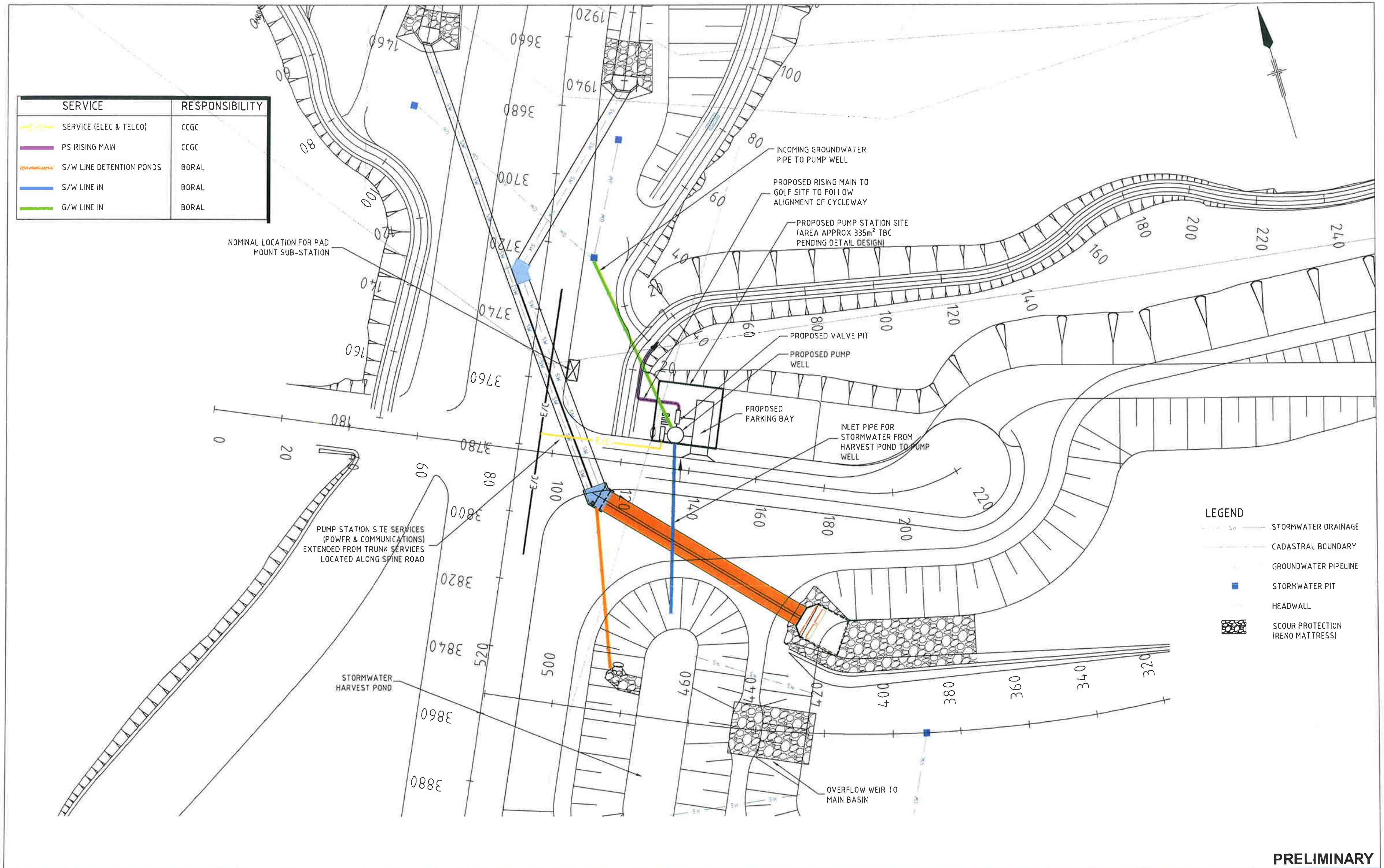
SERVICE	RESPONSIBILITY
SERVICE (ELEC & TELCO)	CCGC
PS RISING MAIN	CCGC
S/W LINE DETENTION PONDS	BORAL
S/W LINE IN	BORAL
G/W LINE IN	BORAL



PRELIMINARY

No	Revision	Drawn	Checked	Approved	Date
A	PRELIMINARY - FOR INFORMATION	KVR			05.10.07

