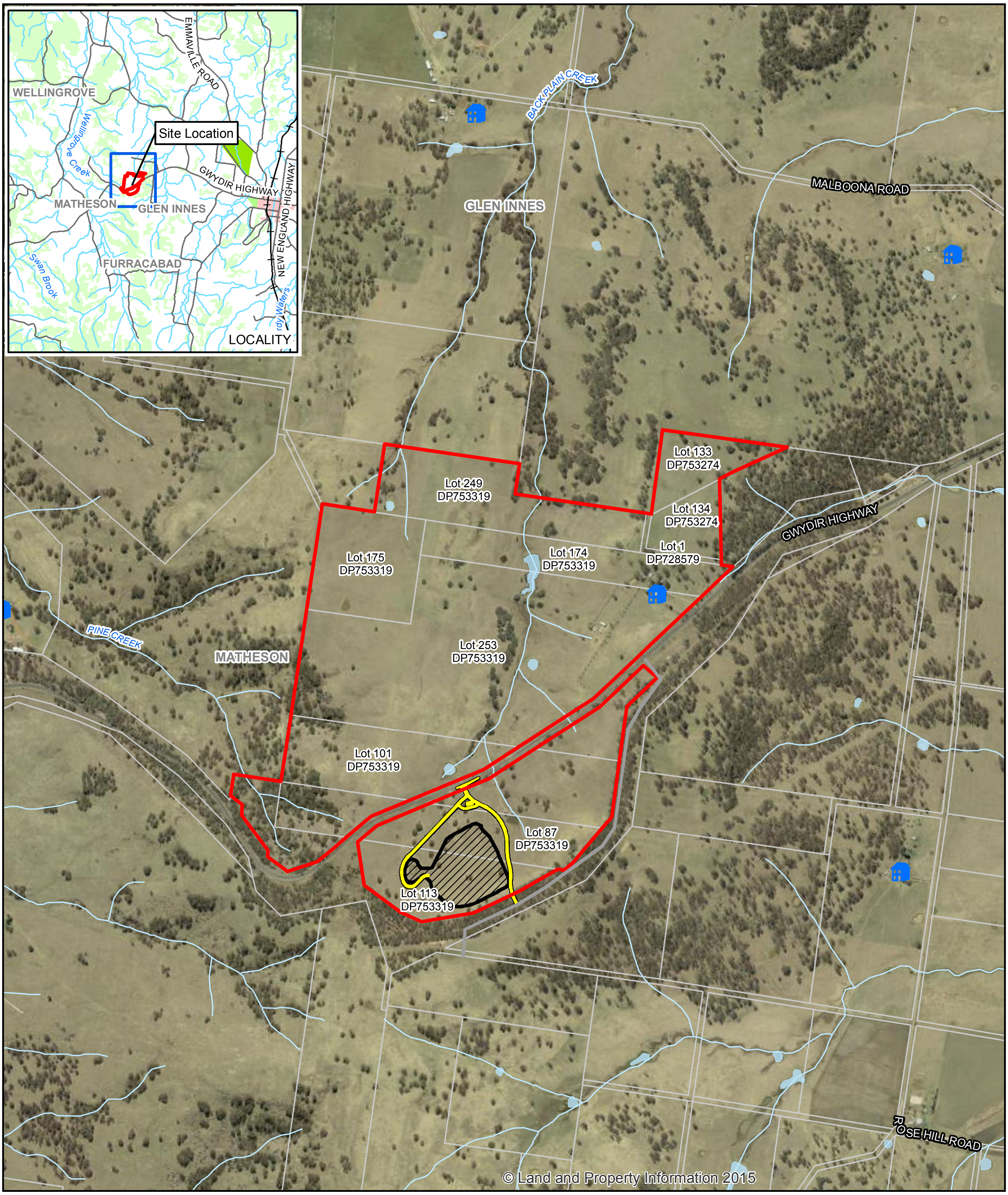


LEGEND

- Project boundary
- Cadastre
- Watercourse
- Waterbody
- Disturbance area
- Site access
- Existing access
- Residences

Paper Size A4

0 80 160 320 480 640

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Glen Innes Severn Council
Wattle Vale Quarry
Environmental Impact Statement

Job Number	22-18380
Revision	A
Date	14 Nov 2016

Site overview

Figure 1-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\18380\GIS\Maps\Deliverables\SouthernQuarryEIS\2218380_SQEIS002_SiteOverview_A.mxd

Data source: LPI: DCDB & DTDB, 2012,Aerial Imagery, 2016; Geoscience Australia: 250k Topographic Data Series 3, 2006; GISSC: Quarry data, 2016. Created by: fmackay

2. Legislation and Policy

2.1 Legislation

2.1.1 Water Act 1912

The *Water Act 1912* governs access, trading and allocation of licences associated with both surface and underground water sources where a Water Sharing Plan (WSP) does not yet exist. The elements to which the *Water Act 1912* applies include extraction of water from a river, extraction of water from underground sources, aquifer interference and capture of surface runoff in dams.

A WSP for the NSW Murray Darling Basin (MDB) Fractured Rock Groundwater Sources commenced in January 2012. Additionally, a WSP for the NSW Border Rivers Unregulated and Alluvial Water Sources commenced in June 2012. The commencement of both these WSPs render the governance of *Water Act 1912* redundant and the act therefore no longer applies to extraction or interception of groundwater at the site.

2.1.2 Water Management Act 2000

The *Water Management Act 2000* (WM Act), administered by Department of Primary Industries Water (WaterNSW), is intended to ensure that water resources are conserved and properly managed for sustainable use to the benefit of both present and future generations. It provides a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

An amendment to the WM Act (Section 60I) came into effect on 1 March 2013. Under this amendment it is an offence to take, remove or divert water from a water source or relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity without an access licence. Various activities are captured by the provisions of the amendment including mining, mineral exploration and petroleum exploration.

The site is covered by the Water Sharing Plan (WSP) for the NSW Macquarie Darling Basin (MDB) Fractured Rock Groundwater Sources which regulates the interception and extraction of groundwater from the fractured rock aquifer. As defined by this WSP, the site is located within the New England Fold Belt MDB Groundwater Source.

The WSP for the NSW Border Rivers Unregulated and Alluvial Water Sources regulates extraction of alluvial groundwater within the site boundary. As defined by this WSP, the site is located within the Glen Innes Water Source.

