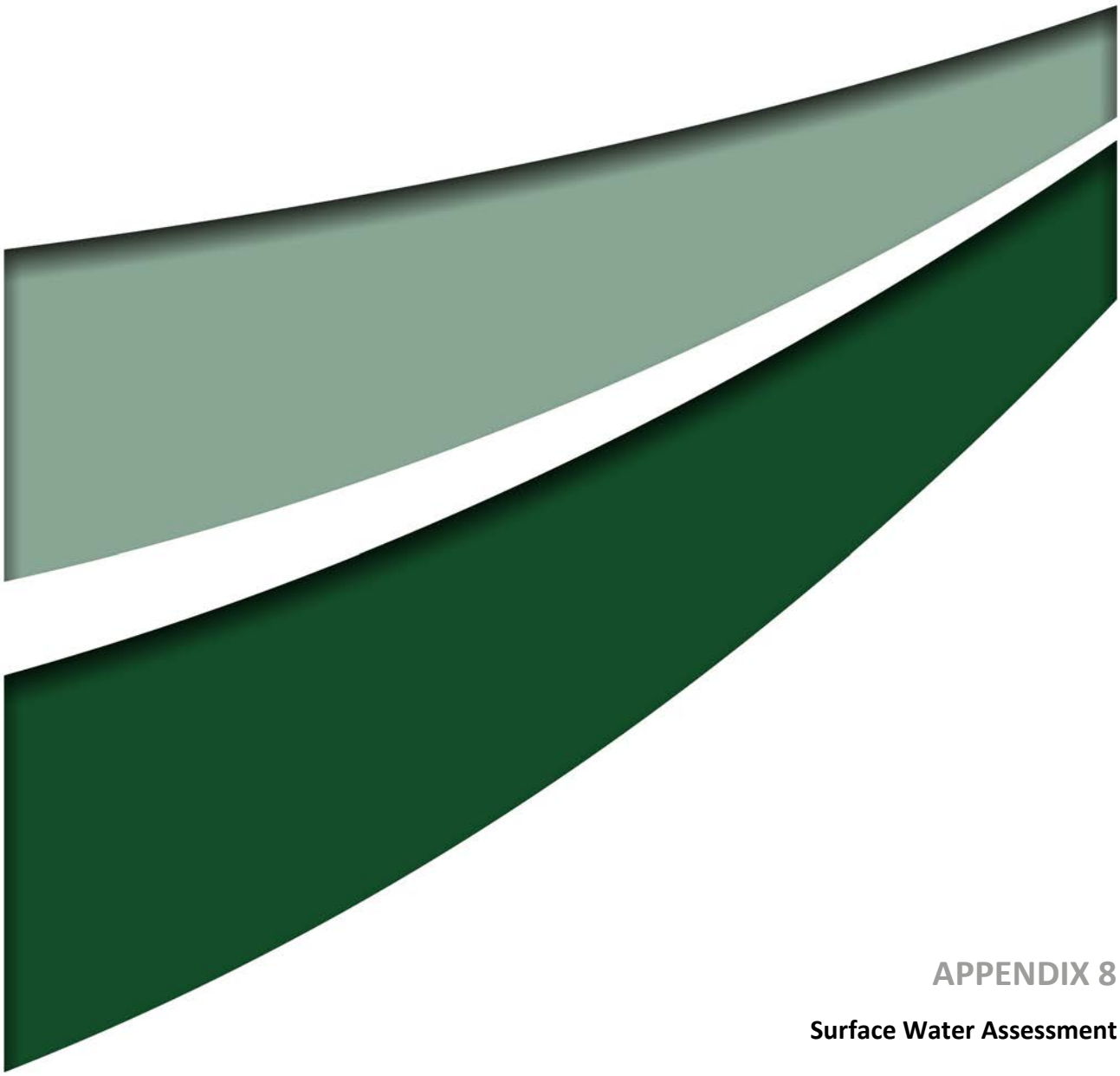

APPENDIX 8

Surface Water Assessment

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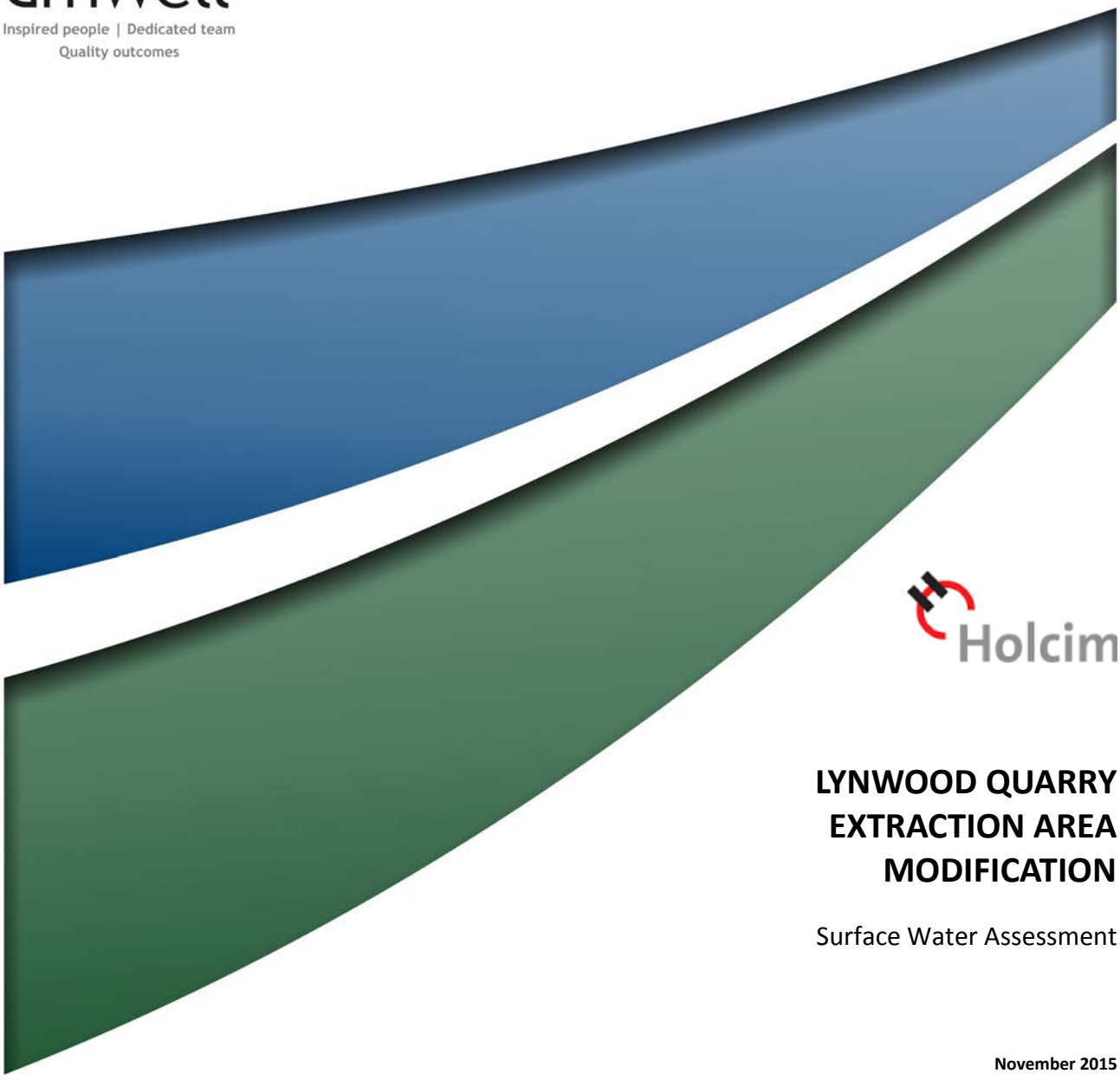
Quality outcomes



Holcim

LYNWOOD QUARRY EXTRACTION AREA MODIFICATION

Surface Water Assessment

November 2015

LYNWOOD QUARRY
EXTRACTION AREA MODIFICATION

Surface Water Assessment

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Holcim Australia

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Report No.	3330/R11
Date:	November 2015

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This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

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1.0 Introduction

Holcim (Australia) Pty Ltd (Holcim Australia) was granted development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) in December 2005 by the NSW Minister for Planning to construct and operate Lynwood Quarry west of Marulan, NSW (refer to **Figure 1.1**). Lynwood Quarry is approved to produce a maximum of 5 million tonnes per annum (Mtpa) of quarry product at the site. Construction of the quarry commenced in late 2010, with operations commencing in late 2015.

As discussed in **Section 1.1**, Holcim Australia is seeking approval to quarry a granite resource located to the west of the existing Lynwood Quarry extraction area. This approval is being sought via a modification to the existing development consent under Section 75W of the EP&A Act. Umwelt (Australia) Pty Limited (Umwelt) has prepared this Surface Water Assessment (SWA) as part of the Environmental Assessment (EA) that has been prepared to accompany the modification application.

1.1 Overview of the Approved Lynwood Quarry and the Modification Project

Holcim Australia has development consent (DA 128-5-2005) to construct and operate Lynwood Quarry to produce up to 5 Mtpa of quarry product until 1 January 2038 (the Approved Operations). The approved quarry includes a quarry pit, overburden and excess product emplacement areas, processing facilities, road and rail loading facility and associated infrastructure and activities (refer **Figure 1.2**). Lynwood Quarry is approved to transport up to 1.5 Mtpa of the approved annual production limit of 5 Mtpa by truck and all of the 5 Mtpa by rail. DA 128-5-2005 was most recently modified in 2011 to provide for reconfiguration of the rail line from a balloon loop to a rail spur and associated changes to the infrastructure layout.

Holcim Australia commenced operational readiness works in the approved quarry pit (an ignimbrite resource) in 2012 as part of the construction phase of the quarry and is now in the commissioning phase with operation of the quarry planned to commence in mid to late 2015. Material extracted from the approved Lynwood Quarry pit (the Approved Pit) was used in the onsite civil works and to prepare the quarry pit ready for operation (e.g. removing overburden to expose the ignimbrite resource).

During the operational readiness works, further drilling and material testing has revealed that the resource in the Approved Pit is more variable and substantial areas are characterised by more significant concentrations of either intense fracturing, alteration, clay, or a combination of these characteristics, than was detected during the earlier resource assessment investigations. The variability and complexity of the approved Lynwood Quarry resource will challenge Holcim Australia's ability to consistently supply in-specification products from Lynwood Quarry to the market.

Holcim Australia is therefore seeking approval to extract quarry resources on Holcim Australia owned land, which adjoins the existing Lynwood Quarry Project Area to the west of the Approved Pit. The proposed additional extraction area (the Granite Pit) is a granite resource and has different properties and mineralogy to the currently approved ignimbrite resource. Extensive drilling and testing of the granite resource has revealed that it is homogeneous, relatively unaltered and unfractured. The proposed granite resource will enable Holcim Australia to consistently produce the in-specification products required to be delivered by Lynwood Quarry to supply the local, regional and Sydney markets.

FIGURE 1.1

Locality Plan

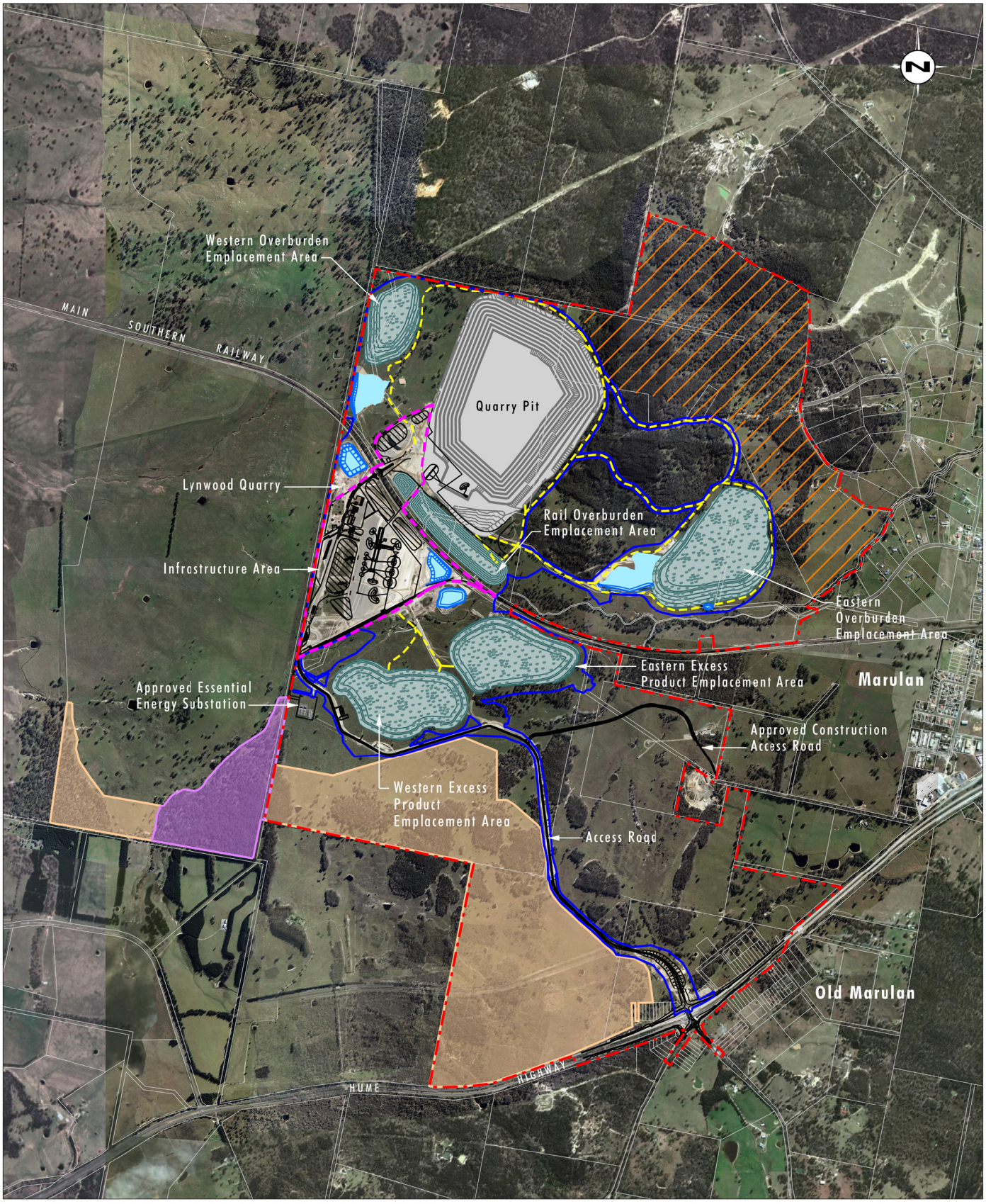

Image Source: Holcim Australia (Aerial Photo March 2012)
Data Source: LPI 2014

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Legend

- Approved Project Area
- Lynwood Infrastructure Facilities
- Haul Road
- Approved Disturbance Footprint
- Quarry Pit
- Rehabilitated Area
- Dam
- Existing Biodiversity Offset Area (EPBC)
- Existing Habitat Management Area (EPBC)
- Existing Habitat Management Area

FIGURE 1.2

Approved Conceptual Quarry Plan (Year 30)

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1.2 Extraction Area Modification

The proposed Extraction Area Modification (hereafter Modification Project) comprises development of the following key features:

- a Granite Pit extraction area to the west of the existing Approved Pit
- reduction in the extent of the Approved Pit to reflect limitations within the ignimbrite resource
- revised overburden emplacement areas
- additional haul roads and water management system structures
- additional visual bund and vegetative screen.