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

BORAL

GHD CLIENTS | PEOPLE | PERFORMANCE

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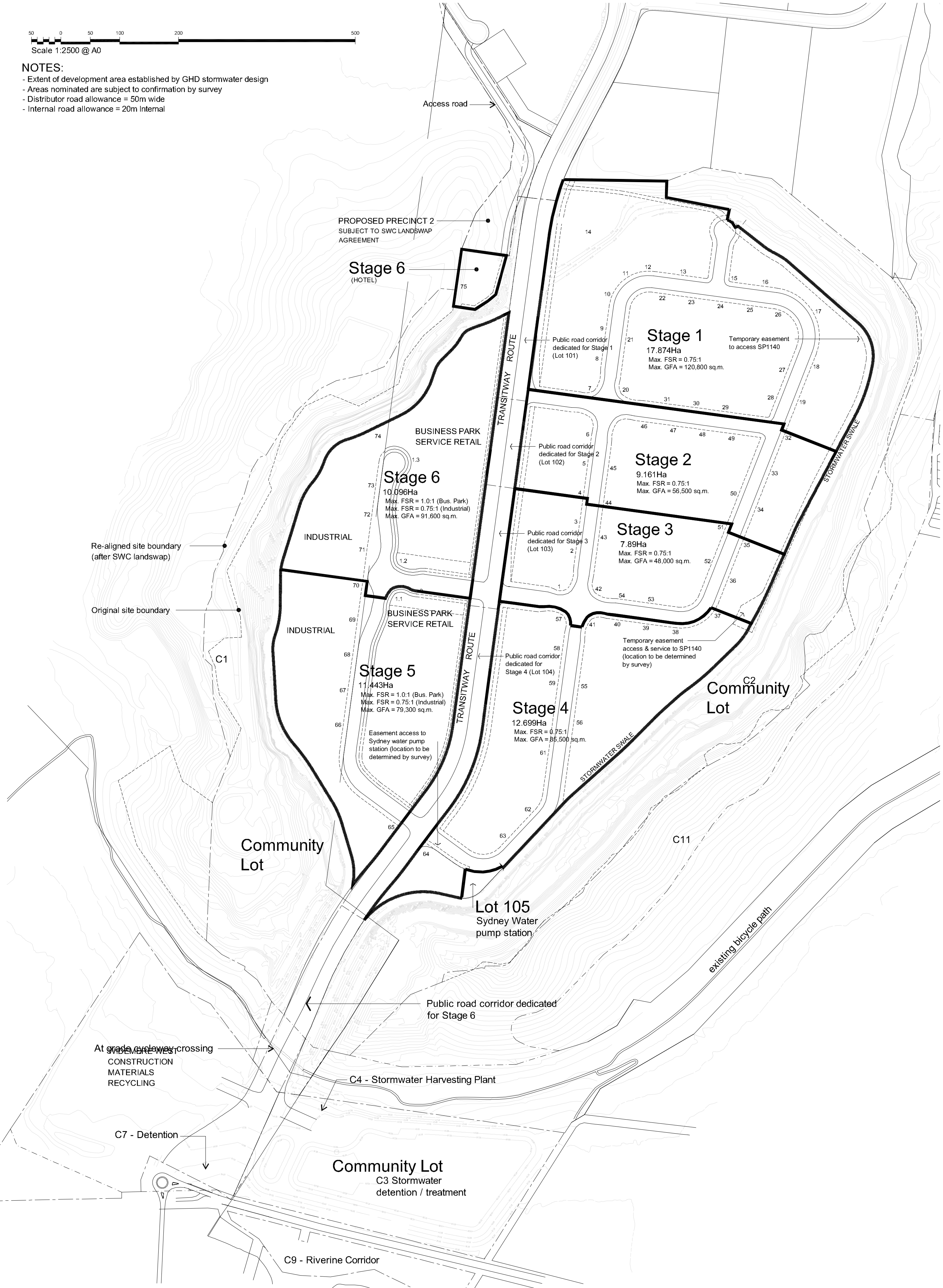
Drawn V.THIAGARAJAH | Designed F.CARROZZA
Drafting Check | Design Check
Approved
Date
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **BORAL RECYCLING PTY. LTD.**
Project **GREYSTANES ESTATE SEL**
Title **WIDEMERE EAST**
CCGC PUMP STATION CONCEPT LAYOUT

Original Size A1 Drawing No: **21-15443-SK-2144** Rev: A

Plot Date 15 October 2007 - 5:38 PM Cad File No G:\21\15443\CADD\Drawings\21-15443-SK-2144.dwg



CONCEPT MASTERPLAN

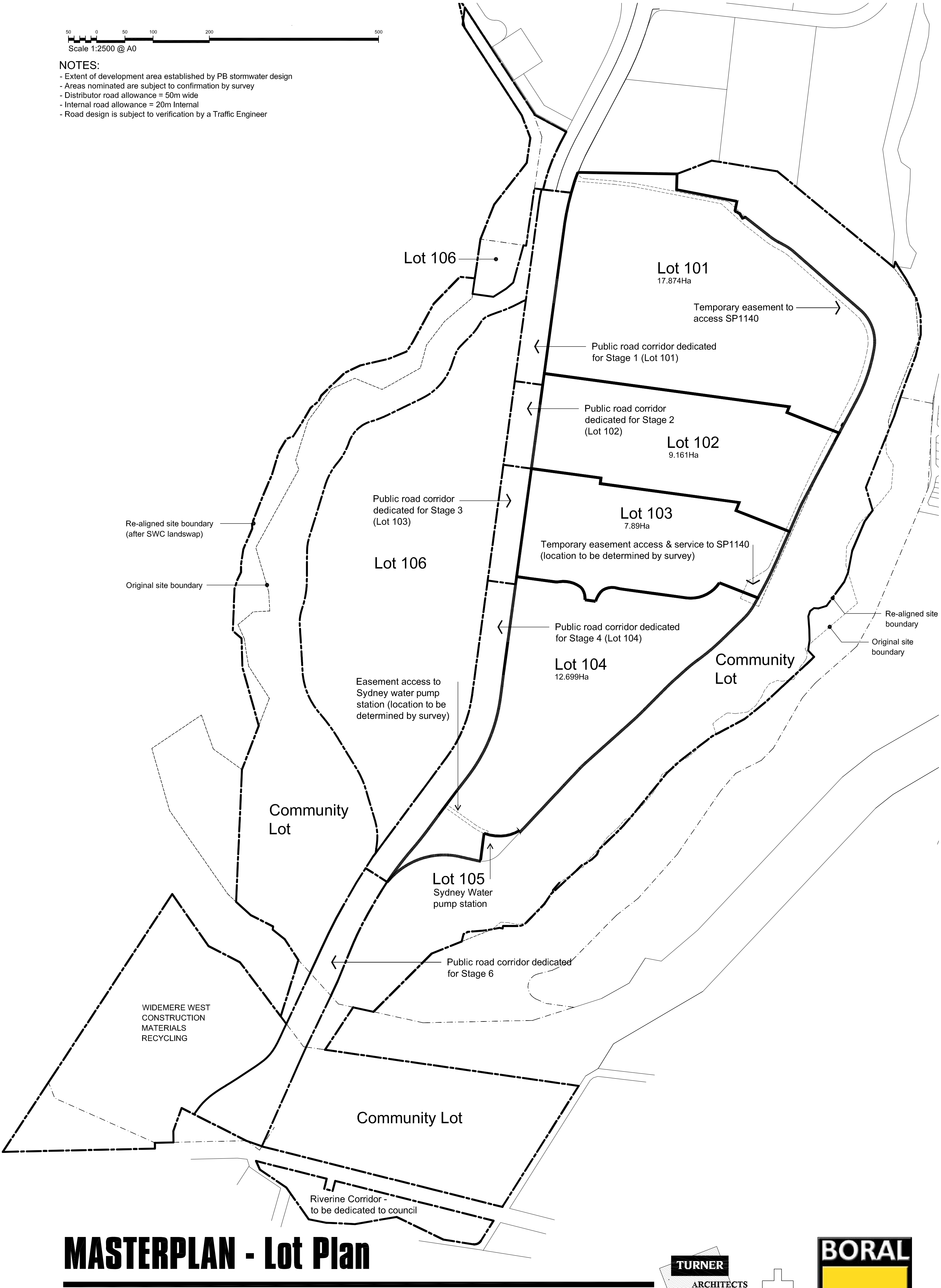
SOUTHERN EMPLOYMENT LANDS
GREYSTANES - NSW