The water collected in the sediment basin, shown in Figure 3-1, is within the “maximum harvestable right dam capacity” (MHRDC) for the site, so a Water Access Licence (WAL) is not be required (refer to Section 4.1.2).

2.2 Policy

2.2.1 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licencing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this Policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced 30 June 2011.

This Policy outlines the water licensing requirements under the WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void) even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Many mining operations continue to take water from groundwater sources after operations have ceased (for example an open pit filling with groundwater). This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and groundwater dependent ecosystems (GDEs), be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The minimal impact considerations relevant to the Project are outlined in Section 4.2.3.

2.2.2 NSW State Groundwater Policy

The objective of the NSW State Groundwater Policy Framework Document (NSW Government 1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Protection Policy
- NSW Groundwater Quality Protection Policy
- NSW Groundwater Dependent Ecosystem Policy

NSW Groundwater Quantity Protection Policy

The principles of this policy include:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.

All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow, halt or reverse any degradation to groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater.

- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

3. Existing Conditions

3.1 Topography

Elevations within the site vary from 1193 m AHD at the southern extent of the site to 1093 m AHD at the northern extent of the site. The southern extent of the site is located on a ridgeline with elevations generally decreasing to the north, east and west.

3.2 Geology

The 1:250,000 Grafton Geological Map indicates that the site is underlain by Tertiary basalt. To the north, east and west of the site lie mapped areas of Quaternary alluvium associated with creek lines.

Geological investigations (SMEC, 2016) included drilling of a number of boreholes in the vicinity of the proposed quarry area. The location of the proposed quarry area is shown in Figure 1-2. Borehole records indicate the site is underlain by thin layer of silty clay that extends to up to 1.7 m deep in the vicinity of the proposed quarry area. This is in turn underlain by a thick layer of basalt that extended to the base of the boreholes (18 to 25 m below ground level).

3.3 Hydrology

An intermittent unnamed tributary of Backplain Creek runs through the Project site. The tributary only flows following rainfall events although there are a number of small farm dams located throughout the Project site that hold water. Backplain Creek is a tributary of the Wellingrove Creek flowing into the Severn River to the north.

The water quality of the unnamed tributary is unknown but due to the cleared, agricultural use of the catchment it is expected to be contaminated with anthropogenic sources (e.g. sediments, nutrients, manure).

3.4 Hydrogeology

3.4.1 Groundwater sources

Geological investigations undertaken by SMEC (2016) included drilling eight boreholes three of which were located in the vicinity of the proposed pit. The three boreholes were drilled to depths of 18 m to 25 m below ground level (approximately 4 m to 13 m below the base of the proposed pit). Groundwater inflows were not noted during drilling however some water was noted in the bores on completion of drilling and was attributed to drilling fluid residues (SMEC, 2016).

Groundwater investigations undertaken by GISC between 10 October 2016 and 21 October 2016 included drilling six boreholes in the footprint of the proposed quarry area (Figure 3-1). Four of which intercepted groundwater at depths ranging 7.5 to 17.4 m BGL (1172.5-1157.6 m AHD). It is noted however that this investigation proceeded after a period of above (double) average rainfall[1]. The floor of the proposed quarry is 1170 m AHD, indicating that groundwater may be intercepted by the quarry.

[1] Recorded rainfall between June 2016 and September 2016 (the four months preceding groundwater monitoring by GISC) at the Glen Innes Agricultural Weather Station [Bureau of Meteorology (BoM) station number 056013] was 427 mm. Based on a review of long term rainfall recorded at this station between 1910 and 2016, average rainfall from June to September was 212 mm and 95th percentile recorded rainfall from June to September was 361 mm.

As stated in Section 3.1, the proposed pit is located on a ridgeline. The GISC results indicate perched groundwater is present along the ridgeline. Based on the GISC data, groundwater levels within the proposed quarry area vary from approximately 1173 m AHD to approximately 1158 m AHD. Monitoring data indicates a groundwater flow direction from the top of the ridgeline towards the north. The groundwater deposit would be directly recharged by rainfall and discharge at lower elevations on the slopes and drainage lines to the north in the vicinity of the proposed quarry area and the site. GHD considers it is likely that GISC observed groundwater levels above typical levels due to above average rainfall. Following periods of lower rainfall, groundwater levels in the vicinity of the quarry area would be lower. The groundwater intercepted as part of groundwater investigations undertaken by GISC is considered to be an isolated deposit of perched groundwater that is separate from the regional groundwater. The regional groundwater table is not expected to be intercepted by the quarry.

The results of the registered bore search, outlined in Section 3.4.2, indicate that the yield from the basalt aquifer is typically less than 2 L/s.

The mapped alluvial sediments are located outside the site boundary. The alluvial sediments lie at lower elevations along creek lines. The proposed extraction will not extract groundwater from the alluvial sediments.

Table 3-1 GISC groundwater monitoring

ID	Depth (m bgl)	Static Water Level (m BGL)					Groundwater Elevation (m AHD)				
		10/10/2016	14/10/2016	17/10/2016	20/10/2016	21/10/2016	10/10/2016	14/10/2016	17/10/2016	20/10/2016	21/10/2016
BH15	NA	7.5	Collapsed to 7.2 m BGL, wet on bottom. Plugged to 0.5 m BGL and backfilled	NA	NA	NA	1172.5	NA	NA	NA	NA
BH16	14/19.3	Collapsed to 14.4 m BGL	Blockage dislodged and well opened to 19.3 m BGL	NA	16.9	17.4	NA	NA	NA	1158.1	1157.6
BH17	NA	Collapsed to 2.2 m BGL. Plugged and backfilled	NA	NA	NA	NA	NA	NA	NA	NA	NA
BH18	23.5	NA	NA	9.4	9.6	9.7	NA	NA	1170.6	1170.4	1170.3
BH12	11.7	NA	NA	NA	7.3	7.9	NA	NA	NA	1172.7	1172.1
BH13	16.5	NA	NA	NA	NA	Dry	NA	NA	NA	NA	Dry

NA: Not available; data unknown/water level not measured

m BGL: metres below ground level

m AHD: metres Australian Height Datum

3.4.2 Registered groundwater users

A search of the NSW Groundwater Bore Database (DPI Water, 2016) was undertaken to identify registered groundwater bores in the vicinity of the site. The search identified 16 bores within a 5 km radius of the site. The majority of the bores (14) were registered for stock or domestic purposes. The purpose of the remaining two bores was not reported. The location of registered bores is shown in Figure 3-2 and details are provided in Table 3-2.