These features are shown in **Figure 1.3**. Other than the proposed changes to the layout or footprint of the development, the Lynwood Quarry project from an operational perspective will be largely unchanged from the currently approved operations. **Table 1.1** compares the proposed modified development to the existing approved operations.

Table 1.1 Comparison of Approved Project and the Modification Project

Major Project Components/Aspects	Approved Project	Proposed Modification Project
Quarry Life	Development consent to cease on 1 January 2038	No change.
Limits on Production	5 Mtpa saleable product	No change.
Maximum Transportation of Product by Rail	5 Mtpa	No change.
Maximum Transportation of Product by Road	1.5 Mtpa	No change.
Rail Facilities	Rail spur and loading facility as shown on **Figure 1.3**	No change.
Infrastructure (e.g. processing plant, rail infrastructure, truck loading infrastructure, workshop, offices etc.)	As shown on **Figure 1.2**	No change to approved infrastructure. Additional haul road to connect to new Granite Pit and water management structures (refer to **Figure 1.3**).

Major Project Components/Aspects	Approved Project	Proposed Modification Project
Hours of Operation	Topsoil / overburden removal / emplacement; Drilling • 7am to 6pm Blasting • Mon to Sat - 9am to 5pm • Sunday and public holidays – none Extraction • 7am to 10pm Processing, loading, delivery and distribution; maintenance • 24 hours per day	No change.
Employment	Employment at maximum production of approximately 115 people (including road transport drivers).	No change.
Quarry Footprint	As shown on **Figure 1.2**	Development of new Granite Pit to the west of the existing Approved Pit (refer to **Figure 1.3**). Reduction of the Approved Pit footprint by approximately 55 hectares.
Overburden and Excess Product Emplacement Areas	As shown on **Figure 1.2**	The approved Western and Eastern Overburden Emplacement Areas will no longer be required. Instead, emplacement areas to handle overburden from the Granite Pit will include backfilling the Approved Pit (refer to **Figure 1.3**), emplacement within part of the currently approved quarry limit, and a proposed emplacement area adjacent to the Granite Pit. A visual bund will also be developed to west of the Granite Pit (refer to **Figure 1.3**).

Major Project Components/Aspects	Approved Project	Proposed Modification Project
Total Disturbance Footprint	As shown on **Figure 1.2** (approximately 383 hectares)	The disturbance footprint will extend to the west to provide for the proposed Granite Pit and associated infrastructure and decrease in the east through a reduction in the Approved Pit disturbance footprint and associated overburden storage and haul roads to the east. Total disturbance footprint approximately 499 hectares.
Construction Phase	Largely completed, quarry currently in commissioning phase.	Construction limited to construction of haul road to proposed extraction area, visual bund and water management infrastructure.

1.3 Potential Surface Water Impacts

The following are the key aspects of the Modification Project that have the potential to impact on the surface water resources:

- landform changes as a result of the proposed Granite Pit and modifications to quarrying operations associated with the Approved Pit, including
    - quarrying
    - overburden emplacement areas
    - clean water management
- changes to the Lynwood Quarry water balance associated with the Modification Project.

The location of these proposed changes are shown on **Figures 1.2** and **1.3** and the associated conceptual surface water management system changes are discussed in **Section 3.0**. The potential impacts of the Project and proposed surface water management strategies are discussed in **Section 5.0**.

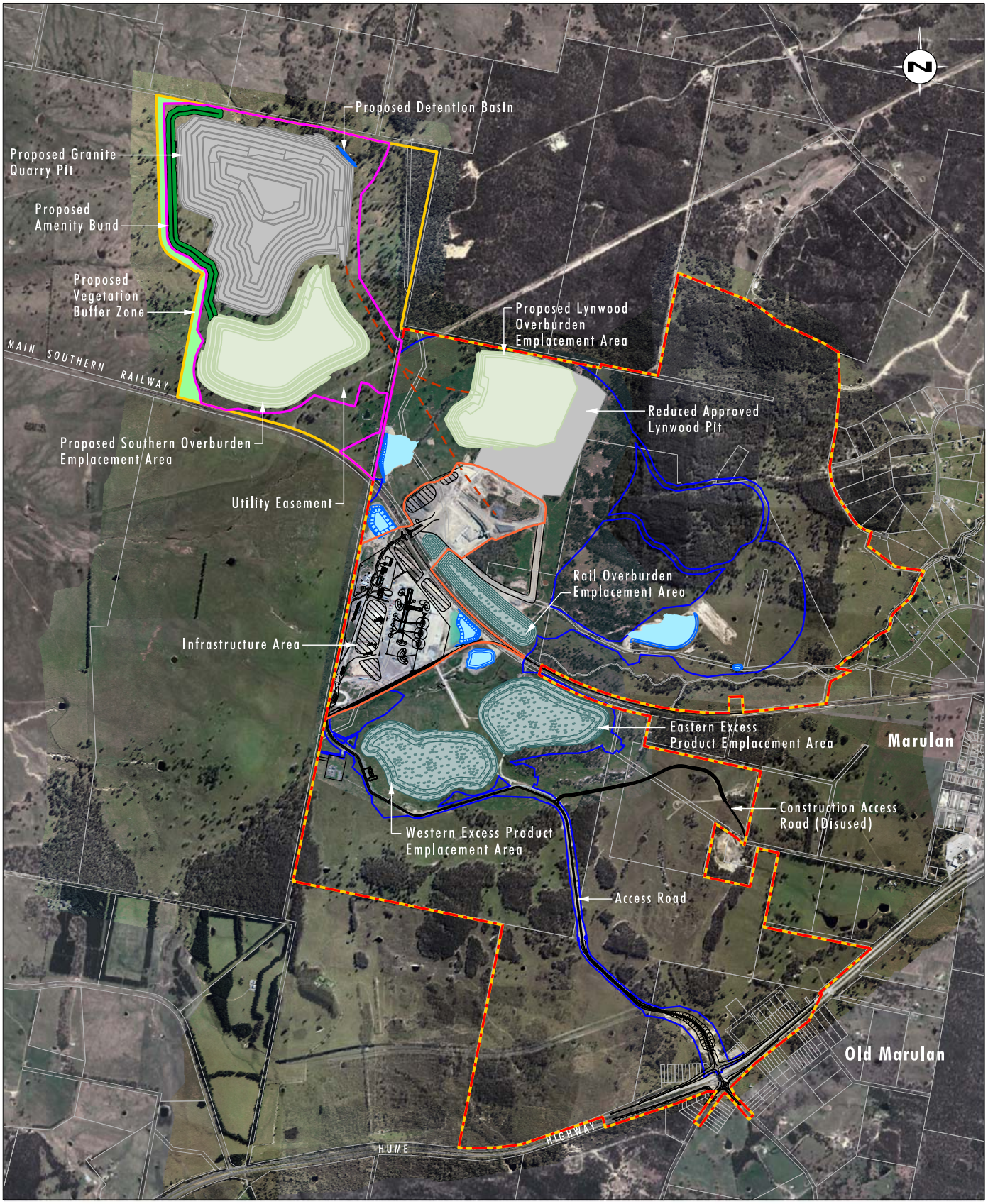

Image Source: Google Earth (2012), Holcim (2012, 2014)
Data Source: LPI (2014), Holcim Australia (2015)

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Legend

- Approved Project Area
- Modification Project Area
- Lynwood Infrastructure Area
- Approved Disturbance Footprint
- Proposed Granite Pit Disturbance Footprint
- Lynwood Infrastructure Layout
- Quarry Pit
- Emplacement Area
- Dam
- Proposed Overburden Emplacement Area
- Proposed Vegetation Buffer Zone
- Proposed Amenity Bund
- Proposed Haul Road

FIGURE 1.3

Proposed Extraction Area Modification Project Conceptual Stage 6 (Life of Project)

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1.4 Structure of this Report

The key components of the Surface Water Assessment Report for the Modification Project are included in the following sections:

- Surface water context, including existing watercourses, catchment context and water quality; **Section 2.0**.
- Water Management System; **Section 3.0**.
- Water balance; **Section 4.0**.
- Potential impacts of the Modification Project and proposed surface water management strategies; **Section 5.0**.
- Monitoring, Licensing and Reporting; **Section 6.0**.

2.0 Surface Water Context

Lynwood Quarry is located within the catchments of Joarimin, Lockyersleigh and Marulan Creeks (refer to **Figure 2.1**). Joarimin Creek has a catchment area of approximately 5440 hectares and drains in a north-easterly direction to the Wollondilly River. Lockyersleigh Creek has a catchment area of approximately 2630 hectares and drains in a north-westerly direction to the Wollondilly River, entering the river upstream of the Joarimin Creek confluence. The Wollondilly River has a catchment area of approximately 10,030 km^2 and is part of the Warragamba Dam catchment which contributes to Sydney's drinking water supplies. Marulan Creek has a catchment area of approximately 2055 hectares and drains in a south-easterly direction to the Shoalhaven River via Barbers Creek. The Shoalhaven River is part of the Tallowa Dam catchment area which is approximately 217 km^2 and contributes to Sydney's drinking water supplies. As such, all runoff from the project area flows into rivers that are managed by Sydney Catchment Authority.

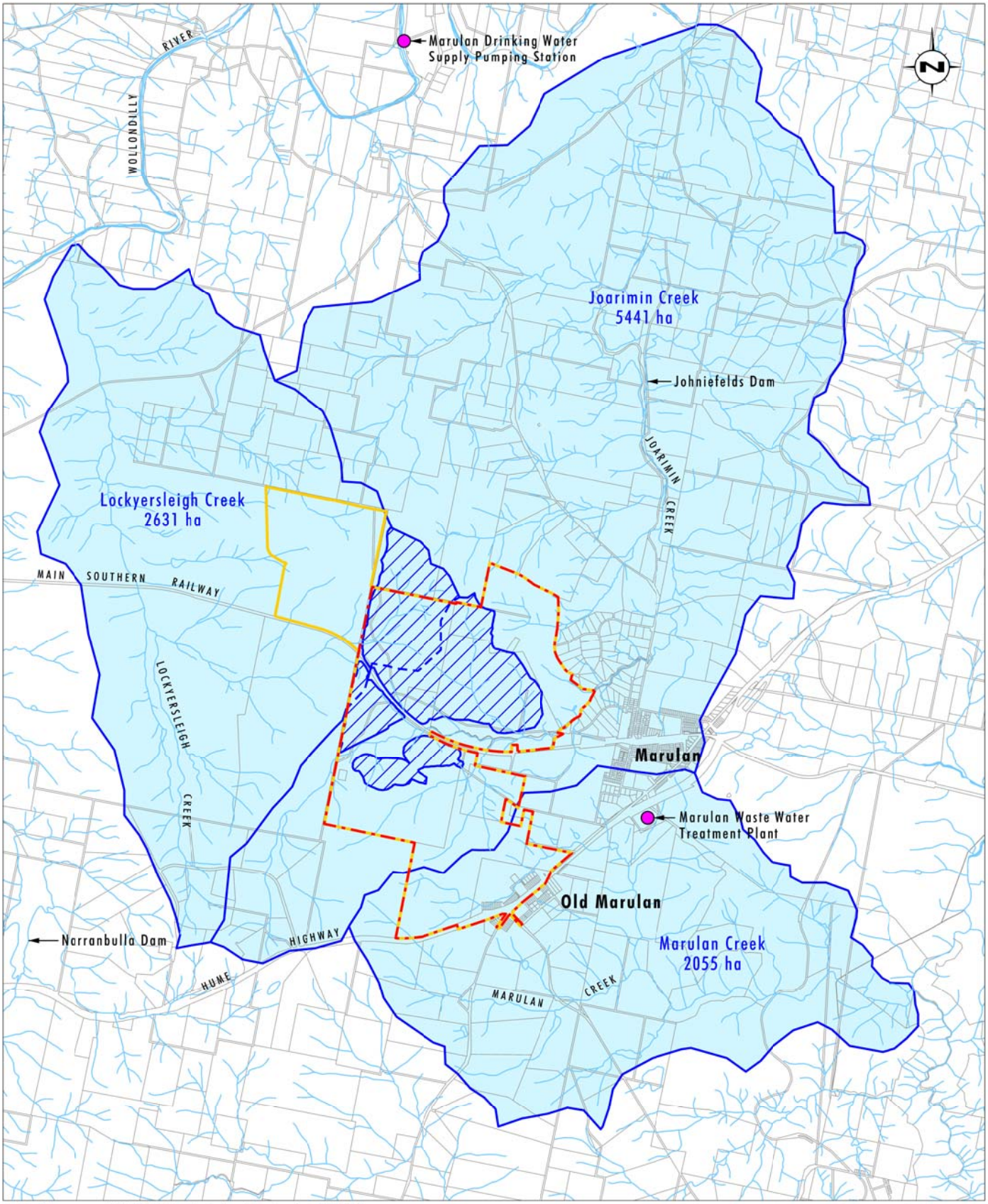
With the existing quarrying operations, portions of the catchments of Joarimin Creek and Lockyersleigh Creek are managed within the quarry water management system (WMS). The approved extent of the WMS is shown on **Figure 2.1**. The existing, approved and proposed WMS is discussed further in **Section 3.0**.

The boundaries of the catchment areas are shown on **Figure 2.1** and the areas listed in **Table 2.1**. The progressive stream order of the creek systems surrounding the Lynwood Quarry, mapped from the 1:25,000 map series using the Strahler stream ordering method, are shown on **Figure 2.2**.

Table 2.1 Catchment Context

Creek	Catchment Area		
	Pre Quarry Area (ha)	Within Approved Lynwood Quarry Project Area (ha)	Within Modification Project Area[1] (ha)
Wollondilly River	1,003,000	1,027	1,254
Joarimin Creek	5,440	748	748
Lockyersleigh Creek	2,630	105	332
Marulan Creek	2,055	174	174

1. Includes Approved Lynwood Quarry Project Area



Legend

- Approved Project Area
- Modification Project Area
- Catchment Boundary
- Approved Water Management System

FIGURE 2.1

Catchment Context

Image Source: Google Earth (2012), Holcim (2012, 2014)
Data Source: LPI (2014), Holcim Australia (2015)

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1:30 000

Legend

- Approved Project Area
- Modification Project Area
- Lynwood Infrastructure Facilities
- Approved Disturbance Footprint
- Proposed Granite Pit Disturbance Footprint
- Lynwood Infrastructure Layout
- Quarry Pit
- Emplacement Area
- Dam
- Proposed Overburden Emplacement Area
- Proposed Vegetation Buffer Zone
- Proposed Amenity Bund
- Proposed Haul Road
- 1st Stream Order
- 2nd Stream Order
- 3rd Stream Order
- 4th Stream Order

FIGURE 2.2

Stream Ordering within the Project Area

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2.1 Joarimin Creek Catchment

Joarimin Creek has a catchment area of approximately 5440 hectares, is a fifth order stream and drains in a north-easterly direction to the Wollondilly River. Land use within the catchment is predominantly grazing and residential with some forested areas. A large proportion of the town of Marulan lies within the catchment area. Johnniefelds Quarry, also operated by Holcim Australia, is also located in the Joarimin Creek catchment to the north of Lynwood Quarry.