Scale 1:2500 @ A0 Date 12-10-07

00.108.SK60F

TURNER HUGHES ARCHITECTS Pty. Ltd

NOTES:
- Extent of development area established by PB stormwater design
- Areas nominated are subject to confirmation by survey
- Distributor road allowance = 50m wide
- Internal road allowance = 20m Internal
- Road design is subject to verification by a Traffic Engineer



MASTERPLAN - Lot Plan

The Royal Australian Institute of Architects
TURNER HUGHES ARCHITECTS Pty. Ltd
L.2 121 Alexander St, Crows Nest NSW 2065 - ABN 42 911 861 283
P: (02) 9439 3200 F: (02) 9439 1238 E: tha@turnerhughes.com.au

SOUTHERN EMPLOYMENT LANDS
GREYSTANES - NSW

Scale 1:2500 @ A0 Date 27-9-07
Drg No: Rev:
00.108-SK56 F

N

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Appendix B

GROUNDWATER MANAGEMENT PLAN

CLIENTS | PEOPLE | PERFORMANCE

Boral Recycling Pty Ltd

Report for Greystanes Estate, Southern Employment Lands

Groundwater Management Plan

July 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Appendices

1. Introduction

1.1 Purpose of Groundwater Management Plan

The purpose of this Groundwater Management Plan (GMP) is to outline a set of procedures to be followed in order to maintain the drainage systems that have been constructed as part of the SEL development. These procedures essentially follow a standard of best practice, and deal with the inspections and maintenance works necessary to keep the drainage system in working condition.

1.2 Related documents

This Groundwater Management Plan shall be read in conjunction with the following management plans:

- Vegetation Management Plan;
- Stormwater Management Plan; and
- Batter Management Plan.

The Vegetation Management Plan describes the procedures for maintaining vegetation planted on the batters, in the stormwater perimeter channels, in the detention basins and treatment basin.

The Stormwater Management Plan describes the procedures for maintaining the stormwater system, consisting of batter drains, perimeter channels, pipes, culverts, pits headwalls and basins.

The Batter Management Plan describes the procedures for maintaining the completed batters including checking the ongoing stability and visual condition of pre-existing and completed batters.

1.3 Scope of Groundwater Management Plan

This GMP defines the scope of inspections and monitoring that are to be carried out.

This GMP provides a methodology for maintaining the drains plus outlet pits & pipes at the end of the drains and from the existing artificial aquifer and includes:

- An approach to scheduled inspections and monitoring, and the requirements for maintaining up to date Inspection and Monitoring Proformas;
- Guidance on the scope of inspections and monitoring requirements, including suitable personnel and frequencies; and
- Guidance on recommended actions that arise from the inspections.

The plan also provides guidance on an Inspection Safety Plan that shall be followed before, during and after the inspections and monitoring, in order to reduce the likelihood of injury.

1.4 Definitions

Asset Manager – the administrative body responsible for the management and maintenance of the development.

Batters – are deemed to be the entire portion of the SEL development that extends from the quarry floor to the quarry crest, and includes (but is not limited to) all batters, trafficable benches and non-trafficable benches, safety bunds and batter drainage.

Engineer/Scientist/Hydrogeologist – the civil/environmental engineer, environmental scientist or hydrogeologist appointed to undertake monitoring or engineering inspections, and to provide ongoing advice with respect to the drainage system.

Drain(s) – the underground constructed network of aggregate filled trenches intended to collect and transmit groundwater.

Artificial Aquifer – existing quarry sump/void historically used as a source for extracted groundwater from an area of the quarry which was filled with, relatively, more permeable material.

2. Location, Setting and Geology

2.1 Location

The Greystanes Estate SEL is located within the Prospect Quarry site. The SEL extends into the three local government areas of Blacktown City, Fairfield City and Holroyd City. The site is surrounded by the Northern Employment Lands (NEL) to the north, the Northern and Southern Residential Lands (NRL and SRL) to the east, the Widemere East property to the south, and Prospect Reservoir and open space to the west.[1]

2.2 Setting

The quarry workings are elongated in a north south direction, are approximately 1.4 km long and about 0.75 km wide. The quarry is essentially bounded by batters on all sides that comprise the following:

- The Western Batters; which are up to about 60 m high;
- The Eastern Batters; which are up to approximately 60 m high; and
- The Southern Cut; which is up to approximately 35 m high and will be formed to provide vehicular access to the SEL from the south.

The Widemere East allotment is located outside of the quarry, to the south of the Southern Cut.

2.3 Geology

Prospect Quarry is located within a geological feature known as the Prospect Igneous Intrusion (that has locally intruded the Wianamatta Group Shales and Hawkesbury Sandstone), which was formed as molten rock was injected between horizontal beds, causing a general arching of the overlying rock. A later collapse of the roof changed the intrusion from an arch-shaped feature to a dish-shaped feature. When it formed, the intrusion was elongated in a north–south direction, with approximate dimensions of 2.5 by 1.5 km. The thickness of the intrusion was greatest at its centre, where it was up to 110 m deep. Whilst the action of the intrusion will have raised the ground level as the magma was injected into the surrounding rocks, weathering and erosion over time have brought the intrusion close to the existing ground surface, such that at the commencement of quarrying, Prospect Hill stood about 90 m above the surrounding plains.