Of the registered bores, the closest stock and domestic bore was located approximately 1 km to the west of the site boundary and approximately 1.8 km to the north west of the proposed extraction area.

The database's records indicate groundwater yields from the basalt aquifer are less than 2 L/s.

Table 3-2 Results of NSW bore database search

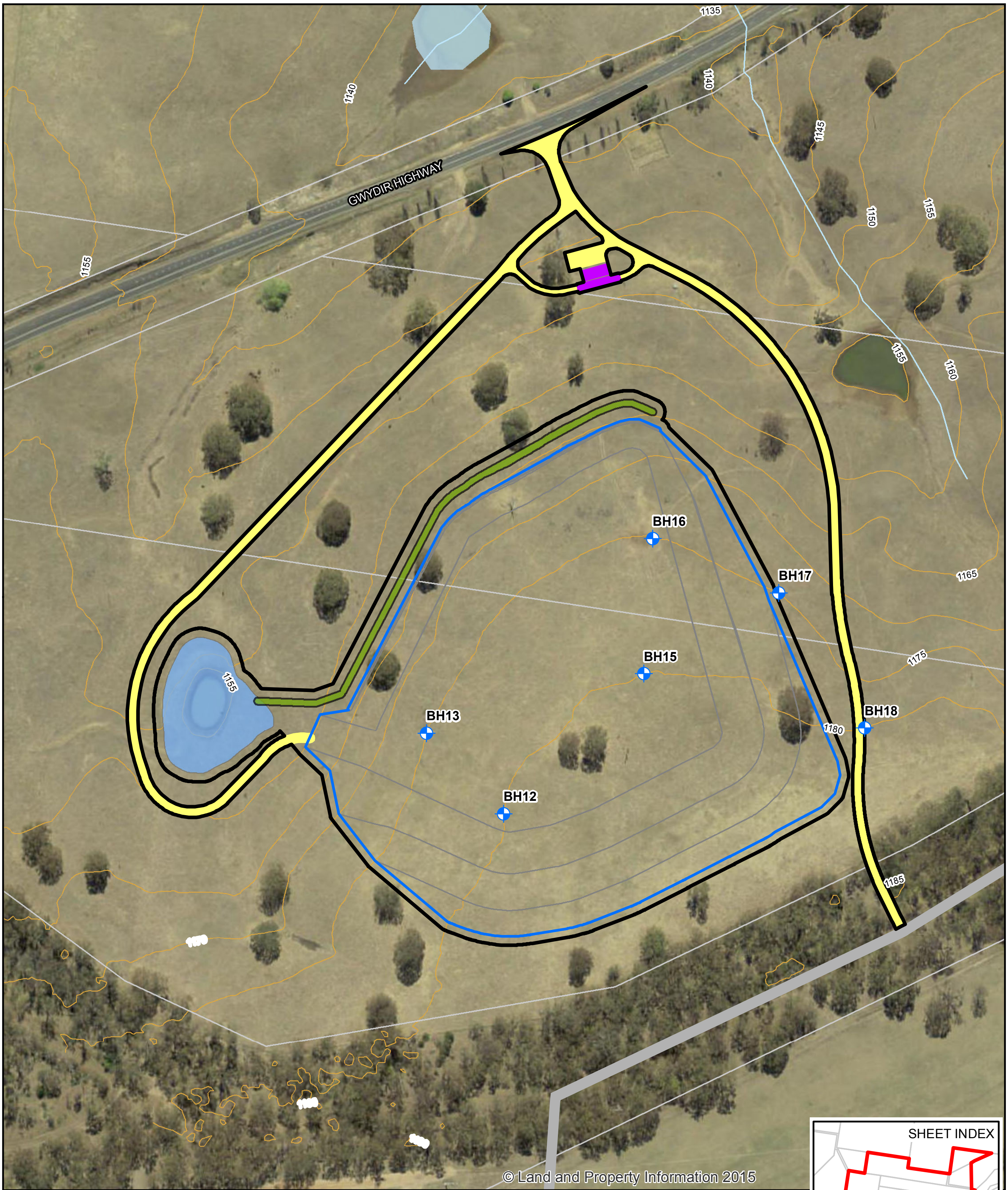
Name	Depth (m)	Use	WBZ (m bgl)	SWL (m bgl)	Salinity	Yield (L/s)	Aquifer
GW031258	17.7	Stock	Unknown	Unknown	Unknown	Unknown	Unknown
GW070602	38.1	Stock, domestic	13.7-16.8			1.13	Rock, basalt
GW048388	36.9	Stock	Unknown	Unknown	Unknown	Unknown	Basalt
GW054047	15.2	Stock, domestic	Unknown	Unknown	Good	Unknown	Unknown
GW054230	12.8	Stock	Unknown	Unknown	Stock	Unknown	Unknown
GW052181	32	Stock	Unknown	Unknown	Unknown	Unknown	Basalt
GW049192	48.8	Stock, domestic	14.6, 22.3-30.8	3.7	Unknown	0.25	Basalt
GW058096	20	Stock, domestic	Unknown	Unknown	Unknown	Unknown	Unknown
GW966020	27	Stock, domestic	21-27			1.8	Basalt
GW033953	21.3	Stock	15.8-16.4, 17.7-18.6, 19.8-21	Unknown	Unknown	Unknown	Basalt, clayey basalt
GW029580	30.5	Stock	Unknown	Unknown	Unknown	Unknown	Unknown
GW051336	18.9	Stock	Unknown	Unknown	Unknown	Unknown	Unknown
GW054055	67.1	Stock	20.2-20.3	31.6	Good	0.12	Basalt
GW971175	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
GW970954	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
GW051447	31.4	Stock	21.6-25.3, 28.6-28.9, 30.4-31.1	19.8	Good	0.91	Basalt

WBZ: Water bearing zone

SWL: Standing water level

3.4.3 Groundwater dependent ecosystems

The closest high priority GDE listed in WSP for the NSW MDB Fractured Rock Groundwater Sources is located approximately 32 km west north-west of the site. There are no high priority GDEs listed in the WSP for the NSW Border Rivers Unregulated and Alluvial Water Sources.



