Appendix E

Surface Water Management Assessment

Jandra Quarry
Surface Water Management Assessment

Report Prepared for:
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1.0 INTRODUCTION

A surface water assessment has been undertaken to review the existing stormwater management system at Jandra Quarry and its capacity to both meet future process water demands, attenuate stormwater runoff and associated suspended solids discharge. The surface water management assessment involved the following:

- A site visit was undertaken on the 6th of March, 2014 to gain an appreciation for the site topography and drainage, existing approved quarry operations and current surface water management practices;
- Review of the existing Water Measurement Protocol, Soil and Water Management Plan (SWMP) as well as water sampling records for Jandra Quarry;
- Review the proposed modifications including disturbance footprint changes as well as water demand and discharge changes;
- Preparation of a water balance model for the site that takes into account the proposed intensification in production;
- Provision of recommendations on any required changes to existing surface water management practices in order to meet the requirements of the proposed intensified production and ensure conformance with current relevant legislation, guidelines and industry best practice;
- Review of NSW Office of Water's letter dated 16th of June, 2014 and licensing requirements or other approvals that relate to water use, management and discharge.

2.0 REVIEW

Soil and Water Management Plan

A Soil and Water Management Plan (SWMP) for the quarry was developed for the site as part of the site Environmental Impact Statement (EIS) in 1999. It was developed to:

- ensure adequate water supplies under most climatic conditions, and
- safeguard the integrity of downstream watercourses.

Overall the water management measures, and erosion and sediment controls proposed in the SWMP have formed the basis of the current surface water management system.

The focus of this surface water management assessment has been to;

- review water balance assumptions (supply and demand) for the site based on currently available data,
- review the sizing of permanent erosion controls to ensure they have been designed in accordance with current guidelines and best management practice, and
- to ensure all measures have sufficient capacity to manage future quarry expansion and site disturbance.

Approvals and Licenses

The Department of Primary Industries, Office of Water (OoW) issued a letter to Element Environment Pty Ltd on the 16th of June, 2014 with their requirements for the Jandra Quarry Intensification Project. The letter has been reviewed and is attached as Appendix G to this document. The OoW requirements contained in the letter and the report responses are outlined in the table below;

Table 2-1: Summary of requirements (Office of Water)

NSW Office of Water Key Issues and Requirements	Response	Report Reference
Requirement 1. Identification of site water demands, water sources, water disposal methods and water storage structures in the form of a water balance. The water balance is to outline the proposed water management on the site and to also include details of any water reticulation infrastructure that supplies water to and within the site.	A water balance has been developed for the site and is discussed in detail in Section 4.0 of this report.	Refer Section 4.0 - Site Water Balance

Requirement 2. An impact assessment of any proposed works within or adjacent to watercourses. Ability to achieve the principles of the Water Management Act 2000 (WMA) and the requirements of the Guidelines for Controlled Activity Approvals. The relevant guidelines can be accessed at the following link: http://www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx. Works on waterfront land (as defined in the WMA) may require a controlled activity approval(s).	Controlled Activity Approval not required	Refer Section 5.1 - Controlled Activity Approval
Requirement 3. Preparation of a site water management plan to integrate the proposed water balance and management for the site and to identify adequate mitigating and monitoring requirements for both water quality and water volume.	A site water management plan has been prepared for the site and is discussed in detail in this report.	Refer Sections 3, 4, and 6
Requirement 4. Proposal to demonstrate the existing and proposed water licensing requirements in accordance with the Water Act 1912 and the WMA. The quarry is located within the Wallamba River Water Source under the Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009.	Harvestable rights dam capacity is 13.2ML. Development consent approves extraction of 5ML/annum of water in addition to harvestable rights. Additional extraction license not required.	Refer Section 5.2 - Harvestable Rights and Extraction License

2.1. Existing Stormwater Management

The site is located at the head of two minor tributaries of Talawahl Creek (refer to Figures 2 and 4). These minor tributaries flow northward, joining just before crossing the Pacific Highway after which they join another tributary that flows southwest to Talawahl Creek. Talawahl Creek is a tributary of Bungwahl Creek, which flows to the Wallamba River approximately 5.5 kilometres south of the site.

Effective control of erosion and sediment movement at the site is currently achieved via the following measures;

- Sedimentation Basins (Main Dam and Pit Dam);
- Wash off water collection and primary treatment systems;
- Minimisation of disturbed areas;
- Diversion of clean water from undisturbed areas around working areas;

- Temporary erosion and sediment controls prior to commencement of topsoil and overburden removal;
- Sequential clearing and rehabilitation of the quarry as extraction of material proceeds; and
- Twice yearly maintenance of erosion and sediment control structures to ensure their efficiency.

2.1.1. Storage and Sediment Control Dams

The main existing stormwater basin (main dam) is located north of the site offices along the main access road (Refer Appendix B). The majority of the surface water runoff from the active site areas drains to two main stormwater basins. Rainwater landing in the quarry is captured in the "pit dam", while the remainder of the active site drains into the main dam. When the pit dam reaches capacity, water is gravity fed into the main dam.

The main dam supplies the majority of the site's water requirements with the exception of water for toilet flushing (supplied from rainwater tanks) and drinking water (which is purchased from an external potable supply). Water is withdrawn from the main dam for use in the crushing and screening plant, wheel wash and dust control. After use, water is reticulated back into the main dam.

A third stormwater basin was previously proposed for the *Approved Secondary Stockpile Area* (refer Appendix B); however this area is not currently utilised for stockpiling of quarried material as previously intended. No further consideration has been given to this basin, and updated sizing information ha snot been included in the following sections.

A survey plan of the main dam including bathymetry and inlet and outlet features is shown in **Appendix A**. The available volume to the low flow outlet is approximately 10ML; and 10.9ML to the overflow spillway.

The pit dam is 100m long, by 33m wide and is 14m deep at its deepest point with a total volume of approximately 13ML.

The discharge of water from the main dam is regulated by and required to comply with the requirements of EPL 2796. The discharge point where water monitoring is undertaken is identified in Appendix B

2.1.2. Stormwater Diversion

Generally, stormwater runoff from areas outside of the active quarry and processing areas is conveyed via series of open channels and a gravity pit and pipe system into the main dam.

The Overburden Emplacement Area is completely bunded, and effectively functions as an enclosed sedimentation basin for collection of stormwater runoff generated from disturbed areas within the emplacement area. All stormwater runoff collects within the bunded area and slowly infiltrates through the unsealed basin floor over time.

2.1.3. Wash off Water Diversion

Water applied in the processing plant for dust suppression drains to a stormwater sump at a low point in the processing area. Collected water is pumped to two small sedimentation basins adjacent to the quarry/extraction area. The basins provide primary sedimentation treatment for silted water and discharges by gravity to the main dam via a vegetated Macrophyte treatment area.

A weighbridge and wheel wash system is located on the main access road to the north west of the main dam. The wheel washdown system is activated by a sensor and cycles for 15mins, cleaning sediment and dust from heavy vehicles leaving the site. Water drains to a sump beneath the wheel washdown system, and when triggered by a level sensor a pump transfers water from the sump to the main dam.

It is recommended that the wheel wash outlet to the main dam be relocated to a better suited location as discussed in Section 6.0.

2.1.4. Fuel Oil Storage Area

Appropriate fuel storage and spill control is necessary for preventing the discharge of hydrocarbons into dams and downstream waterways. Existing site controls partition fuel storage areas from other areas of the site and reduce the risk of stormwater contamination as a result of fuel spills.

The fuel oil storage area is covered by a roofed structure to limit the entry of rainfall, and is designed with bunds to contain any oil or fuel spills, preventing discharge from the site. The floor of the storage area is sloped to a sump with a gate valve outlet. Fuel oil that collects in the sump is removed periodically by an approved maintenance contractor.

3.0 EROSION AND SEDIMENT CONTROL REQUIREMENTS

3.1. Sedimentation Basins

The function of the site sedimentation basins is to catch all stormwater runoff from the disturbed areas within the site, and to minimise the concentration of fines in overflow waters.

Future quarry operations will involve the relocation and resizing of the existing sedimentation basin within the main quarry pit known as the "pit dam." The dam located in the quarry pit during stages 1-3 will be a combined sedimentation basin and sump. The area of the quarry will gradually increase as the extraction area extends to the east (as per the proposed staging plans). The pit dam will be progressively enlarged to ensure it has capacity to control sediment from the maximum extent of the enlarged quarry operations. The floor of the quarry pit will be graded to ensure a fall is maintained towards the sedimentation basin and sump.

The locations of existing and proposed sedimentation basins for all stages are shown in **Appendix B** and **Appendix C** respectively.

3.1.1. Design Criteria

The design criteria for the sediment basins are based on the procedure detailed in Chapter 6 of *Managing Urban Stormwater – Soils and Construction Volume 1* (2004) and *Volume 2E: Mines and Quarries*, DECC (2008). The sediment basins were sized based on a conservative assumption that all disturbed areas consist of Type D soils, which have more than 33% of soil material finer than 0.02 mm and more than 10% dispersible materials (refer soil test results provided in *Appendix I*, *Jandra Quarry EIS 1999*).

The design of the sediment basins provides sufficient storage capacity for quarry operational water demands including dust suppression, process needs and rehabilitation requirements. Sediment basins and associated erosion control measures in mines and quarries are required to cater for the 1 in 20 year average recurrence interval (ARI) peak flow (Refer Table 6.1, *Blue Book* - Volume 2E - Mine sand Quarries (DECC, 2008)).

3.1.2. Volume Requirements

The volumetric requirements for the sediment basins were determined by following the procedures detailed in *Managing Urban Stormwater – Soils and Construction Volume 1* DECC (2004) for Type D soils. Parameters used in the calculations include:

- 5-day total rainfall depth not exceeded in 90% of rainfall events (R) = 58 mm
- C_v – Volumetric Runoff coefficient = 0.9
- Settling Zone Volume = 10 x C_v x A x R
- Sediment Storage Volume = 50% x Settling Zone Volume

The design characteristics of the dams are shown in **Table 3-1** below.

Table 3-1: Sediment Basin design characteristics

Sediment Basin Requirements	Catchment Area (ha)	*Settling zone volume (m3)*	*Sediment storage volume (m3)*	Min. required volume (ML)	Runoff Storage per Hectare of catchment (m3)	Existing Volume (ML)
Quarry Area						
- Current	8.04	4197	2098	6.3	783	13
- Stage 1	8.84	4614	2307	6.9	783	-
- Stage 2	13.57	7084	3542	10.6	783	-
- Stage 3	17.47	9119	4560	13.7	783	-
Facilities Area						
- Current	11.23	5862	2931	8.8	783	10
- Stage 1	10.37	5413	2707	8.1	783	10
- Stage 2	8.44	4406	2203	6.6	783	10
- Stage 3	8.44	4406	2203	6.6	783	10

The sediment basin requirements summarised in **Table 3-1** indicate that the existing sediment basins in the quarry and facilities areas have sufficient volume. The current storage requirement for the quarry area is 6.3 ML, which is less than 50% of the existing basin. The sediment basin configuration within the quarry area will alter with each of the proposed extraction stages, as illustrated in the Sediment Basin Plans in **Appendix C** of this report, Stage 1-3 will utilise the western end of the exhausted extraction area as a sediment basin where appropriate storage will be constructed.

The facilities area (main dam) will remain static throughout the proposed extraction stages. The existing basin volume of 10 ML provides sufficient storage for the current scenario as well as Stages 1-3.

3.1.3. Sedimentation Basin Management

Water from the sedimentation basins is utilised to satisfy non-potable quarry water demands as required. Water from the main dam is pumped out to the site facilities area and used for dust suppression, material processing, and wash down. Excess water from the quarry sedimentation basin (pit dam) currently drains by gravity to the main dam. When the main dam reaches capacity it drains by gravity via a low flow outlet to the watercourse downstream of the facilities area. In stages 1-3 water in the pit dam and sump will be pumped to the main dam.

Previous soil testing undertaken for the *Jandra Quarry EIS* (1999) indicated that site soils range from slightly to highly dispersive, and there is a potential for fine dispersible soils to be suspended in stormwater runoff.

A review of water quality monitoring results provided for the period 1/04/2012-06/03/2014 and shown in **Table 3-1** and **Table 3-2** for Jandra Quarry, indicate that there has been a number of exceedances of the EPL concentration limits for Total Suspended Solids (TSS), and that measured pH levels remain within EPL limits. An improvement in the operation and maintenance of erosion and sediment controls is likely required to improve discharge quality. Flocculation of the main dam is required to settle out the suspended solids if water quality cannot be improved by alternative measures. Acid dosing may be required in the event of measured pH exceedances. If the monitoring results indicate a sustained exceedance trend, an artificial flocculation program should be investigated and if implemented, carried out in accordance with the guidelines shown in *Managing Urban Stormwater – Soils and Construction Volume 1 – Appendix E*, (DECC, 2004) and attached as **Appendix E**.

Refer to Section 6.0 for a more detailed discussion of recommendations for improving discharge water quality.

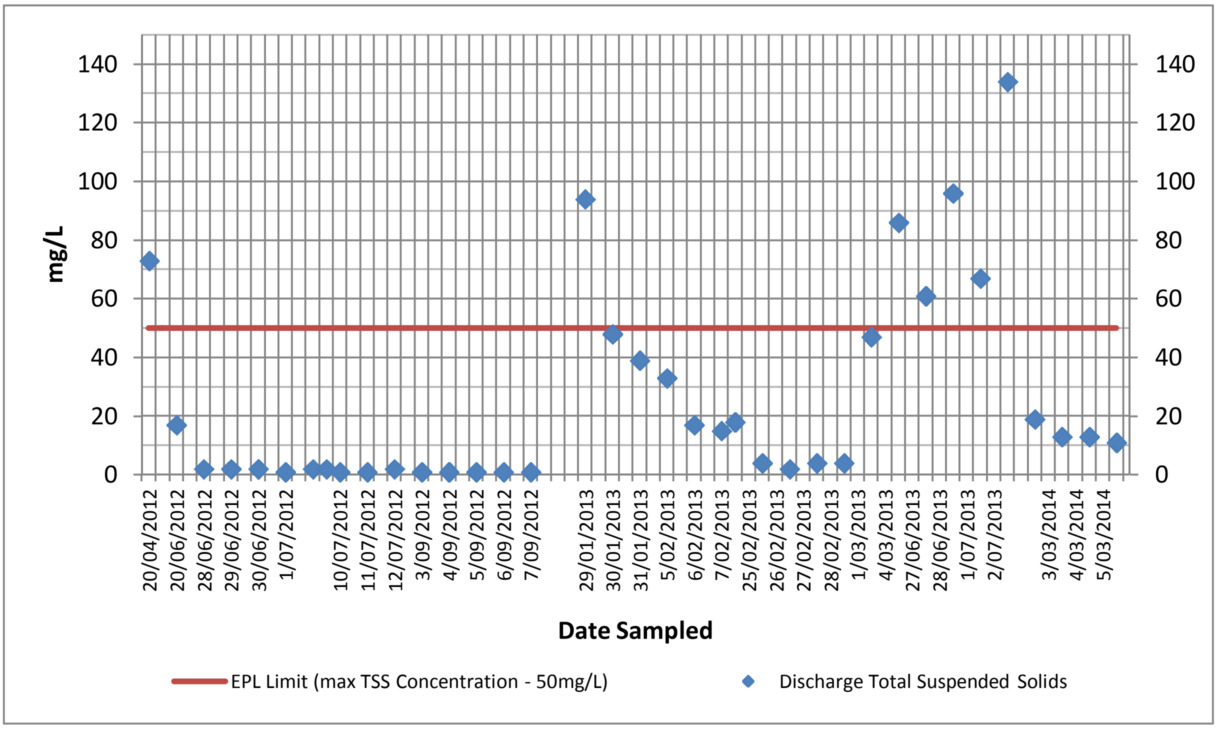

Figure 3-1: Water Quality Monitoring Results (TSS)

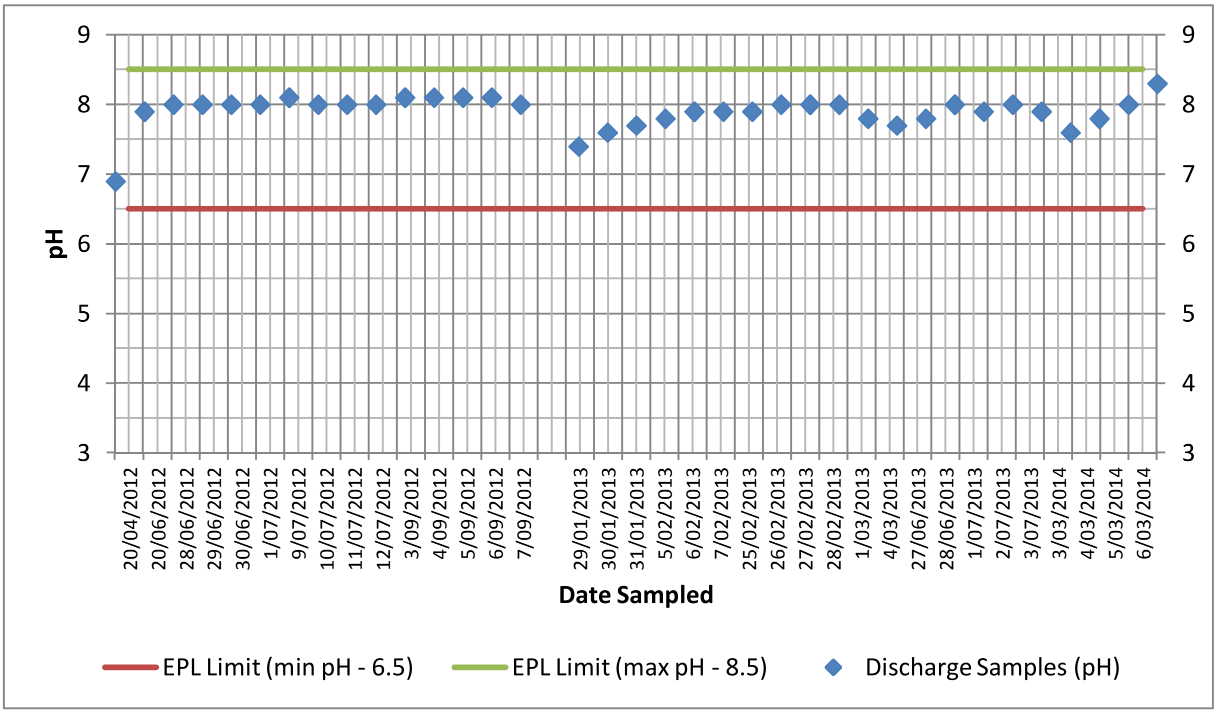

Figure 3-2: Water Quality Monitoring Results (pH)

4.0 SITE WATER BALANCE

4.1. Water Demands

Potable water for personal consumption is sourced off site and brought in as bottled water.