The rock within the quarry was formed by the cooling of molten rock to form generally high strength rock, which when excavated and processed, provides high quality building materials for roads and concrete. The main rock types present in the quarry include:

---

[1] ERM, Acid Dosing Report 2004

- *Shale*: This forms the bedrock enclosing the intrusion, and is generally removed as overburden during quarrying operations;
- *Dolerite*: This is a sound igneous rock that forms the upper third of the intrusion body, providing the majority of the quarried resource;
- *Picrite*: This is an igneous rock that contains minerals which break down after exposure. Picrite forms the lower two-thirds of the intrusion body, and is exposed in the floor of the quarry and some of the lower batters. It is generally considered to be a low grade product of the quarrying operations.
- *Greystanes gravel:* This comprises weathered dolerite, which is generally present as a low strength rock. The gravel is extracted as a quarry product; and
- *Fill:* This mainly comprise soils and weathered rock from stockpiles of the igneous sequence. It has been used to redevelop the SEL lands in the northern quarry area.

2.4 Hydrogeology

Groundwater in the SEL is present in two geological strata:

- *Bedrock* — which is the stratum associated with the igneous intrusion, like the dolerite, picrite, Greystanes gravel and surrounding shale; and
- *Fill* — which, of varying material, has been emplaced in the quarry voids and overlies the bedrock.

Previous investigations indicate that groundwater at the site occurs generally as follows:

- Perched groundwater within the fill;
- Unconfined and semi-confined groundwater in the shallow shale; and
- Semi-confined groundwater within the igneous sequences.

Groundwater is hosted in fractures in the bedrock (picrite, dolerite and shale) in the quarry area and in pore spaces in the matrix of overlying fill materials creating complex groundwater conditions. In the bedrock, groundwater storage has been estimated to be in the order of 1% of the bedrock volume.

The depth to the watertable varies dependant upon the aquifer material, and the location within the quarry:

- Groundwater in the Shale, east of the quarry has been previously intersected at around 50 m below ground surface;
- The groundwater within the quarry in the shale and igneous rocks are at a comparable elevation, however, water quality data indicates potentially discontinuous or limited hydraulic connection; and
- Groundwater, present in the reinstated fill material onsite, occurs at generally 10 m below ground surface.

Groundwater inflows to the quarry occur:

- Through localised groundwater recharge that discharges through the walls and floor of the quarry;
- Through rainfall infiltration into the fill recharging the bedrock, which discharges into the quarry from the fill or from the bedrock; and
- Through regional groundwater through-flow.

Although the volume of groundwater stored per area of bedrock is low, the landform creates a mechanism where groundwater is moving to equilibrium with the new landform. As a result quarrying and associated changes in the landform has resulted in depressurisation of the local groundwater system leading to a reversal of natural groundwater gradients. This process is expected to take place over many years after completion of the quarry and installation of the final quarry redevelopment.

Pumping of the current quarry ponds and sump will be discontinued upon the conversion of the quarry to its final landform. As groundwater is expected to continue seeping into the quarry landform a groundwater drainage system will be constructed to ensure that flooding of the redeveloped quarry does not occur. Details of the groundwater drainage system can be found in GHD's report – *Groundwater Drainage Design Report (July 2007).*

2.5 Water Quality

Groundwater quality monitoring has been undertaken periodically at the site since 2001. Summary statistics of the all the available groundwater water quality within targeted strata are presented in **Table A** in **Appendix B**. In assessing groundwater quality the ANZECC (2000) trigger values for slightly to moderately disturbed freshwater ecosystems (95% Level of Protection) or physical and chemical stressors for south-east Australian slightly disturbed Lowland River ecosystems were adopted.[2]

Much of the groundwater within the SEL is very alkaline and high in nutrients, especially ammonia, which is present at concentrations up to 30 times the ANZECC trigger value (0.9 mg/L) in the picrite and fill aquifers. This water quality is likely representative of natural quarry wide groundwater conditions associated with the alkaline picrite rock geology.

An assessment of the hydrogeochemisty and nutrients of water at Greystanes was undertaken by PB in 2004. This assessment involved hydrogeochemistry and nitrogen isotope analysis of groundwater within the different geological strata intersected at the quarry. The key findings of this assessment as outlined in PB's report (2004) are as follows:

- Nitrogen species are present both within and external to the quarry suggesting a rock geochemistry source rather than explosives. Nitrogen isotopes, combined with hydrogeochemical data, indicates a mineralogical nitrogen source, and discounts explosives as a source of nitrogen;

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[2] Based on the assumption that the main receptors of groundwater from the site are Prospect and Girraween Creeks

- The concentration of each nitrogen species present in solution is controlled by processes of nitrification, volatilisation and ion exchange; and
- High pH values and high dissolved silica values indicate that groundwater is a natural product of the weathering of alkaline rocks.

Previous groundwater assessments undertaken at the site by PB have also revealed a high potential for groundwater at the site to form scale, or calcium carbonate precipitate. The build up of scale overtime has the potential to lead to clogging and progressive failure of the subsurface drainage network proposed for the site. The calcium carbonate precipitation potential (CCPP) was calculated by PB (2006b) based on water quality and temperature using Calwell Lawrence water conditioning diagrams or CCPP calculating software. The CCPP results for individual groundwater tested by PB ranged from 4.7 to 83 mg/L, indicative of a significant scaling potential. Further geochemical modelling undertaken by GHD (GHD, 2007a), estimated that the gradual build-up of scale will clog between 0.001% to 0.019% (average 0.005%) of the void space for 100 mm aggregate (void ratio 0.3) per year under a flow rate of 100 m^3/day.

3. Scope of Routine Inspection

3.1 Purpose and Scope

During and following construction regular routine inspections of the perimeter drainage channels shall be carried out to help assess the performance of the system and to assist in scheduling any required maintenance. Should the inspection reveal that maintenance of any item is required, this is to be reported to the Asset Manager for action (see **Section 5**).

Items that are to be subject to routine inspections may comprise, but are not be limited to those listed in **Table 3-1** below:

Table 3-1: Items/areas for Routine Inspections for Maintenance

Item/Area	Routine Inspections for Maintenance
Drainage Channels	Inspect the surface of the perimeter drainage channels for ponding of water, seepage, scour, and vegetation die-off.
Groundwater Manholes	Inspect groundwater manholes along Groundwater Line 1 and 2 for signs of blockage or scaling.