LEGEND

- Project boundary
- Cadastre
- 5m contours
- Watercourse
- Waterbody
- Existing access
- Site access
- Site office / weigh bridge
- Basin (3000m2)
- Diversion bund
- Quarry pit
- Disturbance area
- Borehole location

Paper Size A4
0 12.5 25 50 75 100
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Glen Innes Severn Council
Wattle Vale Quarry
Water Resources Assessment

Job Number 22-18380
Revision A
Date 15 Nov 2016

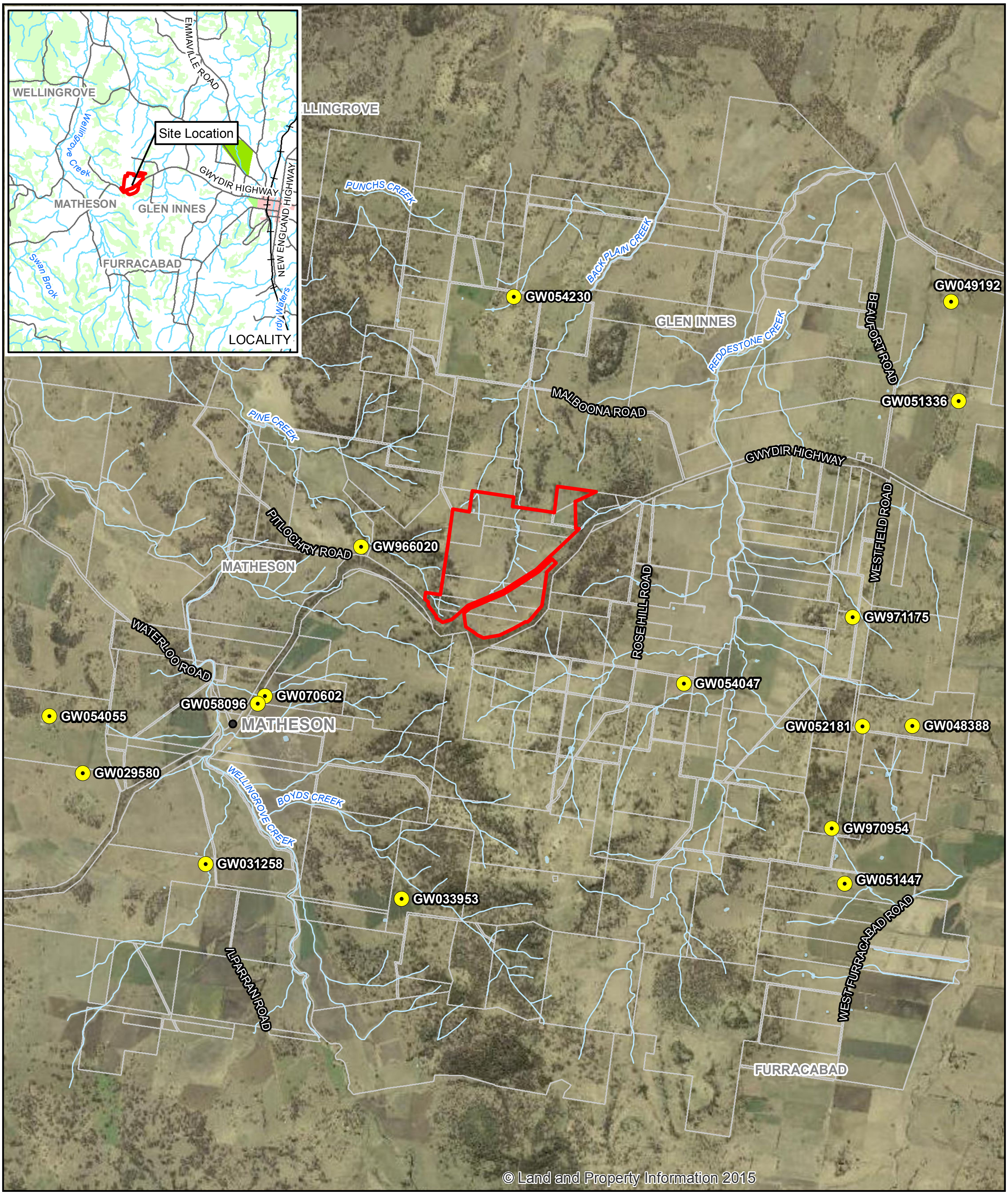
GISC borehole locations

Figure 3-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

G:\22\18380\GIS\Maps\Deliverables\SouthernQuarryEIS\Water\2218380_SQW103_BoreholeLocations_A.mxd

Data source: LPI: DCDB & DTDB, 2012,Aerial Imagery, 2016; GISSC: Aerial Imagery / Quarry Data, 2016. Created by: fmackay, tmorton



LEGEND

- Project boundary
- Cadastre
- Watercourse
- Waterbody
- Registered landholder bores

Paper Size A4

0 265 530 1,060 1,590 2,120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Glen Innes Severn Council
Wattle Vale Quarry
Water Resources Assessment

Job Number 22-18380
Revision A
Date 15 Nov 2016

Registered bore search

Figure 3-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au

G:\22\18380\GIS\Maps\Deliverables\SouthernQuarryEIS\Water\2218380_SQW102_BoreSearch_A.mxd

Data source: LPI: DCDB & DTDB, 2012,Aerial Imagery, 2016; Geoscience Australia: 250k Topographic Data Series 3, 2006; GISSC: Quarry data, 2016. Created by: fmackay, tmorton

4. Impact assessment

4.1 Surface water

Potential risks at the site with relation to surface water were identified based on the nature of the works and the surrounding receiving environment. The key risks identified were:

- Insufficient water available to meet site demands
- Discharge of sediment-laden water
- Modification of downstream flow volumes and regimes

Based on these potential risks it was determined that the key components of the assessment would be the development of a water balance and assessment of erosion and sediment control. The methodology for these key elements of the assessment is detailed in the sub-sections below.

It was noted that due to the nature of the activities onsite, no significant water quality risks are expected other than in relation to erosion and sediment control. Management of potential hydrocarbon spills was considered as a component of the erosion and sediment control assessment.

It was also noted that the location of the proposed works is not adjacent to any major waterway, is located near the top of the catchment and is therefore not considered to have a significant risk of flooding from nearby waterways.

