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Midal Cables International Pty Ltd

Tomago Rod and Conductor Manufacturing Project

Site Water and Groundwater Assessment

February 2012

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

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1. Introduction

1.1 Background

Midal proposes to construct an aluminium rod and conductor manufacturing facility on a 2.8ha parcel of land adjacent to the Tomago Aluminium Smelter at Tomago in Port Stephens.

Key design features will include the following:

- A dedicated haul road from the Tomago Smelter to the northern end of the proposed facility (approximately 150 m long) for the safe and efficient transport of the molten metal.
- A building approximately 98 m by 38 m and 8 m high holding the gas fired furnace and rolling mill for the manufacture of aluminium rod, plus associated gas fired furnace and rolling mill control rooms and undercover rod storage.
- Cooling towers and infrastructure associated with the gas fired furnace and rolling mill.
- A building approximately 124 m by 46 m and 8 m high holding wire drawing machines, stranding machines and associated facilities.
- Laboratories and administration buildings.
- Stores building, electrical and mechanical workshops.
- Hardstand movement, loading areas, and car parking.
- Onsite sewage treatment plant and stormwater treatment and infiltration.
- All required utility upgrades and connections.

It is proposed that the facility will operate 24 hours a day, seven days a week. At its maximum capacity this operation will involve two, 12 hour shifts comprising 42 employees per shift with 35 administration staff for a total employment of approximately 119 persons in a given day.

1.2 Objectives of this Report

The objectives of this assessment are to:

- Describe the integrated system that would be implemented to manage surface water, groundwater and wastewater from the project.
- Address the potential impact of construction and operation of the project on surface and groundwater on the site.
- Address the NSW Office of Water (NOW) requirements as per the letter to Tomago dated on the 17 March 2011.
- Address the water related Director General's Requirements (DGRs) for the Environmental Assessment of the project. These are:
  - *Details of the proposed water requirements and sources.*
  - *A detailed assessment of potential surface and groundwater impact, particularly on the nearby Tomago Sandbeds and Hunter River.*

- *Details of proposed erosion and sedimentation controls.*
- *Details of proposed water requirements, sources of water, usage and efficiency measures, wastewater management, stormwater management, spill containment and bundling.*

1.2.1 Groundwater Dependant Ecosystems

The *NSW State Groundwater Dependant Ecosystems Policy 2002* identifies a Rapid Assessment Process (RAP) for identifying and setting priority actions to manage groundwater dependant ecosystems (GDEs). There are eight steps in this RAP, of which the first six are particularly relevant to the assessment process:

- Step 1: Identify geographic area.
- Step 2: List GDEs.
- Step 3: Assess vulnerability of GDEs.
- Step 4: Assess value of GDEs and decide priority actions.
- Step 5: List management tools for protecting and managing GDEs.
- Step 6: Prioritise management actions.

In this respect the following objectives define the purpose of the GDEs assessment:

- Define a study area.
- Evaluate the vegetation cover contained within the study area in terms of the *NSW State Groundwater Dependant Ecosystem Policy 2002*.
- Identify the relationships between groundwater and vegetation cover, if any, within the study area.
- Characterise the GDEs contained within the study area, if any, which may potentially be impacted by changes to groundwater resources.
- Predict the likely change in any identified GDEs as a consequence of changes to the groundwater regime.
- Recommend management actions, if necessary, to counter any potential negative impacts on identified GDEs that may arise from changes to the groundwater regime.
- Establish the framework for ongoing monitoring of any identified GDEs relative to the impacts on the groundwater regimes.

The remaining two steps of the eight step RAP includes implementation of management actions and review. The review process may involve monitoring and research, should the assessment identify an impact on important GDEs. This assessment would outline the monitoring approach for GDEs identified within the study area.

1.2.2 GDE Assessment Scope

The scope of this assessment involves the identification of relevant locally occurring GDEs through consultation with groundwater specialists in combination with site surveys and literature review. This step aids the identification and distribution of priority GDE areas. Predicted net changes in the groundwater regime were qualitatively compared with identified GDEs within a spatial context. Predicted impacts, if any, were qualitatively quantified from this dataset. Priority management actions and monitoring have been evaluated and recommended where appropriate.

2. Methodology

2.1 Site Water Assessment

A preliminary Environmental Assessment identified that the site and immediate surrounds does not contain any watercourse and/or riparian vegetation areas. A site visit was conducted to confirm that there are no areas likely to be defined as a watercourse, in the legal interpretation, and have a requirement for retaining any riparian vegetation.

Following the site visit a desktop assessment was conducted to identify and detail:

- Likely groundwater infiltration reductions due to the presence of the project.
- Water requirements and sources for the life of project.
- The adequacy and reliability/security of the water supply elements (harvested rainwater, harvested stormwater and potable water) for the life of the project.
- The legislation that is applicable to the project and its relevance.
- Any likely impacts on neighbouring properties due to changes to surface water due to the project.

The stormwater design criteria will be established following the consideration of infiltration rate scenarios analysed in the assessment of groundwater and groundwater dependant ecosystems. These scenarios are as follows:

- Scenario 1: 60m^3/day average infiltration or first 30 mm of daily rainfall (worst case scenario).
- Scenario 2: 50m^3/day average or first 15 mm of daily rainfall.
- Scenario 3: 40m^3/day average infiltration or first 7 mm of daily rainfall.
- Scenario 4: 20m^3/day average infiltration or first 4 mm of daily rainfall.

2.2 Groundwater Assessment

A desktop assessment was undertaken to characterise the existing groundwater resource and identify potential impacts on this resource and existing groundwater users as a result of the project. The following methodology was adopted:

- Review of relevant legislation, water sharing plans (WSPs) and groundwater policy documents and identification of requirements relevant to the project.
- Collation of existing groundwater level and groundwater quality data in the vicinity of the project site and plotting of time series graphs.
- Review of the NSW Groundwater Bore Database to identify existing licenced groundwater users in the vicinity of the site.
- Develop a conceptual hydrogeological model for the area based on existing groundwater level data.

- Analyse historical rainfall records to identify average rainfall conditions and establish an Accumulative Residual Rainfall (ARR) graph for the site, enabling the identification of existing steady state groundwater levels.
- Construct a MODFLOW numerical hydrogeological model to identify spatial changes in steady state groundwater level as a result of the project. Infiltration rate scenarios specified in Section 2.1 were adopted for this analysis.
- Establish baseline groundwater quality using existing data.
- Assess potential groundwater quality impacts associated with the infiltration of stormwater to groundwater.
- Identify mitigation or monitoring measures so that predicted groundwater quantity and quality impacts are acceptable.

2.3 Groundwater Dependant Ecosystems

2.3.1 Study Area Definition

The study area boundary for the GDE assessment is principally derived from the project's predicted impact on groundwater resources (ie net change in groundwater elevation contours). This is defined by the outer limit of affectation where the predicted change in existing steady state groundwater elevations ceases to be relevant. The following stepwise process was adopted to define the study area boundary and was undertaken as part of the groundwater assessment:

1. Model existing steady state groundwater elevations for the site and the surrounding area[1].
2. Model predicted steady state groundwater elevations for the site and surrounding area using worst case infiltration rates (ie Scenario 1).
3. Calculate predicted net change in groundwater elevations.
4. Mask the area modelled in step (3) by the groundwater divide to the north and west and the 0.01 m net change contour. The resultant boundary is termed the study area.

Net change contours within the study area are represented by 0.01 m gradations (ie limit of reading for observed groundwater levels) to spatially characterise the area of affectation.

2.3.2 Vegetation Types

Vegetation type mapping for the study area (NPWS, 2003) was examined to describe the existing biotic environment for spatial comparison against modelled groundwater resources and predicted impacts defined within this report.

[1] The surrounding area is defined as the Hunter River to the south, interpreted groundwater divide to the north and west (Coffey, 2011) and a 4 km distance to the east.

2.3.3 GDE Classification

The existing steady state groundwater elevations for the study area were compared with topographic elevation to determine existing depth to groundwater. Vegetated areas within the study area were then notionally classified in accordance with the following schema (Driscoll and Bell, 2006):

- 0-1 m median depth to groundwater: Obligate wetland or seasonal inundation GDE.
- 1-2 m median depth to groundwater: Obligate GDE.
- 2-3 m median depth to groundwater: Obligate/ Facultative mixed GDE.
- Greater than 3 m median depth to groundwater: Facultative GDE.

This was used as the basis for defining impacts on GDEs in particular 'obligate wetland or seasonal inundation GDEs' where predicted net changes in depths to groundwater are likely to have a proportionally larger effect (GHD, 2010; Driscoll and Bell, 2006). The results of this classification were also compared with vegetation type mapping to examine consistency between the two vegetation classifications.