Additionally, personnel completing the routine inspections shall be generally observant of items such as leaking water, and/or signs of blockages of water flow. If such items are observed, an immediate inspection by a suitably qualified engineer shall be organised, to determine the cause of the observed item and to assess the need for maintenance. Further details on actions arising from inspections are provided in the following sections of this report.

Where routine maintenance is repeatedly carried out in one location, the problem shall also be specifically targeted for further investigation by a suitably qualified engineer.

3.2 Frequency

Routine inspections of drainage channels shall occur quarterly during the construction period, and shall continue on a six monthly basis over the life of the development. Groundwater manholes shall be inspected every six months during construction and during the life of the development.

3.3 Records

Records detailing each of the routine inspections shall be completed during the inspection, and describe in detail any required maintenance. The inspection records are to be provided to the Asset Manager for action and then appropriately filed. Records of any maintenance carried out as a result of the inspection shall be completed immediately after the works have been finalised, and filed appropriately.

The *Record of Routine Inspection* Proforma is attached in **Appendix B**, and shall be used to record inspection activities.

3.4 Personnel

Routine inspections are required to establish the need for basic maintenance; as such inspections do not require professional engineering knowledge and may be carried out by any responsible person, including property management staff or maintenance staff. Alternatively, suitably qualified engineering/scientific staff may be employed to complete routine inspections concurrently with monitoring.

4. Scope of Monitoring

4.1 Purpose and Scope

As discussed in **Section 2.5**, previous groundwater assessments have shown that groundwater at the site has a high potential to form scale, which overtime could lead to clogging and progressive failure of the drainage network. Although the clogging of the drainage trenches is considered to be minimal under the proposed design, routine-monitoring inspections of a purpose designed groundwater piezometer network shall be conducted to allow the relative groundwater levels within the drainage trench to be compared with the area external to the trench. This monitoring shall be used to assess the performance of the system and to assist in the scheduling of required maintenance.

In addition to the drainage channel piezometers, a groundwater monitoring network of shallow piezometers shall also be maintained throughout the quarry in order to:

- Evaluate the overall and localised effectiveness of the drainage system;
- Quantify the affects of the final landform and reduced local rainfall recharge on groundwater inflows, water level and water quality trends; and
- Evaluate potential leakage from stormwater ponds.

Groundwater level data collected during the monitoring of the wells shall also be used to validate the groundwater model created for the site one year after completion of the final landform (see GHD 2007b for further details).

Water level and water quality monitoring shall also be undertaken at a weir constructed at the discharge point of the drainage channel system. This monitoring shall be used to assess the performance of the system and to determine the quantities and quality of flow existing the system.

4.2 Monitoring Locations

The drainage channel piezometer network shall consist of six pairs of wells located at approximately 0.5 to 1 km intervals along the length of the western and eastern channels (refer to Drawing 21-15443-GW-0700). Piezometers shall be installed within the trench and approximately 8 m from the trench towards the access road (refer to Drawing 21-15443-GW-0724).

After the final landform is completed three shallow wells shall be installed along the transitway corridor running through the middle of the site (refer to Drawing 21-15443-GW-0700). Water levels within the bore located within the artificial aquifer shall also be monitored to assess the affects of the final landform on this aquifer.

All monitoring bores shall be licensed, drilled and constructed by a licensed water bore driller, with copies of bore logs submitted to NRMW, as required by the Water Act 2000. All wells shall be constructed in accordance with the ARMCANZ *Minimum Construction Requirements for Water Bores in Australia, Ed 2* (September 2003) (see also Drawing 21-15443-GW-0724).

For security, bores shall be completed with a lockable, heavily-galvanised, steel bore shields or standpipes. The annulus between the PVC casing and the standpipe shall be backfilled with filter pack material or grout to minimise the risk of fire damage to the casing. The standpipe shall be painted in a high-visibility colour, with the well ID (eg BH01) marked on the top of the standpipe. In cases where vegetation may obscure the bore headworks, a star picket, painted in a high-visibility colour, shall be installed, extending above the expected height of the vegetation where feasible. The monitoring bores shall be surveyed to AHD to within ± 0.005 m and MGA to within ± 0.1 m.

Monitoring of flow within the channels shall be undertaken at the v notched weir, as illustrated in on detail shown on Drawing 21-15443-GW-0723, at the discharge point of Groundwater Line 2.

4.3 Water Level Monitoring

The drainage channel piezometer network, artificial aquifer bore, and the three groundwater wells installed within the transitway corridor shall be monitored continuously using a capacitance type water meter (such as the Odyssey Capacitance Logger) or level logger in order to continue recording the response to rainfall events (as measured at prospect Dam weather station Number 67019) and the subsequent effectiveness of the groundwater drainage system. The first year of monitoring of this piezometer network will give some indication of water levels and flow within the drainage system under both high and low rainfall periods. The data collected shall be used to set trigger values to which water levels in these piezometers can be assessed against to assist in the early detection of potential clogging or failure of the system.

In the event that a significant increase in water levels is observed within the drainage trenches this could suggest failure of the system. The cause of this increase shall be investigated by a suitably qualified engineer/hydrogeologist and corrective action taken where required.

Flow within the drainage channel shall be determined using continuous water level monitoring using an ultrasonic water level sensor within the v-notch weir at the Groundwater Line 2 discharge point.

4.4 Water Quality Monitoring

It is possible that water quality conditions could change as a result of reduced rainfall infiltration. Therefore, water quality monitoring shall be undertaken at the three piezometers installed along the transitway corridor and at the drainage channel discharge point. Samples shall be collected and placed in laboratory-supplied sample bottles, with preservatives appropriate for the target analyte, in accordance with Australian and New Zealand Standard *ASNZS 5667 Water Quality – Sampling* and shall include appropriate Quality Assurance/Control.

Some indicative trigger values and analytes to be monitored are shown in **Table 4-1** below. Trigger values are based on the 80th percentile calculated from groundwater quality data for individual groundwater analytes previously monitored within the quarry. Exceedances of these trigger values shall be reported to Asset Manager. The contractor shall evaluate the suitability of these trigger values and the analytes to be monitored after one year of monitoring has been completed.