Joarimin Creek extends from the Hume Highway approximately 12 kilometres north to its confluence with the Wollondilly River. The confluence is located approximately 6.2 kilometres downstream of Marulan Drinking Water Supply Pumping Station on the Wollondilly River. There is one major dam (Johnniefelds Dam) located along the creek approximately 6.4 kilometres downstream of Lynwood Quarry. Johnniefelds Dam is estimated to have a capacity of 550 ML and supplies water for irrigation, domestic, stock, and industrial use (refer to **Section 2.4**). Holcim Australia has access to 74 ML per year of supply from Johnniefelds Dam for use at the Lynwood Quarry.

The catchment area has typical slopes varying from 2 per cent to 3 per cent in the north-east of the catchment and up to 25 per cent in the upper slopes in the west of the catchment.

Joarimin Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. Generally the creek system is predominantly dry, however, some pools of permanent or semi-permanent water are present in the downstream reaches. There is little or no riparian vegetation along the upper reaches of the creek, i.e. upstream of the Main Southern Railway, with well-established riparian vegetation, dominated by Gum-Box-Apple Woodland, downstream of the Main Southern Railway. There is also evidence of erosion of the creek banks in the upper reaches where little or no riparian vegetation is present.

Approximately 295 hectares (5 per cent) of the Joarimin Creek catchment areas lies within the catchment of the currently approved Lynwood Quarry water management system. Approximately 373 hectares (7 per cent) of the catchment area of Joarimin Creek lies upslope of Lynwood Quarry. Approximately 748 hectares (14 per cent) of Joarimin Creek catchment lies within the Approved Lynwood Quarry Project Area. The Modification Project will result in the approved Eastern Overburden Emplacement Area not being constructed within the Joarimin Creek catchment area and associated changes to the proposed land use with the catchment of Dam A (existing).

2.2 Lockyersleigh Creek Catchment

Lockyersleigh Creek has a catchment area of approximately 2630 hectares, is a fourth order stream and drains in a north-westerly direction to the Wollondilly River. Land use within the catchment is predominantly grazing with some forested areas.

Lockyersleigh Creek drains generally in a northerly direction from its headwaters near the Hume Highway approximately 9.2 kilometres north to the Wollondilly River. The confluence of Lockyersleigh Creek with the Wollondilly River is located approximately 9.2 kilometres upstream of Marulan Drinking Water Supply Pumping Station on the Wollondilly River.

The catchment area has typical slopes varying from 2 per cent to 3 per cent in the north of the catchment to 20 per cent in the upper slopes in the south of the catchment.

Lockyersleigh Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. Generally the creek system is predominantly dry, however, some pools of permanent or semi-permanent water are present in the downstream reaches of the creek.

There is little or no riparian vegetation along the upper reaches of the creek, with established riparian vegetation in the downstream reaches. There is also evidence of erosion of the creek banks in the upper reaches where little or no riparian vegetation is present.

Approximately 160 hectares (6 per cent) of the Lockyersleigh Creek catchment areas lies within the catchment of the currently approved Lynwood Quarry water management system. Approximately 68 hectares (3 per cent) of the catchment area of Lockyersleigh Creek lies upslope of Approved Lynwood Quarry Project Area. Approximately 332 hectares (13 per cent) of Lockyersleigh Creek catchment lies within the Modification Project Area. The Modification Project will intersect the catchments of a number of minor tributaries (i.e. first order and second order tributaries) of Lockyersleigh Creek and has the potential to change surface water flows in these tributaries and in a third order tributary to the south of the Modification Project Area.

2.3 Marulan Creek Catchment

Marulan Creek has a catchment area of approximately 2055 hectares, is a fourth order stream and drains in a south-easterly direction to the Shoalhaven River via Barbers Creek. Land use within Marulan Creek catchment is predominantly grazing and residential with some forested areas. A section of the town of Marulan lies within the catchment area.

Marulan Creek extends from its confluence with Barbers Creek approximately 7.5 kilometres due west to the Hume Highway and Marulan. There is one major dam located along a tributary of the creek located approximately 3.6 kilometres to the west of Lynwood Quarry.

The catchment area has typical slopes varying from 1 per cent to 2 per cent in the east of the catchment to 15 per cent in the upper slopes in the west of the catchment.

Marulan Creek is an ephemeral creek system with flows only occurring in the creek during storm events or after prolonged periods of heavy rain. There is limited riparian vegetation along the upper reaches of the creek, with established riparian vegetation downstream of the Hume Highway.

Approximately 40 hectares (2 per cent) of the catchment area of Marulan Creek lies upslope of Lynwood Quarry. Approximately 174 hectares (8 per cent) of the Marulan Creek catchment lies within the Approved Lynwood Quarry Project Area. The existing Lynwood Quarry developments within Marulan Creek catchment area consists of the access road to the proposed quarry and the associated interchange located at the Hume Highway. There are no proposed changes to this infrastructure.

2.4 Water Quality

The NSW Water Quality and River Flow Objectives (as published by the Office of Environment and Heritage (OEH)) are the agreed environmental values and long-term goals for NSW's surface waters. The objectives are consistent with the agreed national framework for assessing water quality as set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines (2000) (ANZECC guidelines).

In addition to meeting the NSW Water Quality and River Flow Objectives, the water management strategy for Lynwood Quarry has been developed to provide for neutral or beneficial water quality impacts on the downstream catchment areas in accordance with *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011*.

The water management strategy includes controlling runoff from all disturbed areas on-site for treatment, minimising sediment transport off-site with the aim of maintaining it below the pre-quarry pollution loads.

Water quality on site and in the downstream creeks is monitored in accordance with the *Lynwood Quarry Surface Water Monitoring Program* (Holcim Australia, 2013). This monitoring program has been developed to encompass all potential sediment dam overflow locations and downstream creek systems are regularly monitored and the results compared against baseline data.

A surface water quality monitoring program was established for Lynwood Quarry in July 2004 to provide baseline surface water data. Surface water quality has been monitored since this time at four locations on Joarimin Creek (SW3 to SW6) and two locations on Marulan Creek (SW1 and SW2) (refer to **Figure 2.3**). Surface water quality has been monitored at one location on Lockyersleigh Creek (SW7) since February 2005 (refer to **Figure 2.3**).

Construction of Lynwood Quarry commenced during November 2010. Surface water monitoring data prior to November 2010 is considered to be baseline data for the operations.

The surface water locations are currently monitored monthly for:

- flow (by way of observation as streams are ephemeral)
- pH
- electrical conductivity
- Total Dissolved Solids (TDS)
- chloride (Cl)
- iron (Fe)
- manganese (Mn)
- arsenic (As)
- nitrite
- nitrate
- total phosphorous
- oxidised nitrogen
- Total Kjeldahl Nitrogen (TKN)
- Benzene, Toluene, Ethylbenzene, and Xylene (BTEX).

To assist in managing the quarry to meet neutral and beneficial effects, as described above, impact assessment criteria were developed as part of the Water Management Plan process. Where sufficient baseline data was collected trigger values were calculated as the 80th percentile of the background values in accordance with the ANZECC Guidelines (ANZECC, 2000). Data samples were limited at some locations due to the lack of water being present in the creeks during the baseline monitoring period. Where sufficient baseline data has not been collected the default trigger values for lowland rivers in NSW were selected. Trigger values have been set for surface water monitoring locations downstream of the site (i.e. SW2, SW5 and SW6) and for site water management system dams (for example, SW7) to provide indicators for monitoring potential environmental pollution.

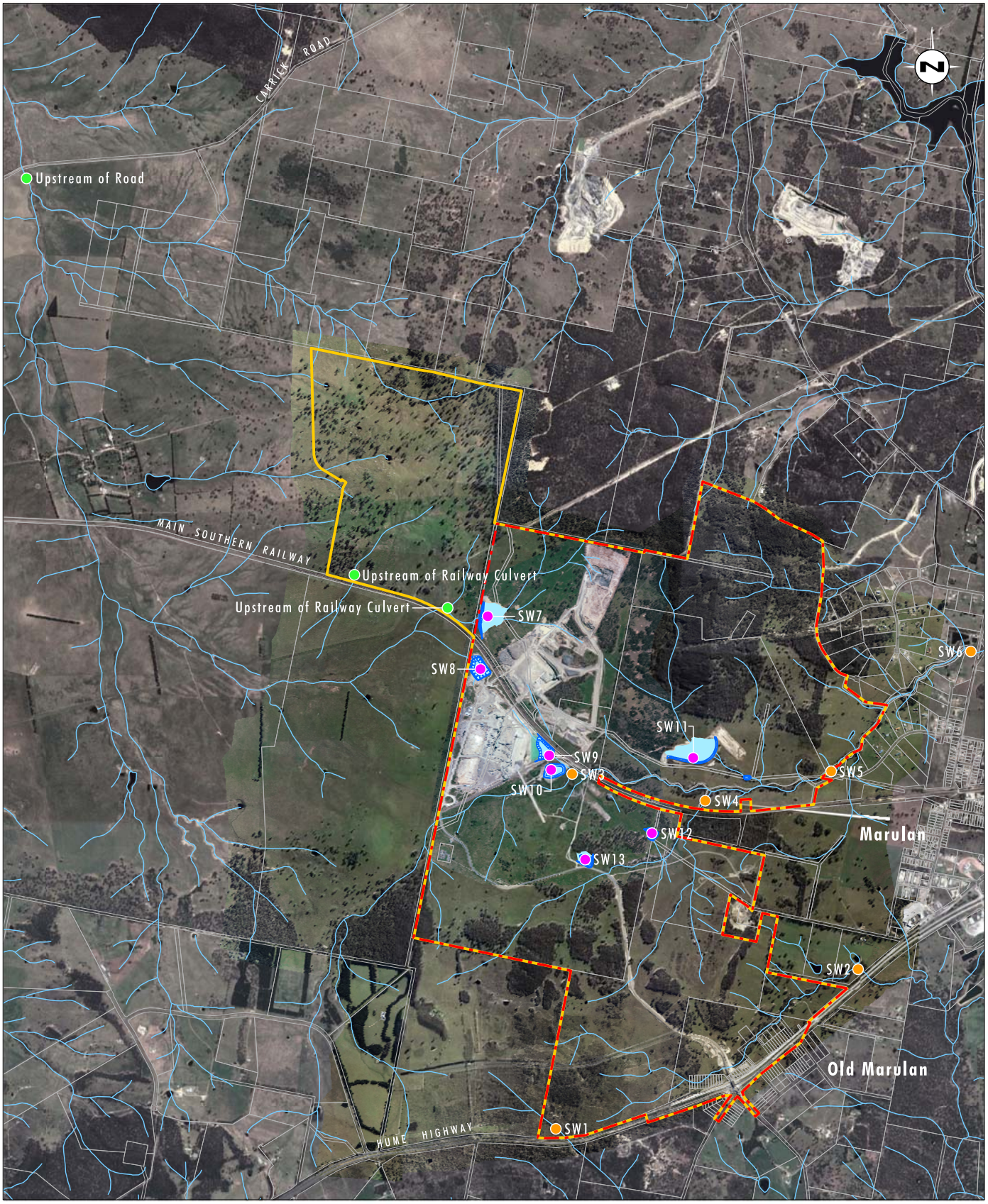

Image Source: Google Earth (2012), Holcim (2012, 2014)
Data Source: LPI (2014), Holcim Australia (2015)

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Legend

- Approved Project Area
- Modification Project Area
- Surface Water Monitoring Location
- Site Water Management Dams
- Proposed Surface Water Monitoring Location

FIGURE 2.3

Surface Water Monitoring Locations

The impact assessment criteria trigger values for the Lynwood Quarry surface water monitoring program are specified in **Table 2.2**. Although trigger values are not listed for SW1, SW3 and SW4 (i.e. monitoring locations upstream of the quarry) it should be noted that surface water quality results from these locations will be used if further analysis or investigations into downstream surface water quality is required, for example if the trigger values in **Table 2.2** are exceeded.

Table 2.2 Trigger Values for Key Water Quality Parameters

Water Quality Variable	Trigger Value			
	SW2	SW5	SW6	Site Water Mgt System[2]
pH	6.5 to 7.5	6.8	7.1	6.5 to 7.5
Electrical Conductivity	2200 µS/cm	732 µS/cm	1197 µS/cm	2200 µS/cm
Oil and Grease[1]	10 mg/L or none visible	10 mg/L or none visible	10 mg/L or none visible	10 mg/L or none visible
Total Suspended Solids[1]	50 mg/L	50 mg/L	50 mg/L	50 mg/L
Total Nitrogen[2]	2.1 mg/L	2.0 mg/L	1.0 mg/L	2.1 mg/L
Total Phosphorus[2]	0.21 mg/L	0.17 mg/L	0.06 mg/L	0.21 mg/L

Note 1: Specified in DA-128-5-2005, Schedule 3, Condition 17

Note 2: SW7 to SW13

In addition, discharge water quality limits for Total Suspended Solids (TSS), pH and oil and grease of 50 mg/L, 6.5 to 8.5, and 10 mg/L or none visible respectively are specified in the Lynwood Quarry development consent in Condition 17 of Schedule 3. Condition 17 Schedule 3 states that except as maybe expressly provided by a licence (i.e. an Environment Protection Licence), Holcim Australia shall ensure that any controlled discharge from the controlled discharge points at Sediment Dams A to F comply with the above limits.

Holcim Australia has had four environmental incidents (one in 2012, one in 2013 and two in 2014) regarding unlicensed discharges from sediment dams occurring during high rainfall events where the above TSS criteria was exceeded. All of these incidents were reported to relevant government agencies in line with Holcim Australia's requirements.

A review of current monitoring data indicates no significant variation of water quality downstream in Joarimin Creek compared to baseline water quality monitoring. All water quality monitoring results are detailed in Annual Reports as required by the development consent and are publically available on the Holcim Australia website.

2.5 Water Users

The *Water Management Act 2000* defines water access and water sharing strategies. As part of this Act, Water Sharing Plans (WSPs) have been developed across NSW to protect the health of rivers, whilst at the same time securing sustainable access to water for all users. The WSP's specify maximum water extractions and allocations.

The *Water Sharing Plan for the Great Metropolitan Region Unregulated River Water Sources 2011* applies to watercourses in the vicinity of Lynwood Quarry. The catchments of Joarimin Creek and Lockyersleigh Creek are located within the Upper Nepean and Upstream Warragamba Water Sources Management Zone in the Lower Wollondilly River Water Source. The catchment of Marulan Creek is located within the Shoalhaven River Water Source Management Zone in the Barbers Creek Water Source. As the creek systems are covered by water sharing plans, surface water use at Lynwood Quarry is governed by the *Water Management Act 2000*.