2.3.4 GDE Importance Ranking

The importance of GDEs identified within the study area were ranked using measures of conservation status as defined by the following:

- International importance: RAMSAR listed wetlands (EPBC Act).
- National importance: Threatened biota, including ecological communities and migratory wetland birds, listed on the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).
- State importance: State Environmental Planning Policy No. 14: Coastal Wetlands; endangered ecological communities listed on the *Threatened Species Conservation Act* 1995 (TSC Act).
- Local importance: GDEs not conforming to any of the above classifications.

2.3.5 Impact Analysis

Infiltration scenarios, as specified in Section 2.1, were evaluated to determine a suitable infiltration rate with tolerable predicted impacts on GDEs. Selecting the most appropriate scenario includes the consideration of GDEs identified as having international and national importance (eg impact avoidance). GDEs of State importance represent areas where negligible impacts are tolerable. Locally important GDEs are assessed on a merits basis with the objective being to reduce impacts to tolerable limits where possible.

2.4 Assumptions and Limitations

This report is based on the following assumptions and limitations:

- Vegetation types mapped by the NPWS (2003) within the study area have been used as a surrogate to identify GDEs.
- Vegetation sampling has been restricted to the site within one season.

- Topographic variation is defined by the 2 m contour data as supplied by the Department of Lands.
- The net change in groundwater elevations is a function of modelling and assumes a range of infiltration scenarios ranging from no surface water discharges to adjoining properties to partial surface water discharges.
- The use of the 0.01 m net change groundwater elevation contour to define the study area boundary is based on the limit of reading for groundwater observation datasets. The appropriateness of this cutoff contour was tested against the modelling calibration statistic.
- The effects of climate change (eg sea level rise) have not been accounted for in the assessment of groundwater and GDEs.
- Local groundwater regimes, as defined by local bore data, are applicable to the site.
- There has been no accounting for any implied changes in groundwater usage such as increased/ decreased recharge rates or changes in vegetation groundwater usage.
- Specific potable water consumption demand rates have been made, as outlined in section 3.1.2.
- Specific sewage generation rates have been made, as outlined in section 3.2.2.
- Specific stormwater modelling assumptions have been made, as outlined in section 3.3.2.
- Specific groundwater modelling assumptions have been made, as outlined in Section 4.4.2.

3. Site Water Assessment

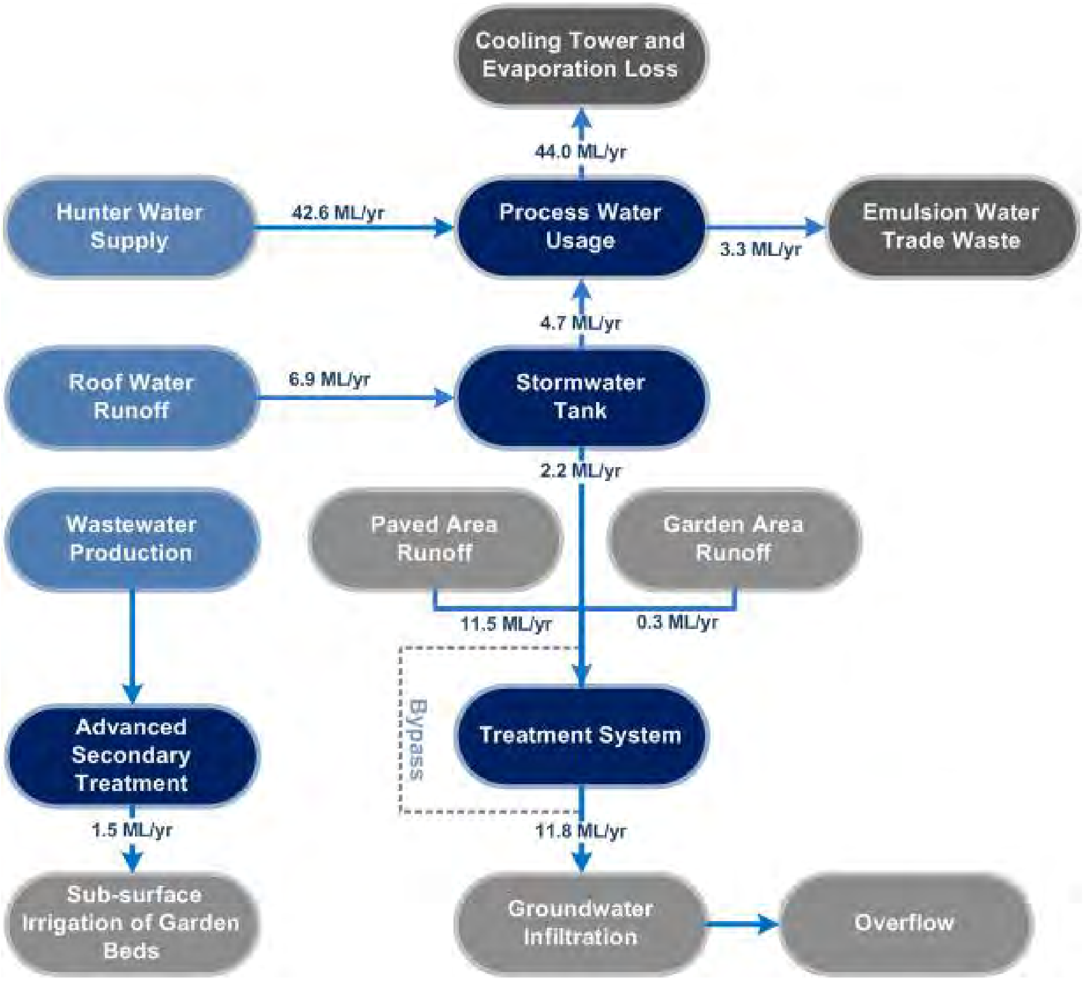
3.1 Integrated Water Balance

A water management report was prepared in July 2011 and investigated the various water management issues relating to the site and Project to provide an integrated approach to site water management. Through the assessment of the interrelationships of potable water, stormwater, groundwater and wastewater flows a number of different water management options were investigated. These were modelled and assessed to provide the most suitable water management options for the site so that:

- Groundwater dependant ecosystems are not impacted on.
- Stormwater is reused where possible and treated and discharged to local standards.
- Wastewater is treated to a high standard and utilised on site in a sustainable and safe manner.

The final adopted integrated water management plan is shown below.

Integrated Water Balance



This plan includs the following elements:

- First flush pavement stormwater will be treated by a Gross Pollutant Trap with overflows bypassing the GPT.
- Infiltration of treated stormwater runoff and bypassed overflows to surface stormwater.
- Process water is supplied by roof water with a first flush system and supplemented by Hunter Water potable supply as a second priority.
- Wastewater will be treated to an advanced secondary level before reuse in site subsoil landscaping irrigation

3.2 Potable Water System

3.2.1 Existing Environment

Hunter Water Corporation (HWC) services the Tomago area and the site of the proposed manufacturing facility. A desktop check of the HWC assets indicates the existence of a 1350 mm trunk main on the south side of the site boundary, a 500 mm trunk main on Tomago road and a 150 mm service line servicing McIntyre Road and the site. There are no existing water users at the site.

3.2.2 Water Demands and Sources

For construction and plant operations, potable water will be serviced from the 150 mm service line serviced by HWC.

Tomago Cable Manufacturing Project is anticipated to employ a maximum of 119 employees per day with a building area of approximately 1ha. Potable water demands were based on a category of light-industrial water demand for a building area of approximately 1 ha using the HWC Water Supply Code of Australia (WSA 03-2002). The expected average and peak flows are shown in Table 1 below.

Site process water demands have been estimated from similar installation by Midal. The expected peak flows were based on the need to refill a 30m^3 emulsion tank in 1 hour on top of the expected potable demand peak during a shutdown period. The expected average and peak flows are shown in Table 1 below. Roof rainwater will be used to offset process water demand through the installation of two 100kLrainwater tanks and associated infrastructure.

Table 1 Expected Water Demand

	Expected Average Demand		Expected Peak Demand	
	ML/year	kL/d	kL/h	L/s
Process Demand	47	129	30	9
Potable Demand	4.2	11.5	18	10
Total Demand	49.2	140.5	48	19

Fire fighting, due to the light industrial area category and the large site will require an instantaneous demand of 20L/s.

As the 150 mm potable water service line is in close proximity to the 500 mm trunk main on Tomago Road, the expected flow and pressure demands will be able to be supplied using the existing potable water network.

3.2.3 Sustainability of Water Sources

HWC have allowed for industrial demand in the Tomago region as part of their network planning strategy. In addition, as the trunk mains running past the site are critical supply lines to residential developments, the water network in the area will be maintained and in operation throughout the life of the project.