Non potable water is required in the following areas:

- **Employee Use**

  Non-potable water required for toilet flushing and hand basin use is supplied from rainwater tanks that harvest roofwater from the buildings in the maintenance area. The rainwater supply is backed up by a mains water top up system.
- **Process Water**

  Water is used in the processing plant for dust suppression. It is applied in the form of fine mist sprays. For the water balance model, it is assumed that water is applied at a rate of 1.5% by weight of product throughput for all aggregate (which accounts for 50% of total finished product from the site).
- **Dust Suppression**

  All haul roads are sprayed by water cart at least 4 - 5 times a day. Finished product stockpiles are fitted with a sprinkler system which is turned on when required. A water cart is also used with a spray cannon for those finished product stockpiles that are not covered by a sprinkler system. The water requirements for dust suppression are the largest of all site water demands. Dust suppression demands accounted for in the water balance model have been calibrated to generally align with historical metered data.

  The volumes of water required for dust suppression will vary with each stage of quarry development and the prevailing weather conditions. Demands have been conservatively estimated assuming the following;
  - all haul roads are sprayed by a water cart at least 4 to 5 times a day when dust suppression is required, and
  - haul road watering application rate estimated to be 1L/m2/hour,
  - watering of haul roads occurs on all days when daily pan evaporation exceeds daily rainfall.
- **Product Moisture**

  Certain types of material such as road bases and other road pavement materials are required to have a moisture content of around seven percent (7%). Quarried material is basically dry and water is added to these products during processing. It is assumed that 25% of annual production will require the addition of water.

- **Truck and Wheel Washing Facilities**

  Trucks and plant used in quarry operations are cleaned as part of general maintenance and prior to servicing. Water used in vehicle washing is treated to remove coarse grit and oil before being recycled back into the quarry water system by discharging to the main sedimentation basin (main dam). A nominal allowance of 10,000L a month (for the current scenario) was made in the water balance to allow for water losses via evaporation, vehicle wetting, and infiltration. Demands are assumed to increase to 20,000L a month by Stage 1 as production intensifies to 475,000 tonnes.
- **Environmental losses**

  Water is lost to the environment from the stormwater basins via evaporation and infiltration from the unlined sides and basin floor. Evaporation losses from open water storage areas have been estimated assuming the pond evaporation occurs at 70% of pan evaporation per unit area.

A summary of annual water demands for key quarry stages is shown in **Table 4.2**. Annual water demands estimated for the water balance model have been calibrated using historical data from the water meter on the transfer pump located next to the main sedimentation basin (main dam). The data supplied covered the extraction period from August 2010 until May 2014 and is shown in **Table 4-3** and **Table 4-4**. The metered data doesn’t account for environmental losses on the system. In the absence of detailed meter data the overall demands have been adjusted higher than actual metered demands (on an annual basis) to reflect conservative demand assumptions.

Table 4-1: Haul Road Areas

Quarry Stage	Dust Suppression Area (m2)
Current	12460
Stage 1	16540
Stage 2	16400
Stage 3	15000

Table 4-2: Annual Water Demands (ML)

Water Use		Current	Stage 1	Stage 2	Stage 3
Production (tonnes)		250000	475000	475000	475000
Haul Road Dust Suppression					
	Dry Year	16.12	21.40	21.21	19.40
	Mean	15.40	20.44	20.27	18.54
	Wet Year	14.63	19.43	19.26	17.62
Product Moisture		4.38	8.31	8.31	8.31
Process Water		1.88	3.56	3.56	3.56
Truck Washing		0.10	0.20	0.20	0.20
Environmental Losses (Main Dam)		3.14	3.14	3.14	3.14
Environmental Losses (Pit Dam)		5.85	5.85	5.85	5.85

Table 4-3: Transfer Pump Details (Main Dam)

Pump Details at Main Dam (Holcim, 2014)		
Pump Type	Southern Cross 100x65 - 250.	
Max Pump Rate	200	L/min
Installation date	Aug-10	
Total Run time with motor speed at 48%	10235	hrs
Actual Pump rate	100	L/min

Table 4-4: Water Supplied from Main Dam (2010-2013)

Estimated water supplied from main dam (2010-2013)		
Pump rate	100	L/min
Pump Period	10235	hours
	614100	mins
Supplied Volume (2010-2013)	61410000	L
	61410	kL
	61.41	ML
Quarry production for period of analysis (Holcim, 2014)	995,517	tonnes
Volume of water supplied / tonne of production	61.7	L/tonnes
Average volume supplied per year	**15.4**	**ML/yr**
Maximum annual volume supplied (2010)	**17.8**	**ML/yr**

4.2. Water Balance Model

A daily water balance model has been developed to simulate the water cycle of the quarry. A daily time step was chosen to account for the sensitivity in open water storage behaviour. The model has been used to compare quarry water demands, with the volume of stormwater runoff water generated and stored within the site. The objective of the model was to determine the magnitude of either water surplus or deficit at various stages of development under varying climatic conditions. Simulated water requirements have been based on the demands outlined above. Water supply has been determined using historical rainfall data to estimate runoff into the dams.

4.2.1. Rainfall

Historical 6-minute pluvio rainfall data for the site catchment model was obtained from the Australian Bureau of Meteorology (BoM) weather station at Taree (Robertson St); Station Number 060030 located 16km to the North of the study site.

15 years of rainfall data was sourced to reflect the climatic variability of the region (including dry, mean and wet years). A spreadsheet model was developed using catchment inflow data from a MUSIC model developed for the site to represent the water supply dam catchment.

The annual average depth of rainfall was found to be 1161mm/annum for the period of analysis (1965-1979).

The model has assessed daily and annual water balances for dry, average, and wet rainfall years. Analysis of available rainfall records for Taree (Robertson St) shows that a dry year (5th percentile year) has an annual rainfall of 725mm, an average year 1175mm, and a wet year (95th percentile year) 1761mm. To simulate real rainfall conditions, years with annual rainfall close to the statistical requirement were used in the model. Representative years included the following;

- 1965 – Dry Year (annual rainfall total 714mm)
- 1968-1979 – Average Years (average annual rainfall 1186 mm)
- 1967 – Wet Year (annual rainfall 1713mm)

4.2.2. Evaporation

Evaporation rates are relatively constant under different climatic conditions and average pan evaporation data was derived using mapping from the Bureau of Meteorology website. Annual pan evaporation for Jandra was estimated to be approximately 1450mm/year.

4.2.3. Catchments

Catchment areas have been delineated using aerial photography and topographical data supplied. Runoff coefficients were estimated for each catchment. Refer **Table 3-1** for catchment areas and **Appendix F** for MUSIC catchment model parameters. Pervious area characteristics for modelled catchments are based on values for Silty Clays provided in the *Draft NSW MUSIC Modelling Guidelines for NSW*.

4.2.4. Sensitivity Analysis

A sensitivity analysis was undertaken to enable assessment of the quarry's water balance at various stages of development and under various climatic conditions. The following scenarios were modelled;

- Current and proposed Stages 1, 2, and 3 of quarry development.
- Dry, Average, and Wet years

4.2.5. Storage

The Pit Dam storage was modelled with a capacity of 13ML in the current scenario and 13.7ML (the min. sedimentation basin volume required in Stage 3) for Stages 1-3. The main dam storage capacity (10ML) was modelled as static for stages of quarry development. At the start of each year both dams were assumed to be 50 per cent full. For the purposes of assessment it was assumed that when the main dam level dropped to 10% full, pumping from the pit dam was triggered and necessary top up water supplied to the main dam.

All catchment runoff from the quarry area was assumed to drain to the pit dam and spilled into the main when the pit dam reached capacity. When the main reached capacity it was assumed to spill into the downstream waterway.

The main dam was assumed to be relatively well sealed, and have a constant exfiltration rate through the walls and base of the dam of 0.01mm/hr.

The pit dam was assumed to be relatively sealed by the underlying material. A constant exfiltration through the walls and base of the pit dam was assumed to be 0.1mm/hr for all stages of quarry development.

4.3. Water Balance Model Results

The model was used to prepare estimates of the following;

- Daily and annual runoff from the dam catchments;
- Monthly and annual demands;
- Any overflows/spills from the dam; and
- Any deficits or top up requirements for the quarry's water supply.

The following table provides a summary of results from the sensitivity analysis undertaken using the water balance model. Full water balance results are provided in **Appendix D**.

Table 4-5: Water Balance Results for varying stages of quarry development

	Current			Stage 1		
Summary Results	**Dry Year**	**Mean Year**	**Wet Year**	**Dry Year**	**Mean Year**	**Wet Year**
Total Runoff (ML/yr)	35	98	165	34	97	164
Total Demands (ML/yr)[1]	25.60	24.88	24.11	36.60	35.64	34.63
Stormwater Supplied (ML/yr)[2]	25.46	24.88	24.11	32.13	35.45	34.63
Total Storage Top Up (ML/yr)	0.13	0.00	0.00	4.46	0.19	0.00
% Demand Met	99%	100%	100%	88%	99%	100%
Spill Volume (ML/yr)	4	68	131	3	57	112

	Stage 2			Stage 3		
Summary Results	**Dry Year**	**Mean Year**	**Wet Year**	**Dry Year**	**Mean Year**	**Wet Year**
Total Runoff (ML/yr)	39	110	186	45	129	219
Total Demands (ML/yr)	36.42	35.47	34.46	34.60	33.74	32.82
Stormwater Supplied (ML/yr)	32.32	35.34	34.46	31.85	33.74	32.82
Total Storage Top Up (ML/yr)	4.09	0.13	0.00	2.75	0.00	0.00
% Demand Met	89%	100%	100%	92%	100%	100%
Spill Volume (ML/yr)	4	70	139	9	90	174

The models results show that the storage is capable of satisfying the quarry's water demands under the climatic conditions considered. Overflows will occur from the main dam under dry, average and wet rainfall conditions.

During Stages 1 to 3 of Quarry Development water shortages may occur in extreme dry conditions (5th percentile year) for up to a month if maximum production and water use is maintained. Modelled water shortages occur when both the main dam and pit dam fall below 5% storage capacity. However, up to 5ML per annum of water can be extracted from the clean water dam under the Part 2 license granted as part of initial development consent for Jandra Quarry. This back up water source may be relied upon in the event of extended drought conditions and provide sufficient water to meet the expected deficit in non-potable water required. The conditions of the Part 2 license should be met prior to commencement of extraction which includes installation of a water meter at the offtake from the clean water dam.

It is also recommended that in the lead up to extended and extreme dry period's water efficiency measures be implemented to prevent any restriction on production due to water shortages.

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[1] Total Demands = Volume of water pumped from main dam to supply site demands + environmental losses (main dam only)

[2] Volume of water that can be supplied from the main dam

Dust suppression demands are the largest proportion of non-potable site demands and will increase during dry periods. Dust suppression watering demands have been conservatively estimated based on conventional quarry operations. Opportunities may exist to implement demand management measures via stabilisation of haul roads through applications of polymer or other chemical additives. Temporary stabilisation of road surfaces will reduce dust suppression watering requirements and can reduce the risk of water shortages during extended dry periods.

Increasing pit dam storage can also improve stormwater harvesting yields during dry periods. **Figure 4-1** and **Figure 4-2** below show the relationship between harvesting yields (% of demand that can be met through harvested stormwater) during Stages 1 and 2 of quarry development - when the highest demands occur. The model results indicate that increasing the quarry pit dam to 25ML will provide sufficient storage to buffer the water supply system during extended dry periods. The likelihood of an extended dry period (resembling a 5th percentile dry year) occurring is very low in which case it may not justify the expense of creating a 25ML storage volume within the quarry pit. The model results are quite sensitive to the modelled exfiltration rate through the pit dam. In Stages 1-3 of quarry development the pit dam should be appropriately sealed to prevent significant loss of water through underlying fractured rock and porous soils.

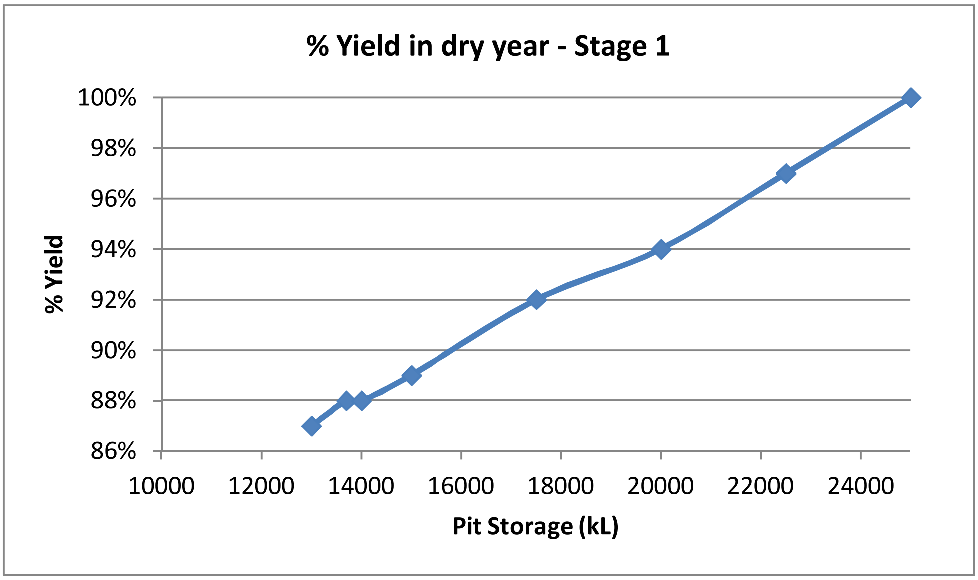

Figure 4-1: Influence of Pit Dam storage on harvesting yields during 5th percentile dry year (Stage 1)

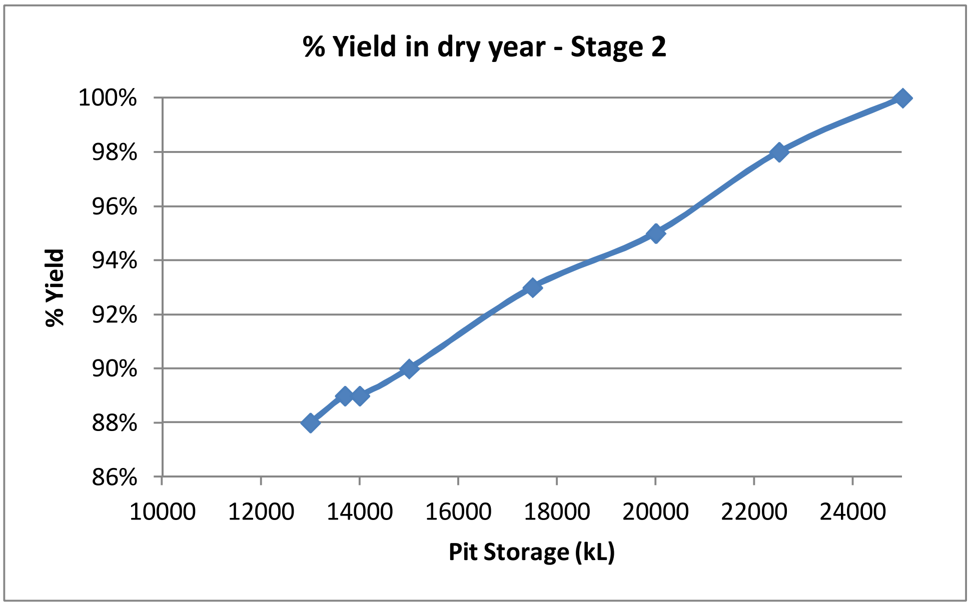

Figure 4-2: Influence of Pit Dam storage on harvesting yields during 5th percentile dry year (Stage 2)

5.0 APPROVALS AND LICENSES

The Department of Primary Industries, Office of Water (OoW) issued a letter to Element Environment Pty Ltd on the 16th of June, 2014 with their requirements for the Jandra Quarry Intensification Project. The following sections discuss the requirements for an impact assessment and controlled activity approval for proposed works, as well as requirements for a water extraction license.

5.1. Controlled Activity Approval

OoW require an impact assessment for any proposed works within or adjacent to watercourses.

A new single lane vehicle access track is proposed adjacent to the Main Dam, and is intended to be constructed in proximity to a first order watercourse. The proposed works include construction of a stabilised road and associated drainage.

Appropriate erosion and sediment controls will be implemented during the construction phase to prevent erosion and sediment transport that may affect the downstream receiving environment.

Under provisions of the WM Act, a controlled activity approval is not required if *the construction of an access track on waterfront land does not impound water and relates to a minor stream in a rural zone (OoW, 2012)*[3].

5.2. Harvestable Rights and Water Extraction License requirements

The Water Act is administered by the OoW. Under the Act, a permit and/or license must be obtained to extract water not covered by a water sharing plan under the WM Act.

A license will be required under Part 2 of the Act if it is intended to extract water from the creek system or from dams with capacities above the harvestable rights dam capacity calculated by the OoW harvestable rights calculator as 13.2ML for the property (refer Appendix H).