The township of Marulan sources water from the Wollondilly River approximately 6.2 kilometres upstream of the confluence of the Wollondilly River and Joarimin Creek (refer to **Figure 2.1**). Johnniefelds Dams (refer to **Section 2.1**) is located on Joarimin Creek downstream of the quarry. Johnniefelds Dam is estimated to have a capacity of 550 ML and supplies water for irrigation, domestic, stock, and industrial use (refer to **Section 3.1**). As noted above, Holcim Australia has access to 74 ML per year of licensed water allocation from Johnniefelds Dam for use at Lynwood Quarry.

Potential impacts on downstream water users from the Modification Project are discussed in **Section 5.6**.

3.0 On Site Water Management

The approach to water management at Lynwood Quarry is set out in the existing *Lynwood Quarry Water Management Plan* (WMP), (Holcim, 2013), which details measures to convey clean water away from the quarry and associated infrastructure areas, and manage water affected by quarrying operations.

The existing water management system (WMS) will need to be modified as a result of the Modification Project. The existing WMS is discussed in **Section 3.1**, with the proposed changes detailed in **Section 3.2**.

3.1 Existing Water Management System

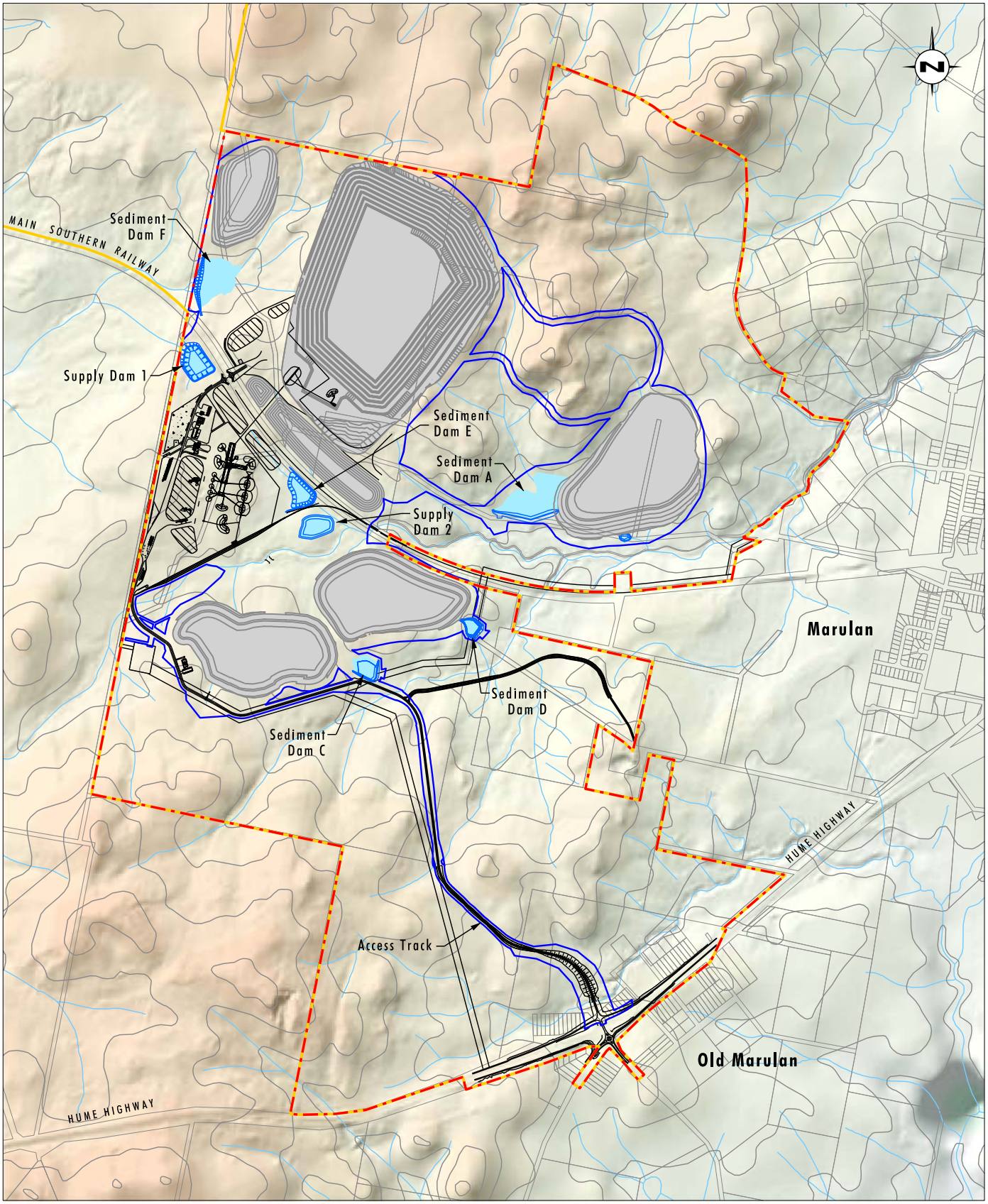
The water management strategy for the site, as detailed in the Environmental Assessment – Proposed Modifications to Lynwood Quarry, Marulan (Modification EA) (Umwelt, 2010) is to capture runoff from the footprint of the Year 30 disturbance area to capture and treat 'dirty' water and to minimise external water supply requirements. This area (refer to **Figure 3.1**) contains the quarry pit, overburden and excess product emplacement areas, haul road routes and the infrastructure area. The runoff water captured is stored on-site, along with any groundwater seepage into the pit, externally sourced water and water recycled through the process plant. During prolonged or heavy rainfall periods, treated water may overflow from the sediment dams off site as is the process for all sediment dams designed in accordance with relevant guidelines (i.e. *Managing Urban Stormwater: Soils and Construction, Volumes 1 and 2* known as the Blue Book (Landcom, 2004 and DECC, 2008)). The key controls that will treat dirty runoff from the Year 30 footprint consist of a series of diversion and catch drains, six sediment control dams and two water storage dams (refer to **Figure 3.2**). Much of this water management infrastructure is already constructed, with further approved components to be constructed as the quarry progresses (e.g. as the emplacement areas are progressively established).

The water management system described above was designed to meet the following aims:

- minimise off site water impacts
- provide for neutral or beneficial effects on downstream catchments
- comply with development consent conditions
- comply with Environment Protection Licence (EPL) conditions
- maximise water use efficiency.

3.1.1 Clean Water Management

Existing clean water management includes drainage systems around the perimeter of the operational areas in order to convey upslope runoff away from active disturbance areas.



Data Source: Data Source: LPI (2009), Holcim Australia (2004)

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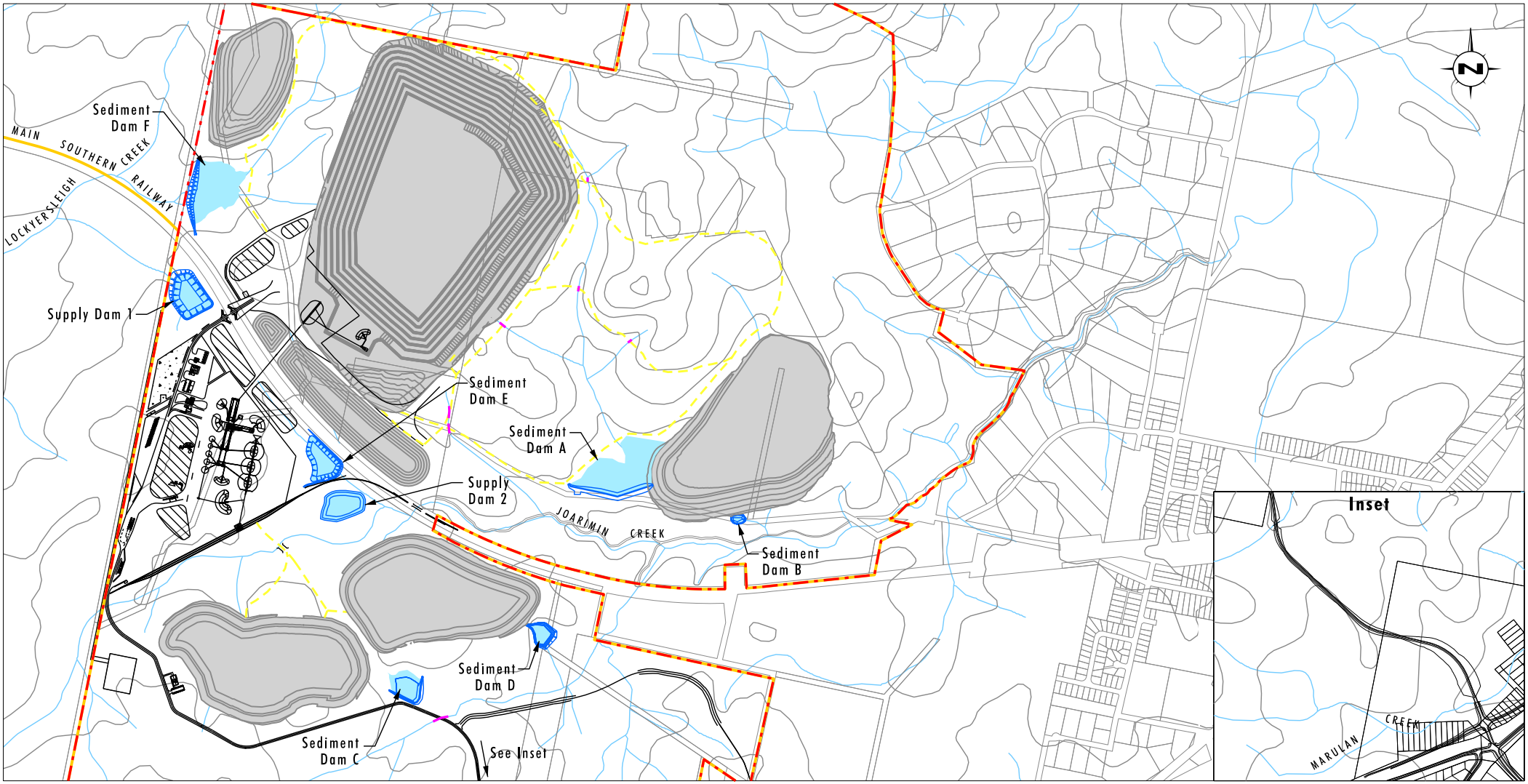
Legend

- Approved Project Area
- Approved Disturbance Footprint
- Modification Project Area

FIGURE 3.1

Approved Year 30
Disturbance Footprint



Legend

- Approved Project Area
- Modification Project Area
- Culvert
- Haul Road

FIGURE 3.2

Approved Water Management Infrastructure

File Name (A4): R11/3330_199.dgn
20150804 11.18

3.1.2 Dirty Water Management

Existing dirty water management includes the collection, management and distribution of water pumped from the active quarry area, runoff and seepage from overburden emplacement areas, and management of water within the processing plant area. The water in these areas is classed as 'dirty' water.

Dirty water includes runoff from disturbed areas and those areas currently being rehabilitated. The dirty water management system includes a series of catch drains and sediment dams located to capture and manage runoff from disturbed areas.

3.1.3 Water Management Dams

Water is managed and stored on site in a series of dams. The key dams that are currently part of the WMS together with their approximate design capacity and function are listed in **Table 3.1** and shown on **Figure 3.2**. The future approved dams (yet to be constructed) are listed in **Table 3.2**.

Table 3.1 Existing Dams

Dam	Purpose	Minimum Design Criteria[1]	Volume (ML)[2]
Dam 1	Water storage	N/A	63 (24)
Dam E	Sediment control and plant water management	Type C critical storm duration	42 (31)
Dam F	Sediment and water storage	90th percentile 5 day rainfall event type D/F	50 (16)
Dam A	Water storage	90th percentile 5 day rainfall event type D/F	117 (83)
Sediment Dam L1	Sediment control	90th percentile 5 day rainfall event type D/F	9 (estimated)*

Note 1 – Design Criteria specified for sediment control dams in accordance with Managing Urban Stormwater Volumes 1 and 2 (Blue Book) (Landcom, 2004 and DECC, 2008). 90th percentile 5 day rainfall event depth is 28.6 mm.

Note 2 – Working volume in parentheses (considering current pump configurations and sediment zones)
*Estimated based on advice from Holcim Australia

Table 3.2 Future Approved Dams

Dam	Purpose	Minimum Design Criteria[1]	Volume (ML)
Dam R1	Sediment control	90th percentile 5 day rainfall event type D/F	2 (estimated)*
Dam R2	Sediment control	90th percentile 5 day rainfall event type D/F	2 (estimated)*
Dam C	Sediment control[1]	Type C critical storm duration	8
Dam D	Sediment control[1]	Type C critical storm duration	8
Dam 2	Water storage	N/A	30

Note – Design Criteria specified for sediment control dams in accordance with Managing Urban Stormwater Volumes 1 and 2 (Blue Book) (Landcom, 2004 and DECC, 2008). 90th percentile 5 day rainfall event depth is 28.6 mm.

Note 1 – Sediment control from excess product emplacement area.

*Estimated based on advice from Holcim Australia

3.1.4 External Water Sourcing

Holcim Australia has an agreement with the owner of the existing industrial allocation (74 ML per year) at Johnniefelds Dam, in regard to future use of this water allocation at Lynwood Quarry. Some of this water is currently used for Holcim Australia's operations at Johnniefelds Quarry.

Holcim Australia also continues to investigate options for purchase and use of other existing allocations for potential use in periods of extended drought, to provide a high level of water supply security.

3.2 Proposed Water Management System

The water management strategy for the Modification Project has been designed to integrate management of the Modification Project with the existing quarry water management system. The strategy includes the separation of clean and dirty water, and managing compliance with statutory obligations.

For the Modification Project, both clean water and dirty water need to be managed. The design criteria for additional components to the WMS are outlined in **Table 3.3**.