3.3 Sewerage System

3.3.1 Existing Environment

The site is currently not sewered or serviced by HWC. The closest HWC sewage system is currently under construction and will be located 6.8 km away at the corner of Tomago Rd and Cabbage Tree Rd. Surrounding industries and the Tomago Aluminium Smelter currently rely on package treatment plants, septic systems, pump out and infiltration systems for disposal. A proposed industrial sub-development at Sweetwater Business Park (approximately 1 km from the site) may build a private rising main to connect to the HWC system, however this is not finalised and Sweetwater is also investigating the option for pump out wet wells until a rising main is built by HWC or another industrial company in the area.

3.3.2 Projected Sewage Loads

The project is anticipated to employ a maximum of 119 employees per day (35 administration and two shifts of 42 employees at the plant).

Raw Sewage quantity

To calculate the site water sewage loads both the Port Stephens Council On-site Sewage Framework and the HWC Sewage Code of Australia have been used to provide initial predictions of sewage quantity.

The 35 administration employees were classed as “commercial” and the 2 shifts of 42 employees each per day as “heavy industry-dry”.

The sewage loads using the HWC Sewage Code of Australia were calculated to be as follows:

- Average Dry Weather Flow (ADWF) = 0.06L/s or 5kL/d.
- Peak Dry Weather Flow (PDWF) = 0.6L/s.
- Peak Wet Weather Flow (PWWF) = 2.4L/s.

The HWC Sewage Code of Australia was designed for large sewerage systems with multiple properties where it is expected that there will be wet weather ingress due to age of pipes and general and natural cracks in sewer lines. In this case, there will be one gravity sewer pipeline of 100 m or less from the building to the sewage treatment plant, it is therefore reasonable to expect very limited to no wet weather infiltration into the sewer line. Therefore peak flows are expected to reach 0.6L/s.

The sewage load using the Port Stephens Council Guidelines was calculated to be as follows:

- Week day shift: 42 shift workers x 2 shifts x 43L/p/d (industrial with showers) + 35 administrative staff x 27L/p/d (industrial) = 4.5kL/d
- Weekend shift: 42 shift workers x 2 shifts x 43L/p/d (industrial with showers = 3.6kL/d

Based on the above assesments, the more site specific Port Stephens Council On-site Sewage Framework was applied to the small onsite installation to provide the daily flowrate.

The system was therefore designed for the flowrate of 4.5kL/d for week day shift and 3.6Kl/d for weekend shift, with a peak instantenous flow of 0.6L/s.

Raw Sewage Quality

The majority of the nutrient load is expected from the 'blackwater' from toilets and urinals. Kitchens and showers will provide some additional nutrient load, however there will be no laundry services which are generally main contributors to high concentrations of nutrients (mainly nitrogen and phosphorus). The values were based on average adopted values from the Environmental Guidelines: Use of Effluent By Irrigation Guidelines, and common expected values for the site activities. As the site will not have laundry facilities which provide a large portion of sewage nutrient load in municipal wastewater systems, average values are expected to be on the conservative side for the predicted values. The adopted expected raw sewage values are as follows:

- Biological Oxygen Demand (BOD) = 300 mg/L
- Total Suspended Solids (TSS) = 250 mg/L
- Total Nitrogen (TN) = 20-100 mg/L
- Total Phosphorus (TP) = 5 mg/L

3.3.3 Wastewaster Management Approach

As there is no sewerage system in the area, and formal advice indicates that there are no plans by Hunter Water Corporation to service the area in the near future, it is intended that an onsite sewage treatment system will be installed to treat the generated wastewater from the site.

Careful consideration was given to the reuse potential of the treated wastewater, however due to the high health risks and minimal flows from the wastewater system, reuse for process water or as a third pipe into the office amenities was not adopted.

The system does not fall within the Hunter Water Corporation drinking water catchment and is 600m downstream of the HWC Special Area of the Tomago Sandbeds.

Currently, some of the industries surrounding the site employ onsite treatment systems consisting of septic tanks for treatment and Wisconsin mounds for infiltration. The current onsite treatment systems are designed based on the Port Stephen Council On-Site Sewage Framework and the Port Stephen Council "Standard Designs for On-site Wastewater Management Systems in Tilligerry Creek, 2005". The guidelines specify the use of septic tanks and Wisconsin mounds for treatment systems that are over 100m from creeks/waterways and state that "The designs presented in this document have proven highly effective in very similar environments to the Tilligerry Creek catchment for as long as 30 years".

Based on the above information, and to ensure minimal impact on the groundwater and downstream waterways, the system has been designed to treat wastewater to a higher standard than the Council guidelines and some of the surrounding industries, which have secondary systems with Wisconsin mounds and primary systems with Wisconsin mounds respectively. The system will treat wastewater to an advanced secondary level with disinfection to substitute potable water for on-site landscaping requirements through subsoil irrigation as per the Environmental Guidelines: Use of Effluent By Irrigation, 2003 for subsurface irrigation.

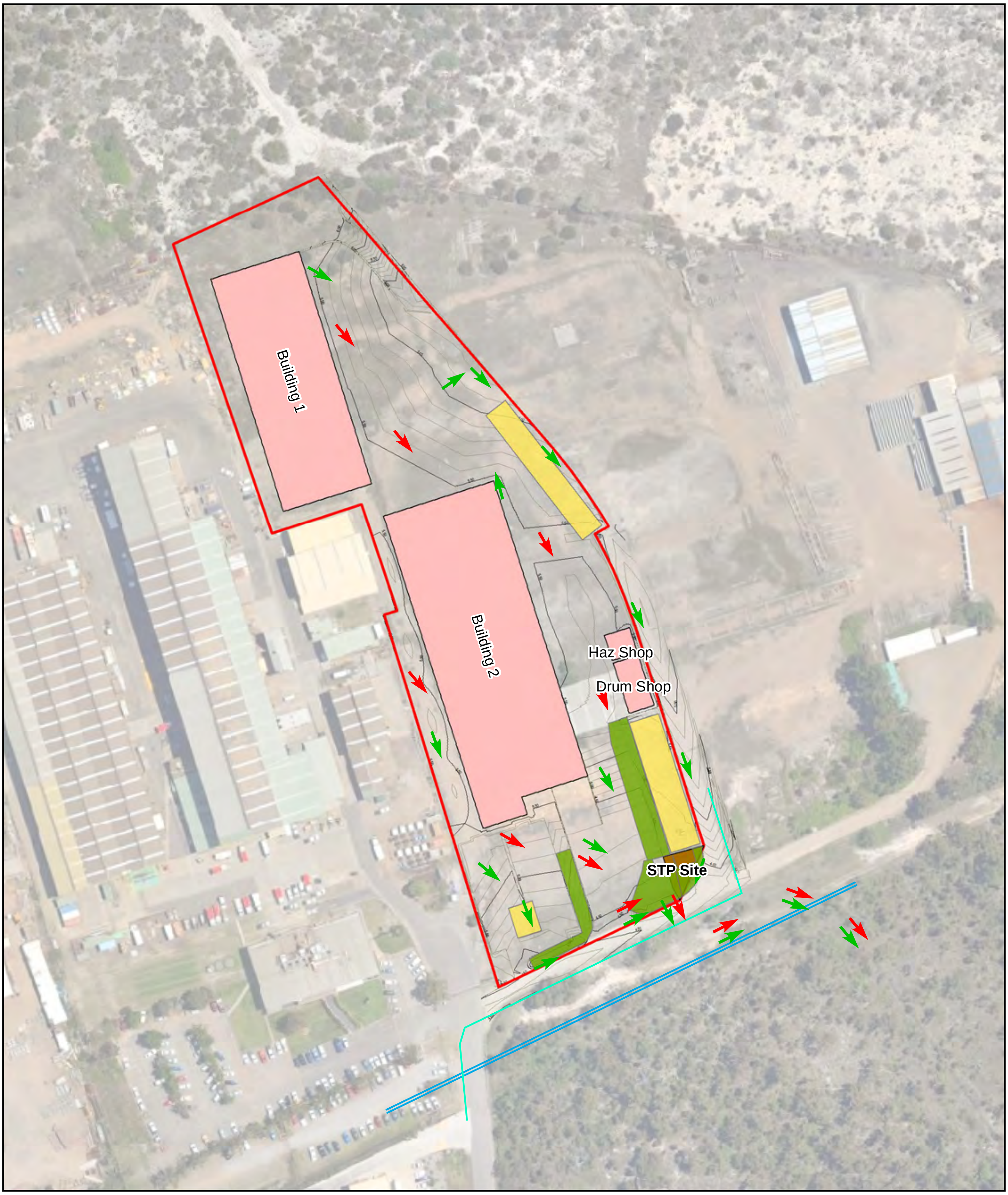
When a storm event occurs at the site where infiltration will occur (on the assumption that a 5mm rain event will result in infiltration to groundwater, this would happen once at least every 3 months based on the last 30 years of historical data), oxygenated water will come through to oxidise the soil and dilute/flush the system through. Any accumulation in this period that is not dealt with by the nutrient balance with the planted flora, the sorption with the soil or the bio-degradation in the soil would only be in the area immediate to the treatment unit at the site and would not impact GDE's further away.