The existing development consent approved a license for extraction of an additional 5ML per annum from the 'clean water' dam located in an undeveloped part of the property; approximately 100m to the North East of the Main Dam (refer Appendix B).

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[3] NSW Office of Water (2012). *Controlled activity exemptions on waterfront land*

Under the Water Management Act 2000 landholders have the right to capture and use 10 per cent of the average regional yearly rainfall runoff from their property. This is known as the harvestable right and corresponds to the maximum dam capacity for the property. The harvestable rights dam capacity does not include '*dams for the capture, containment, and recirculation of drainage and/or effluent*' (OoW, 2010)[4]. The pit dam and the main dam function primarily as dams for the capture and containment of drainage/runoff water for the purposes of water quality improvement and are considered as exempt from harvestable rights calculations.

The water balance prepared for this assessment identified that the main dam (sedimentation basin for the facilities area) and the pit dam (sedimentation basin for the quarry pit) will satisfy anticipated water demands of the quarry for most climatic scenarios except in extreme dry conditions, and the need for the extraction of water from the 'clean water dam' in exceedance of the existing license threshold of 5ML/annum is unlikely.

[4] Office of Water (2010). *Dams in NSW – Do you need a license?*

6.0 CONCLUSIONS

Erosion and Sediment Control

The permanent erosion controls and dams currently in operation at the quarry have sufficient capacity to cope with the expansion of quarry activities, and resilience to manage variability in storm runoff as a result of extreme weather conditions.

The existing dams are appropriately sized to manage stormwater runoff from the quarry and facilities catchments. The dimensions of the main dam are likely to remain consistent for the life of the quarry development; however future quarry operations will require the resizing of the existing pit dam.

Existing sedimentation basins are appropriately sized, however water quality requires improvement. Water quality sampling results from the main dam indicate exceedances of EPL limits for TSS, and it is recommended that improvements in the operation and maintenance of existing erosion and sediment controls be made to ensure that discharge quality doesn't exceed EPL discharge limits.

The following recommendations regarding operational and maintenance practice should be implemented as a means to improve discharge quality from the site and are listed in order of priority:

1. The outlet from the wheel wash system discharges in close proximity to the low flow outlet from the main dam. It is recommended that either:
    i. A baffle (sediment curtain) be installed to lengthen the flow path of wheel wash water to the dam outlet or,
    ii. The wheel wash outlet should be moved further away from the main dam outlet to encourage greater drop out of sediment from wheel wash water, and to reduce the risk of highly sediment laden wash off water from short-circuiting, and discharging into the downstream waterway when the main dam is full and in bypass mode.
2. Runoff from undisturbed catchments should be diverted around the quarry area prior to discharge into the dam.
3. Disturbed sites prone to erosion (i.e. exposed earth batters around processing areas) should be stabilised with vegetation.
4. Ensure inspections of erosion and sediment controls are carried out quarterly.
5. Exposed earth channels and flow paths should be stabilised with vegetation where appropriate.
6. Should monitoring of Total Suspended Solids indicate levels in excess of 50mg/L, the main dam should be;
    i. treated with a flocculating agent immediately following any storm event large enough to cause runoff; and
    ii. such dosing should occur within 24 hours of the conclusion of each storm event;

Reliability of Existing and Proposed Dams

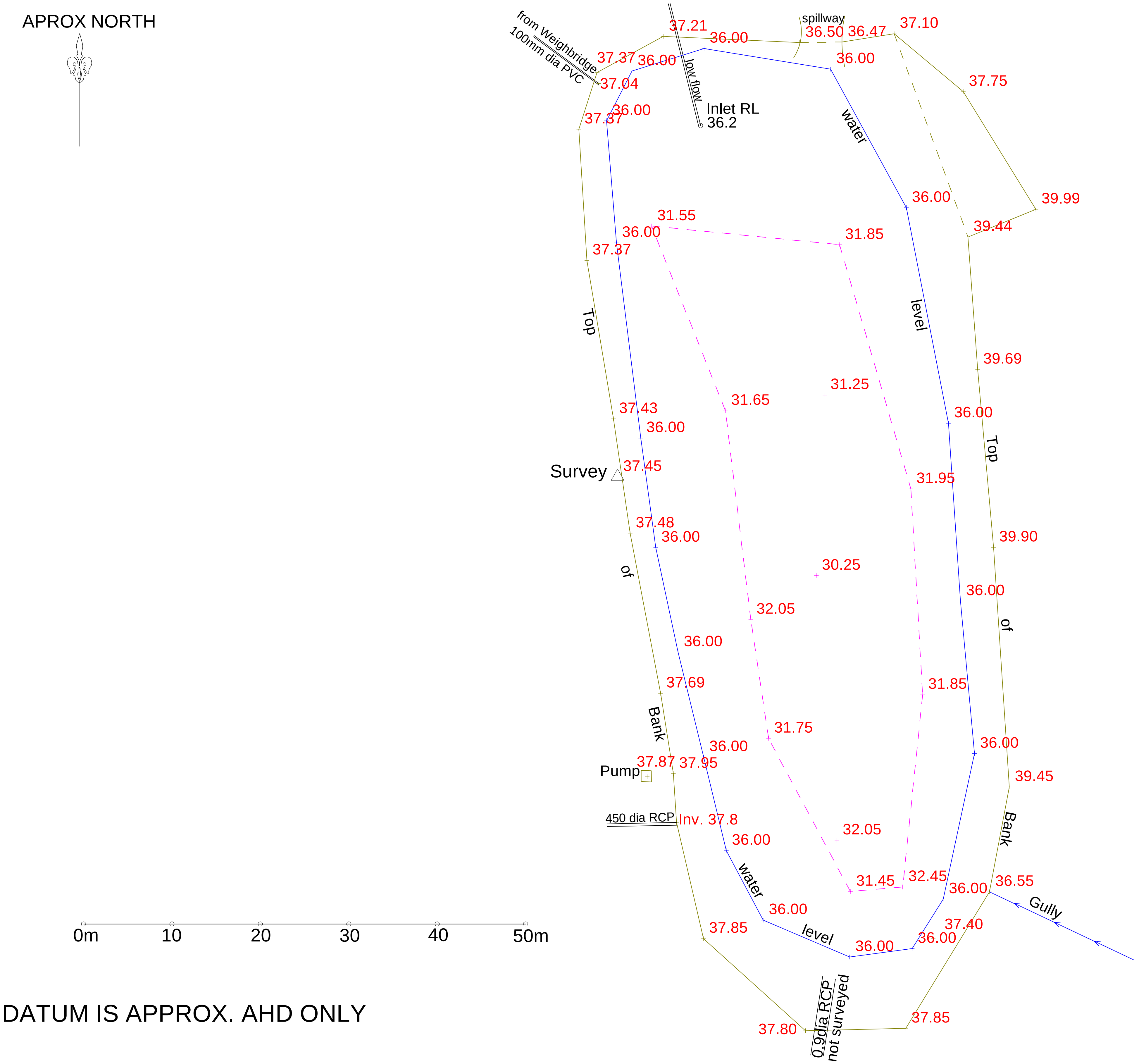
Model results indicate that the Main Dam (10ML) and the Pit Dam (13.7ML) have sufficient storage capacity to supply non-potable demands for all stages of quarry development, during mean and wet climatic conditions.

During extended dry periods (5^{th} percentile dry year), the main and pit dams may be drawn down completely for a period of a month if peak quarry production and water use remains constant. However, up to 5ML per annum of water can be extracted from the clean water dam under the Part 2 license granted as part of the existing development consent for Jandra Quarry. This back up water source may be relied upon in the event of extended drought conditions and provide sufficient water to meet the expected deficit in non-potable water. The conditions of the Part 2 license should be met prior to commencement of extraction which includes installation of a water meter at the offtake from the clean water dam.

In addition demand management (water efficiency) measures, and enlargement of the Pit Dam may buffer the non-potable water supply during these dry periods and reduce the risk of water shortages.

APPENDIX A

Main Dam Survey (2014)

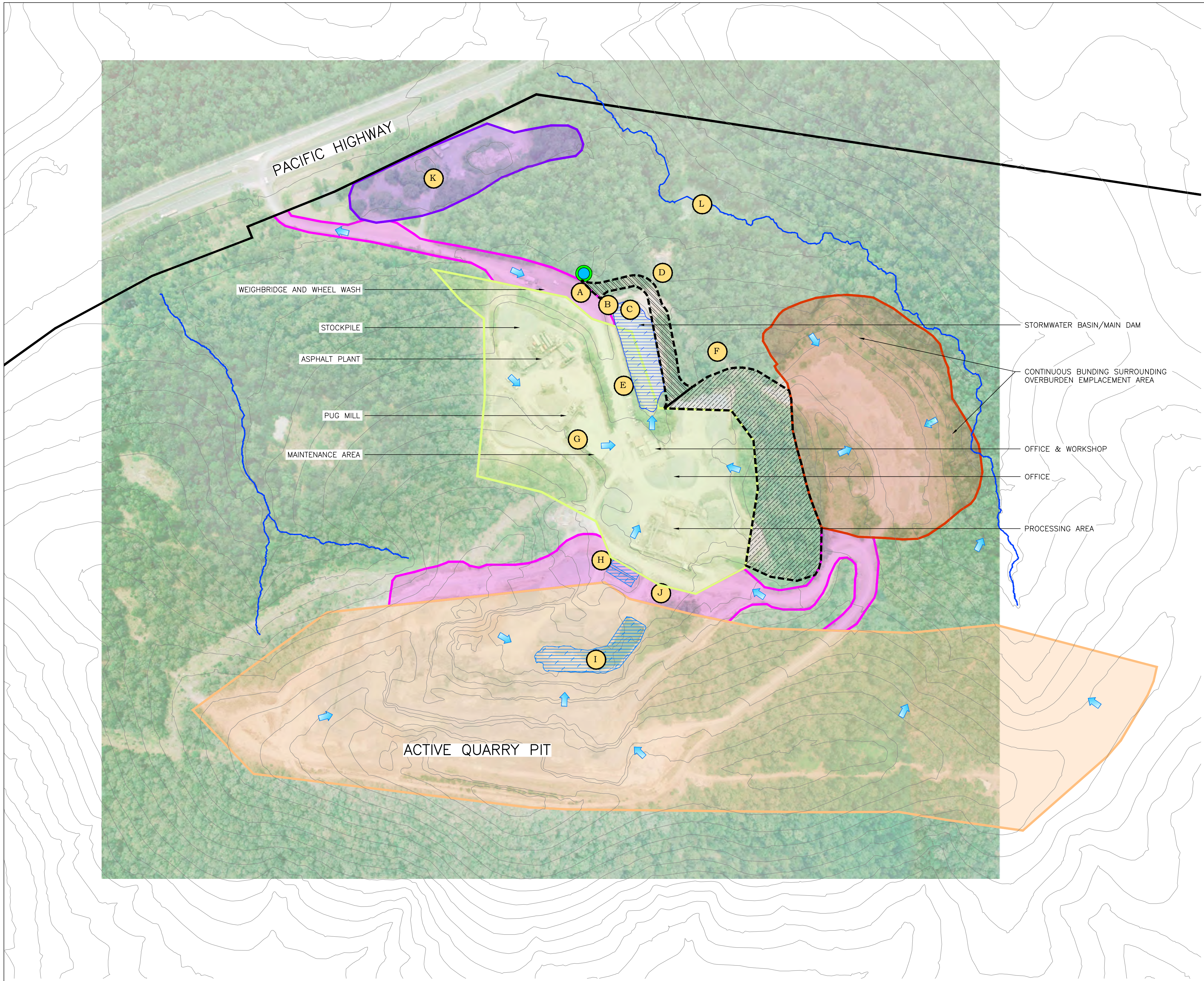


DATUM IS APPROX. AHD ONLY

PLAN				
JANDRA QUARRY MAIN STORMWATER BASIN POSSUM BRUSH	McGLASHAN & CRISP Pty Ltd CONSULTING SURVEYORS 117 VICTORIA STREET, TAREE 2430. Ph:02 65521566. DX 7009	SCALE: 1:500 DRAWN: JVC DATE: 15/5/14	CLIENT: HOLCIM (AUST) PTY LTD LGA PARISH	REFERENCE: F922/4714 COMPUTER FILE: DAM

APPENDIX B

Review of Existing Stormwater Management



A Sedimentation sump and transfer pump. Truckwash water and road runoff discharges into sump and is pumped to the basin/main dam.

B Truck wash water inlet

C Basin orifice outlet to creek

D Basin spillway to creek

E Circulation pump from main dam. Dam water is supplied to pugmill, processing area, water cart, and truck wash as required.

F Unstabilised access road

G Roofwater tank. Harvested roofwater supplied to amenities block

H Primary sedimentation basins for processing area. Basin drain via gravity to main dam via small macrophyte area

I Primary sedimentation basin for quarry area. Drains via gravity through pipe system to the main dam.

J Macrophyte treatment area

K Secondary stockpile area. This area will require a sediment basin and appropriate erosion and sediment controls if it is intended to be used as a stockpiling location

L Clean water dam

Recommendations:
1. Move truck wash water inlet away from basin outlet (or install baffle) to lengthen the flow path and improve sedimentation
2. Apply flocculant to main basin after storm event
3. Increase maintenance frequency

LEGEND:
- DEVELOPMENT CONSENT BOUNDARY
- ACCESS ROAD AND HAUL ROUTES
- PROPOSED HEAVY VEHICLE ACCESS ROAD
- PROPOSED EXPANSION OF FINISHED STOCKPILE AREA
- APPROVED EXTRACTION AREA
- APPROVED SECONDARY STOCKPILE AREA
- APPROVED OVERBURDEN EMPLACEMENT AREA
- APPROVED STOCKPILE AND SITE FACILITIES
- STORMWATER BASIN/MAIN DAM
- SEDIMENTATION BASINS
- WATER SAMPLING LOCATION
- ITEM REFERENCE
- FLOW ARROW
- CREEK/WATERCOURSE
- DRAINAGE CHANNEL

JANDRA QUARRY – REVIEW OF EROSION AND SEDIMENT CONTROLS

Storm

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Original sheet size A3
North

SYDNEY SUITE 18, 12 TRYON RD, LINDFIELD, NSW 2070 P 02 9499 4333

REVIEW OF EXISTING STORMWATER MGMT

Date 21.05.14

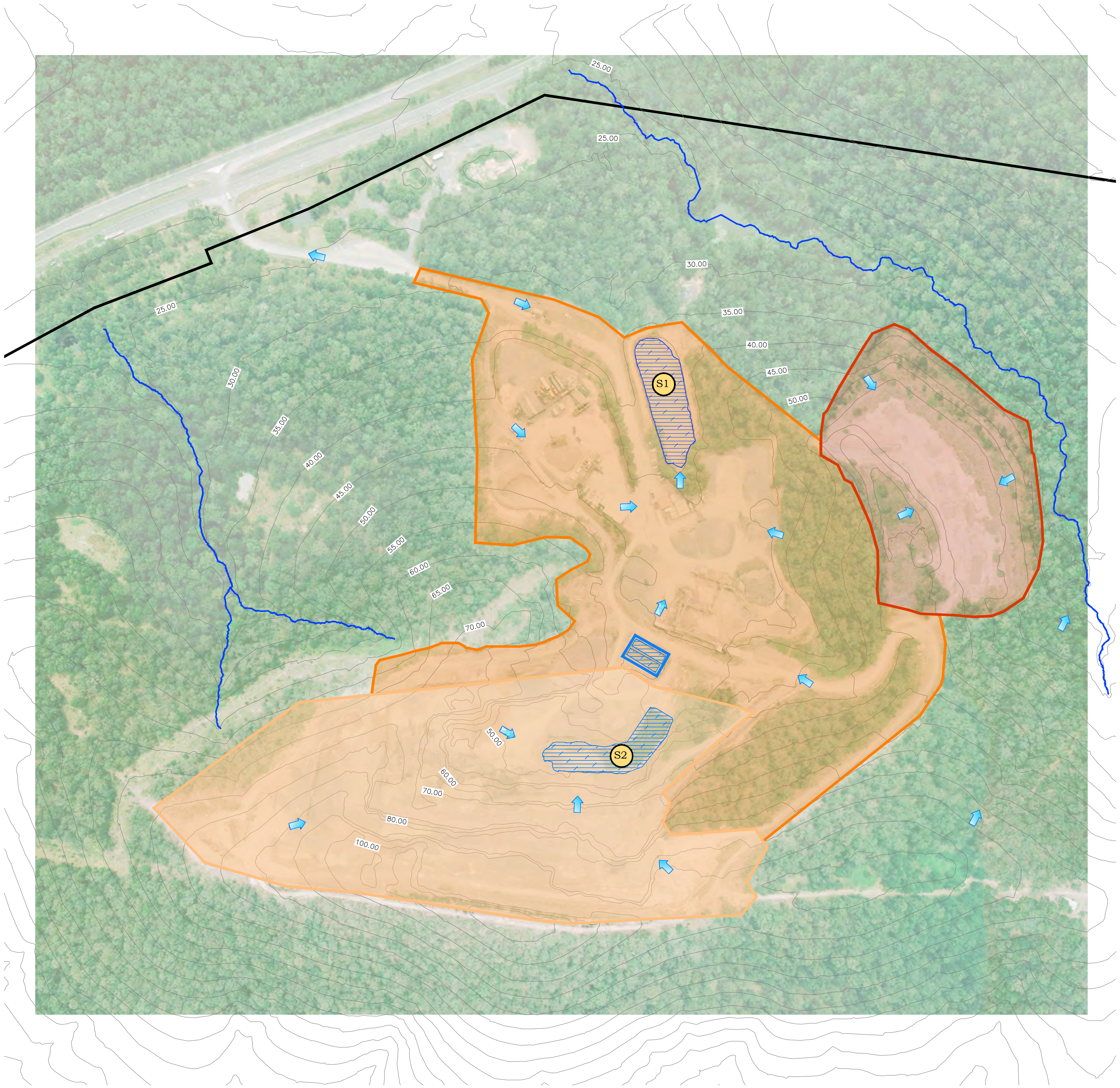
Figure 01

APPENDIX C

Sedimentation Basin Requirements

Sediment Basin Requirements	Catchment Area (ha)	*Settling zone volume (m3)*	*Sediment storage volume (m3)*	Min. required volume (ML)	Existing Volume (ML)
Quarry Area					
-Current	8.04	4197	2098	6.3	13
Facilities Area					
-Current	11.23	5862	2931	8.8	10