4.1.1 Water Balance

A daily time-step water balance model was simulated. This quantified the expected water transfers in the system on a daily basis. The model allowed for estimation of likely volumes of:

- Runoff entering the pit
- Groundwater inflow (2.92ML/year)
- Infiltration out the base of the pit
- Collection of pit runoff in a 4,000 m^3 basin
- Evaporation from the basin
- Dust suppression demand (if required)
- Topping up of the pit with external water to satisfy demands (if required)

Rainfall data from 1974 was simulated to allow a prediction of the range of potential future climatic conditions. The daily transfers were simulated based on input parameters and operational rules such as catchment area (i.e. 6 hectares) and trigger levels (i.e. 10%) below which top up with external water would occur.

Runoff was estimated using an initial loss and runoff coefficient model based on available literature and experience with previous sites.

Site demands were estimated based on available plant information. Dust suppression demand was estimated based on the assumption that the difference between evaporation and rainfall is applied over 500 metres length of road associated with the proposal.

The general structure of the water balance is indicated on the water cycle schematic Figure 4-1.

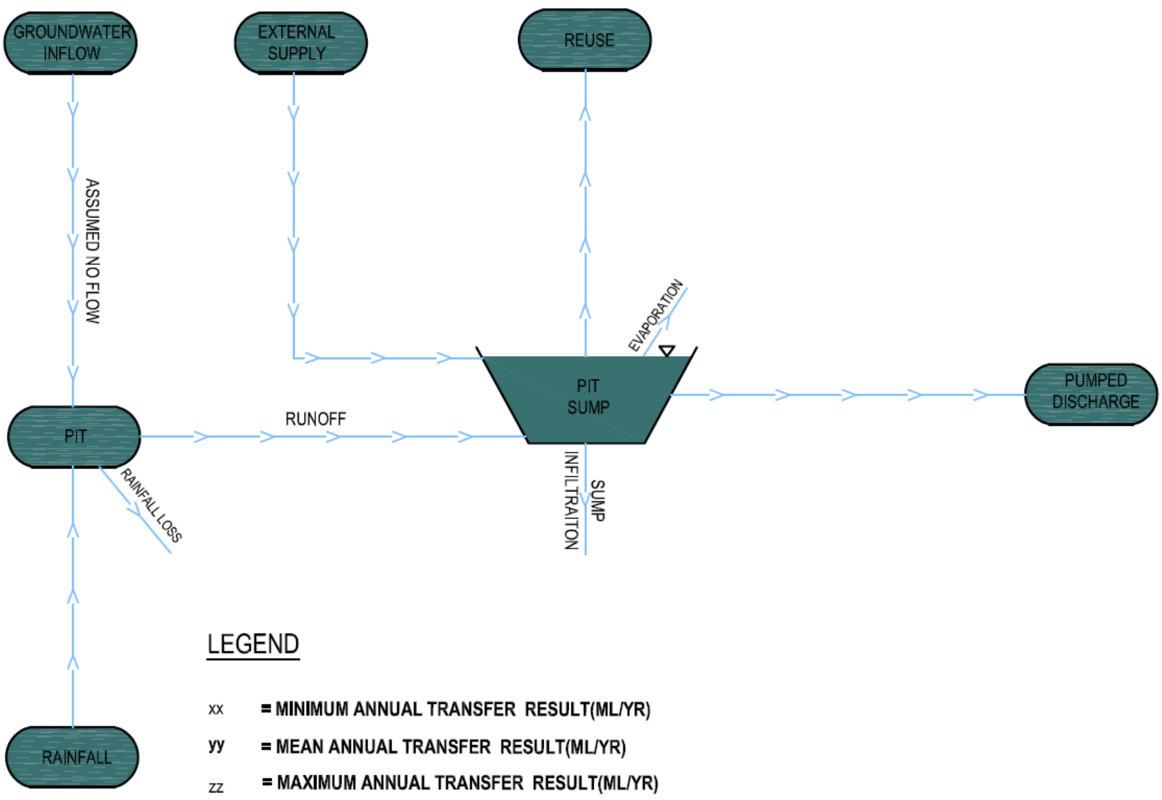


Figure 4-1 Water balance schematic

Once the water balance was simulated, results were exported and plotted on the water cycle schematic in terms of minimum, mean and maximum annual transfer rates, allowing representation of a range of potential annual transfers for varying climate conditions.

The results of the water balance are indicated on Figure 4-2 with a summary of key results below:

- Based on the size of the basin, the quarry would have insufficient runoff volumes during an average and dry year to supply the operational demands of the quarry. The volume of external water required is estimated to be 0.15ML/year in an average year and 2.18ML/year in a dry year.
- The site would discharge water during all scenarios modelled, although this would be less than without the quarry.

It is likely that the external water use will be even less than the model indicates because water resources would be used more conservatively when the supply is limited. The model is also based on a catchment area of six hectares, so if water supply is limited, diversion drains could be used to increase the catchment area. Likewise, the size of the basin could be increased to hold more runoff. As a last resort, the external water would be sourced from other dams on site or from the existing Glen Innes quarry. It is therefore considered the quarry would have sufficient water supply to operate.

Due to the quarry being located in the upper catchment and the lack of sensitive environments downstream, the reduction in the volume of water is not expected to result in a significant volumetric impact on downstream waterways in comparison with natural flow regimes. This is supported by the maximum harvestable rights, as discussed in Section 4.1.2.

4.1.2 Maximum harvestable rights

The maximum harvestable rights for the Project site was determined using the WaterNSW maximum harvestable rights dam capacity online calculator. This indicated the Project site has a maximum harvestable right of 16 ML. The Project site has a number of small dams, as shown on Figure 1-2, but these, combined with the proposed 3 ML basin are less than 16 ML. A water access license is therefore not required.