Table 4-1 Indicative Triggers Values

Parameter	Units	80th Percentile Trigger Value[1]
pH	pH units	11
Electrical Conductivity	uS/cm	2,060
Calcium	mg/L	-
Magnesium	mg/L	-
Sodium	mg/L	-
Potassium	mg/L	-
Alkalinity as $CaCO_3$	mg/L	-
Sulfate	mg/L	-
Chloride	mg/L	-
Ammonia as N	mg/L	40
Nitrite as N	mg/L	4
Nitrate as N	mg/L	3
Total Phosphorus as P	mg/L	0.25
Reactive Phosphorus as P	mg/L	0.05
Suspended Solids	mg/L	250[2]

1. 80th percentile calculated from data collected from piezometers targeting picrite and fill geology (see GHD 2007c for the list of wells that target each geology)

2. Based on values collected from eight samples blended from groundwater taken from MW18, MW14, MW20, MW15, Artificial Aquifer, RepMW10 and MW22

4.5 Frequency

For at least the first year after the construction of the final landform, water levels in the piezometers installed within the quarry and drainage channel network and at the discharge v-notch weir shall be monitored continuously by data loggers. Quarterly downloading of data shall be undertaken to check that the loggers are working and to minimise the chance of data being lost. The data collected over this year shall be reviewed by a suitably qualified engineer/hydrogeologist who shall evaluate the system and determine the frequency of monitoring to be undertaken in future years.

Water quality monitoring at the four piezometers installed within the quarry and at the drainage channel discharge point shall be conducted six monthly for a period of one year after the completion of the final landform. The data collected over this year shall be reviewed by a suitably qualified engineer/scientist who shall evaluate the data and determine the frequency of monitoring to be undertaken in future years. If no major exceedance is reported, water quality sampling could be reduced to just the discharge point after the first year of monitoring is completed.

4.6 Records

Groundwater monitoring records shall be kept for each monitoring event or download of the data loggers. Records detailing each of these events shall be completed during monitoring, and shall describe in detail any maintenance or further investigations required. The monitoring records are to be provided to the Asset Manager for action and then filed appropriately. Records of any maintenance carried out as a result of the inspection shall be completed immediately after the works have been finalised, and filed appropriately.

4.7 Personnel

All monitoring shall be undertaken by suitably qualified engineers/scientists. Professional staff employed to complete the monitoring may also complete the routine inspections.

4.8 Design Model Validation

In order to confirm that the groundwater drainage system is performing as modelled and in accordance with the Groundwater Model report recommendations, the design model is to be verified by suitably qualified engineering personnel using onsite field data. The onsite field data is to be obtained from newly installed monitoring wells one year after the completion of the final landform and occurrence of rainfall resulting in groundwater drain inflows. Data shall be forwarded to the Asset Manager who will inturn commission a Hydrogeologist or other suitably qualified engineering personnel able to verify the groundwater design model.

5. Actions Arising from Inspections and Monitoring

As a result of the routine inspections and monitoring a schedule of maintenance activities shall be drawn up to address those issues identified during the inspection. Examples of possible maintenance activities may comprise, but not be limited to those listed in **Table 5-1** below.

Table 5-1: Typical Routine Maintenance Works

tem	Typical Maintenance Works Likely to be Required	Minimum Frequency
Drainage Channels	a) Clear accumulated sedimentation b) Repair scours and seeps	Annually Annually
Outlet pits and pipe from the artificial aquifer (Groundwater Line 1)	a) Rodding of pipes to remove large scaling/accumulation	Every 5 years
Outlet pits and pipe at the end of the groundwater drainage channels (Groundwater Line 2)	a) Rodding of pipes to remove large scaling/accumulation	Every 5 years

Routine maintenance and monitoring may indicate that further investigations or corrective action may be required to assess a non-compliance or abnormality. These investigations or corrective actions shall be undertaken by a suitably qualified engineer/scientist. Prior to undertaking this work the scientist/engineer shall make themselves familiar with the design of the drainage system, construction records and also review all previous inspection reports. They shall identify discrepancies between previous records and the current site conditions, identify any trends that may be of concern, and assess if these have implications for drainage efficiency, significant or otherwise. A copy of the design documents and construction records shall be kept by the development Asset Manager, along with the previous inspection records.

Reactive maintenance works shall be implemented if an immediate and obvious hazard is observed during the inspections, monitoring or other investigations. The inspecting engineer/scientist shall notify the Asset Manager without delay, both verbally and then in writing, and identify an appropriate course of action. This action shall depend on the particular circumstances, and could range from arranging repair works to site evacuation. If the hazard can be mitigated by simple emergency repair works, these shall be implemented promptly. In a more serious situation, it may be necessary to commission a detailed investigation to establish the cause of the problem and to facilitate the design of rectification works.

6. Inspection and Monitoring Safety

In order to reduce the risk to workers, certain minimum procedures and activities must be carried out before, during and after inspection/monitoring events. OH&S documentation and implementation related to the ongoing management of the groundwater drainage system as described in this management plan is largely the responsibility of the service provider. All service providers must provide Safe Work Procedures (SWP) and Health Environmental Safety Plans (HESP) to address all the relevant safety issues associated with the site and tasks to be undertaken prior to commencement of any works at the site. The Asset Manager must ensure that all procedures outlined in the OH&S documentation are implemented and maintained throughout the works.

7. References

ANZECC/ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

ARMCANZ 2003, *Minimum Construction Requirements for Water Bores in Australia, Ed 2*

Australian and New Zealand Standard *ASNZS 5667 Water Quality – Sampling*

ERM 2004, *Greystanes Estate Development – Southern Employment Lands. Design Details – Acid Dosing System*, 0013820RP2V1.

GHD 2007a, Greystanes Estate Southern Employment Lands- *Groundwater Drainage Design Report.*

GHD 2007b, Greystanes Estate SEL Subdivision- *Groundwater Modelling Report.*

GHD 2007c, Greystanes Estate SEL Subdivision- *Department of Natural Resources Groundwater Extraction License Report.*

Parson Brinckerhoff 2004, *Preliminary Assessment of Hydrogeochemistry and Nutrients in Waters at Prospect Quarry.*

Parson Brinckerhoff 2006a, *Greystanes Estate, Southern Employment Lands – Groundwater Management Plan,* 2113014A-RP-044-D.