Note: Original sediment basin sizing calculations for Jandra Quarry (1999) have been revised and updated, based on modified catchment areas and new sizing method provided in Landcom's Blue Book



LEGEND:

- Active quarry/extraction catchment
- Stockpile and site facilities catchment
- Overburden emplacement catchment
- S1 Main Dam/Sedimentation Basin for facilities area
- S2 Sedimentation basin for active quarry area
- Flow Arrow

SEDIMENTATION BASIN PLAN (EXISTING)

Storm

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Original sheet size A3

North

SYDNEY SUITE 18, 12 TRYON RD, LINDFIELD, NSW 2070 P 02 9499 4333

REVISED SED BASIN REQUIREMENTS FOR EXISTING

Date 21.05.14

Figure 02

Sediment Basin Requirements	Catchment Area (ha)	*Settling zone volume (m3)*	*Sediment storage volume (m3)*	Min. required volume (ML)	Existing Volume (ML)
Quarry Area					
-Stage 1	8.84	4614	2307	6.9	-
Facilities Area					
-Stage 1	10.37	5413	2707	8.1	10

Note: Original sediment basin sizing calculations for Jandra Quarry (1999) have been revised and updated, based on modified catchment areas and new sizing method provided in Landcom's Blue Book

LEGEND:

- Active quarry/extraction catchment
- Stockpile and site facilities catchment
- Overburden emplacement catchment
- S1 Main Dam/Sedimentation Basin for facilities area
- S2 Sedimentation basin for active quarry area
- Flow Arrow

SEDIMENTATION BASIN PLAN (STAGE 1)

Storm

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Original sheet size A3

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SED BASIN REQUIREMENTS FOR STAGE 1

Date 21.05.14

Figure 03

Sediment Basin Requirements	Catchment Area (ha)	*Settling zone volume (m3)*	*Sediment storage volume (m3)*	Min. required volume (ML)	Existing Volume (ML)
Quarry Area					
-Stage 2	13.57	7084	3542	10.6	-
Facilities Area					
-Stage 2	8.44	4406	2203	6.6	10

Note: Original sediment basin sizing calculations for Jandra Quarry (1999) have been revised and updated, based on modified catchment areas and new sizing method provided in Landcom's Blue Book

LEGEND:

- Active quarry/extraction catchment
- Stockpile and site facilities catchment
- Overburden emplacement catchment
- S1 Main Dam/Sedimentation Basin for facilities area
- S2 Sedimentation basin for active quarry area
- Flow Arrow

SEDIMENTATION BASIN PLAN (STAGE 2)

Storm

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SED BASIN REQUIREMENTS FOR STAGE 2

Date 21.05.14

Figure 04

Sediment Basin Requirements	Catchment Area (ha)	*Settling zone volume (m3)*	*Sediment storage volume (m3)*	Min. required volume (ML)	Existing Volume (ML)
Quarry Area					
-Stage 3	17.47	9119	4560	13.7	-
Facilities Area					
-Stage 3	8.44	4406	2203	6.6	10

Note: Original sediment basin sizing calculations for Jandra Quarry (1999) have been revised and updated, based on modified catchment areas and new sizing method provided in Landcom's Blue Book

LEGEND:

- Active quarry/extraction catchment
- Stockpile and site facilities catchment
- Overburden emplacement catchment
- S1 Main Dam/Sedimentation Basin for facilities area
- S2 Sedimentation basin for active quarry area
- Flow Arrow

SEDIMENTATION BASIN PLAN (STAGE 3)

Storm

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Original sheet size A3

North

SYDNEY SUITE 18, 12 TRYON RD, LINDFIELD, NSW 2070 P 02 9499 4333

SED BASIN REQUIREMENTS FOR STAGE 3

Date 21.05.14

Figure 05

APPENDIX D

Water Balance Models

Current Scenario (2014)

Rainfall Data - Taree Airport AWS 60141
Evap Data - Taree Airport AWS 60141

Main Dam Storage size (kL)	10000
Storage (min. % full)	5%
Pit Dam Storage size (kL)	13000
Storage (min. % full)	5%

Daily Rainfall Threshold for DS	1	mm
Haul Road DS Application Rate	1	L/m2/hr
Haul Rd Area	12460	m2
# of applications	4.5	hrs/m2/day
DS Demands	56.07	kL/day
Pit Dam Exfiltration Rate	0.1	mm/hr

Demands

	Mth	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	
1	Jan		156.25	364.58	8.33	390.17	31.0
2	Feb		156.25	364.58	8.33	322.03	28.2
3	Mar		156.25	364.58	8.33	295.99	31.0
4	Apr		156.25	364.58	8.33	221.34	30.0
5	May		156.25	364.58	8.33	141.27	31.0
6	Jun		156.25	364.58	8.33	117.18	30.0
7	Jul		156.25	364.58	8.33	134.54	31.0
8	Aug		156.25	364.58	8.33	188.36	31.0
9	Sep		156.25	364.58	8.33	247.38	30.0
10	Oct		156.25	364.58	8.33	316.17	31.0
11	Nov		156.25	364.58	8.33	345.03	30.0
12	Dec		156.25	364.58	8.33	417.07	31.0
	Total	15429.74	1875.00	4375.00	100.00	3136.52	**24916.25**

Summary of Results

Total Runoff (kL/yr)	94088.0	
Total Demands (kL/yr)	24910.4	
Rainwater supplied (kL/yr)	24901.5	
Total Tank Top Up (kL/yr)	8.9	8.9
% Total Water Demand met	100.0	
No. of spills/yr	16.0	
Spill Volume (kL/yr)	63419.3	
#topups/yr (days)	0.0	

% of demand is met by raintank

Summary Results	Dry Year	Mean Years	Wet Year
Total Runoff (ML/yr)	34.8	97.6	164.9
Total Demands (ML/yr)	25.6	24.9	24.1
Rainwater supplied (ML/yr)	25.5	24.9	24.1
Total Storage Top Up (ML/yr)	0.1	0.0	0.0
% Total Water Demand met	99%	100%	100%
Spill Volume (ML/yr)	4.3	67.5	130.5
Annual Rainfall (mm/yr)	671.4	1185.5	1701.5

Day	Month	Date	Rainfall (mm)	Evap mm	Catchment Runoff Volume (kL/day) Quarry	Facilities	Total Runoff (kL)	Demands (kL) Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	Total Demands (kL)	Main Storage Storage (kL) Notional	Actual (Notional less demands)	spill (kL)	Top up (kL)	Supplied (kL)	Enviro Losses Dam Evap	Infiltration	Pit Storage Storage (kL) Notional	Actual (Notional less demands)	spill (kL)	Top up (kL)	Supplied (kL)
4	1	1/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	5000.0	4898.1	0.0	0.0	101.9	12.5860	7.4	6500.0	6480.0	0.0	0.0	0.0
5	1	2/01/1965	2	5.8	8.3	17.3	25.6	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4915.4	4813.5	0.0	0.0	101.9	12.5860	7.4	6488.2	6468.2	0.0	0.0	0.0
6	1	3/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4813.5	4711.6	0.0	0.0	101.9	12.5860	7.4	6468.2	6448.2	0.0	0.0	0.0
7	1	4/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4711.6	4609.6	0.0	0.0	101.9	12.5860	7.4	6448.2	6428.2	0.0	0.0	0.0
1	1	5/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4609.6	4507.7	0.0	0.0	101.9	12.5860	7.4	6428.2	6408.1	0.0	0.0	0.0
2	1	6/01/1965	2	5.8	6.3	13.1	19.4	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4520.9	4418.9	0.0	0.0	101.9	12.5860	7.4	6414.4	6394.4	0.0	0.0	0.0
3	1	7/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4418.9	4317.0	0.0	0.0	101.9	12.5860	7.4	6394.4	6374.4	0.0	0.0	0.0
4	1	8/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4317.0	4215.1	0.0	0.0	101.9	12.5860	7.4	6374.4	6354.3	0.0	0.0	0.0
5	1	9/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4215.1	4113.2	0.0	0.0	101.9	12.5860	7.4	6354.3	6334.3	0.0	0.0	0.0
6	1	10/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4113.2	4011.2	0.0	0.0	101.9	12.5860	7.4	6334.3	6314.3	0.0	0.0	0.0
7	1	11/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4011.2	3909.3	0.0	0.0	101.9	12.5860	7.4	6314.3	6294.3	0.0	0.0	0.0
1	1	12/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3909.3	3807.4	0.0	0.0	101.9	12.5860	7.4	6294.3	6274.2	0.0	0.0	0.0
2	1	13/01/1965	19	5.8	144.1	301.8	445.9	0.0000	5.0403	11.7608	0.2688	12.5860	29.66	4109.2	4079.6	0.0	0.0	29.7	12.5860	7.4	6418.3	6398.3	0.0	0.0	0.0
3	1	14/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	4079.6	3977.7	0.0	0.0	101.9	12.5860	7.4	6398.3	6378.2	0.0	0.0	0.0
4	1	15/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3977.7	3875.7	0.0	0.0	101.9	12.5860	7.4	6378.2	6358.2	0.0	0.0	0.0
5	1	16/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3875.7	3773.8	0.0	0.0	101.9	12.5860	7.4	6358.2	6338.2	0.0	0.0	0.0
6	1	17/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3773.8	3671.9	0.0	0.0	101.9	12.5860	7.4	6338.2	6318.2	0.0	0.0	0.0
7	1	18/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3671.9	3570.0	0.0	0.0	101.9	12.5860	7.4	6318.2	6298.1	0.0	0.0	0.0
1	1	19/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3570.0	3468.0	0.0	0.0	101.9	12.5860	7.4	6298.1	6278.1	0.0	0.0	0.0
2	1	20/01/1965	1	5.8	1.4	3.0	4.5	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3471.0	3369.1	0.0	0.0	101.9	12.5860	7.4	6279.6	6259.5	0.0	0.0	0.0
3	1	21/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3369.1	3267.2	0.0	0.0	101.9	12.5860	7.4	6259.5	6239.5	0.0	0.0	0.0
4	1	22/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3267.2	3165.3	0.0	0.0	101.9	12.5860	7.4	6239.5	6219.5	0.0	0.0	0.0
5	1	23/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3165.3	3063.4	0.0	0.0	101.9	12.5860	7.4	6219.5	6199.5	0.0	0.0	0.0
6	1	24/01/1965	8	5.8	56.0	117.4	173.4	0.0000	5.0403	11.7608	0.2688	12.5860	29.66	3180.8	3151.1	0.0	0.0	29.7	12.5860	7.4	6255.5	6235.5	0.0	0.0	0.0
7	1	25/01/1965	3	5.8	12.6	26.4	39.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3177.5	3075.6	0.0	0.0	101.9	12.5860	7.4	6248.1	6228.1	0.0	0.0	0.0
1	1	26/01/1965	4	5.8	20.6	43.1	63.7	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3118.7	3016.8	0.0	0.0	101.9	12.5860	7.4	6248.6	6228.6	0.0	0.0	0.0
2	1	27/01/1965	1	5.8	2.2	4.5	6.7	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	3021.3	2919.4	0.0	0.0	101.9	12.5860	7.4	6230.8	6210.7	0.0	0.0	0.0
3	1	28/01/1965	3	5.8	14.3	29.9	44.2	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	2949.4	2847.4	0.0	0.0	101.9	12.5860	7.4	6225.0	6205.0	0.0	0.0	0.0
4	1	29/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	2847.4	2745.5	0.0	0.0	101.9	12.5860	7.4	6205.0	6185.0	0.0	0.0	0.0
5	1	30/01/1965	1	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	2745.5	2643.6	0.0	0.0	101.9	12.5860	7.4	6185.0	6165.0	0.0	0.0	0.0
6	1	31/01/1965	0	5.8	0.0	0.0	0.0	72.2680	5.0403	11.7608	0.2688	12.5860	101.92	2643.6	2541.7	0.0	0.0	101.9	12.5860	7.4	6165.0	6144.9	0.0	0.0	0.0
7	2	1/02/1965	10	5.3	69.5	145.5	215.0	0.0000	5.5364	12.9183	0.2953	11.4104	30.16	2687.2	2657.0	0.0	0.0	30.2	11.4104	7.4	6214.4	6195.5	0.0	0.0	0.0
1	2	2/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2657.0	2561.3	0.0	0.0	95.7	11.4104	7.4	6195.5	6176.7	0.0	0.0	0.0
2	2	3/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2561.3	2465.7	0.0	0.0	95.7	11.4104	7.4	6176.7	6157.8	0.0	0.0	0.0
3	2	4/02/1965	1	5.3	3.8	7.9	11.7	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2473.6	2377.9	0.0	0.0	95.7	11.4104	7.4	6161.6	6142.8	0.0	0.0	0.0
4	2	5/02/1965	7	5.3	46.7	97.8	144.5	0.0000	5.5364	12.9183	0.2953	11.4104	30.16	2475.7	2445.5	0.0	0.0	30.2	11.4104	7.4	6189.4	6170.6	0.0	0.0	0.0
5	2	6/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2445.5	2349.9	0.0	0.0	95.7	11.4104	7.4	6170.6	6151.7	0.0	0.0	0.0
6	2	7/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2349.9	2254.2	0.0	0.0	95.7	11.4104	7.4	6151.7	6132.9	0.0	0.0	0.0
7	2	8/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2254.2	2158.5	0.0	0.0	95.7	11.4104	7.4	6132.9	6114.0	0.0	0.0	0.0
1	2	9/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2158.5	2062.8	0.0	0.0	95.7	11.4104	7.4	6114.0	6095.2	0.0	0.0	0.0
2	2	10/02/1965	1	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	2062.8	1967.2	0.0	0.0	95.7	11.4104	7.4	6095.2	6076.3	0.0	0.0	0.0
3	2	11/02/1965	1	5.3	3.6	7.6	11.2	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1974.7	1879.1	0.0	0.0	95.7	11.4104	7.4	6080.0	6061.1	0.0	0.0	0.0
4	2	12/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1879.1	1783.4	0.0	0.0	95.7	11.4104	7.4	6061.1	6042.3	0.0	0.0	0.0
5	2	13/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1783.4	1687.7	0.0	0.0	95.7	11.4104	7.4	6042.3	6023.4	0.0	0.0	0.0
6	2	14/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1687.7	1592.0	0.0	0.0	95.7	11.4104	7.4	6023.4	6004.6	0.0	0.0	0.0
7	2	15/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1592.0	1496.4	0.0	0.0	95.7	11.4104	7.4	6004.6	5985.7	0.0	0.0	0.0
1	2	16/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1496.4	1400.7	0.0	0.0	95.7	11.4104	7.4	5985.7	5966.9	0.0	0.0	0.0
2	2	17/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1400.7	1305.0	0.0	0.0	95.7	11.4104	7.4	5966.9	5948.0	0.0	0.0	0.0
3	2	18/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1305.0	1209.3	0.0	0.0	95.7	11.4104	7.4	5948.0	5929.2	0.0	0.0	0.0
4	2	19/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1209.3	1113.6	0.0	0.0	95.7	11.4104	7.4	5929.2	5910.3	0.0	0.0	0.0
5	2	20/02/1965	7	5.3	45.0	94.2	139.2	0.0000	5.5364	12.9183	0.2953	11.4104	30.16	1207.9	1177.7	0.0	0.0	30.2	11.4104	7.4	5955.3	5936.4	0.0	0.0	0.0
6	2	21/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1177.7	1082.0	0.0	0.0	95.7	11.4104	7.4	5936.4	5917.6	0.0	0.0	0.0
7	2	22/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	1082.0	986.3	0.0	0.0	95.7	11.4104	7.4	5917.6	5898.7	0.0	0.0	0.0
1	2	23/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	986.3	890.7	0.0	0.0	95.7	11.4104	7.4	5898.7	5879.9	0.0	0.0	0.0
2	2	24/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	890.7	795.0	0.0	0.0	95.7	11.4104	7.4	5879.9	5861.0	0.0	0.0	0.0
3	2	25/02/1965	8	5.3	57.3	120.0	177.3	0.0000	5.5364	12.9183	0.2953	11.4104	30.16	915.0	884.9	0.0	0.0	30.2	11.4104	7.4	5918.3	5899.5	0.0	0.0	0.0
4	2	26/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	884.9	789.2	0.0	0.0	95.7	11.4104	7.4	5899.5	5880.6	0.0	0.0	0.0
5	2	27/02/1965	9	5.3	64.4	135.0	199.4	0.0000	5.5364	12.9183	0.2953	11.4104	30.16	924.1	894.0	0.0	0.0	30.2	11.4104	7.4	5945.0	5926.2	0.0	0.0	0.0
6	2	28/02/1965	0	5.3	0.0	0.0	0.0	65.5180	5.5364	12.9183	0.2953	11.4104	95.68	894.0	798.3	0.0	0.0	95.7	11.4104	7.4	5926.2	5907.3	0.0	0.0	0.0
7	3	1/03/1965	0	4.4	0.0	0.0	0.0	54.8240	5.0403	11.7608	0.2688	9.5480	81.44	798.3	716.9	0.0	0.0	81.4	9.5480	7.4	5907.3	5890.4	0.0	0.0	0.0

Stage 1

Rainfall Data - Taree Airport AWS 60141
Evap Data - Taree Airport AWS 60141

Main Dam Storage size (kL)	10000	
Storage (min. % full)	5%	
Pit Dam Storage size (kL)	13700	
Storage (min. % full)	5%	

Daily Rainfall Threshold for DS	1	mm
Haul Road DS Application Rate	1	L/m2/hr
Haul Rd Area	16540	m2
# of applications	4.5	hrs/m2/day
DS Demands	74.43	kL/day
Pit Dam Exfiltration Rate	0.1	mm/hr