To provide nutrient balance calculations an annual balance was produced to compare the amount of specific nutrient assumed to be applied in a year to the amount taken up by the biological and physical processes of the crop-soil system. An annual balance was based on the Use of Effluent by Irrigation Guidelines method and values. This is consistent with the Port Stephen Council requirements for non-domestic on-site systems of less than 10 kl/d.

The nutrient balance is also conservative in nature as it assumes the conservative prediction of daily flowrates for the year to be 4.5 kl/d on weekdays and 3.6 kl/d on weekends, where the actual volumes will fluctuate between 1.5kl/d and 4.5kl/d. The model assumes that there will be some nutrient removal from the package sewage treatment plant due to the solids settling, biological action in the activated sludge chamber, and further clarification and filtration. Therefore the predicted irrigation area is on the conservative side for the system. This will be confirmed further during the detailed design stage of the project.

The limited load of heavy metals associated with hand washing and showers would be removed in the sewage treatment system through settling in the primary treatment chamber, bio-accumulation in the secondary aerated chamber and settling in the clarification chamber. The trace concentrations of metals would not impact on the groundwater system or the GDE's further away.

Periodic soil tests will confirm the sustainability of the treatment and irrigation system. This is discussed further in mitigation measures below.



LEGEND

Stormwater Flow Existing

Stormwater Flow Proposed

Water Services

WATER MAIN 1350 DIA

WATER MAIN 150 DIA

Approximate Sub Surface Irrigation Zones

Approximate Infiltration Zones

Package Sewage Treatment Plant (STP) Site

Building Footprints

Design Surface Contours

Contour Major

Contour Minor

1:2,000 Paper Size A4

0 5 10 20 30 40

Metres

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

N

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Midal Cables International Pty Ltd
Tomago Rod and Conductor Manufacturing Facility
Environmental Assesment

Water, Stormwater & Sewer Layout
Existing & Proposed

Job Number	22-1528031
Revision	4
Date	22 Dec 2011

Figure 1

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

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3.3.4 Treatment System Design

The sewage treatment and disposal system has been designed to be an advanced secondary treatment system with onsite subsoil irrigation. The package plant will include a balance tank, an aeration chamber, settling chamber, sludge tank and a disinfection unit. Some proprietary units may include a primary settling tank, septic tank or screening system within it's package system. The sludge tank will collect all waste sludge from the process which will require pump out every three months to a year depending on the tank size and actual wastewater flows. The irrigation system has been designed as per the Environmental Guidelines, Use of Effluent By Irrigation, 2003 and has also used the Australian Standard for On-site Domestic Wastewater Management (AS 1547:2000) as a guide for soil infiltration rates for the subsoil irrigation system.

Performance Standards

The treatment system will be designed to handle daily flows of up to 4.5 kL/d and a peak instantaneous flow of 1L/s (66% more than the calculated peak dry weather flow).

The buffer capacity within the package sewage treatment plant will be designed to hold a minimum of 8h emergency storage at average dry weather flow. The package plant will be designed with an audible and visual alarm to notify of any plant failure. As the package plant is located next to the main gates and thoroughfare of the facility, there will be little delay in the response time in an event of a failure.

The package plant will be specified to treat domestic wastewater to an advanced secondary level. The performance targets are as follows:

Table 2 Advanced Secondary Treatment Package Plant Water Quality Targets

Parameter	Typical Water Quality Targets (mg/l)
Biological Oxygen Demand (BOD)	<10
Total Suspended Solids (TSS)	<10
Faecal Coliforms	<10 (org/100 ml)

The package plant will require access for pump out of the sludge tank and for periodic monitoring and servicing of the treatment system.

Irrigation System Design

The subsurface irrigation system has been designed as per the Environmental Guidelines, Use of Effluent By Irrigation, 2003 and the Australian Standard for On-site Domestic Wastewater Management (AS 1547:2000). At this stage, the irrigation system is indicative and final details will be confirmed during detailed design. This will involve ensuring that the irrigation area and associated vegetation is sufficient to remove the nutrients contained in the wastewater to comply with the intent of the Councils guidelines and the Environmental Guidelines, Use of Effluent by Irrigation, 2003.

A shallow subsurface drip system will be installed at a typical depth in the soil of 150 -200mm in grassed or other suitably vegetated areas. It will utilize a system of dosed distribution of effluent from perforated small-diameter pipes or dripper lines. Only commercially available pressure compensating subsurface irrigation pipework specifically designed for the dispersal of treated wastewater will be installed. The typical groundwater level will be approximately 1.5 to 2m below the ground level of the irrigation areas.

The irrigation area will have an adequate depth of a minimum of 1 metre of imported topsoil to store the applied effluent and to support the growth of vegetation to maximize nutrient uptake and evapotranspiration. The exact species of vegetation will be refined during detailed design, however they will include high yield grasses (including natives) that will be able to be harvested periodically and will be appropriate for the surrounding environment. The system will be installed with appropriate set-back distances required by the Port Stephens Council.

The landscaping area will be predominantly in three sections at the southern end of the site, in between the car parks and the site boundary as well as around the sewage treatment plant site area. The total irrigation area will be just over 1,000 m^2 (refer to Figure 1 and appendix D for more details

The hydraulic calculations show that based on set irrigation area, the weekly Design Irrigation Rate (DIR) will be 31mm/week on average and will peak at 50mm/week during the winter months. The AS 1547:2000 Standards specify a conservative maximum application rate on sandy loam soils to be 50mm/week for secondary treated wastewater with characteristics of BOD <20 mg/l and TSS <30 mg/l. The treated wastewater will be advanced secondary withwastewater characterisitics of BOD <10 mg/l and TSS <10 mg/l, which is two to three times better than the AS 1547:2000 criteria, and the application rate will be on average 40% lower then the AS the AS 1547:2000 criteria, which will ensure a sustainable hydraulic design of the irrigation system. Details of the hydraulic monthly balance, including rainfall and transevaporation can be shown in Appendix D.

The nutrient calculations show that the site will have a net negative organic loading (BOD) and nitrogen balance and a positive phosphorus balance. Based on a conservative sorption capacity of the imported soil, the irrigation system is expected to last for 86 years before the phosphorus capacity of the soil may be reached. The nutrient calculations were based on the Environmental Guidelines: Use of Effluent By Irrigation, 2003 and are shown in Appendix E.

Buffer distances have been taken into account as per the Use of Effluent by Irrigation Guidelines Table 4.9. The recommended and actual values are shown in table x below.

Table 3 Use of Effluent by Irrigation buffer distances

Sensitive Area	Recommended Buffer Distance (low strength effluent)	Actual Buffer Distance	Comments
Natural waterbodies (e.g. rivers, lakes)	50 m	1 km to Hunter River	Well outside the buffer distance required.
Other waters (e.g. artificial waters with	Site-specific	5m to stormwater	Water treated to advanced secondary level with disinfection to

Sensitive Area	Recommended Buffer Distance (low strength effluent)	Actual Buffer Distance	Comments
beneficial uses, small streams, intermittent streams, water distribution and drainage channels, farm dams)		drain	ensure no adverse effect on downstream water quality.
Domestic well used for household water supply	Site-specific	N/A	Area serviced by HWC for potable water. No household bores in area
Town water supply bores	Site-specific	N/A	No town water supply bores in area
Where spray irrigation gives rise to aerosols near houses, schools, playing fields, roads, public open space and waterbodies	50 m	N/A	No spray irrigation used
Other sensitive areas (e.g. waters in drinking water catchments, aquatic ecosystems with high conservation value, wetlands, native stands of vegetation)	Site-specific (250m for medium or high strength)	N/A	The sub-soil irrigation area is approximately 800m downstream of of the boundary with the HWC drinking water catchment.

Compliance and Monitoring

The sewage treatment system and sub-surface irrigation system is required to be installed by a qualified contractor to the AS 1547 standard. All On-site Sewage Management Systems are required to be registered and their owners required to lodge an application for an 'Approval to Operate' with Port Stephens Council as part of the Council's On-Site Sewerage Management Strategy.

Any new system will not be allowed to operate until Council has given the applicant approval notice in writing. The approval will include verification of performance targets during commissioning and proof of performance testing as per AS 1547:2000.

The monitoring system in place will measure record and identify any action to maintain the environmental performance of the system.