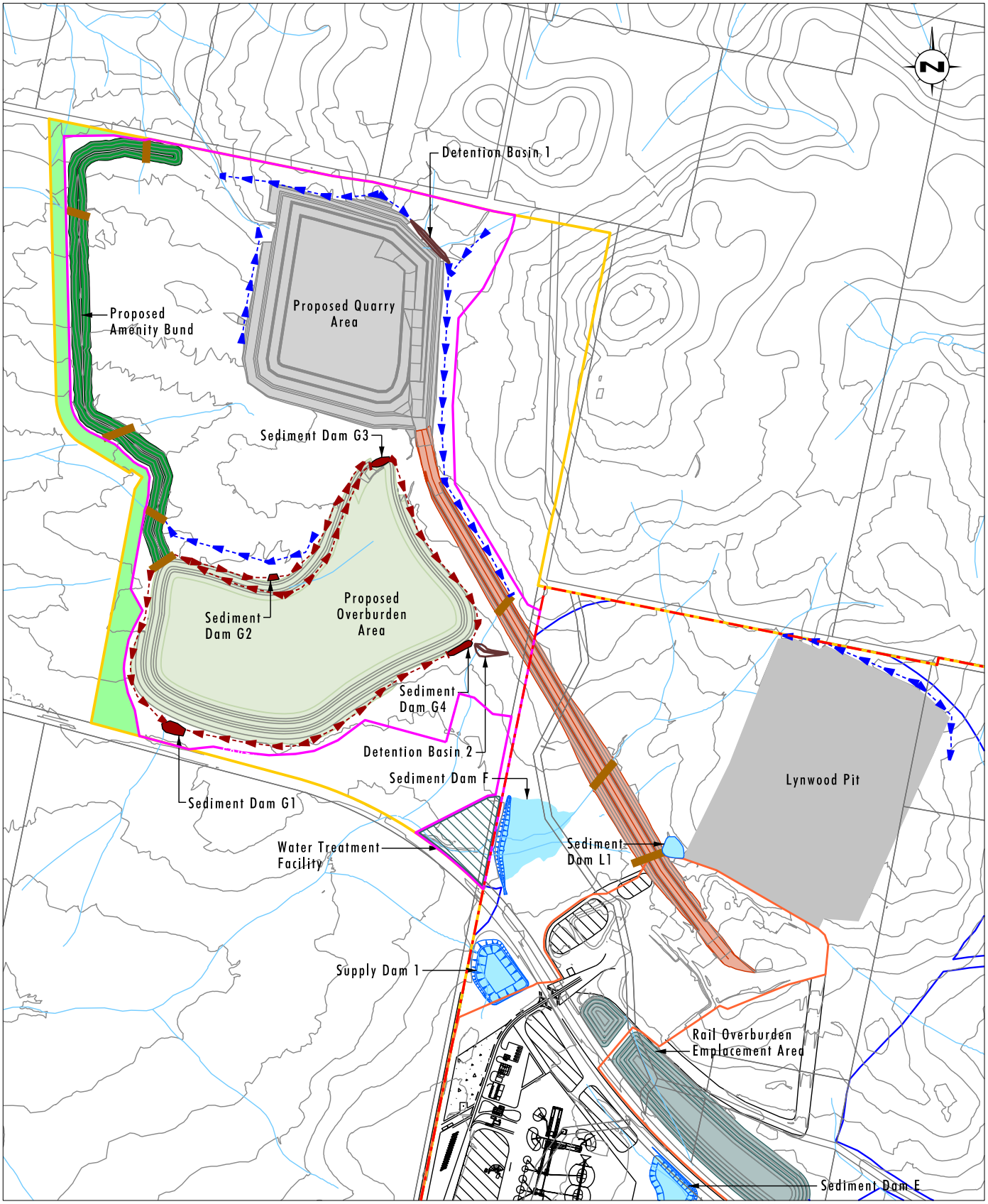
Table 3.3 Design Criteria for Components of the WMS

Water Category	Water Description	Target Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas	Release, where practicable, to downstream environment.
Dirty	Runoff from disturbed areas	Managed in line with the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*).

3.2.1 Clean Water Management

The existing clean water management system includes a series of drains around the perimeter of the operational areas in order to convey upstream catchment runoff away from disturbed areas. As quarrying progresses into the Granite Pit area, the existing clean water management system will be revised to manage clean water for the Modification Project through the construction of new drains and dams (refer to **Figures 3.3** to **3.5**).

Clean water drains will be sized to safely convey the 5 per cent Annual Exceedance Probability (AEP) storm event flows to clean water dams or downstream receiving catchment areas. All clean water drains will be constructed to be non-scouring for design flow velocities. Rock protection and energy dissipation structures will be installed at the downstream outlets, where required, to minimise the potential for runoff to cause scour or erosion in downstream drainage systems, including the natural tributaries and main channels.



Data Source: LPI (2009), Holcim Australia (2014)
Notes: 5m Contour Interval. Conceptual only and subject to detailed design.

0 250 500 750m
1:15 000

Legend

- Approved Project Area
- Modification Project Area
- Lynwood Infrastructure Area
- Approved Disturbance Footprint
- Proposed Granite Pit Disturbance Footprint
- Lynwood Infrastructure Layout
- Quarry Pit
- Approved Emplacement Area
- Existing Dam
- Proposed Overburden Emplacement Area
- Proposed Vegetation Buffer Zone
- Proposed Amenity Bund
- Proposed Haul Road
- Clean Dam
- Diversion Drain
- Sediment Dam
- Dirty Drain
- Culvert

FIGURE 3.3

Conceptual Water Management System - Stage 1

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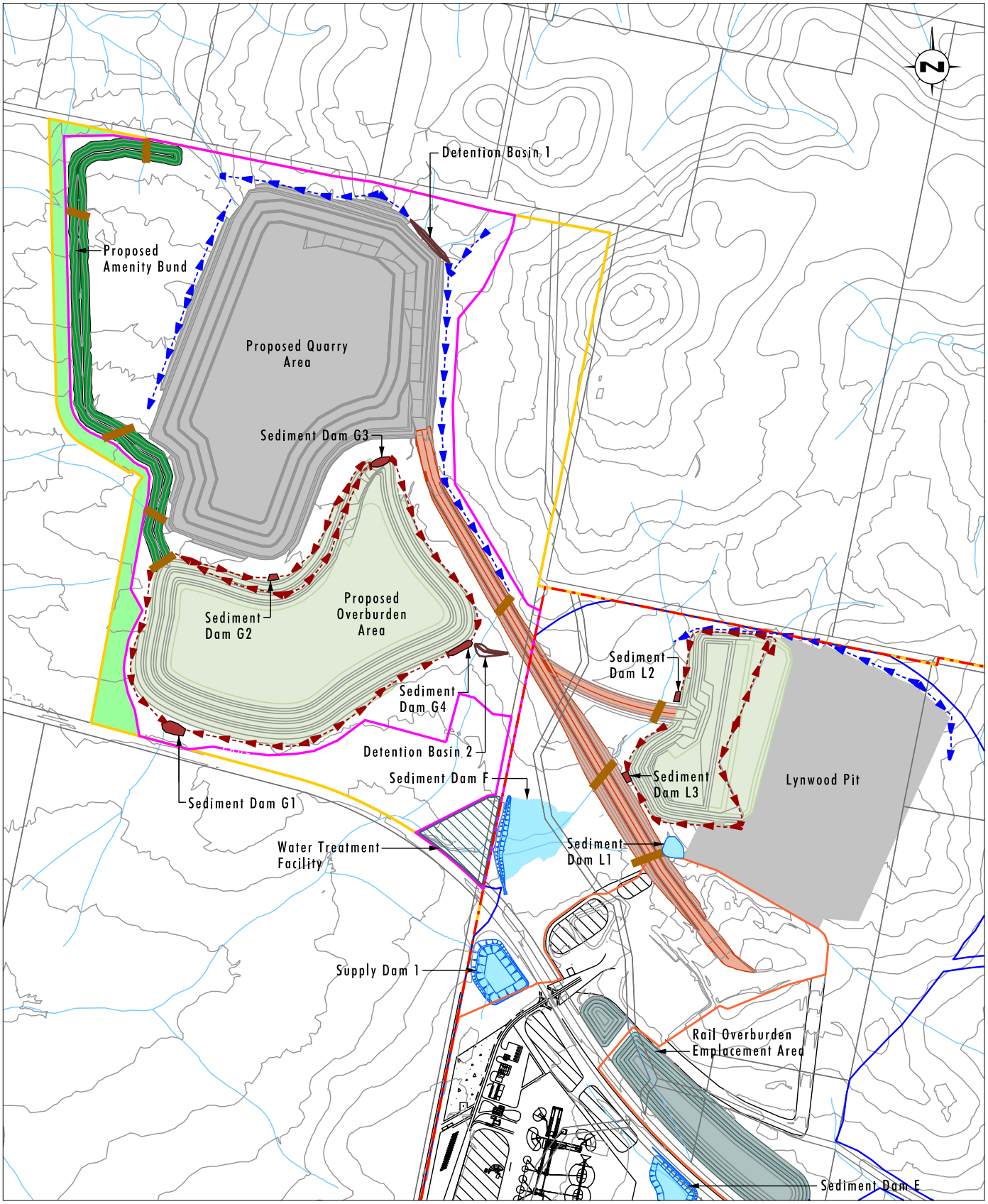
20151112 10.28



Data Source: LPI (2009), Holcim Australia (2014)
Notes: 5m Contour Interval. Conceptual only and subject to detailed design.

0 250 500 750m
1:15 000

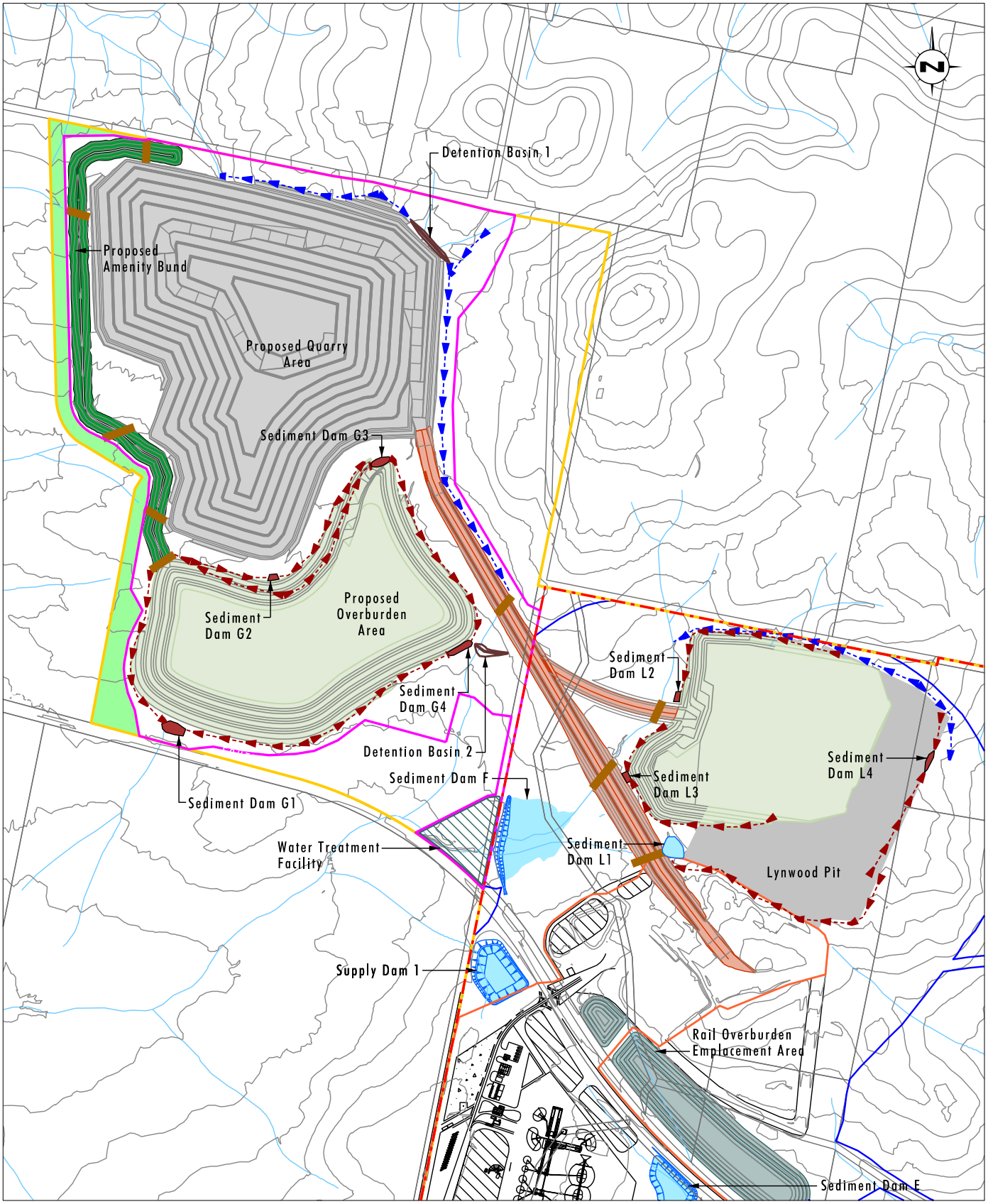
Legend

- Approved Project Area
- Modification Project Area
- Lynwood Infrastructure Area
- Approved Disturbance Footprint
- Proposed Granite Pit Disturbance Footprint
- Lynwood Infrastructure Layout
- Quarry Pit
- Approved Emplacement Area
- Existing Dam
- Proposed Overburden Emplacement Area
- Proposed Vegetation Buffer Zone
- Proposed Amenity Bund
- Proposed Haul Road
- Clean Dam
- Diversion Drain
- Sediment Dam
- Dirty Drain
- Culvert

FIGURE 3.4

Conceptual Water Management System - Stage 3

File Name (A4): R11/3330_074.dgn
20151112 10.29



Data Source: LPI (2009), Holcim Australia (2014)
Notes: 5m Contour Interval. Conceptual only and subject to detailed design.

0 250 500 750m
1:15 000

Legend

- Approved Project Area
- Modification Project Area
- Lynwood Infrastructure Area
- Approved Disturbance Footprint
- Proposed Granite Pit Disturbance Footprint
- Lynwood Infrastructure Layout
- Quarry Pit
- Approved Emplacement Area
- Existing Dam
- Proposed Overburden Emplacement Area
- Proposed Vegetation Buffer Zone
- Proposed Amenity Bund
- Proposed Haul Road
- Clean Dam
- Diversion Drain
- Sediment Dam
- Dirty Drain
- Culvert

FIGURE 3.5

Conceptual Water Management System - Stage 6

File Name (A4): R11/3330_075.dgn
20151112 10.41

3.2.2 Dirty Water Management

The existing dirty water management system includes a series of drains and sediment dams located to capture and manage runoff from disturbed areas. The existing dirty water management system is, and the changes for the Modification Project will be, designed in accordance with *Managing Urban Stormwater: Soils and Construction* (the Blue Book), *Volumes 1* and *2E - Mines and Quarries* (Landcom, 2004 and DECC, 2008) to manage runoff from the 5 day, 90th percentile rainfall event.

As quarrying progresses, runoff from disturbed areas will be managed within the water management system and reused, or if water quality meets required guidelines, will be released to downstream waterways. The surfaces of the overburden emplacement area will be shaped to have swales, small drainage hollows and a generally irregular landform to resemble the natural surrounding landform. These areas will drain to the dirty water management system until rehabilitation has been established.

The sediment dams will be emptied using a pump and pipe or gravity systems after rainfall events. It is proposed to construct a water treatment facility (refer to **Figure 3.3**) to the west of the existing Dam F. The proposed water treatment facility would be used to treat water quality to meet water quality parameters for release to downstream watercourses if required. The water treatment facility is subject to detailed design but may include temporary water storage dams and treatment techniques such as flocculation and settling.

Dirty water drains will be sized to safely convey the 5 per cent AEP storm event. All dirty water drains will be constructed to be non-scouring under design flow velocities. Rock protection and energy dissipation structures will be installed at the downstream outlets, where required, to minimise the potential for that runoff to cause scour or erosion in downstream drainage systems.

Erosion and sediment controls will be implemented to mitigate the impacts of construction and quarrying operations on nearby watercourses and the surrounding environment. Standard erosion and sediment control techniques will be used in accordance with the requirements of *Managing Urban Stormwater: Soils and Construction* (the Blue Book) (Landcom, 2004 and DECC, 2008), and are detailed in **Section 5.3.3**.

3.2.3 Overview of Proposed Water Management System

The layout of the key components of the WMS for the life of the Modification Project in relation to surrounding watercourses is shown on **Figures 3.3** to **3.5** and detailed below.