Demands

	Mth	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	
1	Jan		296.88	692.71	16.67	390.17	31.0
2	Feb		296.88	692.71	16.67	322.03	28.2
3	Mar		296.88	692.71	16.67	295.99	31.0
4	Apr		296.88	692.71	16.67	221.34	30.0
5	May		296.88	692.71	16.67	141.27	31.0
6	Jun		296.88	692.71	16.67	117.18	30.0
7	Jul		296.88	692.71	16.67	134.54	31.0
8	Aug		296.88	692.71	16.67	188.36	31.0
9	Sep		296.88	692.71	16.67	247.38	30.0
10	Oct		296.88	692.71	16.67	316.17	31.0
11	Nov		296.88	692.71	16.67	345.03	30.0
12	Dec		296.88	692.71	16.67	417.07	31.0
	Total	20482.17	3562.50	8312.50	200.00	3136.52	**35693.69**

Summary of Results

Total Runoff (kL/yr)	93527.9	
Total Demands (kL/yr)	35684.3	
Rainwater supplied (kL/yr)	35233.5	
Total Tank Top Up (kL/yr)	450.8	450.8
% Total Water Demand met	98.7	
No. of spills/yr	11.8	
Spill Volume (kL/yr)	52983.2	
#topups/yr (days)	81.0	

% of demand is met by raintank

Summary Results	Dry Year	Mean Years	Wet Year
Total Runoff (ML/yr)	34.5	97.1	164.0
Total Demands (ML/yr)	36.6	35.6	34.6
Rainwater supplied (ML/yr)	32.1	35.5	34.6
Total Storage Top Up (ML/yr)	4.5	0.2	0.0
% Total Water Demand met	88%	99%	100%
Spill Volume (ML/yr)	2.6	56.7	111.9
Annual Rainfall (mm/yr)	671.4	1185.5	1701.5

Day	Month	Date	Rainfall (mm)	Evap mm	Catchment Runoff Volume (kL/day) Quarry	Catchment Runoff Volume (kL/day) Facilities	Catchment Runoff Volume (kL/day)	Total Runoff (kL)	Demands Haul Road DS	Demands Process Water Plant DS	Demands Road Base (Product Moisture)	Demands Truck Wash	Demands Dam Evap	Total Demands (kL)	Main Storage Storage (kL) Notional	Main Storage Storage (kL) Actual (Notional less demands)	spill (kL)	Top up (kL)	Supplied (kL)	Enviro Losses Dam Evap	Enviro Losses Infiltration	Pit Storage Storage (kL) Notional	Pit Storage Storage (kL) Actual (Notional less demands)	spill (kL)	Top up (kL)	Supplied (kL)
4	1	1/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	5000.0	4859.0	0.0	0.0	141.0	12.5860	7.4	6850.0	6830.0	0.0	0.0	0.0
5	1	2/01/1965	2	5.8	9.1	16.0		25.1	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4875.0	4734.1	0.0	0.0	141.0	12.5860	7.4	6839.1	6819.0	0.0	0.0	0.0
6	1	3/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4734.1	4593.1	0.0	0.0	141.0	12.5860	7.4	6819.0	6799.0	0.0	0.0	0.0
7	1	4/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4593.1	4452.1	0.0	0.0	141.0	12.5860	7.4	6799.0	6779.0	0.0	0.0	0.0
1	1	5/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4452.1	4311.1	0.0	0.0	141.0	12.5860	7.4	6779.0	6759.0	0.0	0.0	0.0
2	1	6/01/1965	2	5.8	6.9	12.1		19.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4323.3	4182.3	0.0	0.0	141.0	12.5860	7.4	6765.9	6745.8	0.0	0.0	0.0
3	1	7/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4182.3	4041.3	0.0	0.0	141.0	12.5860	7.4	6745.8	6725.8	0.0	0.0	0.0
4	1	8/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	4041.3	3900.3	0.0	0.0	141.0	12.5860	7.4	6725.8	6705.8	0.0	0.0	0.0
5	1	9/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3900.3	3759.3	0.0	0.0	141.0	12.5860	7.4	6705.8	6685.8	0.0	0.0	0.0
6	1	10/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3759.3	3618.4	0.0	0.0	141.0	12.5860	7.4	6685.8	6665.7	0.0	0.0	0.0
7	1	11/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3618.4	3477.4	0.0	0.0	141.0	12.5860	7.4	6665.7	6645.7	0.0	0.0	0.0
1	1	12/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3477.4	3336.4	0.0	0.0	141.0	12.5860	7.4	6645.7	6625.7	0.0	0.0	0.0
2	1	13/01/1965	19	5.8	158.4	278.7		437.1	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	3615.1	3570.1	0.0	0.0	45.0	12.5860	7.4	6784.1	6764.1	0.0	0.0	0.0
3	1	14/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3570.1	3429.1	0.0	0.0	141.0	12.5860	7.4	6764.1	6744.0	0.0	0.0	0.0
4	1	15/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3429.1	3288.1	0.0	0.0	141.0	12.5860	7.4	6744.0	6724.0	0.0	0.0	0.0
5	1	16/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3288.1	3147.2	0.0	0.0	141.0	12.5860	7.4	6724.0	6704.0	0.0	0.0	0.0
6	1	17/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3147.2	3006.2	0.0	0.0	141.0	12.5860	7.4	6704.0	6684.0	0.0	0.0	0.0
7	1	18/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	3006.2	2865.2	0.0	0.0	141.0	12.5860	7.4	6684.0	6663.9	0.0	0.0	0.0
1	1	19/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2865.2	2724.2	0.0	0.0	141.0	12.5860	7.4	6663.9	6643.9	0.0	0.0	0.0
2	1	20/01/1965	1	5.8	1.6	2.8		4.4	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2727.0	2586.0	0.0	0.0	141.0	12.5860	7.4	6645.5	6625.5	0.0	0.0	0.0
3	1	21/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2586.0	2445.1	0.0	0.0	141.0	12.5860	7.4	6625.5	6605.4	0.0	0.0	0.0
4	1	22/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2445.1	2304.1	0.0	0.0	141.0	12.5860	7.4	6605.4	6585.4	0.0	0.0	0.0
5	1	23/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2304.1	2163.1	0.0	0.0	141.0	12.5860	7.4	6585.4	6565.4	0.0	0.0	0.0
6	1	24/01/1965	8	5.8	61.6	108.4		170.0	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	2271.5	2226.5	0.0	0.0	45.0	12.5860	7.4	6627.0	6607.0	0.0	0.0	0.0
7	1	25/01/1965	3	5.8	13.9	24.4		38.3	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2250.9	2109.9	0.0	0.0	141.0	12.5860	7.4	6620.8	6600.8	0.0	0.0	0.0
1	1	26/01/1965	4	5.8	22.6	39.8		62.4	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2149.7	2008.7	0.0	0.0	141.0	12.5860	7.4	6623.4	6603.4	0.0	0.0	0.0
2	1	27/01/1965	1	5.8	2.4	4.2		6.6	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	2012.9	1871.9	0.0	0.0	141.0	12.5860	7.4	6605.8	6585.8	0.0	0.0	0.0
3	1	28/01/1965	3	5.8	15.7	27.6		43.3	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	1899.6	1758.6	0.0	0.0	141.0	12.5860	7.4	6601.5	6581.5	0.0	0.0	0.0
4	1	29/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	1758.6	1617.6	0.0	0.0	141.0	12.5860	7.4	6581.5	6561.4	0.0	0.0	0.0
5	1	30/01/1965	1	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	1617.6	1476.7	0.0	0.0	141.0	12.5860	7.4	6561.4	6541.4	0.0	0.0	0.0
6	1	31/01/1965	0	5.8	0.0	0.0		0.0	95.9320	9.5766	22.3454	0.5376	12.5860	140.98	1476.7	1335.7	0.0	0.0	141.0	12.5860	7.4	6541.4	6521.4	0.0	0.0	0.0
7	2	1/02/1965	10	5.3	76.4	134.4		210.7	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1470.1	1423.0	0.0	0.0	47.1	11.4104	7.4	6597.7	6578.9	0.0	0.0	0.0
1	2	2/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	1423.0	1289.0	0.0	0.0	134.0	11.4104	7.4	6578.9	6560.0	0.0	0.0	0.0
2	2	3/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	1289.0	1154.9	0.0	0.0	134.0	11.4104	7.4	6560.0	6541.2	0.0	0.0	0.0
3	2	4/02/1965	1	5.3	4.2	7.3		11.5	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	1162.2	1028.2	0.0	0.0	134.0	11.4104	7.4	6545.3	6526.5	0.0	0.0	0.0
4	2	5/02/1965	7	5.3	51.3	90.3		141.6	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1118.5	1071.4	0.0	0.0	47.1	11.4104	7.4	6577.8	6559.0	0.0	0.0	0.0
5	2	6/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	1071.4	937.4	0.0	0.0	134.0	11.4104	7.4	6559.0	6540.1	0.0	0.0	0.0
6	2	7/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	937.4	803.4	0.0	0.0	134.0	11.4104	7.4	6540.1	6521.3	0.0	0.0	0.0
7	2	8/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	803.4	669.3	0.0	0.0	134.0	11.4104	7.4	6521.3	6502.4	0.0	0.0	0.0
1	2	9/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	669.3	535.3	0.0	0.0	134.0	11.4104	7.4	6502.4	6483.6	0.0	0.0	0.0
2	2	10/02/1965	1	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	535.3	500.0	0.0	98.7	134.0	11.4104	7.4	6483.6	6366.0	0.0	0.0	98.7
3	2	11/02/1965	1	5.3	4.0	7.0		11.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	507.0	500.0	0.0	127.0	134.0	11.4104	7.4	6370.0	6224.1	0.0	0.0	127.0
4	2	12/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	6224.1	6071.2	0.0	0.0	134.0
5	2	13/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	6071.2	5918.3	0.0	0.0	134.0
6	2	14/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5918.3	5765.4	0.0	0.0	134.0
7	2	15/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5765.4	5612.5	0.0	0.0	134.0
1	2	16/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5612.5	5459.7	0.0	0.0	134.0
2	2	17/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5459.7	5306.8	0.0	0.0	134.0
3	2	18/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5306.8	5153.9	0.0	0.0	134.0
4	2	19/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	5153.9	5001.0	0.0	0.0	134.0
5	2	20/02/1965	7	5.3	49.4	87.0		136.4	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	587.0	539.9	0.0	0.0	47.1	11.4104	7.4	5050.4	5031.6	0.0	0.0	0.0
6	2	21/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	539.9	500.0	0.0	94.1	134.0	11.4104	7.4	5031.6	4918.6	0.0	0.0	94.1
7	2	22/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	4918.6	4765.7	0.0	0.0	134.0
1	2	23/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	4765.7	4612.9	0.0	0.0	134.0
2	2	24/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	500.0	500.0	0.0	134.0	134.0	11.4104	7.4	4612.9	4460.0	0.0	0.0	134.0
3	2	25/02/1965	8	5.3	63.0	110.8		173.8	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	610.8	563.8	0.0	0.0	47.1	11.4104	7.4	4523.0	4504.1	0.0	0.0	0.0
4	2	26/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	563.8	500.0	0.0	70.3	134.0	11.4104	7.4	4504.1	4415.0	0.0	0.0	70.3
5	2	27/02/1965	9	5.3	70.8	124.6		195.5	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	624.6	577.6	0.0	0.0	47.1	11.4104	7.4	4485.8	4467.0	0.0	0.0	0.0
6	2	28/02/1965	0	5.3	0.0	0.0		0.0	86.9717	10.5192	24.5448	0.5906	11.4104	134.04	577.6	500.0	0.0	56.5	134.0	11.4104	7.4	4467.0	4391.7	0.0	0.0	56.5
7	3	1/03/1965	0	4.4	0.0	0.0		0.0	72.7760	9.5766	22.3454	0.5376	9.5480	114.78	500.0	500.0	0.0	114.8	114.8	9.5480	7.4	4391.7	4259.9	0.0	0.0	114.8

Stage 2

Rainfall Data - Taree Airport AWS 60141
Evap Data - Taree Airport AWS 60141

Main Dam Storage size (kL)	10000	
Storage (min. % full)	5%	
Pit Dam Storage size (kL)	13700	
Storage (min. % full)	5%	
Daily Rainfall Threshold for DS	1	mm
Haul Road DS Application Rate	1	L/m2/hr
Haul Rd Area	16400	m2
# of applications	4.5	hrs/m2/day
DS Demands	73.8	kL/day
Pit Dam Exfiltration Rate	0.1	mm/hr

Demands

	Mth	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	
1	Jan		296.88	692.71	16.67	390.17	31.0
2	Feb		296.88	692.71	16.67	322.03	28.2
3	Mar		296.88	692.71	16.67	295.99	31.0
4	Apr		296.88	692.71	16.67	221.34	30.0
5	May		296.88	692.71	16.67	141.27	31.0
6	Jun		296.88	692.71	16.67	117.18	30.0
7	Jul		296.88	692.71	16.67	134.54	31.0
8	Aug		296.88	692.71	16.67	188.36	31.0
9	Sep		296.88	692.71	16.67	247.38	30.0
10	Oct		296.88	692.71	16.67	316.17	31.0
11	Nov		296.88	692.71	16.67	345.03	30.0
12	Dec		296.88	692.71	16.67	417.07	31.0
	Total	20308.80	3562.50	8312.50	200.00	3136.52	**35520.32**

Summary of Results

Total Runoff (kL/yr)	106045.9	
Total Demands (kL/yr)	35510.9	
Rainwater supplied (kL/yr)	35132.3	
Total Tank Top Up (kL/yr)	378.6	378.6
% Total Water Demand met	98.9	
No. of spills/yr	12.9	
Spill Volume (kL/yr)	65563.1	
#topups/yr (days)	124.1	

% of demand is met by raintank

Summary Results	**Dry Year**	**Mean Years**	**Wet Year**
Total Runoff (ML/yr)	38.7	110.1	186.5
Total Demands (ML/yr)	36.4	35.5	34.5
Rainwater supplied (ML/yr)	32.3	35.3	34.5
Total Storage Top Up (ML/yr)	4.1	0.1	0.0
% Total Water Demand met	89%	100%	100%
Spill Volume (ML/yr)	4.1	69.8	138.6
Annual Rainfall (mm/yr)	671.4	1185.5	1701.5