For ongoing assessment of monitoring and compliance, the aerated wastewater treatment system will be serviced, monitored and certified quarterly by a Port Stephens Council accredited service provider. The servicing will include inspection and routine cleaning of the treatment chambers, UV system and effluent filter. The treated wastewater quality will be sampled and sent to a NATA laboratory to check performance against the treatment plant requirements. The wastewater quality and quantity (from the online flowmeter) will provide an estimate of the loading rate applied to the irrigation area.

The soil will be sampled annually by a qualified person with knowledge of soil science to monitor any changes in soil structure or accumulation of nutrients. Groundwater will also be monitored, as described in more detail in Section 4.6. The vegetation will be harvested as per the routine landscaping servicing of the site to remove the nutrients and promote growth.

The treatment and irrigation systems will require an Annual Approval from Port Stephens Council to operate.

3.4 Surface Water and Hydrology (Stormwater)

3.4.1 Existing Environment

The site visit on the 6 June 2011 confirmed that there are no water bodies, water courses or riparian vegetation on, or adjacent to, the site. Photos from the site visit of the existing surface water environment are shown in Appendix A.

The site is above flood prone lands identified on the Port Stephens Council Flood Prone Land Maps.

Approximately 20% of the site is impervious due to existing concrete or bitumen layers. Based on the relatively deep sands of the site and surrounding areas it is anticipated that very little overland flow occurs across the site. The site visit, which followed a few weeks of wet weather, did not identify any evidence of stormwater flows on or near the site. The desktop design calculations, assuming a specific infiltration rate based on local geotechnical information also found that little to no overland flows were expected in the existing environment.

Figure 1 shows the current approximate stormwater path on and around the site. The site visit identified a shallow stormwater channel and a damaged culvert on the southern boundary of the site. The soil and vegetation in the culvert and channel showed little evidence of recent stormwater flows.

The project is approximately 600 m downstream of the HWC Special Area of the Tomago Sandbeds.

There are no water bodies, watercourses or riparian vegetation near or on the site. The nearest water body is the Hunter River, located to the south of the site.

3.4.2 Stormwater System Design

The impervious area of the site will increase following construction of the manufacturing facility, generating larger stormwater flows.

To reduce the impact of the reduced stormwater infiltration due to the large impervious area of the site, it is proposed to design and construct a number of underground stormwater infiltration areas within the site and collect rainwater from roofs. Roof runoff will be collected and stored in aboveground rainwater tanks for process water re-use. Paved area runoff will be collected via a conventional pit and pipe network design to 1 in 10yr ARI and discharged to groundwater, with high flows being discharged via a constructed stormwater overflow into the watermain easement to the south of the site.

The stormwater would undergo basic treatment for the removal of oil and grit through a combination of pit inlet baskets and gross pollutant traps (GPT's)/CDS units or equivalent before being directed to the underground infiltration areas to minimise stormwater flows from site. The proposed stormwater system will detain and infiltrate the first 14mm of rainfall. The stormwater infiltration capacity was determined from the outcomes of the GDE impact analysis The assessment determined that an average infiltration rate of $50m^3$/day as the preferred infiltration volume of which 5 m3/d will come from sub-soil irrigation of treated wastewater, leaving 45m3/day which is approximately equal to the infiltration of the first 14mm of daily rainfall from the site on an annualised basis.

Flows greater than the capacity of the infiltration system will follow the existing direction of stormwater flows. As shown in Figure 1 the stormwater will first pass through the existing culvert (replaced as part of the road upgrade), before infiltrating near the 1,350 mm diameter water main easement area. Any remaining surface flows would infiltrate into the land area south of the easement (potential impacts on vegeatation in this land are covered in Section 2.3).

As the system will be fitted with a GPT to treat the 'first flush' runoff, the excess runoff is expected to be relatively clean. The GPT units will be maintained in accordance with the manufacturer's guidelines. Water quality treatment devices are designed for a frequent 1 in 3 month ARI rainfall in accordance with industry standard practice with water treatment removal targets to EPA reduction guidelines.

The site is approximately 600 m downstream of the HWC Special Area of the Tomago Sandbeds and therefore will not cause any impacts on the drinking water source.

3.4.3 Water Bodies, Watercourses and Riparian Vegetation

There are no water bodies, watercourses or riparian vegetation near or on the proposed development site. Therefore, apart from the above mentioned stormwater mitigation measures, no monitoring or mitigation measures are required for surface water flows.

3.4.4 Erosion and Sedimentation Control

To offset the potential impacts of the project on water quality during construction and operation, both temporary and permanent sediment and erosion control measures would be incorporated. The permanent control measures would be incorporated into the works as part of the detail design while the temporary measures would be incorporated within the Spoil and Fill Management Plan (SFMP) as part of the Construction Environmental Management Plan (CEMP).

Both the SFMP and the CEMP would include details of the proposed control measures, where and how the measures are to be applied, as well as a response plan and monitoring. A broad outline of these is provided below.

Standard Measures

A range of standard mitigation measures to minimise the impact of excavation, storage and placement of material on the surface and groundwater systems during construction includes, but is not limited to:

- Minimise area of disturbance.
- Temporary catch and diversion drains to divert runoff from upslope land and reduce erosion hazard.
- Temporary diversions should outlet to stable discharge areas with additional protection as necessary.
- Progressively revegetate disturbed areas to encourage infiltration.
- Direct sediment laden runoff through a sediment trap or basin to minimise discharge of pollutants to downstream environment.
- Direct smaller volumes of sediment laden runoff to sediment filters such as straw bale filters and sediment fences.
- Locate stockpiles clear of flood prone areas, stream banks, channels and stormwater drainage areas.
- Stabilise stockpiles that are to be in place for longer than 10 days.
- Divert flows around stockpiles by bunds/diversion drains.
- Place sediment fences downstream to capture sediment and minimise sediment discharge to downstream environment.

The range of standard mitigation measures that would be adopted as permanent sediment and erosion control measures includes, but is not limited to:

- Permanent catch and diversion drains to divert runoff from upslope land and reduce erosion hazard.
- Permanent diversions to outlet to stable discharge areas with protection as necessary.
- Revegetation of disturbed areas to encourage infiltration.
- Locate permanent areas of spoil clear of flood prone areas, stream banks, channels and stormwater drainage areas.
- Scour protection to structures and embankments as necessary.
- Permanent diversion of flows around spoil areas and quarries by bunds / diversion drains.
- Permanent areas of spoil to have maximum batter slopes of 1 vertical to 2 horizontal and stabilised by vegetation.

Emergency Response Plan and Spill Containment

The development of an emergency response plan, as a component of the CEMP, would address the steps required in the event that the capacities of sediment control measure were exceeded. This emergency response plan would also be required to address other potential pollution incidents such as a chemical spill.

There is the potential for a spill to occur during construction of a project. This can lead to an impact on water quality and groundwater health. During construction, refuelling of plant and machinery be undertaken either by fuel trucks with spill trays or within bunded areas or off-site in appropriate locations wherever possible and, where topography and track elevations allow, consideration be given to the provision of a secondary containment measure to limit the discharge of spills. Consideration would be given to the likelihood of the spill event in determining the appropriate mitigation measure.

Additional Measures

Other aspects of the construction that would be addressed within the CEMP include:

- Project team members involved in the construction of the project would be made aware of their environmental responsibilities and the measures to minimise impacts.
- Stabilisation of disturbed soils through such measures as revegetation.
- Establishment of the works compound, including the machinery, fuel and chemical storage areas with bunded areas away from drainage lines.
- Appropriate storage of construction materials on site so as to prevent leaching, leaking or other transfer of material into groundwater or onto land.
- Development of an Emergency Response Plan. This would include, but not be limited to, the requirement that an appropriate spill kit is to be kept on site at all times and any spillage is to be immediately cleaned up. In the event of a large or hazardous spill, the fire brigade, police, ambulance and OEH would be contacted as appropriate.

3.5 Relevant Technical and Policy Guidelines

A desktop review was performed to identify the relevant Legislation and Technical and Policy Guidelines, and their key requirements and the projects relevance and compliance with the legislation and guidelines. The information is provided in the Table 4.

Table 4 Relevant Legislation, Technical and Policy Guidelines

Legislation	Key Requirements	Relevance and Compliance to the Project
Water Act 1912	The requirement for a licence or authority to take water from river or stream, capture surface water or extract groundwater in areas where a water sharing plan has not commenced.	1912 Water Act is being phased out and for this project is superseded by the 2000 WM Act
Water Management Act 2000 (WM Act)	Under the WM Act, an access license is required for water extraction	No water extraction is proposed as part of the proposal.
	The WM Act provides that certain types of development and activities that are carried out in or near a river, lake or estuary are “controlled activities” and require a controlled activity approval under section 91.	The site is outside of the prescribed maximum distance for waterfront land of 40 m.