It is important to note that the stage plans presented in **Figures 3.3** to **3.5** are conceptual, being determined by current construction and quarry schedules. The WMS will be constructed and modified as and when required so as to support the infrastructure and quarry development. Further, the stage plans indicate only the components of the WMS which are required for a particular stage of the project, and does not preclude the construction of some components earlier in the Project.

Similarly, the conceptual storage capacities required for the various water management dams are provided to indicate the quantum of the proposed dams. Refinement of the design criteria and capacities will be undertaken during detailed design stages of the Modification Project, as well as the ongoing operational stages.

The existing WMS will continue to be used to manage runoff with all runoff within the existing disturbance footprint of Lynwood Quarry directed to the WMS.

3.2.3.1 Stage 1

In Stage 1 of the Modification Project (refer to **Figure 3.3**) both the Approved Pit and proposed Granite Pit will be active. The Approved Pit will have reached its proposed footprint.

Clean water from the catchments to the north of the Approved Pit will be drained to the east and west to the downstream catchments as per the approved WMS for this area.

Clean water drains will be constructed upslope of the proposed Granite Pit to return clean water flows, where possible, to downstream catchments. Runoff capture in a natural depression to the north-east of the pit will be temporary detained (in Detention Basin 1) and then pumped out to the downstream catchments. Although the flooding assessment (refer to **Section 5.2.2**) indicates that the proposed extraction area modification will not increase flood flows, velocities or depths in the downstream tributaries of Lockyersleigh Creek, Holcim Australia has included in the Modification Project an option to construct a second detention basin (Detention Basin 2) to the south of the haul road as required.

Product will be hauled from the Granite Pit to the processing plant area via a haul road linking the Granite Pit to the existing operational area. Overburden will be emplaced in the proposed overburden emplacement area to the south of the Granite Pit. Runoff from the proposed overburden emplacement area will be managed in sediment dams and reused within the WMS.

3.2.3.2 Stage 3

At Stage 3 of the Modification Project (refer to **Figure 3.4**) the Granite Pit will be active and will have extended to the west and south. Clean water drains will continue to be utilised to manage upslope runoff from undisturbed catchment areas. This will include the continued use of Detention Basin 1 (refer to **Section 3.2.3.1**).

Overburden will continue to be placed in the proposed southern overburden emplacement area with runoff from this area continuing to be managed in sediment dams and reused within the WMS. During this stage overburden will also be hauled, via the extended haul road, for placement in the Approved Pit. As placement of overburden in the Approved Pit continues, sediment dams will be constructed to manage dirty water runoff for reuse within the WMS.

3.2.3.3 Stage 6

By Stage 6 of the Modification Project (refer to **Figure 3.5**) the Granite Pit will be active and at its full extent. Overburden emplacement will be complete on the proposed overburden emplacement area to the south of the Granite Pit. Overburden placement will also be nearing completion in the Approved Pit.

3.2.3.4 Conceptual Proposed Dams for the Project

The conceptual proposed clean water and dirty water dams required to manage dirty and clean runoff from disturbance areas and rehabilitated areas for the Modification Project in addition to existing constructed and approved dams are listed in **Table 3.4**.

Table 3.4 Additional Dams Related to the Project

Dam	Purpose	Minimum Design Criteria[1]	Approximate Volume (ML)	Stage 1	Stage 2	Stage 3
Detention Basin 1	Clean water management	100 year 24 hour storm event[1]	Detention Storage Only[2]	In place	In place	In place
Detention Basin 2	Clean water management (optional)	N/A	Detention Storage Only[3]	In place	In place	In place
Sediment Dam G1	Sediment control	90th percentile 5 day rainfall event type D/F	3.9	Dirty	Dirty	Clean
Sediment Dam G2	Sediment control	90th percentile 5 day rainfall event type D/F	0.4	Dirty	Dirty	Clean
Sediment Dam G3	Sediment control	90th percentile 5 day rainfall event type D/F	1.2	Dirty	Dirty	Clean
Sediment Dam G4	Sediment control and water transfer	90th percentile 5 day rainfall event type D/F	6.4	Dirty	Dirty	Clean
Sediment Dam L2	Sediment control	90th percentile 5 day rainfall event type D/F	1.9	N/A	Dirty	Dirty
Sediment Dam L3	Sediment control	90th percentile 5 day rainfall event type D/F	2.5	N/A	Dirty	Dirty
Sediment Dam L4	Sediment control	90th percentile 5 day rainfall event type D/F	1.3	N/A	Dirty	Dirty

1. Design capacity based on safety aspects related to detention dam above quarry pit
2. Maximum estimate detention storage for Detention Basin 1 is 22 ML
3. Maximum estimated detention for Detention Basin 2 is 16 ML
4. Estimated dam volumes are based on settling volume + sediment volume. Sediment volume is calculated to be 30% of settling volume.

Rehabilitation will be undertaken as the operations progress. Where appropriate, runoff from final, stable rehabilitated areas will be conveyed to the downstream catchment areas once the required runoff water quality criteria are achieved. In the final landform, clean and dirty WMS controls will be removed where possible. Components of the WMS may remain in place on decommissioning.

4.0 Water Balance

Inflows to the water balance include site runoff, groundwater inflows, and external water sourced from Johnniefelds Quarry (refer to **Section 3.1**).

A detailed Site Water Balance Report has been completed for the Project and is included as **Appendix A**. A summary of the water balance findings are included in this section. The water balance model is a daily timestep model based in GoldSim and calculates the probability of different water balance outcomes based on the variability of the model input data.

Table 4.1 presents a summary of the gross water balance results for Lynwood Quarry with the Modification Project, for Stage 1, Stage 3 and Stage 6 in isolation of any water imports from Johnniefelds Dam.

Table 4.1 Lynwood Quarry Gross Water Balance (ML/year) with the Modification Project @ 5 Mtpa

Stage	10th Percentile	50th Percentile	90th Percentile
1	-147	130	766
3	-210	79	737
6	-282	11	695

The water balance predicts that the Modification Project is likely (i.e. 50th percentile) to operate with a small water surplus for all modelled stages. The reduction in water surplus between the stages can be attributed to an increase in haul road surface area, and therefore, an increase in haul road dust suppression water demand as the operation progresses.

During periods of water surplus it is currently assumed that surplus water will be stored in the Approved Pit prior to reuse within the WMS. During dry periods water supply will be primarily supplemented by imports from the water resource at Johnniefelds Dam. The water balance modelling indicates that on average up to 57 ML per year would need to be supplied during Stage 6 of the operation (refer to **Table 4.1**). However, during sustained dry periods, where the secondary water storage in the Approved Pit is empty, and with consideration of water imports from Johnniefelds Dam, water deficits might range between 147 ML per year in Stage 1 to 282 ML per year in Stage 6 (refer to **Table 4.1**) based on a full approved production level of 5 Mtpa.

Table 4.2 presents a summary of the most recent water balance for the existing approved Lynwood Quarry operation with a production rate of 5 Mtpa.

Table 4.2 Existing approved Lynwood Quarry Gross Water Balance (ML/year) @ 5 Mtpa

Year	10th Percentile	50th Percentile	90th Percentile
5	-92	47	275
12	-105	32	261
20	-87	58	281
30	-70	71	298

Source: Umwelt, 2010

The proposed Modification Project and existing approved median water balance results are similar, however, the extremes vary more significantly. The larger water surplus for Lynwood Quarry with the Modification Project during wet years can be attributed to the increased catchment area in the WMS.

The dirty water management system has been designed and will be constructed in accordance with the Blue Book (Landcom, 2004 and DECC, 2008) and as such the risk of spill from the dirty water management system is consistent with Blue Book design criteria. By designing this system in accordance with Blue Book criteria, the risk of adverse environmental impacts associated with design spills from the dirty water management system is minimised.

Contingency measures associated with impacts of extended dry periods or drought are discussed further in **Section 6.1.5**.

5.0 Surface Water Impacts and Mitigation Measures

The Modification Project and associated WMS (refer to **Section 3.0**) has the potential to impact on surface water systems. This includes the potential to impact on:

- catchment areas and flow volumes in local watercourses (refer to **Section 5.1**)
- flooding, including flow rates, velocities and depths (refer to **Section 5.2**)
- water quality in local watercourses (refer to **Section 5.3**)
- geomorphological and hydrological values of watercourses, including environmental flows (refer to **Sections 5.4**)
- riparian and ecological values of watercourses (refer to **Section 5.5**)
- water users, both in the vicinity and downstream of the Project (refer to **Section 5.6**).

A detailed assessment of these potential impacts has been undertaken for the Modification Project with the assessment findings outlined in **Sections 5.1** to **5.6**.

5.1 Catchment Areas and Annual Flow Volumes

During the operational and rehabilitation phases of the Modification Project, clean water runoff from upslope of the operational areas will need to be conveyed around the WMS and runoff from disturbed areas will need to be managed in the WMS. In the absence of local stream gauging data, catchment areas provide an indicator of the potential relative changes in flow volumes that might occur. As such, changes in catchment areas have been used to predict the potential impacts on annual flow volumes.

The existing approved operations include a number of measures to mitigate the impacts on catchment areas. These measures will be continued throughout the life of Lynwood Quarry including for works associated with the Modification Project. These include conveyance of clean water around disturbed areas and where practicable, once rehabilitation is established on disturbed area, draining runoff to the downstream environment. The predicted impacts on catchment areas assume that no spills from water dams (e.g. Dam A) during the operational stages (i.e. Stages 1, 3 and 6) of the quarry. As such it is expected that the impacts to annual flow volumes in the downstream catchment areas during the life of the Lynwood Quarry will be less than predicted to in **Table 5.1**.

Table 5.1 Predicted Impacts on Catchment Areas

Catchment	Pre Quarry (ha)	With Currently Approved Operational Lynwood Quarry (ha)	With Currently Approved Final Landform (ha)	Modification Project Maximum Operational Extent (i.e. Stage 6) (ha)	Modification Project Proposed Final Landform (ha)
Wollondilly River	1,003,000	1,002,544	1,002,917	1,002,462	1,002,898
Joarimin Creek	5,411	5,115	5,372	5,168	5,411
Lockyersleigh Creek	2,629	2,469	2,585	2,333	2,527

During the operational quarry life (i.e. while the quarry water management system is in place) the Modification Project will reduce the impact of Lynwood Quarry on the catchment area of Joarimin Creek compared to the currently approved operations, by approximately 53 hectares primarily as a result of the removal of the approved Eastern Overburden Emplacement Area. This reduction in impact of the Lynwood Quarry within the Joarimin Creek catchment area will return the Joarimin Creek catchment area closer to its pre quarry catchment area during the operational stages of the quarry.

The Modification Project will reduce the Lockyersleigh Creek catchment compared to the currently approved Lynwood Quarry during the operational stages of the quarry. The proposed Stage 6 landform will result in a reduction of Lockyersleigh Creek catchment compared to the approved Lynwood Quarry, by approximately 136 hectares (5 per cent), primarily as a result of the proposed Granite Pit. The subsequent potential impact of the Modification Project on the catchment area of the Wollondilly River during the operational life of the quarry, of which Lockyersleigh Creek is a tributary, is considered negligible (i.e. less than 0.01 per cent).

The predicted long-term impacts on catchment areas (i.e. as a result of water capture in the final void) on the Wollondilly River catchment area is negligible for the approved Lynwood Quarry (i.e. < 0.01 per cent) and this impact is predicted to lessen with the Modification Project. Similarly the final landform impact on the Joarimin Creek catchment area is predicted to decrease as no final void is now proposed in this catchment. There is a minor increase in the final void impacts in the Lockyersleigh Creek catchment area from 2.7 per cent with the approved Lynwood Quarry to 3.9 per cent with the Modification Project.

Due to the limited localised impact, it is anticipated that the Modification Project will have negligible impact on the Wollondilly River and Joarimin Creek, with some minor impacts on flows in Lockyersleigh Creek (refer to **Section 6.3** for licensing requirements).

5.2 Flooding

5.2.1 Joarimin Creek

The removal of the approved Eastern Overburden Emplacement Area is the only component of the proposed extraction area modification that is considered to have the potential to impact on flooding in Joarimin Creek.

Previous flooding assessments for Joarimin Creek (the most recent presented in Umwelt, 2010) indicate that the approved quarry will reduce peak flows, velocities and flood depths in the main channel of Joarimin Creek for both the 5 per cent and 1 per cent AEP storm events. Some minor impacts on minor access roads, on land owned by Holcim Australia, were also predicted. The flood impacts on Joarimin Creek are primarily a result of the removal of catchment area associated with the Approved Pit and detention that occurs through approved Dam A.

It is considered that the removal of the approved Eastern Overburden Emplacement Area (an area of approximately 53 hectares) with this area continuing to flow directly to Joarimin Creek and not being directed to a sediment dam (approved Dam A) will have negligible changes to the flooding impacts in Joarimin Creek.

As such the Modification Project is not expected to adversely impact on flooding, on channel stability or in stream habitat of the Joarimin Creek system.

5.2.2 Lockyersleigh Creek

The Modification Project will result in the removal of part of the upslope catchment from four tributaries of Lockyersleigh Creek. In addition, the Modification Project will result in localised subcatchment changes with clean water runoff from upstream of the quarry conveyed around the quarry to downstream watercourses (refer to **Section 3.2**). As such there is potential for flooding impacts to occur downstream of Lynwood Quarry on the tributaries of Lockyersleigh Creek and this potential was further assessed as discussed in the following sections.

5.2.2.1 Methodology

A dynamic flood model was originally developed of Lockyersleigh Creek to support the original Development Consent (Umwelt, 2005). This model was also used to assess the following project changes (Umwelt, 2009 and Umwelt, 2010). The existing dynamic flood model has subsequently been extended, updated and used for this assessment. The dynamic flood model of Lockyersleigh Creek is an XPStorm® model. Flood modelling was undertaken for the approved final landform and the Stage 6 landform. Flood events that were simulated included the 5 per cent and 1 per cent AEP events (also referred to as the 20 year and 100 year Average Recurrence Interval (ARI) events).

The flood modelling for all events and landforms is based on the assumption that all sediment dams are partially full within the operational WMS so as to obtain a conservative estimate of flood peaks and as such potential impacts.

5.2.2.2 Overview of Results

Results summarising peak flows, velocities and water levels for Lockyersleigh Creek for the 1 per cent and the 5 per cent AEP storm events are detailed in **Tables 5.2** and **5.3**. The model layout and data locations are shown on **Figure 5.1**.

Table 5.2 Modelling Results – Lockyersleigh Creek – 1 per cent AEP storm event

Location	Approved			Stage 6		
	Peak Flow (m3/s)	Peak Water Level (mAHD)	Peak Velocity (m/s)	Peak Flow (m3/s)	Peak Water Level (mAHD)	Peak Velocity (m/s)
A	5.2	648.67	2.50	0.4	648.49	0.50
B	1.8	642.36	1.14	1.5	642.35	0.99
C	2.7	634.80	1.00	1.0	634.72	0.48
D	2.5	637.39	1.25	2.4	637.38	1.20
E	27.8	638.29	1.70	26.7	638.26	1.64
F	28.7	633.18	1.53	26.9	633.12	1.19
G	117.2	613.30	1.45	108.8	613.19	1.41

Table 5.3 Modelling Results – Lockyersleigh Creek – 5 per cent AEP storm event

Location	Approved			Stage 6		
	Peak Flow (m3/s)	Peak Water Level (mAHD)	Peak Velocity (m/s)	Peak Flow (m3/s)	Peak Water Level (mAHD)	Peak Velocity (m/s)
A	3.8	648.56	2.30	0.3	648.41	0.49
B	1.3	642.30	0.96	1.1	642.29	0.89
C	1.9	634.70	0.88	0.7	634.63	0.44
D	1.7	637.31	1.11	1.7	637.31	1.11
E	20.4	637.93	1.70	16.4	637.69	1.53
F	21.6	632.79	1.53	18.1	632.68	1.23
G	84.8	612.82	1.31	77.2	612.71	1.27

The modelling results indicate that the Modification Project will not increase downstream flooding impacts (refer to **Tables 5.1** and **5.2**).