Day	Month	Date	Rainfall	Evap	Catchment Runoff Volume (kL/day)			Total Runoff	Demands					Total Demands	Main Storage Storage (kL)		spill (kL)	Top up (kL)	Supplied (kL)	Enviro Losses		Pit Storage Storage (kL)		spill (kL)	Top up (kL)	Supplied (kL)
			(mm)	mm	Quarry	Facilities		(kL)	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	(kL)	Notional	Actual (Notional less				Dam Evap	Infiltration	Notional	Actual (Notional less demands)			
4	1	1/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	5000.0	4859.8	0.0	0.0	140.2	12.5860	7.4	6850.0	6830.0	0.0	0.0	0.0
5	1	2/01/1965	2	5.8	14.0	13.0		27.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4872.9	4732.7	0.0	0.0	140.2	12.5860	7.4	6843.9	6823.9	0.0	0.0	0.0
6	1	3/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4732.7	4592.5	0.0	0.0	140.2	12.5860	7.4	6823.9	6803.9	0.0	0.0	0.0
7	1	4/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4592.5	4452.4	0.0	0.0	140.2	12.5860	7.4	6803.9	6783.9	0.0	0.0	0.0
1	1	5/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4452.4	4312.2	0.0	0.0	140.2	12.5860	7.4	6783.9	6763.8	0.0	0.0	0.0
2	1	6/01/1965	2	5.8	10.6	9.9		20.5	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4322.1	4181.9	0.0	0.0	140.2	12.5860	7.4	6774.4	6754.4	0.0	0.0	0.0
3	1	7/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4181.9	4041.7	0.0	0.0	140.2	12.5860	7.4	6754.4	6734.4	0.0	0.0	0.0
4	1	8/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	4041.7	3901.6	0.0	0.0	140.2	12.5860	7.4	6734.4	6714.3	0.0	0.0	0.0
5	1	9/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3901.6	3761.4	0.0	0.0	140.2	12.5860	7.4	6714.3	6694.3	0.0	0.0	0.0
6	1	10/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3761.4	3621.2	0.0	0.0	140.2	12.5860	7.4	6694.3	6674.3	0.0	0.0	0.0
7	1	11/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3621.2	3481.1	0.0	0.0	140.2	12.5860	7.4	6674.3	6654.3	0.0	0.0	0.0
1	1	12/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3481.1	3340.9	0.0	0.0	140.2	12.5860	7.4	6654.3	6634.2	0.0	0.0	0.0
2	1	13/01/1965	19	5.8	243.2	226.9		470.0	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	3567.8	3522.7	0.0	0.0	45.0	12.5860	7.4	6877.4	6857.4	0.0	0.0	0.0
3	1	14/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3522.7	3382.6	0.0	0.0	140.2	12.5860	7.4	6857.4	6837.3	0.0	0.0	0.0
4	1	15/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3382.6	3242.4	0.0	0.0	140.2	12.5860	7.4	6837.3	6817.3	0.0	0.0	0.0
5	1	16/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3242.4	3102.2	0.0	0.0	140.2	12.5860	7.4	6817.3	6797.3	0.0	0.0	0.0
6	1	17/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	3102.2	2962.1	0.0	0.0	140.2	12.5860	7.4	6797.3	6777.3	0.0	0.0	0.0
7	1	18/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2962.1	2821.9	0.0	0.0	140.2	12.5860	7.4	6777.3	6757.2	0.0	0.0	0.0
1	1	19/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2821.9	2681.7	0.0	0.0	140.2	12.5860	7.4	6757.2	6737.2	0.0	0.0	0.0
2	1	20/01/1965	1	5.8	2.4	2.3		4.7	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2684.0	2543.8	0.0	0.0	140.2	12.5860	7.4	6739.6	6719.6	0.0	0.0	0.0
3	1	21/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2543.8	2403.7	0.0	0.0	140.2	12.5860	7.4	6719.6	6699.6	0.0	0.0	0.0
4	1	22/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2403.7	2263.5	0.0	0.0	140.2	12.5860	7.4	6699.6	6679.6	0.0	0.0	0.0
5	1	23/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2263.5	2123.3	0.0	0.0	140.2	12.5860	7.4	6679.6	6659.5	0.0	0.0	0.0
6	1	24/01/1965	8	5.8	94.6	88.2		182.8	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	2211.6	2166.5	0.0	0.0	45.0	12.5860	7.4	6754.1	6734.1	0.0	0.0	0.0
7	1	25/01/1965	3	5.8	21.3	19.9		41.2	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2186.4	2046.2	0.0	0.0	140.2	12.5860	7.4	6755.4	6735.4	0.0	0.0	0.0
1	1	26/01/1965	4	5.8	34.7	32.4		67.1	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	2078.6	1938.5	0.0	0.0	140.2	12.5860	7.4	6770.1	6750.1	0.0	0.0	0.0
2	1	27/01/1965	1	5.8	3.7	3.4		7.1	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	1941.9	1801.7	0.0	0.0	140.2	12.5860	7.4	6753.7	6733.7	0.0	0.0	0.0
3	1	28/01/1965	3	5.8	24.1	22.5		46.6	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	1824.2	1684.0	0.0	0.0	140.2	12.5860	7.4	6757.8	6737.8	0.0	0.0	0.0
4	1	29/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	1684.0	1543.9	0.0	0.0	140.2	12.5860	7.4	6737.8	6717.8	0.0	0.0	0.0
5	1	30/01/1965	1	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	1543.9	1403.7	0.0	0.0	140.2	12.5860	7.4	6717.8	6697.7	0.0	0.0	0.0
6	1	31/01/1965	0	5.8	0.0	0.0		0.0	95.1200	9.5766	22.3454	0.5376	12.5860	140.17	1403.7	1263.5	0.0	0.0	140.2	12.5860	7.4	6697.7	6677.7	0.0	0.0	0.0
7	2	1/02/1965	10	5.3	117.2	109.4		226.6	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1372.9	1325.8	0.0	0.0	47.1	11.4104	7.4	6794.9	6776.1	0.0	0.0	0.0
1	2	2/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	1325.8	1192.5	0.0	0.0	133.3	11.4104	7.4	6776.1	6757.2	0.0	0.0	0.0
2	2	3/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	1192.5	1059.2	0.0	0.0	133.3	11.4104	7.4	6757.2	6738.4	0.0	0.0	0.0
3	2	4/02/1965	1	5.3	6.4	6.0		12.3	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	1065.2	931.9	0.0	0.0	133.3	11.4104	7.4	6744.8	6725.9	0.0	0.0	0.0
4	2	5/02/1965	7	5.3	78.8	73.5		152.3	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1005.4	958.3	0.0	0.0	47.1	11.4104	7.4	6804.7	6785.9	0.0	0.0	0.0
5	2	6/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	958.3	825.0	0.0	0.0	133.3	11.4104	7.4	6785.9	6767.0	0.0	0.0	0.0
6	2	7/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	825.0	691.7	0.0	0.0	133.3	11.4104	7.4	6767.0	6748.2	0.0	0.0	0.0
7	2	8/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	691.7	558.4	0.0	0.0	133.3	11.4104	7.4	6748.2	6729.3	0.0	0.0	0.0
1	2	9/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	558.4	500.0	0.0	74.9	133.3	11.4104	7.4	6729.3	6635.6	0.0	0.0	74.9
2	2	10/02/1965	1	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	6635.6	6483.4	0.0	0.0	133.3
3	2	11/02/1965	1	5.3	6.1	5.7		11.8	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	505.7	500.0	0.0	127.6	133.3	11.4104	7.4	6489.6	6343.1	0.0	0.0	127.6
4	2	12/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	6343.1	6191.0	0.0	0.0	133.3
5	2	13/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	6191.0	6038.8	0.0	0.0	133.3
6	2	14/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	6038.8	5886.7	0.0	0.0	133.3
7	2	15/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5886.7	5734.5	0.0	0.0	133.3
1	2	16/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5734.5	5582.4	0.0	0.0	133.3
2	2	17/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5582.4	5430.2	0.0	0.0	133.3
3	2	18/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5430.2	5278.1	0.0	0.0	133.3
4	2	19/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5278.1	5125.9	0.0	0.0	133.3
5	2	20/02/1965	7	5.3	75.9	70.8		146.7	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	570.8	523.7	0.0	0.0	47.1	11.4104	7.4	5201.8	5183.0	0.0	0.0	0.0
6	2	21/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	523.7	500.0	0.0	109.6	133.3	11.4104	7.4	5183.0	5054.5	0.0	0.0	109.6
7	2	22/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	5054.5	4902.4	0.0	0.0	133.3
1	2	23/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	4902.4	4750.2	0.0	0.0	133.3
2	2	24/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	500.0	500.0	0.0	133.3	133.3	11.4104	7.4	4750.2	4598.1	0.0	0.0	133.3
3	2	25/02/1965	8	5.3	96.7	90.2		186.9	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	590.2	543.2	0.0	0.0	47.1	11.4104	7.4	4694.8	4675.9	0.0	0.0	0.0
4	2	26/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	543.2	500.0	0.0	90.2	133.3	11.4104	7.4	4675.9	4566.9	0.0	0.0	90.2
5	2	27/02/1965	9	5.3	108.7	101.4		210.2	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	601.4	554.4	0.0	0.0	47.1	11.4104	7.4	4675.7	4656.8	0.0	0.0	0.0
6	2	28/02/1965	0	5.3	0.0	0.0		0.0	86.2356	10.5192	24.5448	0.5906	11.4104	133.30	554.4	500.0	0.0	78.9	133.3	11.4104	7.4	4656.8	4559.0	0.0	0.0	78.9
7	3	1/03/1965	0	4.4	0.0	0.0		0.0	72.1600	9.5766	22.3454	0.5376	9.5480	114.17	500.0	500.0	0.0	114.2	114.2	9.5480	7.4	4559.0	4427.9	0.0	0.0	114.2

Stage 3

Rainfall Data - Taree Airport AWS 60141
Evap Data - Taree Airport AWS 60141

Main Dam Storage size (kL)	10000	
Storage (min. % full)	5%	
Pit Dam Storage size (kL)	13700	
Storage (min. % full)	5%	
Daily Rainfall Threshold for DS	1	mm
Haul Road DS Application Rate	1	L/m2/hr
Haul Rd Area	15000	m2
# of applications	4.5	hrs/m2/day
DS Demands	67.5	kL/day
Pit Dam Exfiltration Rate	0.1	mm/hr

Demands

	Mth	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	
1	Jan		296.88	692.71	16.67	390.17	31
2	Feb		296.88	692.71	16.67	322.03	28
3	Mar		296.88	692.71	16.67	295.99	31
4	Apr		296.88	692.71	16.67	221.34	30
5	May		296.88	692.71	16.67	141.27	31
6	Jun		296.88	692.71	16.67	117.18	30
7	Jul		296.88	692.71	16.67	134.54	31
8	Aug		296.88	692.71	16.67	188.36	31
9	Sep		296.88	692.71	16.67	247.38	30
10	Oct		296.88	692.71	16.67	316.17	31
11	Nov		296.88	692.71	16.67	345.03	30
12	Dec		296.88	692.71	16.67	417.07	31
	Total	18575.12	3562.50	8312.50	200.00	3136.52	**33786.64**

Summary of Results

Total Runoff (kL/yr)	124352.1	
Total Demands (kL/yr)	33777.3	
Rainwater supplied (kL/yr)	33593.9	
Total Tank Top Up (kL/yr)	183.3	183.3
% Total Water Demand met	99.5	
No. of spills/yr	15.5	
Spill Volume (kL/yr)	85257.4	
#topups/yr (days)	116.0	

% of demand is met by raintank

Summary Results	Dry Year	Mean Years	Wet Year
Total Runoff (ML/yr)	45.2	129.1	218.9
Total Demands (ML/yr)	34.6	33.7	32.8
Rainwater supplied (ML/yr)	31.9	33.7	32.8
Total Storage Top Up (ML/yr)	2.8	0.0	0.0
% Total Water Demand met	92%	100%	100%
Spill Volume (ML/yr)	9.1	90.3	174.1
Annual Rainfall (mm/yr)	671.4	1185.5	1701.5

Day	Month	Date	Rainfall	Evap	Catchment Runoff Volume (kL/day)			Total Runoff	Demands					Total Demands	Main Storage Storage (kL)		spill (kL)	Top up (kL)	Supplied (kL)	Enviro Losses		Pit Storage Storage (kL)		spill (kL)	Top up (kL)	Supplied (kL)
			(mm)	mm	Quarry	Facilities		(kL)	Haul Road DS	Process Water Plant DS	Road Base (Product Moisture)	Truck Wash	Dam Evap	(kL)	Notional	Actual (Notional less demands)				Dam Evap	Infiltration	Notional	Actual (Notional less demands)			
4	1	1/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	5000.0	4868.0	0.0	0.0	132.0	12.5860	7.4	6850.0	6830.0	0.0	0.0	0.0
5	1	2/01/1965	2	5.8	18.0	13.0		31.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4881.0	4748.9	0.0	0.0	132.0	12.5860	7.4	6848.0	6827.9	0.0	0.0	0.0
6	1	3/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4748.9	4616.9	0.0	0.0	132.0	12.5860	7.4	6827.9	6807.9	0.0	0.0	0.0
7	1	4/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4616.9	4484.8	0.0	0.0	132.0	12.5860	7.4	6807.9	6787.9	0.0	0.0	0.0
1	1	5/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4484.8	4352.8	0.0	0.0	132.0	12.5860	7.4	6787.9	6767.8	0.0	0.0	0.0
2	1	6/01/1965	2	5.8	13.6	9.9		23.5	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4362.7	4230.6	0.0	0.0	132.0	12.5860	7.4	6781.5	6761.4	0.0	0.0	0.0
3	1	7/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4230.6	4098.6	0.0	0.0	132.0	12.5860	7.4	6761.4	6741.4	0.0	0.0	0.0
4	1	8/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	4098.6	3966.5	0.0	0.0	132.0	12.5860	7.4	6741.4	6721.4	0.0	0.0	0.0
5	1	9/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3966.5	3834.5	0.0	0.0	132.0	12.5860	7.4	6721.4	6701.4	0.0	0.0	0.0
6	1	10/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3834.5	3702.4	0.0	0.0	132.0	12.5860	7.4	6701.4	6681.3	0.0	0.0	0.0
7	1	11/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3702.4	3570.4	0.0	0.0	132.0	12.5860	7.4	6681.3	6661.3	0.0	0.0	0.0
1	1	12/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3570.4	3438.4	0.0	0.0	132.0	12.5860	7.4	6661.3	6641.3	0.0	0.0	0.0
2	1	13/01/1965	19	5.8	313.0	226.9		539.9	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	3665.2	3620.2	0.0	0.0	45.0	12.5860	7.4	6954.3	6934.3	0.0	0.0	0.0
3	1	14/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3620.2	3488.1	0.0	0.0	132.0	12.5860	7.4	6934.3	6914.3	0.0	0.0	0.0
4	1	15/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3488.1	3356.1	0.0	0.0	132.0	12.5860	7.4	6914.3	6894.3	0.0	0.0	0.0
5	1	16/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3356.1	3224.0	0.0	0.0	132.0	12.5860	7.4	6894.3	6874.2	0.0	0.0	0.0
6	1	17/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3224.0	3092.0	0.0	0.0	132.0	12.5860	7.4	6874.2	6854.2	0.0	0.0	0.0
7	1	18/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	3092.0	2959.9	0.0	0.0	132.0	12.5860	7.4	6854.2	6834.2	0.0	0.0	0.0
1	1	19/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2959.9	2827.9	0.0	0.0	132.0	12.5860	7.4	6834.2	6814.2	0.0	0.0	0.0
2	1	20/01/1965	1	5.8	3.1	2.3		5.4	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2830.2	2698.1	0.0	0.0	132.0	12.5860	7.4	6817.3	6797.3	0.0	0.0	0.0
3	1	21/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2698.1	2566.1	0.0	0.0	132.0	12.5860	7.4	6797.3	6777.2	0.0	0.0	0.0
4	1	22/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2566.1	2434.0	0.0	0.0	132.0	12.5860	7.4	6777.2	6757.2	0.0	0.0	0.0
5	1	23/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2434.0	2302.0	0.0	0.0	132.0	12.5860	7.4	6757.2	6737.2	0.0	0.0	0.0
6	1	24/01/1965	8	5.8	121.8	88.2		210.0	0.0000	9.5766	22.3454	0.5376	12.5860	45.05	2390.2	2345.2	0.0	0.0	45.0	12.5860	7.4	6858.9	6838.9	0.0	0.0	0.0
7	1	25/01/1965	3	5.8	27.4	19.9		47.3	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2365.0	2233.0	0.0	0.0	132.0	12.5860	7.4	6866.3	6846.3	0.0	0.0	0.0
1	1	26/01/1965	4	5.8	44.7	32.4		77.1	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2265.4	2133.3	0.0	0.0	132.0	12.5860	7.4	6891.0	6871.0	0.0	0.0	0.0
2	1	27/01/1965	1	5.8	4.7	3.4		8.1	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2136.8	2004.7	0.0	0.0	132.0	12.5860	7.4	6875.7	6855.7	0.0	0.0	0.0
3	1	28/01/1965	3	5.8	31.0	22.5		53.5	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	2027.2	1895.2	0.0	0.0	132.0	12.5860	7.4	6886.7	6866.7	0.0	0.0	0.0
4	1	29/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	1895.2	1763.1	0.0	0.0	132.0	12.5860	7.4	6866.7	6846.7	0.0	0.0	0.0
5	1	30/01/1965	1	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	1763.1	1631.1	0.0	0.0	132.0	12.5860	7.4	6846.7	6826.6	0.0	0.0	0.0
6	1	31/01/1965	0	5.8	0.0	0.0		0.0	87.0000	9.5766	22.3454	0.5376	12.5860	132.05	1631.1	1499.0	0.0	0.0	132.0	12.5860	7.4	6826.6	6806.6	0.0	0.0	0.0
7	2	1/02/1965	10	5.3	150.9	109.4		260.3	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1608.4	1561.3	0.0	0.0	47.1	11.4104	7.4	6957.5	6938.7	0.0	0.0	0.0
1	2	2/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	1561.3	1435.4	0.0	0.0	125.9	11.4104	7.4	6938.7	6919.8	0.0	0.0	0.0
2	2	3/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	1435.4	1309.4	0.0	0.0	125.9	11.4104	7.4	6919.8	6901.0	0.0	0.0	0.0
3	2	4/02/1965	1	5.3	8.2	6.0		14.2	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	1315.4	1189.5	0.0	0.0	125.9	11.4104	7.4	6909.2	6890.3	0.0	0.0	0.0
4	2	5/02/1965	7	5.3	101.4	73.5		174.9	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	1263.0	1215.9	0.0	0.0	47.1	11.4104	7.4	6991.8	6972.9	0.0	0.0	0.0
5	2	6/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	1215.9	1090.0	0.0	0.0	125.9	11.4104	7.4	6972.9	6954.1	0.0	0.0	0.0
6	2	7/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	1090.0	964.0	0.0	0.0	125.9	11.4104	7.4	6954.1	6935.2	0.0	0.0	0.0
7	2	8/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	964.0	838.1	0.0	0.0	125.9	11.4104	7.4	6935.2	6916.4	0.0	0.0	0.0
1	2	9/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	838.1	712.1	0.0	0.0	125.9	11.4104	7.4	6916.4	6897.5	0.0	0.0	0.0
2	2	10/02/1965	1	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	712.1	586.2	0.0	0.0	125.9	11.4104	7.4	6897.5	6878.7	0.0	0.0	0.0
3	2	11/02/1965	1	5.3	7.9	5.7		13.6	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	591.9	500.0	0.0	34.0	125.9	11.4104	7.4	6886.6	6833.7	0.0	0.0	34.0
4	2	12/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6833.7	6688.9	0.0	0.0	125.9
5	2	13/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6688.9	6544.1	0.0	0.0	125.9
6	2	14/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6544.1	6399.3	0.0	0.0	125.9
7	2	15/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6399.3	6254.5	0.0	0.0	125.9
1	2	16/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6254.5	6109.7	0.0	0.0	125.9
2	2	17/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	6109.7	5964.9	0.0	0.0	125.9
3	2	18/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	5964.9	5820.2	0.0	0.0	125.9
4	2	19/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	5820.2	5675.4	0.0	0.0	125.9
5	2	20/02/1965	7	5.3	97.7	70.8		168.5	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	570.8	523.7	0.0	0.0	47.1	11.4104	7.4	5773.1	5754.2	0.0	0.0	0.0
6	2	21/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	523.7	500.0	0.0	102.2	125.9	11.4104	7.4	5754.2	5633.2	0.0	0.0	102.2
7	2	22/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	5633.2	5488.4	0.0	0.0	125.9
1	2	23/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	5488.4	5343.6	0.0	0.0	125.9
2	2	24/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	500.0	500.0	0.0	125.9	125.9	11.4104	7.4	5343.6	5198.8	0.0	0.0	125.9
3	2	25/02/1965	8	5.3	124.5	90.2		214.7	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	590.2	543.2	0.0	0.0	47.1	11.4104	7.4	5323.3	5304.4	0.0	0.0	0.0
4	2	26/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	543.2	500.0	0.0	82.8	125.9	11.4104	7.4	5304.4	5202.8	0.0	0.0	82.8
5	2	27/02/1965	9	5.3	140.0	101.4		241.4	0.0000	10.5192	24.5448	0.5906	11.4104	47.06	601.4	554.4	0.0	0.0	47.1	11.4104	7.4	5342.8	5323.9	0.0	0.0	0.0
6	2	28/02/1965	0	5.3	0.0	0.0		0.0	78.8740	10.5192	24.5448	0.5906	11.4104	125.94	554.4	500.0	0.0	71.6	125.9	11.4104	7.4	5323.9	5233.5	0.0	0.0	71.6
7	3	1/03/1965	0	4.4	0.0	0.0		0.0	66.0000	9.5766	22.3454	0.5376	9.5480	108.01	500.0	500.0	0.0	108.0	108.0	9.5480	7.4	5233.5	5108.5	0.0	0.0	108.0

APPENDIX E

Settlement of Dispersed Fines (Appendix E – Managing Urban Stormwater: Soils and Construction Volume 1)

E Settlement of Dispersed Fines

E1 The Problem

Dispersible soils are those where the clay and fine silt particles (<0.005 mm) disperse into a state of separation into extremely fine colloidal units when exposed to water. These particles can remain suspended in water essentially forever because of common electrical charges on the colloidal surfaces, causing them to repel each other and stay in suspension. Stormwater runoff from exposed dispersible soils typically contains high levels of suspended solids (>500-1,000 mg/L) and turbidity. The failure of dispersed clays to settle is commonly exacerbated by wind-generated turbulence within sediment retention basins.