Legislation	Key Requirements	Relevance and Compliance to the Project
Water Sharing Plan for the Tomago Tomaree Stockton Groundwater Sources (2004) (NOW)	Provides requirements for groundwater extraction under access licence.	No water extraction is proposed as part of the proposal.
Australian Guidelines for Fresh and Marine Water Quality (2000) (ANZECC)	Trigger values for pollutants in the mixing zone of the water system.	No river discharge as part of this proposal. Hunter River may not meet ANZECC guidelines in this context.
Australian Guidelines for Water Quality Monitoring and Reporting (2000) (ANZECC)	Guidelines on sample collection and reporting for nominated parameters.	Considered in setting up groundwater monitoring programs.
NWQMS: Guidelines for Sewerage Systems – Effluent Management (ANZECC)	Dictates the minimal levels of treatment for effluent discharge and reuse, and management and operations parameters.	Onsite package plant to meet guideline requirements for proposed water end use.
Port Stephens Onsite Sewerage Management Strategy	This strategy outlines the framework to manage and regulate the impact of on-site sewage management systems in the Port Stephens LGA.	Onsite package plant to meet guideline requirements for proposed water end use.
NWQMS: Guidelines for Sewerage Systems – Use of Reclaimed Water (ANZECC)	Provides guidelines on the level of treatment of wastewater depending on the end use of the treated water.	Onsite package plant to meet guideline requirements for proposed water end use.
NWQMS: Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (EPHC)	Detailed risk based assessment guidelines for non-potable recycling of treated wastewater.	To be adhered to if decision is made to recycle treated wastewater to the process stream or as a third pipe for indoor use.
Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC)	Applies to Hunter River Water Quality.	Not applicable as set by issues external to site.
Managing Urban Stormwater: Treatment Techniques (EPA)	Provides a range of techniques for stormwater treatment and quality management.	Appropriate consideration to be given to water quality targets and techniques.
Managing Urban Stormwater: Source Control (EPA)	Looks at identifying point sources for pollutants and techniques at treating point source.	No point source water pollution is identified in this project.

Legislation	Key Requirements	Relevance and Compliance to the Project
Managing Urban Stormwater: Soils & Construction (Landcom)	Processes and procedures in civil earthworks stormwater design.	Consideration to be given to the stormwater management plan during the construction phase.
Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)	Guidelines on Sampling Procedures.	To be considered together with ANZECC guidelines when setting up monitoring programs.
NSW State Wetlands Management Policy (DWE)	To replicate historical flow regimes.	Selected infiltration on site to restrict runoff and mimic historic flow regime.
NSW State Floodplain Management Manual (DWE)	Development requirements within floodplains.	Site outside the 1:100 year flood extent.
NSW State Farm Dams Policy (DIPNR)	Requirements for approvals for farm dams for commercial purposes.	No farm dams on site.
Floodplain Risk Management Guidelines: Practical Consideration of Climate Change (DECC)	Requires consideration of floodplain assessment due to climate change.	Site outside the 1:100 year flood extent and 1:100 year sea level rise.
Technical Guidelines: Bunding and Spill Management (DECC)	Guidelines around bundling and storage for chemical tanks and refuelling areas.	No chemical tanks or liquid fuel refuelling area on site
Environmental Guidelines: Use of Effluent by Irrigation (DECC)	Guidelines on hydraulic and load limits for irrigation.	To be considered when designing sub-soil irrigation of landscape areas using treated wastewater.

4. Groundwater Assessment

4.1 Legislation and Policy Review

Relevant legislation and policies are outlined in Table 5, together with their key requirements and relevance to the project. GHD understands that NOW requires particular consideration be given to the:

- Water Act 1912.
- Water Management Act 2000.
- Water Sharing Plan for the Tomago Tomaree Stockton Groundwater Sources 2003.

Table 5 Legislation and Policy Review for Groundwater Assessment

Legislation / Policy	Key Requirements	Relevance and Compliance to the Project
Water Act 1912	Part 5 requires a licence to be obtained for aquifer interference and groundwater extraction.	Does not apply at this site because the site is within an area covered by a Water Sharing Plan (WSP).
Water Management Act 2000	Section 90 requires approval for water supply works and water access. Applies to areas covered by a WSP. A water supply works approval allows for the installation and operation of a particular pump, bore or other water management work at a particular location. A water use approval or aquifer access licence allows for the use of water for a particular purpose at a particular location.	As the project is subject to approval under Part 3A of the EP&A Act, approvals under Section 90 of the Water Management Act 2000 are not required.
Water Sharing Plan for the Tomago Tomaree Stockton Groundwater Sources (amended 2004)	WSP made under the Water Management Act 2000. The plan manages the provision of groundwater for the environment (particularly groundwater dependent ecosystems (GDEs)), basic landholder rights and water extraction.	The site is located within the Tomago Groundwater Source, although the WSP will have little relevance to the project because groundwater extraction is not proposed.

Legislation / Policy	Key Requirements	Relevance and Compliance to the Project
NSW State Groundwater Policy Framework Document (1997)	Manage the State's groundwater resources so that they can sustain environmental, social and economic uses. Has three component parts: • Quantity Protection. • Quality Protection. • GDE Protection.	Relevance outlined in rows below. NOW requires that the assessment considers impacts on adjacent licensed groundwater users, basic landholder rights, groundwater sources and GDEs.
NSW State Groundwater Quantity Management Policy	Manage groundwater extraction to prevent unacceptable impacts and maintain the sustainable yield of the aquifer. All groundwater extraction for water supply is to be licensed.	Groundwater extraction for water supply is not proposed.
NSW State Groundwater Quality Protection Policy	Slow, halt or reverse groundwater quality degradation by requiring impact assessments for new developments, directing potentially polluting activities to the most appropriate geological setting so as to minimise risk to groundwater and utilise groundwater protection zones and vulnerability maps where appropriate.	Project site overlies a relatively vulnerable aquifer (shallow, unconfined, permeable) and therefore the development need to be designed to minimise impacts to groundwater quality.
NSW Groundwater Dependent Ecosystem Policy	Outlined in Section 5 of this report.	GDE impact assessment in Section 5 of this report.

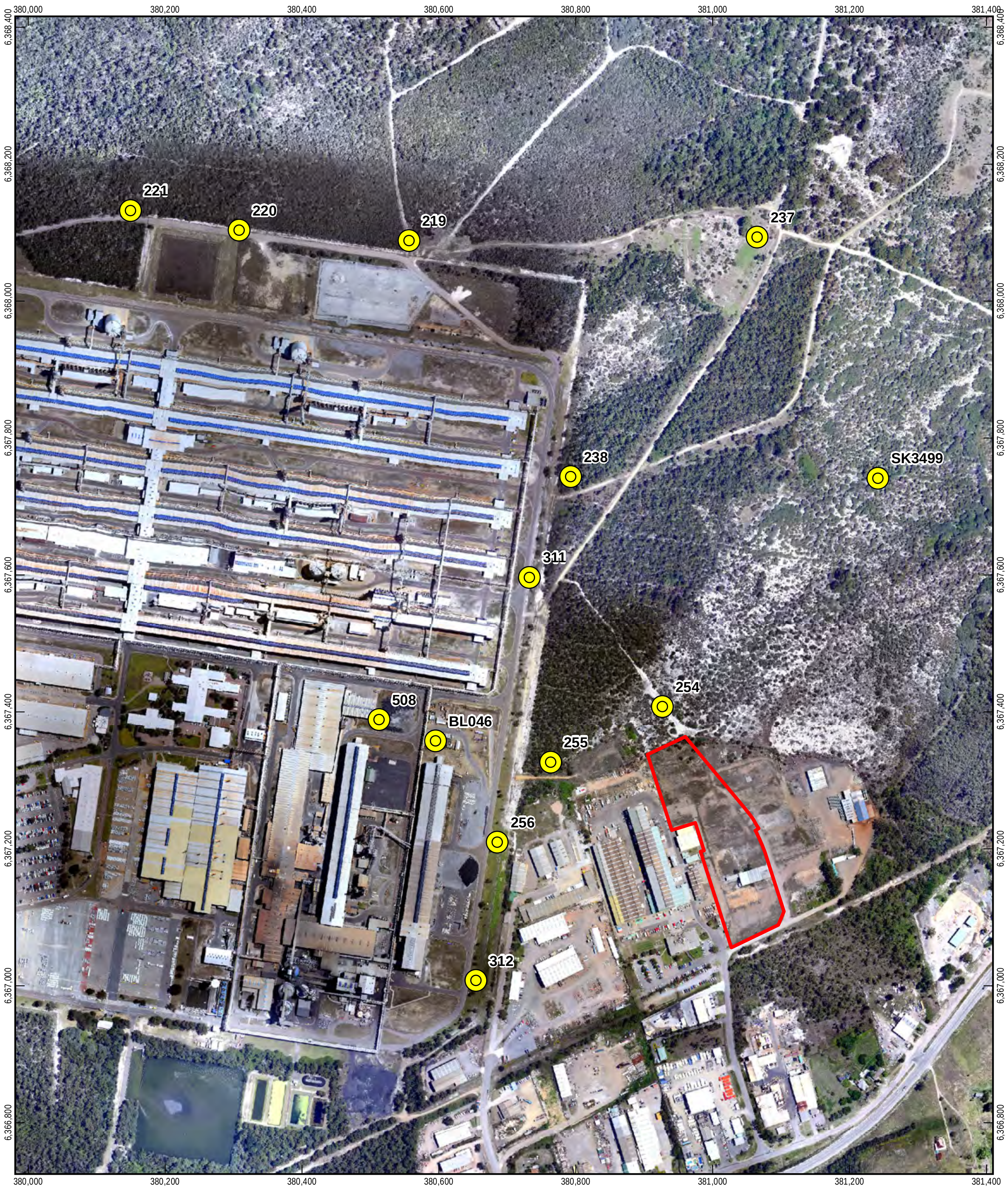
4.2 Existing Data

The following data were available for this assessment:

- Tomago Aluminium Company (TAC) monthly groundwater level and quality (pH, EC) data for the period 2005 to 2011 (monitoring bores 219, 220, 221, 237, 238, 254, 255, 256, 311 and 312). Note that TAC monitoring bore 254 is located on the north-eastern boundary of the project site.
- Hunter Water Corporation (HWC) monthly groundwater quality (pH, EC, fluoride) data for the period 1997 to 2004 (monitoring bores 508 and BL046) and monthly groundwater level data for the period 1976 to 2011 (monitoring bore SK3499).

The locations of existing monitoring bores used for this assessment are given in Figure 2. In addition, reference was made to the following:

- Coffey Geotechnics (2011). *Newcastle Gas Storage Facility Project: Groundwater Assessment Tomago, NSW*. Report for AGL Energy Limited.
- TAC Environment Protection Licence (EPL) No. 6163.



LEGEND

Site Boundary

Monitoring Bore Locations

1:7,500 Paper Size A4

0 25 50 100 150 200

Metres

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

N

CLIENTS | PEOPLE | PERFORMANCE

Midal Cables International Pty Ltd
Tomago Rod and Conductor Manfacturing Facility

Job Number 22-15280-34
Revision A
Date 17 Aug 2011

Existing Groundwater Monitoring Bores in the Vicinity of the Project Site

Figure 2

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

G:\22\15280\GIS\Maps\Working\NOW_Report_StuartGray\22_1528031_002_ExistGroundwaterMonitoringBores_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier

4.2.1 NSW Groundwater Database Search

NOW has provided GHD with results of a search of the NSW Groundwater Bore Database within 5 km of the project site. The results of this search showed that there are 68 registered bores within 5 km of the site.

All registered bores within approximately 3 km of the site are HWC monitoring bores. Site details, water bearing zones, driller logs and groundwater quality data are not available for these bores.

4.3 Existing Hydrogeological Environment

Existing data and information (as outlined in Section 4.2) was used to build a conceptual representation of the hydrogeology underlying the site and to establish typical groundwater elevations and groundwater quality.

4.3.1 Site Geology

The site is situated near the south western extent of the Quaternary unconsolidated sand deposit known as the Tomago Sandbeds. According to Woolley et al (1995), the Tomago Sandbeds is an exposed fine to medium grained sand body of accumulated beach, dune and near-shore shelly sands of area approximately 152 km^2.

The sand is approximately 15 to 20 m thick at the site and is underlain by unconsolidated clay (Medowie Clay) up to 30 m thick. The thickness of the sand reduces in a westerly direction towards a bedrock outcrop of the Permian Tomago Coal Measures approximately 1.2 km to the west of the project site.

4.3.2 Site Hydrogeology

The Tomago Sandbeds is a shallow unconfined groundwater source that provides about 20% of the Lower Hunter’s drinking water supply. According to Woolley et al (1995), the hydraulic conductivity of the sand aquifer typically ranges between 10 to 20m/d. The underlying Medowie Clay is relatively impermeable.

A groundwater divide is known to exist within the sand aquifer to the north of the site, orientated in an east-west to northeast-southwest direction. The divide is the result of the influence of the Hunter River, which is located both to the west and the south of the site. In the vicinity of the site, groundwater flows in a southerly direction from the divide to the north and discharges into the Hunter River to the south.

Groundwater recharge occurs primarily by direct rainfall infiltration. According to Woolley et al (1995), groundwater recharge throughout the Tomago Sandbeds is variable both spatially and temporally and ranges from less than 20% to 80% of average annual rainfall. The Water Sharing Plan for the Tomago Tomaree Stockton Groundwater Sources (amended 2004) reports an average annual recharge for the Tomago Sandbeds of 35,700ML/year, which is based on a rainfall recharge coefficient of 20%.

Rainfall Analysis

Historical daily rainfall data from Raymond Terrace (Bureau of Meteorology station number 61031) was available for the period April 1894 to April 2011. An Accumulative Residual Rainfall (ARR) graph was generated from this data, whereby the difference between the monthly observed rainfall over the period and the mean monthly rainfall (89.8 mm, based on an annual average of 1,078 mm) was summed cumulatively for each month. It is considered that a period representing zero ARR is more representative of average or steady state groundwater elevations than simply a period of average rainfall. A portion of the ARR graph is shown in Figure 3.

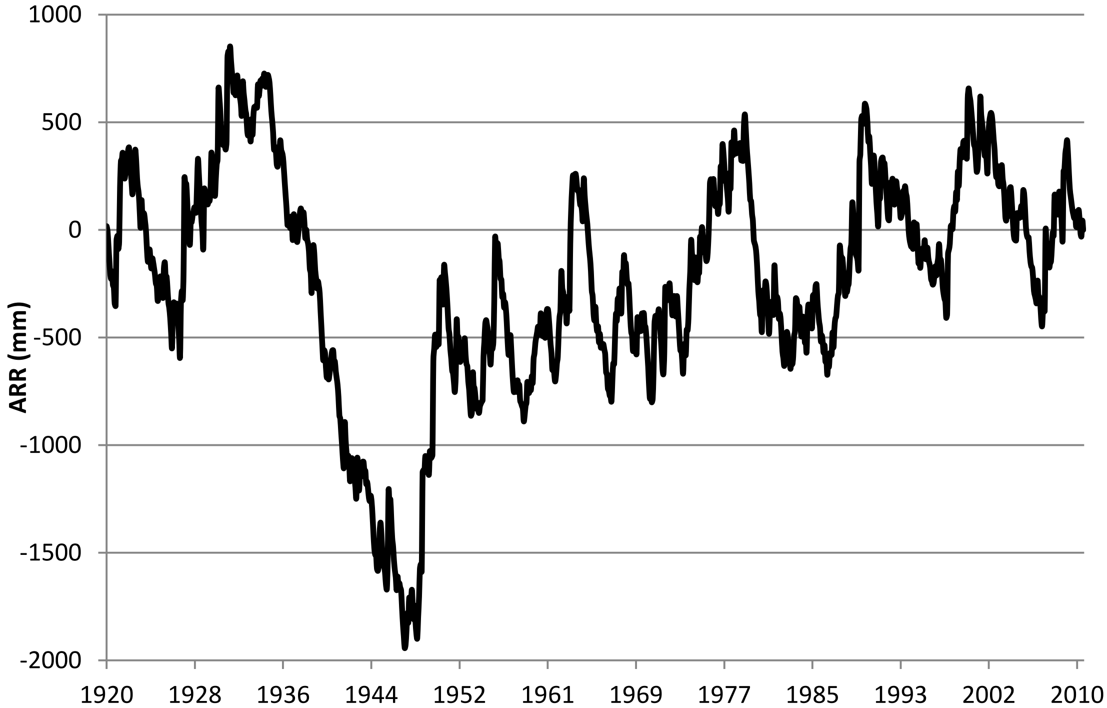


Figure 3 Accumulated Annual Residual Rainfall for Raymond Terrace BOM Station No. 61031

Groundwater Elevation

Groundwater elevation data reported over the period January 2005 to December 2010 in the vicinity of the site is presented in time series graphs in Appendix B. Over this period groundwater elevations have generally ranged from approximately 3 m to 5 m AHD in close proximity to the site (based on data for bores 254, 255, 256 and 312) while groundwater elevations along the groundwater divide to the north and northeast of the site have ranged from approximately 4 m to 6 m AHD (based on data for bores SK3499, 219, 220 and 221). Based on available data, the hydraulic gradient in the vicinity of the site is typically 0.002. Assuming a horizontal hydraulic conductivity of 10m/d and effective porosity of 0.3, the horizontal groundwater velocity in the vicinity of the project site is 0.067m/d or 24m/year.