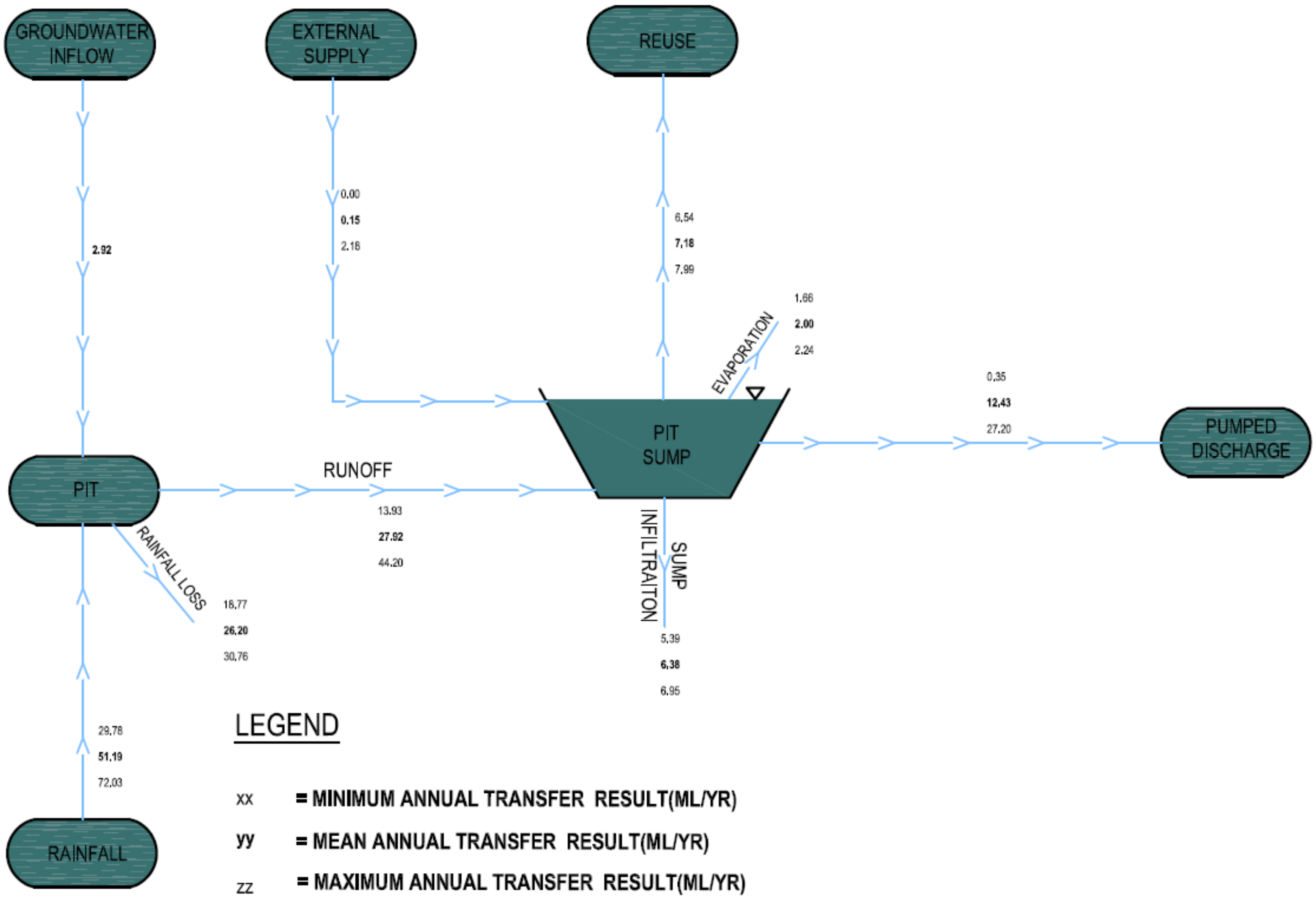


Figure 4-2 Water balance results

4.1.3 Erosion and Sediment Control

The erosion and sediment control assessment was conducted in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2E (Mines and Quarries)* (Landcom, 2005). In particular, sediment generation estimates were calculated in accordance with the Revised Universal Soil Loss Equation (RUSLE) using the predicted rainfall erosivity, soil type and management practices for the site.

The RUSLE indicated the rate of sediment generation from the quarry and access roads will be less than 150 cubic metres per year, meaning that a sediment basin is not required in accordance with Landcom (2005). However, a 1.2 ML sediment basin has been calculated, in accordance with Landcom (2005), to collect water from the quarry pit. This would collect runoff up to the design rainfall event of 38 mm.

Water quality runoff from the remainder of the site would be managed via controls in accordance with Landcom (2005).

4.2 Groundwater

Based on reported groundwater elevations (discussed in Section 3.4) and a pit floor elevation of 1170 m AHD, it is possible that groundwater will be intercepted during excavation of the proposed quarry area.

Preliminary groundwater inflow estimates have been calculated using the analytical equations and approach outlined in Marinelli and Niccoli (2000). The equations presented by Marinelli and Niccoli (2000) provide a simple means of estimating steady state or long term average inflows to a pit. The modelling methodology is outlined in Appendix A.

4.2.1 Input data

Data sources and assumptions used to derive input values for each of the parameters required for the equations developed by Marinelli and Niccoli (2000) are outlined below.

Initial (pre-construction) saturated thickness (h_o)

The initial (pre-construction) saturated thickness was taken as the maximum level recorded (1172.7 m AHD) and is considered to be highly conservative.

Saturated thickness at pit wall (h_p)

The excavations are assumed to be fully dewatered throughout the period of mining. Therefore the saturated thickness at pit wall (hp) was put to zero.

Distributed recharge flux (W)

The WSP for the for the NSW MDB Fractured Rock Groundwater Sources assumes a recharge rate of four per cent of annual average rainfall in the New England Fold Belt MDB Groundwater Source (DPI Water, 2012a). The net recharge rate of four per cent of long term average rainfall recorded at the Glen Innes Agricultural Weather Station (BoM station number 056013) was adopted for the assessment. This station was adopted based on its proximity to the site and the length and the quality of the data record . Long term average annual rainfall over the period 1910 to 2015 was 843.1 mm/year. A net recharge rate of four per cent gives an estimated long term average recharge rate of 33.7 mm/year or 9.24×10^{-5} m/day.

Hydraulic conductivity Zones 1 and 2 (K_{h1}, K_{h2} and K_{v2})

Boreholes indicate that the site is underlined by basalt. Hydraulic conductivity values for the fractured rock aquifer have therefore been assumed equal to generally accepted values for volcanic rock (0.05 m/day[2]). Based on the Horizontal hydraulic conductivity has been assumed 10 times greater than vertical hydraulic conductivity.

Effective radius (r_p)

Effective pit radius for the quarry was determined based on the proposed area of the pit. The area of each pit was input into the formulae for the area of a circle (ie $A = \pi r_p^2$) in order to calculate the effective radius. The calculated radius for the southern pit was 136 metres.

Radius of influence (r_o)

The radius of influence (r_o) of groundwater abstraction is influenced by the hydraulic conductivity of the strata, the rate of recharge. The radius of influence is therefore affected by flow boundaries be they active (such as throughflow or outflow from surface waters) or inactive (no flow boundaries such as geological boundaries). In the absence of site specific test data, the area of influence cannot be accurately estimated.