Settlement of these suspended particles typically requires the application of a chemical agent, which neutralises the surface charges, allowing the particles to settle relatively quickly. This process occurs naturally in estuaries, where fresh water inflows are exposed to a saline environment. This Appendix provides guidance on how chemical agents can be used to reduce the levels of suspended solids and turbidity in stormwater captured by sediment retention basins to an acceptable level, prior to discharge to the environment.

Information about dispersibility in soils at each land disturbance site should be provided in the *SWMP* along with a statement about how it will be managed. For many areas in New South Wales, information on dispersibility can be taken from Tables at Appendix C, together with the 1:100 000 soil landscape mapping available from the Department of Infrastructure Planning and Natural Resources. Information on techniques for managing the dispersible fines is given below.

E2 A Quick Field Test

Where sites might have dispersible soils and confirmation is necessary, a simple procedure that can eliminate the need for laboratory analysis is the "field" Emerson test, a test based on the Emerson Aggregate Test (Emerson, 1967). Here, a sample of soil material is taken from the likely sediment source and worked up as a bolus.[1]

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1. A sample of soil is taken that can comfortably fit into the palm of the hand, but ensure first that hands are clean (particularly, free of grease or oil). Water is added very slowly and the sample kneaded until all structure is broken down and the ball of soil just fails to stick to the fingers (it might help to crush the soil structure first with a pestle and mortar and pass it through a 2 mm sieve to remove any gravel or coarser materials). More water or soil can be added to attain this condition that is called the "sticky point", and approximates field capacity for that soil. Continue kneading and moistening until there are no further apparent changes in the soil ball, usually about two or three minutes. The soil ball so formed is called a "bolus". Note: that some soils:
   - (i) feel sticky as soon as water is added, but lose the condition as the bolus is formed – or at least until sticky point is reached;
   - (ii) are far stickier than others; and are very much harder to knead than others, e.g. heavy clays.

Next, a 5 to 10-mm cube of the bolus material is placed gently in a clear glass container containing sufficient distilled water to cover it. It is left to stand undisturbed for about three minutes with any change in condition noted.

One of two results is likely:

- no change will occur
- the sample will slake and/or disperse.[2]

If there is no change or the sample slakes, the sample is not dispersible and further laboratory testing should not be necessary. However, if any of the bolus disperses and goes into suspension (the water near the sample becomes milky), undertake laboratory testing to find out whether more than 10 percent of the soil material is dispersible. Note that the more material that goes into suspension, the more dispersible is that sample. Regular sediment trapping devices are ineffective with soils having more than 10 percent dispersible materials and require artificial methods to help in the settling process or enhance filtration.

E3 Management of Dispersible Fines

E3.1 The Process

Two broad processes can be considered to help reduce suspended solids loads where a significant proportion of these are dispersible fines: coagulation and flocculation. Coagulating agents destabilise colloidal suspensions by neutralising the surface charges allowing settlement; flocculating agents cause the colloidal particles to clump into larger units or "flocs" that can either settle in a reasonable time or be filtered.

Users of flocculating and coagulating agents should also be aware that soils can be dispersible because of either common positive or common negative charges on the colloid surfaces. Users of these agents can start from the premise that, in New South Wales, most colloid surfaces are negatively charged. However, this might not be the case at any particular site.

E3.2 Common Agents

Many agents exist, including gypsum, alum, ferric chloride, ferric sulfate, polyelectrolytes (long-chain natural and synthetic organic polymers) including polyacrylamides (PAMS) and common salt (sodium chloride) or brine. Gypsum, PAMS and alum have traditionally been applied to treat stormwater runoff in New South Wales.

2. Soils that disperse must be distinguished from those that slake. Aggregates of soils that slake break down in water, but do not go into suspension as do dispersible soils, i.e. the particles settle relatively quickly.

When choosing a settling agent, note that:

(i) the trivalent aluminium (Al^{3+}) ion present in alum is 2,000 times more effective than the monovalent sodium (Na^{+}) ion present in salt; and

(ii) the bivalent calcium (Ca^{2+}) ion present in gypsum is only 50 times more effective than sodium (Barnes, 1981).

As such, alum produces a much faster settling rate than gypsum (Goldrick, 1996).

E3.3 Application Rates

Except where discussed at Section E4, below, always apply proprietary settling agents following the manufacturer's instructions as a first premise. Despite this, all sediment basins should be analysed after the first two storm events to determine the actual settling agent application rate and the settling time required. This requirement is because most soils respond differently to any particular settling agent. Standard jar tests are the usual method, undertaken following procedures set by suitably qualified laboratories.

In some situations, preliminary testing of water samples in a laboratory before discharge might be necessary to prove that the suspended solid content is below recommended levels, e.g. where the receiving waters are particularly sensitive. Naturally, all measures and procedures should be mindful of statutory requirements not to pollute waters with sediment or the agent, or from any secondary effects. In these cases, sampling details should be clearly set out in the *SWMP*.

The final application rate should be sufficiently high to permit removal of suspended solids and discharge of treated waters within an acceptable time without polluting waters with the agent itself. A rough field test that approximates an acceptable suspended solids content of 50 milligrams per litre is to fill a clear plastic or glass 65 mm diameter soft drink bottle with the water and hold it up to the light. If seeing very clearly through the sample is not possible, it is probably above 50 milligrams per litre and needs further treatment. Note, though, that materials other than suspended solids can cause water to be discoloured and laboratory testing might be necessary anyway.

E3.4 Some Warnings

Care should be taken with the choice of an agent, its dosing rate and any special conditions to ensure that toxic situations are not created with consequent damage to the ecology – some flocculating agents can become toxic if these matters are not given due consideration. Some, such as alum, have resulted in extensive destruction to large tracts of ecosystems in the United States when not managed properly.

Many New South Wales waters are acidic (pH<7.0) and some are quite so (pH<5.5).[3] The ionic form of aluminium, which is highly toxic, is likely to occur below about pH 5.0 and more likely to occur at even lower pH levels. With the use of aluminium-based settling agents, accurate measurement and treatment of water pH must be undertaken to ensure that values are above 5.5 always. Regular ongoing testing of the runoff water should be undertaken to ensure that the recent exposure of certain soils in the catchment area has not caused pH levels to drop to less than 5.5. Further, any residual concentrations of alum remaining in the supernatant before discharge should not exceed the ANZECC (2000) freshwater quality "trigger value" of 0.055 milligrams per litre for aluminium at pH levels above 6.5.[4]

As for residual polyelectrolytes, ANZECC (2000) suggests that a program of field testing for them cannot be justified because they cannot be measured reliably. They do not bioaccumulate, are highly biodegradable, and do not persist in the environment. Furthermore, the guidelines state that trigger levels for polyelectrolytes have not been established yet. The Responsible Care® Guidelines for Use of Polyelectrolytes are a Code of Practice for their use. When these guidelines are followed, PACIA (1998) suggest that they have very low mammalian toxicities and, generally, are considered to be innocuous materials. Nevertheless, excessive dosing with polyelectrolytes has been shown to:

- result in the release of materials that can kill fish and other aquatic life, especially when in the cationic form
- reduce the effectiveness of the agent.

Care should therefore be exercised in the use of these chemicals in stormwater treatment.

Finally, it is important that an individual on site is charged with the responsibility of overseeing the operations and maintenance of any sediment settling systems. Detailed monitoring and maintenance records should be kept detailing rainfall on site, the

3. Soil pH is a measure of the acidity or alkalinity of a soil. It relates to the concentration of the hydrogen ions (H^+) in the soil solution measured on a negative logarithmic scale of 1 to 14. The concentrations of hydrogen ions are equal to the hydroxyl ions (OH^-) at pH 7, greater below pH 7 (acid) and fewer above (alkaline). In the urban environment, the importance of pH is usually confined to its effect on the availability of elements in the soil and, therefore, possible deficiencies and/or toxicities. Whether these elements are available to plants depends on their solubilities, being available only when in soluble forms. The "essential" plant nutrients are in their most soluble forms around pH 6 to 7.
4. The precipitation reaction that takes place in sediment basins can rapidly reduce the concentrations of alum in the water. Research on the leaching characteristics of alum sludge suggests that the alum is tightly bound to the sediment under both oxidising and reducing conditions at pH ranges between 5 and 7 (Metcalf, 2001). Sufficiently acid water conditions to loosen these bonds are unlikely to occur naturally in New South Wales except near poorly managed acid sulfate soils. Furthermore, pH reduction is unlikely to be induced by the use of aluminium agents themselves. Where aluminium settling agents are used properly, the sediment containing the settling agent is not considered toxic as the aluminium is bound up with the soil particles. It is common practice for the accumulated sediment to be dried on site and incorporated into fills. It should not be placed in a manner where runoff from this material can enter surface water directly.

catchment area(s) being served by the settling system(s), the degree of stabilisation, the volumes of settling agents used, and any other relevant matters.

E4 Two Suggested Methodologies

Two possible approaches to flocculation of sediment-laden stormwater within sediment retention basins are described in the following sections. These approaches differ markedly, from the manual dosing of captured stormwater following the cessation of a storm event (i.e. batch treatment'), through to "real-time" dosing of stormwater during the storm event, typically using some automated dosing system. Manual dosing, such as the most common application of gypsum to sediment basins following storm events, is simple but time- and labour intensive, whereas an automated system is more complex in terms of design and installation, but less intensive in terms of ongoing operation (although still requiring periodic monitoring and maintenance). Consequently, this latter approach may be most suitable for long-term disturbances, where the set-up requirements are most warranted.

The following sections describe these two approaches to the flocculation of sediment basins, comprising the manual dosing of basins using gypsum, and the automated dosing of stormwater using polyaluminium chloride (PAC). Of course, other types of flocculants can be used with either of these approaches, and other methods of dosing may be used. In all cases, managers should ensure that chemical treatment of stormwater is undertaken in a way that ensures that no harmful residual levels of the chemical agent are discharged to the receiving environment while still ensuring the desired degree of settlement.

E4.1 Manual Dosing of Basins Using Gypsum

Gypsum (calcium sulfate) is a relatively insoluble settling agent. Consequently, spreading it very evenly over the entire pond surface is essential for proper treatment of sediment-laden water. Normally, gypsum should be applied at a rate of about 30 kilograms per 100 cubic metres of stored water.

Figure E1 shows a suggested method of gypsum application for larger ponds where spreading evenly by hand is impractical. Ideally, the drum shown in figure E1 should have about a 50 litre capacity and holes about 25–mm diameter drilled on a 150-mm grid so pond water can enter. Constant stirring is necessary with the resultant slurry picked up through the inlet to a pump and sprayed evenly over the pond surface. In some instances, much higher rates of application than 30 kilograms per 100 cubic metres are necessary to achieve an acceptable suspended solids concentration, typically less than 50 milligrams per litre. Rates of up to 100 kilograms have been known to be necessary. As discussed at Section E3.1, above, each pond should be analysed after the first two storm events to determine the actual settling agent application rate and the settling time required.

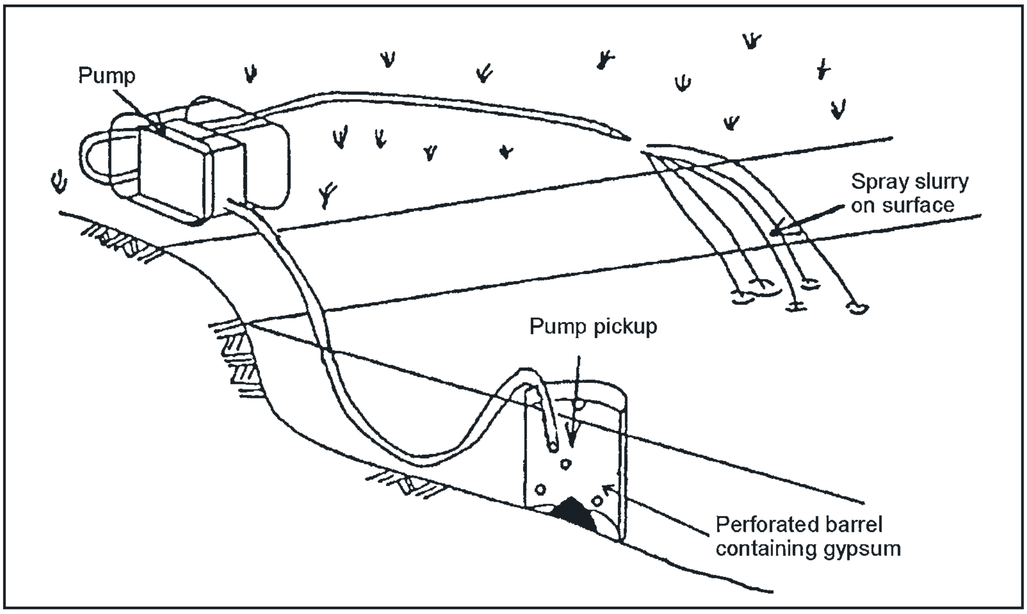

Figure E1. Application of gypsum

Figure E2. Poor gypsum application technique.

Spreading the gypsum evenly over the pond surface is essential. Figure E2 shows gypsum application where the slurry jet enters the water at too large an angle. In this instance, rates of up to 100 kilograms per 100 cubic metres of pond water were required to achieve the necessary water quality. Had the slurry jet entered the water at a much lower angle (e.g. at 10 or 20 degrees from the water surface), lower gypsum dosing rates could have been acceptable.

Assuming the pond is designed to the 5-day, y-percentile depth (Section 6.3.4(c)), adequate settling is required in about four days from the conclusion of each storm event. This will allow one day to pump it out. The critical issue is to ensure the basin is pumped out and ready to receive more sediment-laden water within five days from the conclusion of a storm event. The water can be discharged from the basin once the suspended solid concentration has been lowered to the acceptable level. Treated basins should be dewatered with a system that:

(i) ideally permits drainage of the pond in less than 24 hours ; and[5]

(ii) has a floating inlet to prevent settled sediments being removed as well – it is essential that materials from the sediment layer are not entrained and discharged in the dewatering process.

Of course, if the pond is designed to the 2, 10 or 20-day, y-percentile depth, shorter or longer settling times apply, respectively.

E4.2. Automated Dosing of Stormwater Using Polyaluminium Chloride

The rainfall activated settling system outlined here is based on the use of polyaluminium chloride (PAC) and is adapted from TP90 Flocculation Guidelines prepared for Auckland Regional Council (Beca Carter Hollings & Ferner, 2003). Aluminium settling agents other than PAC, including alum (aluminium sulphate) might also be suitable for use in this system. Irrespective of which agent is used, the system should be designed following Section E3.3, above.

While not as simple in design and operation as the gypsum system described in Section E4.1, above, the PAC system avoids the need for regular pumping out of a sediment basin after rainfall. As such, it could be more suitable where sediment retention basins are designed for the 2-day, y-percentile storm depth or for use at those times of the year when rainfall can occur more frequently than every five days.

(a) General System Details

The general components of the PAC sediment settlement system include a rainfall catchment tray, header tank, displacement tank and settling agent reservoir tank

5. Longer dewatering times are acceptable, so long as the full capacity of the settling zone is evacuated within the time period assumed in the design of the basin (e.g. five days from the completion of the storm event).

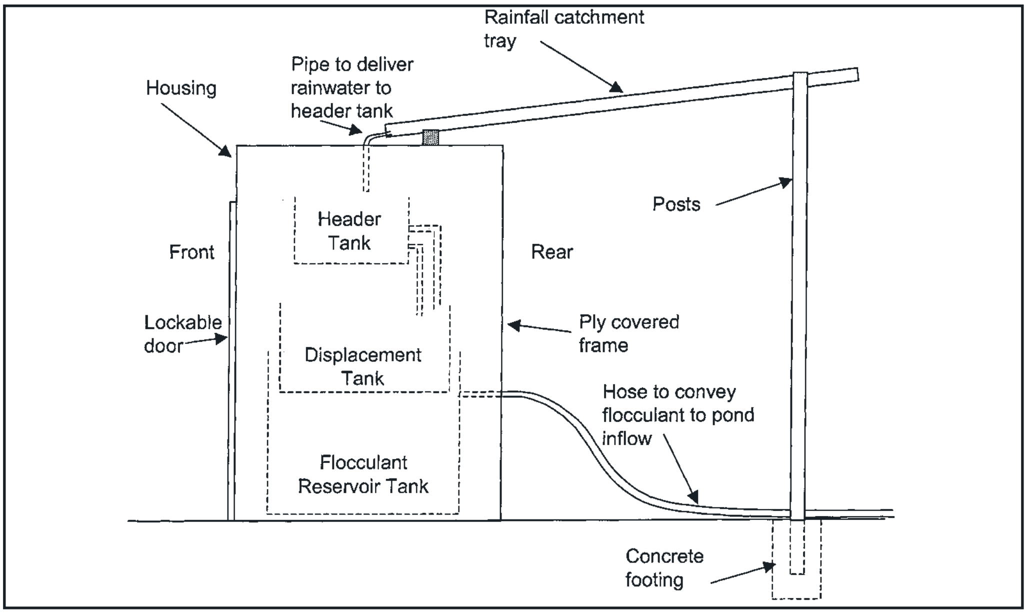

Figure E3. Sediment settlement system components (Beca Carter Hollings & Ferner, 2003).