The modelling also indicates that there will be no cumulative increase in flood flows downstream of the Lynwood Quarry on the main channel of Lockyersleigh Creek (refer to location F in **Tables 5.1** and **5.2**).

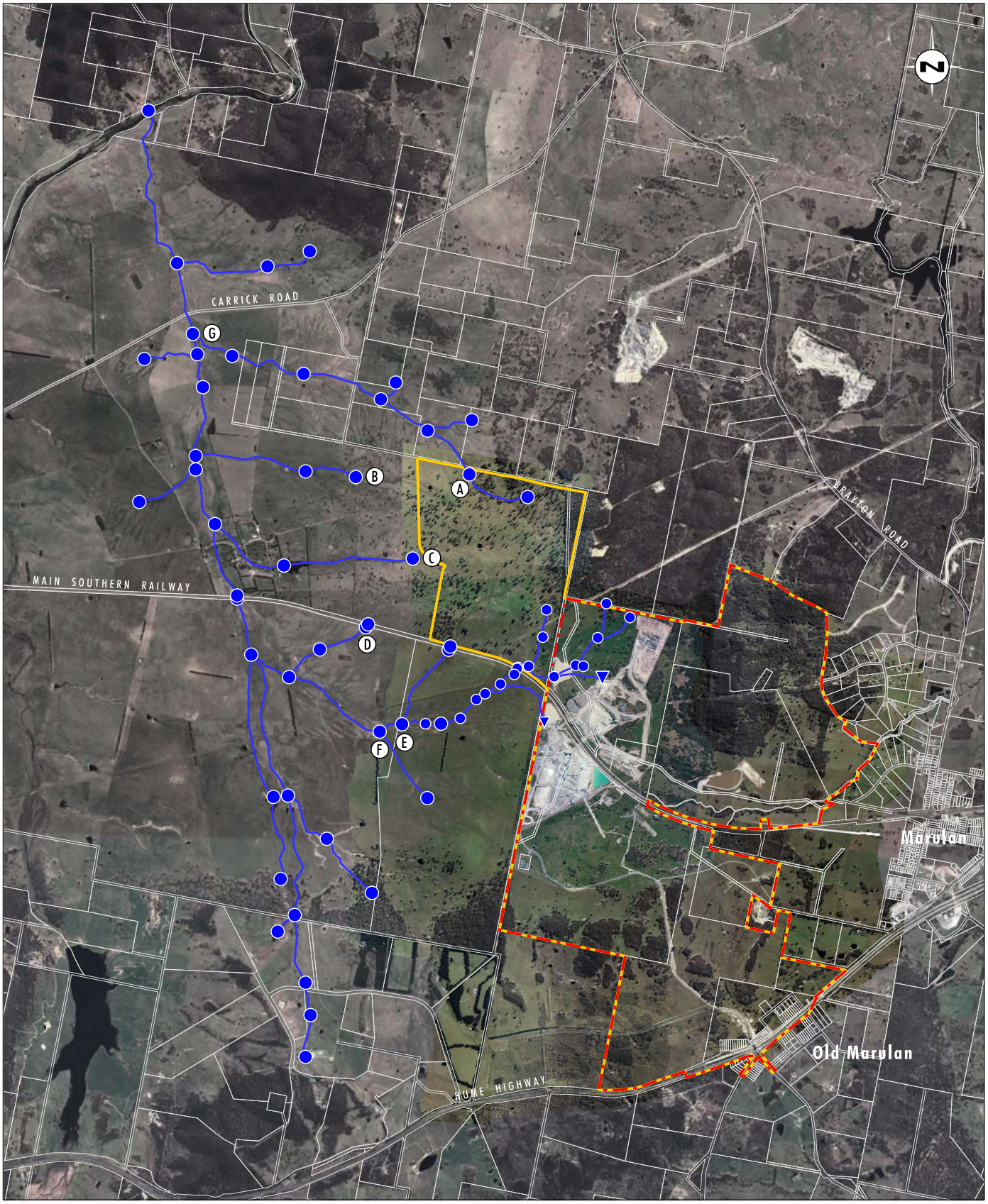


Image Source: Google Earth (2013), Holcim (2012, 2014)
Data Source: LPI (2014), Holcim Australia (2015)

0 1.0 2.0 2.5km
1:50 000

Legend
- Approved Project Area
- Modification Project Area
- Link
- Node

FIGURE 5.1

Lockyersleigh Creek Flood Modelling

5.3 Water Quality

Lynwood Quarry lies within the catchment areas of Joarimin Creek, Lockyersleigh Creek and Marulan Creek. Joarimin Creek and Lockyersleigh Creek drain to the Wollondilly River which is part of the Warragamba Dam catchment. Marulan Creek drains to the Shoalhaven River via Barbers Creek which is part of the Tallowa Dam catchment. Both Warragamba and Tallowa Dams contribute to Sydney's drinking water supplies. As such, all runoff from Lynwood Quarry that is not reused on site flows into rivers that are managed by the Sydney Catchment Authority. The water management strategy for the Modification Project has therefore been developed to provide for a neutral or beneficial water quality impact on downstream catchment areas in accordance with *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011*.

A water cycle management study was undertaken for the original EIS for Lynwood Quarry (Umwelt, 2005). Current guidelines published by the Sydney Catchment Authority (SCA) titled *Developments in the Drinking Water Catchment – Water Quality Information Requirements* (2015) indicate that all development applications in the drinking water catchment must include a water cycle management study (WCMS) to help 'Council' and Water NSW assess whether the development will have a neutral or beneficial effect on water quality. The information requirements listed for extractive industries include:

- stormwater quality modelling
- conceptual soil and water management plan
- on-site wastewater management report (if relevant)
- development specific pre- and post-development pollutant assessment requirements.

A detailed water quality model (using XP-Storm, previously known as AQUALM) was used to model the approved Lynwood Quarry Development as part of the Surface Water Assessment (Umwelt, 2005). The model was used to predict impacts of the Lynwood Quarry on phosphorus, nitrogen and suspended solids levels in downstream water systems.

The assessment indicated that the quarry would have a beneficial effect on downstream water quality in Joarimin Creek and Lockyersleigh Creek. The beneficial effect was due to reduction of sediment, nitrogen and phosphorus loads leaving the Lynwood Quarry site due to the reuse of water in the plant and for dust suppression, and treatment of water prior to release from the water management system. No changes were predicted in water quality in Marulan Creek. The improved management, including encouraging natural regeneration of the riparian corridors was also predicted to result in improved water quality over time. Management commitments in this regard are contained in the approved *Rehabilitation and Landscape Management Plan* (Holcim Australia, 2013).

As such the original EIS Surface Water Assessment (Umwelt, 2005) and subsequent modifications (Umwelt, 2009 and Umwelt, 2010) indicated that the Lynwood Quarry would have a beneficial effect on water quality in the downstream creeks and in the Wollondilly River.

It is proposed to employ the same environmental protection mechanisms for the Modification Project as for the approved Lynwood Quarry. As such the Modification Project is considered to maintain the identified beneficial effects of the approved Lynwood Quarry on downstream water qualities.

Holcim Australia proposes to continue to operate Lynwood Quarry in accordance with the controls and procedures specified in the approved *Lynwood Quarry Water Management Plan* (Holcim, 2013), including the conceptual water management systems outlined in **Section 3.0** and erosion and sediment controls

outlined in **Section 5.3.1**. Runoff from all disturbed areas within the Modification Project Area will be controlled on site for treatment ensuring that sediment transport off site is minimised and maintained below existing pollution loads.

If the Modification Project is approved, Holcim Australia proposes to review and update the quarry management plans including those related to water management.

5.3.1 Erosion and Sediment Control Measures

Erosion and sediment control will be undertaken in accordance with the *Lynwood Erosion and Sediment Plan* (ESCP) (Holcim, 2013), which will be updated if the Modification Project is approved. The ESCP provides a framework for the management of erosion and sedimentation at Lynwood Quarry.

The objective of the ESCP is to ensure that appropriate structures and programs of work are in place to:

- identify activities that could cause erosion and generate sediment
- describe the location, function and capacity of erosion and sediment control structures required to minimise soil erosion and the potential for transport of sediment downstream
- ensure erosion and sediment control structures are appropriately maintained
- fulfil the statutory conditions of the project approval
- meet the requirements of the Blue Book (Landcom, 2004 and DECC, 2008).

5.3.1.1 Construction

Construction environmental management plans will detail the specific inspection, maintenance and revegetation requirements for each works area based on the construction program schedule. These control measures will be set out in a detailed Erosion and Sediment Control Plan for ground disturbance works and will be in accordance with relevant guidelines for erosion and sediment control, including the relevant volumes of the Blue Book, as follows:

- Landcom 2004. Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.
- Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2A – Installation of Services.
- Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, 2C – Unsealed Roads.
- Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, 2D – Main Road Construction.
- Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

When work is required within or adjacent to watercourses, work will be in accordance with guidelines from *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volumes 2A, 2C, 2D and 2E* (DECC, 2008) (the Blue Book), including:

- works within the riparian zone will maximise, where possible the preservation of any existing vegetation and minimise disturbance
    - designs for works within or near water bodies will ensure the retention of natural functions and maintenance of fish passage in accordance with NSW Fisheries Guidelines (undated) *Fish Friendly Waterway Crossings*
- planned works will, where possible, be scheduled for forecasted dry weather periods.

5.3.1.2 Operations

During the operational phase, additional WMS components will be constructed as work progresses. The operational phase will involve the ongoing management of the WMS, and be consistent with:

- Landcom 2004. Managing Urban Stormwater – *Soils and Construction, Volume 1, 4th Edition*.
- Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

Specific erosion and sediment control measures proposed to be implemented for the Project will also include those measures outlined the main EA document.

5.4 Geomorphological and Hydrological Values

The flooding modelling (refer to **Section 5.2**) indicates that the Modification Project will not adversely impact on flooding, on channel stability or in stream habitat of either the Joarimin Creek or Lockyersleigh Creek systems or the Wollondilly River. As such the Modification Project is not expected to have a significant impact on the geomorphological and hydrological values of local surface water systems (refer to **Section 5.2**).

5.5 Riparian and Ecological Values

As discussed in the preceding sections, the water management systems for the existing Lynwood Quarry and Modification Project have been designed in accordance with relevant guidelines and to minimise the potential downstream impacts of the quarry on riparian environments. This includes effective management of flooding regimes, water flows and water quality.

The changes in annual flow volumes associated with changes to the Lockyersleigh Creek catchment area from the final approved landform to the final proposed landform are considered to be small within the context of ephemeral streams. The predicted changes in flows in Lockyersleigh Creek are significantly less than the seasonal and annual variations in flow volumes comparing dry years to wet years. In addition, the Modification Project is considered to have negligible impacts on baseflows (refer to Appendix 8 of the EA).

The Project is consequently considered likely to have negligible impact on downstream riparian ecosystems and downstream users as the predicted impact is within the natural variation of the existing creek systems.

5.6 Water Users

As discussed in **Section 2.5** the *Water Sharing Plan for the Great Metropolitan Region Unregulated River Water Sources 2011* applies to watercourses in the vicinity of Lynwood Quarry. The catchments of Joarimin Creek and Lockyersleigh Creek are located within the Upper Nepean and Upstream Warragamba Water Sources Management Zone in the Lower Wollondilly River Water Source. The catchment of Marulan Creek is located within the Shoalhaven River Water Source Management Zone in the Barbers Creek Water Source. As the creek systems are covered by water sharing plans, surface water use at Lynwood Quarry is governed by the *Water Management Act 2000*.

The Modification Project will intersect the catchments of a number of minor tributaries (i.e. first order and second order tributaries) of Lockyersleigh Creek and has the potential to change surface water flows in these tributaries and in a third order tributary to the south of the Granite Pit area. As such the Modification Project has the potential to impact the water available for both harvestable rights extraction and licensed water extraction from these tributaries. However, as there are minimal farm dams located on the properties immediately downstream of the proposed Granite Pit area that capture and use this runoff and Holcim Australia has agreements with the property owners to the north and west of the proposed Granite Pit area, is it considered that the impact of the Modification Project on downstream water users will be minimal. As discussed in **Section 6.3**, on average capture of runoff from clean catchments at Lynwood Quarry is predicted to be within Holcim Australia's harvestable rights.

As discussed in **Section 5.1**, the Modification Project will result in a negligible impact on the catchments of both Joarimin Creek and the Wollondilly River and will therefore have a negligible impact on water users in those catchments.

There is predicted to be negligible impacts on water users on both due to the negligible impact on the catchment areas of these systems (refer to **Table 5.1**).

5.7 Summary of Potential Impacts

The outcomes from the surface water assessment of the Modification Project indicate that the proposed modifications will, consistent with the assessment findings for the approved Lynwood Quarry, not significantly alter the flow regimes or annual flow volumes in either Joarimin Creek or Lockyersleigh Creek in terms of peak discharges, flood levels or peak in-stream velocities either upstream of downstream of Lynwood Quarry. As a result, the Modification Project is not expected to adversely impact on channel stability or in-stream habitat of either the Joarimin Creek or Lockyersleigh Creek systems.

The assessment also found that the Modification Project will not adversely impact upon water quality in Joarimin Creek or Lockyersleigh Creek or the downstream drainage systems.

As water use within the catchments is regulated by Water Sharing Plans and Holcim Australia's take of clean water catchment will be on average within its harvestable rights, the Modification Project is not expected to have a significant impact on downstream water users.

6.0 Monitoring, Licensing and Reporting

Water systems are monitored at Lynwood Quarry and its surrounds in accordance with the *Lynwood Quarry Water Management Plan*.

Water monitoring at Lynwood Quarry is undertaken to assess compliance against licence conditions and consent conditions, and for operational purposes. This includes monitoring of erosion and sediment controls, the site water balance and water quality.

If the proposed Modification Project is approved, the *Lynwood Quarry Water Management Plan* and associated sub plans, including the *Rehabilitation and Landscape Management Plan* will be updated to include the monitoring and reporting aspects discussed in **Sections 6.1** to **6.4**.

A substantial record of baseline data has been collected for Lynwood Quarry (refer to **Section 2.3**) and will be used to inform the ongoing review of monitoring data, allowing any potential impacts of the quarry operations to be identified and management measures implemented where appropriate.

6.1 Monitoring

6.1.1 Erosion and Sediment Control Measures

Erosion and sediment controls will be monitored during construction and operation in accordance with the *Blue Book* (Landcom, 2004 and DECC, 2008). Monitoring of the performance of the water management systems and associated erosion and sediment control measures will be set out in the WMP, with monitoring typically undertaken monthly and after major storm events.