Parsons Brinckerhoff 2006b. *Draft Greystanes Estate -Southern Employment Lands Groundwater Drainage Detailed Design Report*, Revision A, 2113014A-RP-108-A.

Appendix A

Typical Inspection and Monitoring Forms

Date of Current Inspection: ____________________
Date of Previous Inspection: ____________________

Record of Routine Inspection for Groundwater Maintenance

1. Inspectors

	Name:	Organisation:	Contact No.:
Completed By: 1.			
2.			
3.			
4.			

2. Inspection Area

3. Weather

Condition

- Fine ☐
- Overcast ☐

Rainfall (previous 12 hours)

- None ☐
- Light/Intermittent ☐
- Moderate ☐
- Heavy ☐

Temperature

- Overnight Frost ☐
- Cold <15˚C ☐
- Mild 15-25˚C ☐
- Hot 25-35˚C ☐
- Extreme >35˚C ☐

Wind

- None/Light ☐
- Moderate ☐
- High ☐

Recent Weather

(describe general weather trends as per parameters above for previous 7 days)

4. Routine Inspection Observations *(see Table 3.1 of GMP)*

Cursory observations of the following items should form the basis, but not be limited to, all items included as part of this routine inspection. It is not the intention for the inspector to assess the overall functionality of the drainage system

a. Groundwater Manholes	Satisfactory (Note 1)	Routine Maintenance Req'd (Note 2)	Engineering Inspection Required (Note 3)	Comments (Ref No.) Photo (Ref No.) (Note 4)
Lids are secured				
Lids function as required with no evidence of damage				
Surfacing around manholes appears intact				
Signs of flow blockage including scale				

Record of Routine Inspection for Groundwater Maintenance

Other				
Other				

Routine Inspection Observations Cont'd *(see Table 3.1 of SMP)*

Cursory observations of the following items should form the basis, but not be limited to, all items included as part of this routine inspection. It is not the

b. **Drainage Channels**	Satisfactory (Note 1)	Routine Maintenance Req'd (Note 2)	Engineering Inspection Required (Note 3)	Comments (Ref No.) Photo (Ref No.) (Note 4)
No evidence of ponding of water				
No evidence of seepage				
No evidence of scour				
No evidence of vegeation die-off				
Other				
Other				

d. **Site Condition/General Safety**	Satisfactory (Note 1)	Routine Maintenance Req'd (Note 2)	Engineering Inspection Required (Note 3)	Comments (Ref No.) Photo (Ref No.) (Note 4)
Evidence of ponding on areas of landform				
Visible damage to apparatus				
Other				
Other				
Other				
Other				
Other				

Note 1	**The item checked is in a functioning, safe condition, and no specific maintenance is required.**
Note 2	**The item checked requires routine maintenance, but does not require immediate engineering assessment to assess safety or design functionality**
Note 3	**The item requires an Engineering Inspection to assess design functionality or to prevent damage to other components**
Note 4	**Description/Comments regarding status and urgency of action required if columns 2 and 3 are checked, and Photographic Reference.**

5. Comments

C1.

C2.

C3.

C4.

C5.

C6.

Record of Routine Inspection for Groundwater Maintenance

6. Actions to be taken

A1.

A2.

A3.

A4.

A5.

A6.

7. Report Distribution

		(tick)		
	File	☐	File reference	________
Name	________	☐	Date	________
Name	________	☐	Date	________

Additional Pages (e.g. sketches, notes):

Signature **Date**

Date of Current Inspection: ______
Date of Previous Inspection: ______

Groundwater Water Quality and Level Monitoring

1. Inspectors

	Name:	Organisation:	Contact No.:
Completed By:	1.		
	2.		
	3.		
	4.		

2. Sampling

water quality sampling to be completed by a NATA accredited laboratory

Date of Sample

Sample Reference Number

3. Weather

Condition
- Fine ☐
- Overcast ☐

Rainfall (previous 12 hours)
- None ☐
- Light/Intermittent ☐
- Moderate ☐
- Heavy ☐

Temperature
- Overnight Frost ☐
- Cold <15˚C ☐
- Mild 15-25˚C ☐
- Hot 25-35˚C ☐
- Extreme >35˚C ☐

Wind
- None/Light ☐
- Moderate ☐
- High ☐

Recent Weather

(describe general weather trends as per parameters above for previous 7 days)

4. Summary of Monitoring Results and Assessment Against Trigger values and/or Previous Results

Parameter	Units	80th Percentile Trigger Value	Range (min-max)	Current Results	Notes
pH	pH units	11	9.2-11.8		
Electrical Conductivity	uS/cm	2,060	518-3140		
Calcium	mg/L	-	<1-25		
Magnesium	mg/L	-	<1-7.2		
Sodium	mg/L	-	27-640		
Potassium	mg/L	-	3.3-13		
Alkalinity as $CaCO_3$	mg/L	-	90-557		
Sulfate	mg/L	-	6-1200		
Chloride	mg/L	-	32-284		
Ammonia as N	mg/L	40	0.03-116		
Nitrite as N	mg/L	4	<0.01-5.5		
Nitrate as N	mg/L	3	<0.01-18		
Total Phosphorus as P	mg/L	0.25	0.03-0.3		
Reactive Phosphorus as P	mg/L	0.05	<0.01-0.1		
Suspended Solids	mg/L	2503	-		

Note 80th Percentile Trigger Value and range based on groundwater quality in picirite and fill aquifers

Groundwater Water Quality and Level Monitoring

5. Comments

6. Actions to be taken

Groundwater Water Quality and Level Monitoring

7. Report Distribution

File	☐	File reference	______
	☐	Date	______
	☐	Date	______

Additional Pages (e.g. sketches, notes):