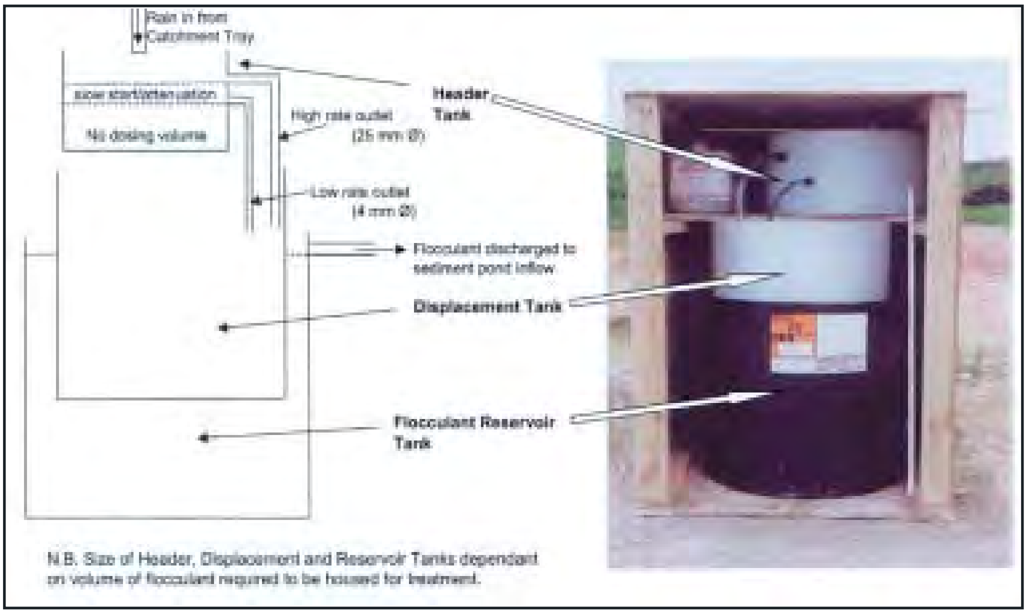

Figure E4. Sediment settlement system dosing details (Beca Carter Hollings & Ferner, 2003).

(figures E3 and E4). Apart from the catchment tray, these should be locked in a housing to discourage vandalism. Further, any settling agent storage area must be bunded to protect the site from spillages or leaks.

Rainfall from the catchment tray drains to a header tank. The header tank provides storage capacity to avoid dosing during initial rainfall following a dry period and attenuate dosing at the beginning and end of a rainfall event (to simulate the runoff hydrograph), i.e.:

(i) zero settling agent discharge occurs until a preselected quantity of rain has fallen to allow for initial infiltration and saturation of dry ground before runoff commences;

(ii) a slow start to the dosing rate occurs to allow for the response time of runoff flowing off the site at the beginning of a storm; and

(iii) an extension of the dosing period beyond the rainfall period occurs to provide treatment of runoff following cessation of rainfall.

From the header tank, the rainwater discharges by gravity into a displacement tank that floats in the settling agent reservoir. As the displacement tank fills with rainwater, the settling agent is displaced through the outlet in the reservoir tank and flows by gravity to the dosing point. The dosing point should be selected in an area of high turbulence in the sediment basin inflow channel.

Important Note: For many soils in New South Wales, the required dose of aluminium is 8 milligrams per litre. One litre of liquid PAC typically contains 64.2 grams of aluminium (based on 10.1 percent of Al_2O_3 by weight). Therefore, 1 litre of PAC should treat 8,020 litres of stormwater at the above dosing rate. Nevertheless, when designing the rainfall tray, the settling agent supplier should be contacted to confirm the actual percentage of Al_2O_3.

(b) Rainfall Catchment Tray

The size of the constructed catchment tray is determined by the size of the catchment draining to the sediment retention pond. Assume all the runoff from disturbed lands should be treated and 60 percent of the runoff from stable lands will require treatment at the design dose rate. The construction of the tray is set out in figure E5.

For the purposes of sizing the tray, a 50-mm storm event is considered. The runoff volume to be treated from 50-mm of rainfall is 500 cubic metres for a 1 hectare catchment. The volume of PAC required to treat 500 cubic metres is 62.3 litres. Given that the density of PAC is 1.2, 74.8 litres of rainwater needs to be collected to displace 62.3 litres of PAC. Further, a tray of 1.5 square metes is required to collect 74.8 litres of rainwater from a 50-mm event. Naturally, a larger tray would be required for a larger contributing catchment area.

Table E1 shows the tray surface areas required for different PAC dose rates.

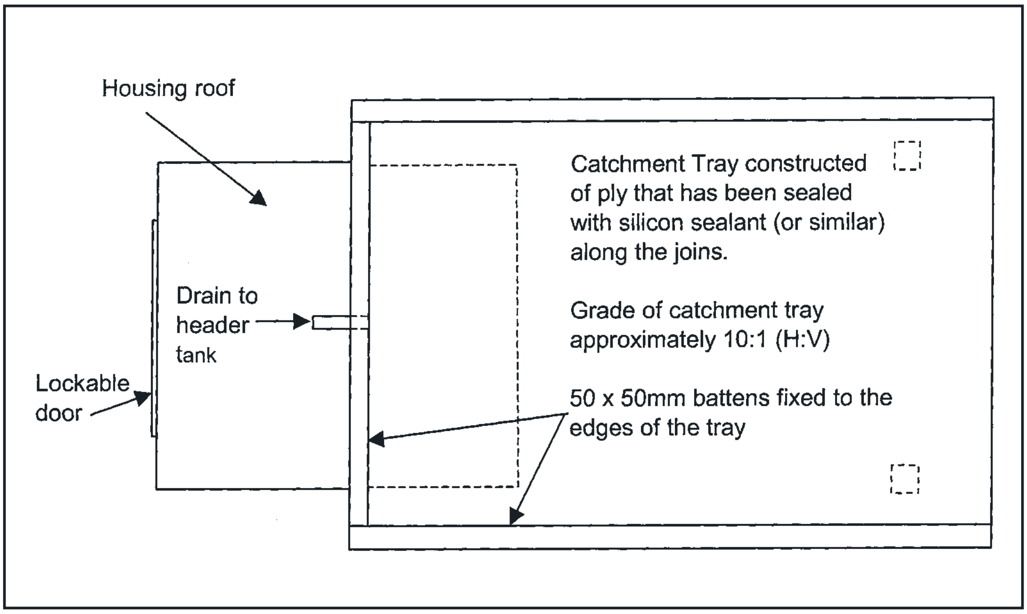

Figure E5. Construction of the catchment tray (Beca Carter Hollings & Ferner, 2003).

Table E1. Rainfall Catchment Tray Areas for Different Aluminium Dose Rates for a 50-mm Rainfall Depth

Aluminium dose required (mg/L)	Catchment tray area per hectare of catchment (m^2)
2	0.375
4	0.750
6	1.125
8	1.500
10	1.875
12	2.250
Assumptions: PAC has 10.1% Al_2O_3 by weight and the whole catchment is disturbed	

(c) Header Tank

The zero (settling agent) discharge rainfall volume can be adjusted manually for site characteristics by adding or removing water from the header tank. Both low rate and high rate outlets should be installed:

(i) The low rate outlet consists of a 4-mm internal diameter hose.

(ii) The high rate outlet needs to have sufficient capacity to convey the maximum predicted flow from short-term rainfall, at least covering the 1 in 3 month storm event (unless otherwise stipulated by the local consent authority, this can be taken as half the 1 year, ARI time of concentration event. Generally, a pipe with an internal diameter of 25-mm should suffice, although systems treating large catchments might require larger pipes.

(iii) The slow start/attenuation characteristics can be regulated for site characteristics by providing more than one low rate outlet and at different levels in the header tank.

The standard header tank design provides for up to 10 mm of rainfall before dosing commences. This requires provision of a delayed start volume below the low rate outlet of the header tank of 10 litres per square metre of rainfall catchment tray. So, for a 0.654 square metre catchment tray, the invert of the low rate outlet will be at the height reached by 6.5 L of water within the header tank. The high rate outlet invert should be positioned at that point reached by half the design storm depth. So, for a 0.654 square metre catchment tray, the invert of the high rate outlet will be at the height reached by 16.6 litres of water (33.2/2) within the header tank.

The header tank should have sufficient capacity to contain rainfall without over topping. A 50-mm freeboard above the top of the high rate outlet pipe provides this capacity.

(d) Displacement Tank

The displacement tank needs to be a neat fit inside the settling agent reservoir tank (figure E3). It should have sufficient capacity to provide for the dosing of at least the runoff from the whole of the 90th percentile 5-day rainfall depth from the tray.

(e) Settling Agent Reservoir Tank

The settling agent reservoir tank needs to be only slightly larger than the displacement tank. However, the larger the reservoir and displacement tanks are, the less servicing required. The settling agent reservoir tank requires sufficient capacity to provide for the dosing of at least the runoff from the whole of the 90th percentile 5-day rainfall depth from the tray. An outlet hose needs to be installed in the side of the tank to drain the settling agent to the pond inlet channel.

(f) Maintenance

The maintenance requirements of the PAC settling agent system need assessing following every rainfall event and during rainfall events if exceptionally heavy and/or prolonged rainfall occurs. Before staff leaves the site unattended for weekends, the sediment settling unit requires servicing by the responsible site staff member so that the maximum amount of runoff can be treated by the dosing system.

The following matters outline maintenance requirements for the PAC sediment settlement system. Note that the system will probably require some ongoing manipulation to suit the site characteristics and runoff:

Header Tank

(i) The water level of the header tank is to be set to allow for certain rainfall before dosing starts. When the site is dry, it is estimated that up to 10-mm of rain might fall before significant runoff reaches the sediment retention basin. Therefore the header tank should remain empty in such conditions to allow for a delayed response.

(ii) In wet weather or if the site is generally wet, water can be added manually to the header tank to cut down the response time so that dosing starts more rapidly after rain commences. If the system is to be operated at times of the year when precipitation normally exceeds evaporation (e.g. during winter in some parts of New South Wales), the system should also be set to no delay.

(iii) Adjusting the water level within the header tank is to prevent under or overdosing of the pond. Under dosing can lead to higher levels of suspended sediment being discharged from the pond; conversely, overdosing can cause a reduction in water pH, in turn raising the potential for the aluminium within the PAC to react and forming toxic compounds that are bioavailable to fresh and marine water organisms.

Refilling with Settling Agent

(i) When the volume of settling agent in the reservoir tank is reduced so much that insufficient time is available to dose a major storm, the displacement tank needs emptying and the reservoir refilled.

(ii) The displacement tank can be emptied either by using a siphon or by being baled out by hand. The settling agent reservoir can be filled using a drum pump.

Monitoring and Adjustment for Changing Site Conditions

(i) Each new settling agent treatment system needs to be monitored carefully during the first few rainfall events to check that the system is effective and to ensure that overdosing is not occurring (Section E3.3). Overdosing should be suspected if the pond dead storage water is exceptionally clear – samples must be taken from the pond for pH and dissolved aluminium analysis. The dosing regime should be adjusted depending on the outcome of these results.

(ii) If overdosing occurs or it is clear that the quality of stormwater runoff is improving because of stabilisation of the site, the settling agent dose must be reduced by reducing the size of the catchment tray. This can be done by placing and sealing a board (batten) diagonally across the tray with a hole through the tray rim at the lower corner, so that water from the tray area above the batten discharges to waste.

(iii) The size of the rainfall catchment tray requires modification if earthworks alter the extent of the contributing catchment. Failure to do so will cause either under or over dosing of flows entering the sediment retention pond.

(iv) Debris such as leaves should be removed from the catchment tray to ensure that rainwater continues to enter the header tank. The low and high rate hoses need to be checked regularly for blockages. All hose fittings should be inspected regularly to identify any leakages.

APPENDIX F

MUSIC Model Data

Catchment ID	Current Facilties	Current Quarry Pit	Facilties Stage1	Quarry Pit Stage 1	Facilties Stage 2	Quarry Pit Stage 2	Facilties Stage 3	Quarry Pit Stage 3
Catchment Areas (Ha)								
Total Area (ha)	11.23	8.04	10.37	8.84	8.44	13.57	8.44	17.47
Area Impervious (ha)	1.68	0.79	1.55	0.90	1.26	1.38	1.26	1.78
Area Pervious (ha)	9.55	7.25	8.82	7.94	7.18	12.19	7.18	15.69
Pervious Area Properties								
Field Capacity (mm)	51	51	51	51	51	51	51	51
Pervious Area Infiltration Capacity coefficient - a	180	180	180	180	180	180	180	180
Pervious Area Infiltration Capacity exponent - b	3	3	3	3	3	3	3	3
Pervious Area Soil Storage Capacity (mm)	54	54	54	54	54	54	54	54
Pervious Area Soil Initial Storage (% of Capacity)	25	25	25	25	25	25	25	25
Groundwater Properties								
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	25	25	25	25	25	25	25	25
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0
Impervious Area Properties								
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1

APPENDIX G

NSW Office of Water Letter dated 16th June, 2014

Contact Rohan Macdonald
Phone 02 4904 2642
Email rohan.macdonald@water.nsw.gov.au

Neville Hattingh
Element Environment Pty Ltd
PO Box 1563
WARRIEWOOD NSW 2102

Our ref ER21809

BY EMAIL: neville@elementenvironment.com.au

Dear Neville

Jandra Quarry Intensification Project
Request for comment on Background Scoping Document

The NSW Office of Water has reviewed the Background Scoping Document for the proposed Jandra Quarry Intensification Project and provides the following key issues and comments for consideration in the preparation of the Environmental Assessment (EA).

Key Issues

NSW Office of Water requires the EA for the proposal to demonstrate the following:

1. Identification of site water demands, water sources, water disposal methods and water storage structures in the form of a water balance. The water balance is to outline the proposed water management on the site and to also include details of any water reticulation infrastructure that supplies water to and within the site.
2. An impact assessment of any proposed works within or adjacent to watercourses. Ability to achieve the principles of the *Water Management Act 2000* (WMA) and the requirements of the Guidelines for Controlled Activity Approvals. The relevant guidelines can be accessed at the following link: http://www.water.nsw.gov.au/Water-Licensing/Approvals/Controlled-activities/default.aspx. Works on waterfront land (as defined in the WMA) may require a controlled activity approval(s).
3. Preparation of a site water management plan to integrate the proposed water balance and management for the site and to identify adequate mitigating and monitoring requirements for both water quality and water volume.
4. Existing and proposed water licensing requirements in accordance with the *Water Act 1912* and the WMA. The quarry is located within the Wallamba River Water Source under the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009.*

Groundwater

The Background Scoping Document states:

> The existing quarry is not subject to groundwater inflow and no groundwater was recorded by the geological investigations undertaken for the original EIS. The geological investigations concluded that any groundwater was likely to be located in the fractured material above the basement rock. The groundwater impact assessment concluded that there was limited

potential for groundwater flow as any groundwater would originate from subsurface flows following recent rainfall events rather than from interception of an aquifer.

Relatively shallow earthworks excavations required for the construction of the proposed new heavy vehicle access road, stormwater basin overflow diversion and expansion of the existing finished product stockpile area are unlikely to impact on groundwater.

The proposed modification will not result in any changes to the approved quarry pit in terms of both depth and disturbance area. Further consideration of flooding and groundwater is therefore not required in assessment of the potential environmental impacts associated with the proposed modification.

Based upon these comments the Office of Water is satisfied that there is no requirement for the EA to provide further assessment of potential groundwater impacts as a result of the proposal. In the event of any changes to the proposal, or should groundwater interception or extraction become likely, the proponent should liaise with the Office of Water to determine assessment and licensing requirements.

Yours sincerely

Mitchell Isaacs
Manager Strategic Stakeholder Liaison
16 June 2014

APPENDIX H

Harvestable Right Dam Capacity

NSW GOVERNMENT | Department of Primary Industries Office of Water

Maximum Harvestable Right Dam Capacity

Information provided by the user

1. The location of the proposed dam is:

- Latitude: **-32.047923**
- Longitude: **152.456012**

2. Total property area to use for calculating the size of the dam is **1.2 Square kilometres**

Result

The maximum Harvestable right dam capacity for your property is **13.2** ML (Megalitres)

Date

28/05/2014

Name

dov ben-avraham

Limitations of the calculator

a) Where to site a dam

You can only construct a harvestable rights dam where the Harvestable Rights Orders apply, refer to NSW Government Gazette 40 dated 31 March 2006 (pages 1628 to 1631).

b) First and Second order streams

The maximum harvestable right calculator does not verify that the location of the proposed dam sits on a first or second order stream. A factsheet : "Where can they be built without a licence?" is available on the Office of Water website to help you work out the stream orders.

You will need to use the legislated topographic map for your area to identify the stream order. This map is the gazetted map as per NSW Government Gazette 57 dated 23 March 2001 (pages 1481-1489).

c) Size of property and dam

The calculator does not take into account other dams already on your property. If you have existing harvestable rights dams on your property, you must take the capacity of these dams into account when constructing a new dam. In the Eastern and Central Divisions other dams must also be taken into account, as described in the NSW Government Gazette 40 dated 31 March 2006 (pages 1628 to 1631).

d) Protected wetlands

The Harvestable Rights Orders specify that you are not allowed to build a dam on or within 3 km of a RAMSAR wetland site. There are 12 RAMSAR wetlands in NSW. Further information on the location of those 12 RAMSAR sites in NSW can be found on the NSW Environment and Heritage government website.