The radius of influence has been estimated from the analytical equations.

4.2.2 Predicted groundwater inflow and radius of influence

Groundwater inflows have been estimated for the proposed pit using the analytical equations developed by Marinelli and Niccoli (2000) as described in Appendix A. Groundwater inflows have been estimated for the following six scenarios:

- Scenario 1 - Base case, whereby the best estimate for hydraulic conductivity, mean recharge and initial saturated thickness (height of groundwater level above pit floor) were used in the assessment.
- Scenario 2 - Recharge sensitivity where recharge was reduced to 2 per cent of the long term average rainfall.
- Scenario 3 – Conductivity sensitivity where K was doubled relative to Scenario 1.
- Scenario 4 - Conductivity sensitivity where K was increased to 20 times that of Scenario 1.
- Scenario 5 - Conductivity sensitivity where K was decreased by 5 times relative to Scenario 1.
- Scenario 6 – Saturated thickness sensitivity where h was reduced by 2 metres relative to scenario 1. As discussed in Section 3.4, groundwater levels were monitored following a period of above average rainfall and Scenario 6 is intended to model a period of average or below average rainfall.

The results presented in Table 4-1 indicate that groundwater inflows could be between 1.9 m^3/day and 81.2 m^3/day with the most likely estimate considered to be 8.0 m^3/day (based on scenario 1). Note that the groundwater inflow rates are average long term rates and no groundwater inflow will occur until the quarry pit intercepts the water table.

The radius of influence on groundwater from the proposed quarry is estimated to be between 152 m and 372 m. The most likely estimate for radius of influence is considered to be 195 m (based on scenario 1).

[2] Hydraulic conductivity values for volcanic rock presented in Kruseman and de Ridder (1994) range almost zero to 1×10^3 metres per day.

Table 4-1 Predicted groundwater inflows and radius of influence

Scenario	Effective pit radius (m)	Distributed recharge flux W (m/d)	Horizontal hydraulic conductivity k_h (m/d)	Initial saturated thickness h_o (m)	Radius of influence r_o (m)	Horizontal groundwater inflow Q_1 (m^3/day)	Vertical groundwater inflow Q_2 (m^3/day)	Total groundwater inflow Q_t (m^3/day)
1	136	9.24×10^{-5}	0.05	2.7	195.1	5.7	2.3	8.0
2	136	4.62×10^{-5}	0.05	2.7	217.9	4.2	2.3	6.5
3	136	9.24×10^{-5}	0.1	2.7	217.9	8.4	4.7	13.1
4	136	9.24×10^{-5}	1	2.7	371.5	34.7	46.5	81.2
5	136	9.24×10^{-5}	0.01	2.7	163.2	2.4	0.5	2.9
6	136	9.24×10^{-5}	0.05	0.7	152.0	1.3	0.6	1.9

4.2.3 Aquifer interference policy

Assessment criteria

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. Based on the reported yield of registered bores in the vicinity of the site, discussed in Section 3.4.2, the Level 1 minimal impact considerations for Less Productive Fractured Groundwater Sources have been adopted for this groundwater impact assessment and are as follows:

- Water table: less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m water table decline cumulatively at any water supply work.
  - If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any high priority groundwater dependent ecosystem; or high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work then make good provisions should apply.
- Water pressure: a cumulative pressure head decline of not more than a 2 m decline at any water supply work.
  - If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Water quality: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.
  - If the predicted change in water quality is greater than the requirement above, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long term viability of groundwater ecosystems, significant sites or affected water supply works.

Impact assessment

Water supply works

The closest landholder bore is located approximately 1.8 km from the proposed extraction area. The predicted radius of drawdown is estimated to be less than 372 m from the proposed quarry area. Therefore, the proposed quarry construction and operation is not predicted to impact any water supply works.

High priority culturally significant site

There are no high priority culturally significant sites listed in the WSP for the NSW Border Rivers Unregulated and Alluvial Water Sources or the WSP for the NSW MDB Fractured Rock Groundwater Sources. Therefore, the project would not result in impacts to any culturally significant sites.

Groundwater dependent ecosystems

There are no GDEs listed in the WSP for the NSW Border Rivers Unregulated and Alluvial Water Sources. The closest high priority GDE listed in WSP for the NSW MDB Fractured Rock Groundwater Sources is located approximately 32 km west north-west of the site. The predicted radius of drawdown is estimated to be less than 372 m from the proposed quarry area. Therefore, the project would not result in any impacts to high priority GDEs.

Groundwater quality

Surface runoff from the site and captured in the pit will be collected in a sump at the bottom of the pit and extracted for use elsewhere onsite. Following large rainfall events, some surface water runoff may need to be discharged to downstream creek lines. While no significant hazardous processes are identified at the site the following are considered possible:

- Minor petroleum hydrocarbon impacts related to machinery fuel spills and leaks
- Oxidation of fresh basalt potentially releasing metals

No water quality data was available for review at the time of reporting to provide greater clarity however the proposed excavation is not predicted to have adverse impacts on groundwater quality.

5. Mitigation measures

5.1 General

- An environmental protection licence (EPL) will be obtained for the quarry. All relevant conditions relating to soil and water management will be implemented as required by the EPL.
- An Environmental Management Plan will be compiled for the works which will contain a Soil and Erosion Management Plan. Training will be provided to all quarry staff including relevant sub-contractors on erosion and sediment control practices and the requirements of the Plans through inductions, toolboxes and targeted training.
- If groundwater is intercepted, WaterNSW is to be contacted and a groundwater water access licence (WAL) obtained. Based on the most likely estimate for groundwater inflow of 8.0 m^3/day, an annual allocation of 2.9 ML/year will need to be licenced under the WM Act.

5.2 Water supply

- A 4,000 m^3 basin will be required for water supply. Where available, and of appropriate quality, the quarry operation will use recycled runoff for quarry activities.

5.3 Erosion and sedimentation control

- Implement erosion and sediment controls in accordance with *Managing Urban Stormwater Soils and Construction – Volume 2e Mines and quarries* (Landcom, 2004)
- Increase the size of the water supply basin by 1.2 ML to act as a sediment basin.