Signature **Date**

NOTES

Appendix B

Groundwater Quality Summary

Table A: Groundwater Quality Summary Statistics

Parameter	Units	ANZECC Trigger Value	SHALE (MW04)		PICRITE (JK1, JK2, JK4, MW09, MW10/RepMW10[a], MW11, MW14, MW20)		DOLERITE (MW01, MW02, MW03, MW05, MW07, MW22)		FILL (MW13, MW15, AA1)	
			Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean ±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)
Temperature	°C	-	20.4	NA (1)	21.4±2.0 (18.5-26.2)	NA (23)	22.4±2.0 (17.9-24.4)	NA (11)	20.9±1.5 (18.8-22.0)	NA (4)
TDS	mg/L	-	9131	NA (1)	1084±460 (352.1-1806)	NA (15)	1012±550 (283-1987)	NA (9)	789±67 (723-856)	NA (3)
EC	uS/cm	-	10600	NA (1)	1622±661 (518-3140)	NA (23)	1285±710 (410-2681)	NA (11)	1139±89 (1018-1217)	NA (4)
pH	pH units	6.5-8.5[c]	7.35	0 (1)	10.6±0.6 (9.3-11.8)	23 (23)	8.6±1.1 (7.3-10.9)	5 (11)	9.5±0.2 (9.2-9.8)	4 (4)

Parameter	Units	ANZECC Trigger Value	SHALE (MW04)		PICRITE (JK1, JK2, JK4, MW09, MW10/RepMW10[a], MW11, MW14, MW20)		DOLERITE (MW01, MW02, MW03, MW05, MW07, MW22)		FILL (MW13, MW15, AA1)	
			Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean ±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)
Dissolved Oxygen	mg/L	-		NA (0)	1.1±1.5 (0.1-4.3)	NA (8)	2.4±2.8 (0.4-4.4)	NA (2)	3.0	NA (1)
ORP	mV	-	62	NA (1)	-42±122 (-287-159)	NA (23)	1±79 (-115-168)	NA (11)	45±68 (-9-138)	NA (4)
Calcium	mg/L	-	292	NA (1)	5±6 (<1-25)	NA (23)	29±41 (1-147)	NA (11)	4±2 (2-7)	NA (4)
Magnesium	mg/L	-	445	NA (1)	1±2 (<1-7.2)	NA (23)	28±28 (<1-95)	NA (11)	1 (<1-3)	NA (4)

Parameter	Units	ANZECC Trigger Value	SHALE (MW04)		PICRITE (JK1, JK2, JK4, MW09, MW10/RepMW10[a], MW11, MW14, MW20)		DOLERITE (MW01, MW02, MW03, MW05, MW07, MW22)		FILL (MW13, MW15, AA1)	
			Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean ±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)
Sodium	mg/L	-	1520	NA (1)	325±154 (59-640)	NA (23)	224±145 (40-423)	NA (11)	185±108 (27-273)	NA (4)
Potassium	mg/L	-	47	NA (1)	8±3 (3.3-13)	NA (23)	8±3 (3-12)	NA (11)	7±2 (4-9)	NA (4)
Bicarbonate as $CaCO_3$	mg/L	-		NA (0)	30±40 (0-109)	NA (15)	140±142 (0-337)	NA (4)	70	NA (1)
Carbonate as $CaCO_3$	mg/L	-		NA (0)	139±70 (5-240)	NA (11)	103 (5-200)	NA (2)	100	NA (1)
Hydroxide as $CaCO_3$	mg/L	-		NA (0)	95±141 (0-409)	NA (11)	48 (5-90)	NA (2)	0	NA (1)

Parameter	Units	ANZECC Trigger Value	SHALE (MW04)		PICRITE (JK1, JK2, JK4, MW09, MW10/RepMW10[a], MW11, MW14, MW20)		DOLERITE (MW01, MW02, MW03, MW05, MW07, MW22)		FILL (MW13, MW15, AA1)	
			Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean ±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)
Alkalinity as $CaCO_3$	mg/L	-	669	NA (1)	249±145 (90-557)	NA (23)	255±148 (69-505)	NA (11)	189±16 (170-209)	NA (4)
Sulphate	mg/L	-	292	NA (1)	402±317 (6-1200)	NA (23)	287±345 (35-1070)	NA (11)	269±42 (216-320)	NA (4)
Chloride	mg/L	-	3430	NA (1)	85±56 (32-284)	NA (23)	103±102 (34-374)	NA (11)	65±16 (48-80)	NA (4)
Ammonia	mg/L	0.9		NA (0)	27.4±35.1 (0.03-116)	13 (16)	1.1±2.2 (<0.01-5.7)	1 (6)	1.8±0.5 (1-2.1)	2 (2)
Nitrite	mg/L	0.7		NA (0)	1.7±2.2 (<0.01-5.5)	5 (11)	0.04±0.05 (<0.01-0.1)	0 (5)	0.04	0 (1)

Parameter	Units	ANZECC Trigger Value	SHALE (MW04)		PICRITE (JK1, JK2, JK4, MW09, MW10/RepMW10[a], MW11, MW14, MW20)		DOLERITE (MW01, MW02, MW03, MW05, MW07, MW22)		FILL (MW13, MW15, AA1)	
			Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean ±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)	Mean±Stdev (min – max)	# samples > trigger value (total # of samples)
Nitrate	mg/L			NA (0)	2.0±4.5 (<0.01-18)	NA (16)	0.2±0.2 (<0.01-0.5)	NA (6)	4.1±3.1 (2-6.3)	NA (2)
Total P	mg/L	0.05[c]		NA (0)	0.2±0.1 (0.03-0.3)	6 (7)	0.1±0.05 (0.04-0.1)	2 (3)		NA (0)
PO_4^{3+}-P	mg/L	0.02[c]		NA (0)	0.04±0.02 (<0.01-0.1)	10 (12)	0.03±0.02 (<0.01-0.05)	1 (4)	<0.05	1 (0)
Dissolved Iron	mg/L	0.3[d]		NA (0)	0.15±0.26 (0.01-0.5)	1 (4)	0.05±0.01 (0.04-0.05)	0 (2)	1.6	1 (1)
Dissolved Silica	mg/L			NA (0)	64.8±28.3 (27.6-95.6)	NA (4)	37.5±23.3 (21.0-53.9)	NA (2)	44.7	NA (1)

Notes

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Document Status

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