6.1.2 Water Balance Monitoring

As part of the water balance monitoring for the water management system, water imported to site, water used on site and water discharged from site will be monitored in accordance with *Water Reporting Requirements for Mines* (NSW Office of Water, undated).

6.1.3 Surface Water Quality Monitoring

Surface water quality monitoring is currently undertaken within the WMS and at various upstream and downstream locations on the creeks located near Lynwood Quarry. Water quality parameters monitored in watercourses include monthly sampling of pH; electrical conductivity; Total Dissolved Solids (TDS); chloride (Cl); iron (Fe); manganese (Mn); arsenic (As); nitrite; nitrate; total phosphorous; oxidised nitrogen; Total Kjeldahl Nitrogen (TKN); and Benzene, Toluene, Ethylbenzene, and Xylene (BTEX). Surface water monitoring will be continued over the life of the Project. Holcim Australia proposes to:

- continue to record and document the existing water quality at the current water quality monitoring points so as to highlight any areas of concern or impact. As part of the implementation of the Modification Project, the WMP will be updated to reflect additional surface water monitoring points on Lockyersleigh Creek (refer to **Figure 2.3**), downstream of the quarry. The water quality parameters and frequency of sampling for watercourses surrounding the quarry will remain as for the existing approved operations

- continue to record and document water quality within the WMS as outlined in the WMP

- review and monitor the performance of erosion and sediment controls
- continue the reporting of monitoring results in the Annual Review.

The existing and proposed surface water quality monitoring points are shown in **Figure 2.3**. Three new monitoring points on Lockyersleigh Creek are proposed to provide information on potential impacts from the Modification Project.

6.1.4 Flow Monitoring

Flow monitoring will continue to be undertaken by visual observation of the flows during water quality sampling (flow, no-flow). The flow observations will be used to inform the assessment of water quality data.

6.1.5 Contingency Measures

The process of detailed design, construction and monitoring/maintenance of the proposed WMS during the operational phase is intended to reduce the risks associated with unplanned spillages or other unforeseen circumstances with potential to result in unexpected environmental impacts. That is, the system has been designed considering the range of potentially relevant environmental factors and variables, reducing the risk of the implemented system not performing as planned.

As a further contingency measure, the following key components will be used as required during the Project, to address potential surface water impacts:

- Water shortages: The water balance modelling indicates that during prolonged dry periods and at peak production levels, water demand may exceed supplies. If water shortages develop Holcim Australia will either source additional off-site water supplies or reduce operations to match the available water supply.
- Water surplus: temporary storage of surplus water in the Approved Pit and if required the proposed Granite Pit. Treatment of water in sediment dams to meet release requirements. Holcim Australia is also currently applying for a modification to EPL 12939 to allow for discharges from the quarry WMS.
- Unforeseen failure or catastrophic events: In the event of an unforeseen spillage associated with incidents such as accidental damage, operational failures or extreme catastrophic occurrences, the hazard notification protocols in the Surface Water and Groundwater Response Plan (Holcim Australia, 2013) will be followed.
- Possible impacts of climate change: Climate change poses an increased risk of both water shortages and extreme flood events. Given the predicted water surplus in the latter years of the quarry, it is considered likely that the possible reduced availability of water will not significantly impact the quarry.

6.2 Decommissioning of the Water Management System

As part of decommissioning, water management dams will either remain in use for identified and approved future land uses or will be removed. If the dams are to be retained, the capacity of the dams will be reviewed and the size/volume modified as necessary. Some of the proposed drains will remain in place as part of the final landform where considered to be stable in the long term and where required to minimise erosion. Areas disturbed by removal or modification of water management structures will be reshaped and revegetated. The measures required to effectively decommission the water management system and the water management controls required in the post mining landform will be considered in further detail as part of the detailed quarry closure planning process. This closure planning process is addressed in the closure section of the main text of the EA.

6.3 Licensing Requirements

6.3.1 Protection of the Environment Operations Act 1997

Operations at Lynwood Quarry currently are currently operated in accordance with Environment Protection Licence (EPL) 12939 under the *Protection of the Environment Operations Act 1997*. EPL 12939 currently does not allow controlled discharges from the site, although the development consent allows overflows from sediment dams when relevant design criteria are exceeded.

Holcim Australia is currently applying for a modification to EPL 12939 to allow for discharges from the quarry WMS.

6.3.2 Water Act 1912 and Water Management Act 2000

The Water Sharing Plan for the Great Metropolitan Region Unregulated River Water Sources 2011 applies to watercourses in the vicinity of Lynwood Quarry. The catchments of Joarimin Creek and Lockyersleigh Creek are located within the Upper Nepean and Upstream Warragamba Water Sources Management Zone in the Lower Wollondilly River Water Source. The catchment of Marulan Creek is located within the Shoalhaven River Water Source Management Zone in the Barbers Creek Water Source. As the creek systems are covered by water sharing plans, surface water use in the Project Area is governed by the *Water Management Act 2000*.

Under the Harvestable Rights regulations (*Water Management Act 2000*), landholders may harvest up to 10 per cent of the average regional runoff on a property. The existing and proposed WMS includes drainage systems around the perimeter of the quarry operations in order to divert upslope catchment runoff away from these areas (refer to **Figures 3.3** to **3.5**).

Existing Dam A and Dam F (both sediment dams) have catchments that include a portion of land that will not be disturbed by the quarry. The undisturbed catchment areas of Dam A and Dam F (which remain constant for Stages 1, 3 and 6) are located within the WMS. The modelled range of volume of runoff captured from these undisturbed areas for the range of meteorological conditions modelled is listed in **Table 6.1**.

Table 6.1 Runoff from Undisturbed Areas

Stages	Minimum	Percentile			Maximum
		10%	50%	90%	
1,3 and 6	0	4	107	410	615

The water take estimated to be harvested from natural undisturbed catchment areas ranges between 4 ML per year in a 10th percentile year to 410 ML per year in a 90th percentile year. The 50th percentile modelled value for runoff harvested from natural undisturbed catchments is 107 ML per year.

Holcim Australia owns a land area of approximately 1556 hectares. Based on 100 per cent capture of runoff at the regional runoff rates (refer to www.farmdamscalculator.dnr.nsw.gov.au) of 0.75 ML per hectare per year, this equates to capture of approximately 117 ML per year of harvestable rights. As such, on average the capture of clean water runoff (refer to **Table 6.1**) is within the harvestable rights provisions of Holcim Australia. As described in **Section 3.1**, both Dam A and Dam F are part of the water management system for the Approved Project and currently exist. No changes are proposed to either dam as part of the Modification Project, however, a further dam is proposed downstream of Dam F for water quality control purposes.

Holcim Australia will licence all surface water take from clean water catchments, i.e. water not managed for pollution control purposes, that is in excess of harvestable rights provisions.

6.4 Reporting

A summary of surface water monitoring results will be provided in the Annual Review. As a minimum, the following information will be reported in the Annual Review:

- a summary of monitoring results
- an analysis of monitoring results against impact assessment criteria, historical monitoring results and the predictions in the EA
- annual site water balance and comparison against predictions in the EA
- an identification of any trends in the monitoring results
- any non-compliances reported during the year
- actions taken to address any non-compliances.

In addition, any significant findings regarding the implementation of the WMP will be reported in the Annual Review, including:

- the effectiveness of the erosion and sediment controls
- changes to the site water balance
- any identified issues or exceedances of trigger values.

The Annual Review will also document reviews and feedback relating to the maintenance and performance of the water management system.

7.0 References

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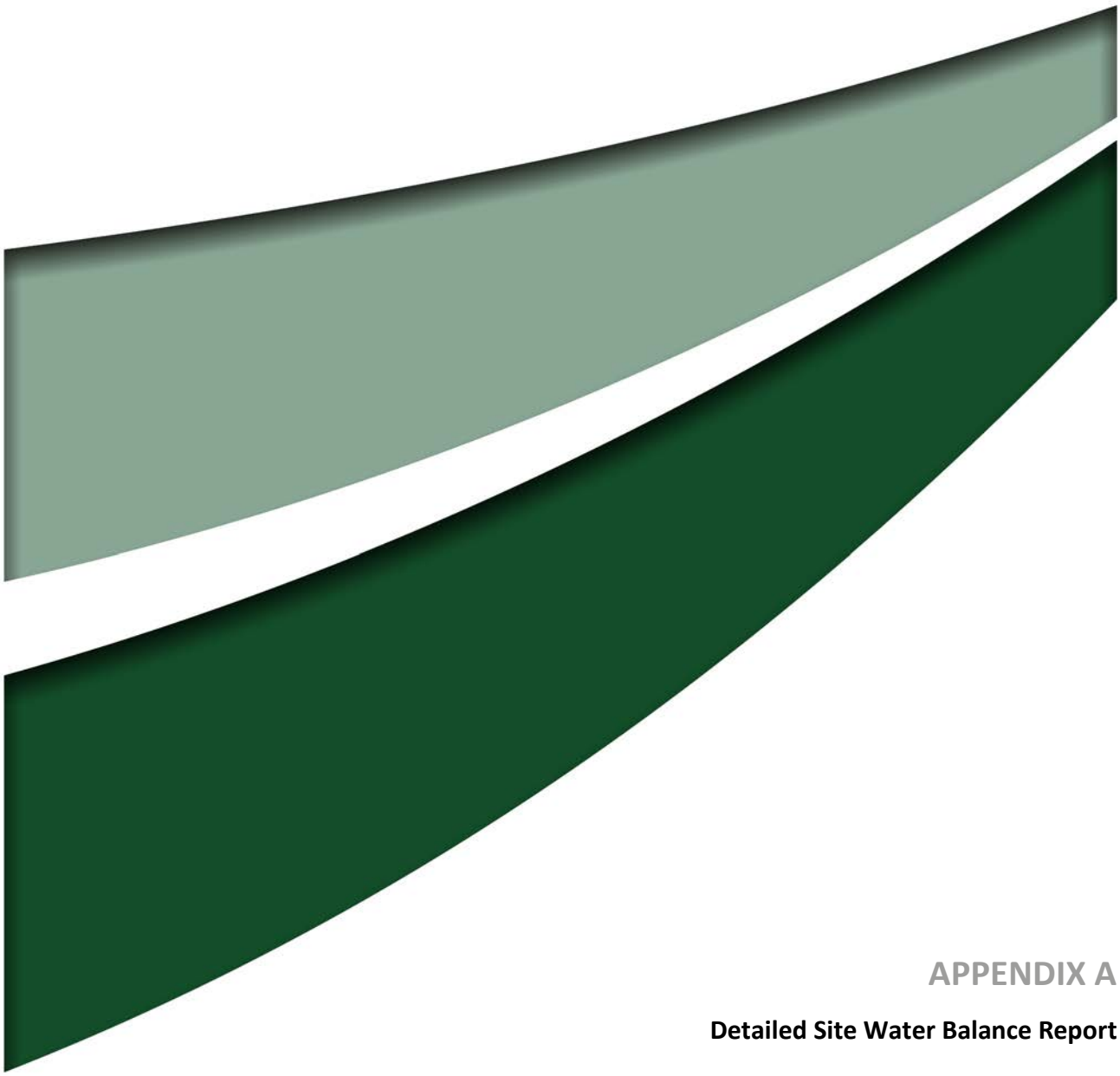
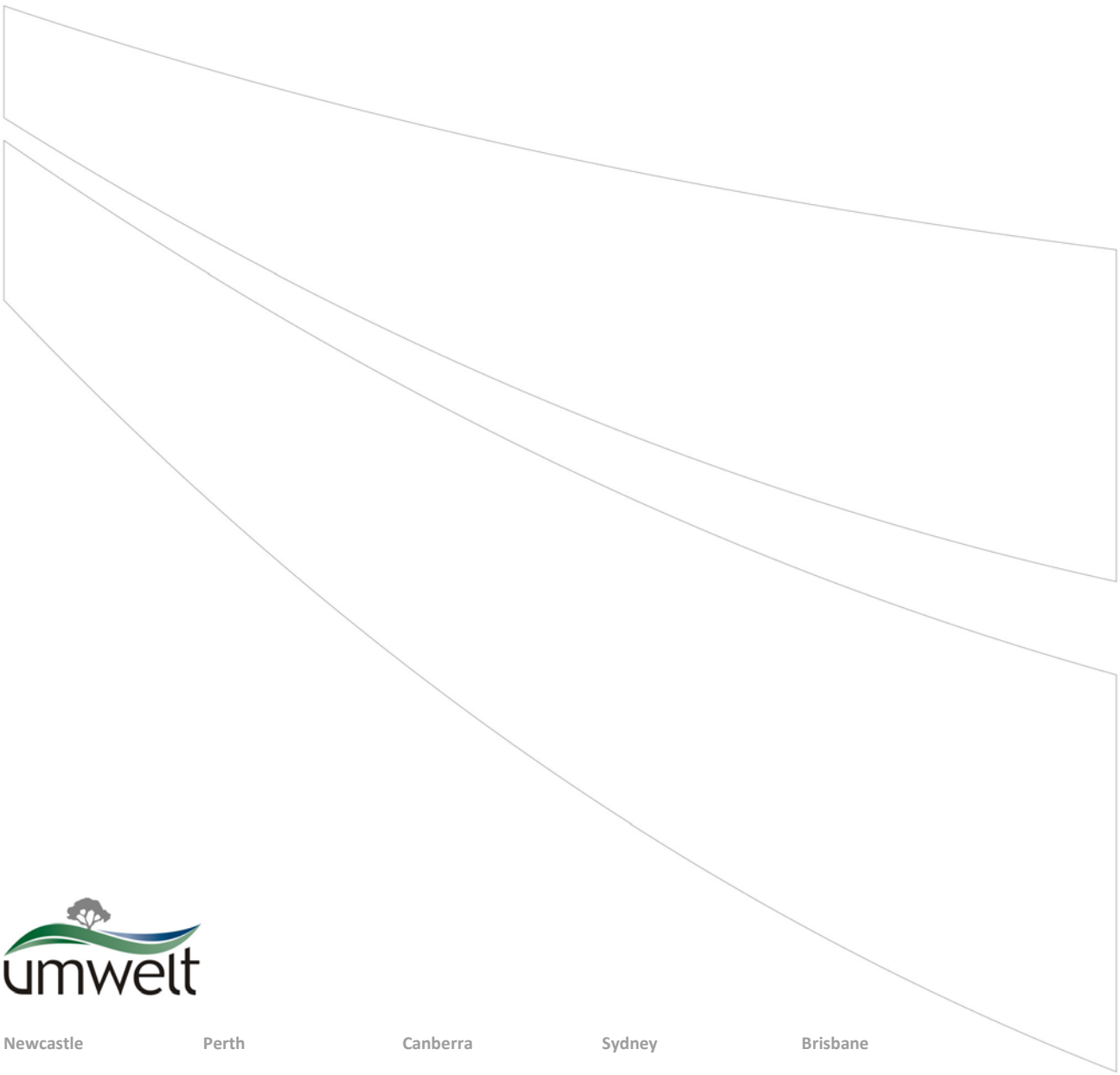


APPENDIX A

Detailed Site Water Balance Report



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