5.4 Material storage and management

- Designated impervious bunded facilities will be provided for cleaning and/or maintenance of vehicles, plant or equipment. These facilities will be located at least 20 metres away from natural and built drainage lines.
- All chemicals and fuels associated with the quarry will be stored in roofed and bunded areas. Spill kits will be provided at all chemical storage facilities/compound sites.
- Where refuelling is required onsite, the following management practices will be implemented:
  - Refuelling will be undertaken on level ground and at least 20 metres from drainage lines, waterways and/or environmentally sensitive areas
  - Refuelling will be undertaken within the designated refuelling areas with appropriate bunding and/or absorbent material
  - Refuelling will be via a designated refuelling truck
  - Will be attended at all times
  - Spill kits will be readily available and all personnel trained in their use. A spill kit will be kept on the refuelling truck at all times
  - Hand tools will be refuelled within lined trays of site vehicles wherever possible
  - An emergency spill kit (such as oil absorbent material) will be available onsite at all times to contain and clean up any accidental hydrocarbon spill
  - Any contaminated material will be disposed at an appropriately licensed facility and used spill kit materials replaced

- Regular checks of vehicles working at the quarry will be conducted to ensure that no oils or fuels are leaking.

5.5 Monitoring

- The basin is to be monitored to confirm it complies with the EPL and *Managing Urban Stormwater Soils and Construction – Volume 2e Mines and quarries* (Landcom, 2004) requirements.
- To confirm groundwater levels, a series of groundwater wells should be established around the quarry pit.
- A routine monitoring program should be established to include regular inspections and maintenance of erosion controls, especially after rain.

Appendices

Appendix A – Groundwater modelling methodology

Preliminary groundwater inflow estimates have been calculated using the analytical equations and approach outlined in Marinelli and Niccoli (2000). The equations presented by Marinelli and Niccoli (2000) provide a simple means of estimating steady state or long term average inflows to a pit.

The solutions presented consider:

- The effect of decreased saturated thickness near the pit walls.
- Distributed recharge to the water table.
- Upward flow through the pit bottom.

As discussed in Section 3.4, the groundwater intercepted by the quarry is considered to be representative of an isolated perched aquifer. The calculated groundwater inflow rate has been calculated for a groundwater table that is representative of a regional aquifer (groundwater flow is consistent over time) as this is a more conservative estimate of potential groundwater inflow.

Separate calculations are undertaken to estimate inflow via pit walls (Q_1, Zone 1) and the base of the pit (Q_2, Zone 2) (refer to Figure A-1). Assumptions made in the flow calculation for Zone 1 include:

- Pit walls are approximated as a circular cylinder;
- Groundwater flow is horizontal (Dupuit - Forchheimer approximation is valid).
- The static (pre-mining) water table is horizontal.
- Groundwater flow towards the pit is axially symmetric.
- Uniform distributed recharge occurs across the site as a result of surface infiltration.
- All recharge in the radius of influence is captured by the pit.
- The aquifer extends below the base of the pit.

Assumptions made in the flow calculation to Zone 2 include:

- Hydraulic head is initially uniform throughout the zone. Initial head is equal to the elevation of the initial water table in Zone 1.
- The disk sink has a constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is completely dewatered the disk sink is equal to the elevation of the pit bottom.
- Flow to the disk sink is three dimensional and axially symmetric.
- Materials within Zone 2 are anisotropic and the principal co-ordinate directions for hydraulic conductivity are horizontal and vertical.

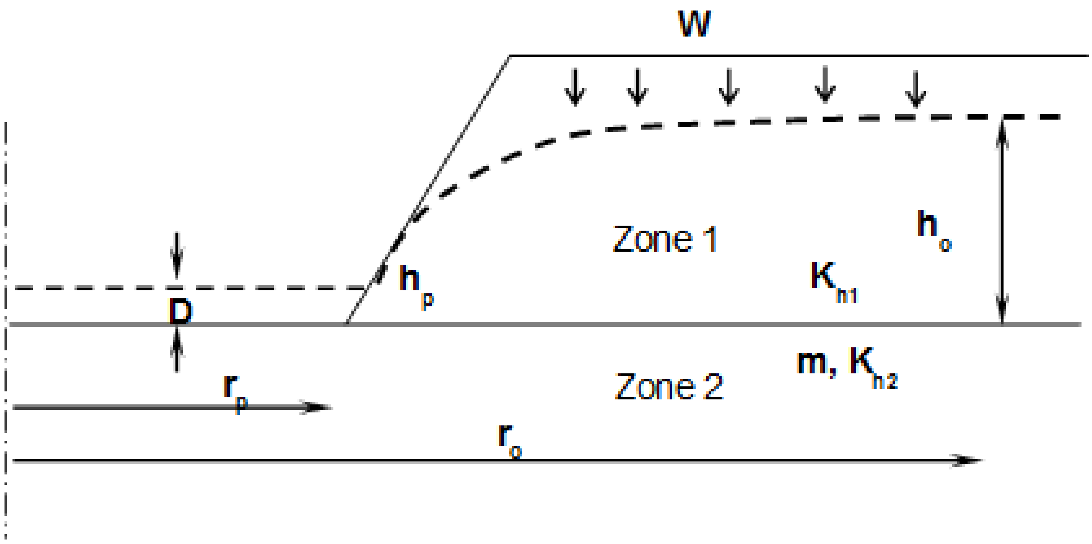


Figure A-1 Pit inflow hydraulic model (Marinelli and Niccoli 2000)

Relevant equations presented in Marinelli and Niccoli (2000) are as follows:

$$h_o = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left(r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \left(\frac{r_o^2 - r_p^2}{2}\right)\right)}$$

$$Q_1 = W\pi\left(r_o^2 - r_p^2\right)$$

$$Q_2 = 4r_p\left(\frac{K_{h2}}{m_2}\right)\left(h_o - d\right)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

Where:

- h_o = initial (pre-mining (cutting)) saturated thickness (metres above base of pit)
- h_p = saturated thickness at pit wall (metres above base of pit)
- W = distributed recharge flux (metres per day)
- K_{h1} = Horizontal hydraulic conductivity Zone 1 (metres per day)
- K_{h2} = Horizontal hydraulic conductivity Zone 2 (metres per day)
- K_{v2} = Vertical hydraulic conductivity Zone 2 (metres per day)
- r_p = Effective pit radius (metres)
- r_o = Radius of influence (metres)
- d = Depth of the pit lake (metres)

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Appendix G Air Quality Impact Assessment

Glen Innes Severn Shire Council

Wattle Vale Quarry EIS

Air Quality Assessment

December 2016

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