Temporal change in groundwater elevation appears to closely reflect the change in ARR. Using HARTT (Hydrograph Analysis: Rainfall and Time Trends, Ferdowsian et al., 2000) regressions of groundwater elevation against ARR, very strong correlations are established between groundwater elevation and rainfall at each monitoring location with p values typically in the order of 1×10^{-9}.

Based on the ARR graph, it was considered that March 2005 groundwater levels adequately represent steady state conditions for the area since the ARR at this time was close to 0 mm. In the vicinity of the site, the groundwater elevation was about 3.3 to 3.8 m AHD in March 2005 (based on TAC data). This represents a depth to groundwater of approximately 3.2 m below ground level (bgl) at the north western corner of the site (closest to TAC) to 1.2 m bgl at the southern end of the site.

4.3.3 Existing Groundwater Quality

TAC's EPL requires that groundwater monitoring for pH, electrical conductivity (EC) and fluoride[2] be undertaken. TAC undertakes this monitoring on a monthly basis and GHD has been provided with monthly pH and EC results reported between 2005 and 2010 at the monitoring bore locations outlined in Section 4.2. TAC did not provide GHD with fluoride concentration data, although average annual concentrations for the period 2005-2009 are available in the TAC Annual Environment Report 2009.

Time series plots of available groundwater quality data in the vicinity of the site are presented in Appendix B.

pH and EC

GHD considers that the available pH and EC data provides adequate baseline groundwater quality data (greater than two years monitoring) for this project. Basic statistics for pH and EC at each monitoring bore are outlined in Table 6.

Table 6 Existing Groundwater Quality Data (pH and EC)

TAC Monitoring Bore	pH					EC (µS/cm)				
	Min	Max	Av	20%[a]	80%[b]	Min	Max	Av	20%[a]	80%[b]
219	4.1	5.8	4.6	4.4	4.7	180	290	223	210	238
220	4.3	5.9	5.1	4.9	5.3	110	330	195	170	220
221	4.0	5.5	4.8	4.6	5.0	130	320	178	150	200
237	4.0	6.1	5.6	5.5	5.8	160	480	313	270	370
238	4.2	6.1	5.2	5.0	5.5	150	600	309	200	400
254	4.2	6.5	5.2	5.0	5.4	110	240	141	120	150

[2] Fluoride emissions occur as part of the aluminium smelting process, resulting in potential impacts on surface water and groundwater quality.

TAC Monitoring Bore	pH					EC (µS/cm)				
	Min	Max	Av	20%[a]	80%[b]	Min	Max	Av	20%[a]	80%[b]
255	4.1	5.9	5.0	4.9	5.2	240	470	315	272	350
256	4.2	6.3	5.6	5.5	5.7	370	1200	589	490	668
311	4.2	5.8	5.4	5.2	5.6	100	580	232	150	286
312	4.6	6.2	5.4	5.2	5.6	100	640	317	102	502

a 20th percentile of reported data

b 80th percentile of reported data

Groundwater in the vicinity of the site is generally fresh and slightly to moderately acidic. Groundwater pH and EC are generally consistent spatially across the monitoring bores, although both appear to increase slightly in a southerly direction towards the Hunter River as groundwater begins to interact with estuarine water.

Temporal pH variation at each monitoring location is relatively small, with only a 0.2 to 0.5 pH unit difference in the 20th percentile and 80th percentile pH at each bore. Based on a visual assessment of the time series pH plots in Appendix B, temporal trends are not evident. The Mann-Kendall non-parametric trend test has been applied to these datasets using Minitab statistical software to detect statistically significant trends. At the 95% confidence level, Mann-Kendall testing indicates that there are statistically significant increasing trends in pH at northern bores 237, 220 and 221 and at eastern bores 238 and 255 over the period 2005 to 2010. Statistically significant decreasing trends are evident at eastern bores 311, 312 and 254 over this period. Sen’s slope analysis indicates that the slope of these trends are equal to or less than the limit of reading of pH (0.01 pH unit) and therefore may be largely attributable to the accuracy of pH measurement in the field and the time of day at which the measurement was taken relative to tidal variation.

Temporal EC variation appears to be slightly higher closer to the Hunter River, likely as a result of interaction with estuarine water and tidal variation, as shown in the time series EC plots in Appendix B. At the 95% confidence level, Mann-Kendall testing indicates that there are statistically significant increasing trends in EC at northern bore 219 and at eastern bores 311, 312, 255 and 256 over the period 2005 to 2010. Statistically significant decreasing trends are evident at northern bore 237 and at eastern bores 238 and 254 over this period. Sen’s slope analysis indicates that the slope of these trends are equal to or less than the limit of reading of EC (1 mS/m) with the exception of bore 312 which is the closest bore to the Hunter River and most affected by tidal variation.

Fluoride

Average groundwater fluoride concentration data presented in the TAC Annual Environment Report 2009 for the period 2005 to 2009 for selected monitoring bores are outlined in Table 7 and plotted in Appendix B.

Table 7 Existing Average Groundwater Fluoride Concentration Data

TAC Monitoring Bore	Fluoride (mg/L)				
	2005	2006	2007	2008	2009
219	0.11	0.11	0.12	0.12	0.12
220	0.61	1.09	0.75	1.97	2.27
221	1.49	1.09	2.26	4.30	4.41
237	0.16	0.12	0.26	0.47	0.13
238	4.95	5.04	4.33	2.43	2.11
254	0.44	0.57	1.85	3.18	3.17
255	1.31	1.23	2.16	3.46	3.94
256	0.76	0.64	1.32	1.88	1.72
311	-	-	-	13.0	11.0
312	-	-	-	4.65	4.29

Average fluoride concentrations at most monitoring bores exceeded the Australian Drinking Water Guideline (NHMRC, 2004) health based guideline for fluoride of 1.5 mg/L, particularly in more recent years. Fluoride concentrations at several locations increased over the period 2005 to 2008, particularly those to the south east of the smelter site (reflecting the direction of groundwater flow), and then stabilised or reduced slightly between 2008 and 2009. The concentration of fluoride at the monitoring bores closest to the project site (254, 255, 256 and 312) exceeded the drinking water guideline by up to three times in 2009.

Available fluoride data from HWC are limited to results reported between 1997 and 2004 at monitoring bores 508 and BL046 to the west of the project site. 20th and 80th percentile concentrations are 0.02mg/L and 0.05mg/L for bore 508 and 0.04mg/L and 0.1mg/L for bore BL046. These concentrations are one to two orders of magnitude lower than the Australian Drinking Water Guideline (NHMRC, 2004) health based guideline for fluoride of 1.5mg/L.

Other Parameters

Limited groundwater quality sampling was undertaken by Coffey Geotechnics as part of a groundwater assessment to the north of the site (Coffey Geotechnics, 2011). No detections in petroleum hydrocarbons were detected, while exceedances above ANZECC/ARMCANZ (2000) fresh water trigger values for the protection of 95% aquatic ecosystems were reported for dissolved chromium III + VI (slightly above the trigger value for Cr VI), iron and zinc.

These heavy metal concentrations are likely indicative of background concentrations of the Tomago Sandbeds. The mobilisation of iron and other metals, including arsenic, aluminium, zinc, and manganese, within the Tomago Sandbeds has been induced through the oxidation of grey sands found at 13 m to 21 m below ground level (bgl). This oxidation process has a well-documented link to the historical mineral sand mining and water extraction that has taken place within the Sandbeds (Woolley et al., 1995).

4.4 Groundwater Quantity Impact Analysis

A preliminary steady state hydrogeological numerical model was used to assess the impact of the proposed project on groundwater levels within the unconfined sand aquifer. The model is based on the conceptual model outlined in Section 4.3. Note that the model includes various simplifications and assumptions and only provides a preliminary representation of the groundwater resource for the purpose of impact assessment. It has been developed with reference to the Murray-Darling Basin Commission Groundwater Flow Modelling Guideline (Murray-Darling Basin Commission, 2000).

4.4.1 Data Input

Data requirements for the model can be divided into hydrogeological framework data and hydrological stress data.

Hydrogeological framework data includes extent, thicknesses and boundaries of geological (and aquifer) units, and aquifer properties (hydraulic conductivity, porosity, specific yield etc). The framework data included in the model are:

- Ground surface contours (2 m) to represent the top elevation of the aquifer.
- Base elevations of the sand unit (obtained from Coffey Geotechnics (2011)) to represent the bottom elevations of the aquifer. The base elevations generally range from – 15 m to – 30 m AHD in the vicinity of the modelling area.
- Northern extents of the local hydrogeological flow domain, defined by the groundwater divide (approximate location obtained from Coffey (2011)). The groundwater divide is assumed to be a no flow boundary.
- Southern extent of the local hydrogeological flow domain, defined by the Hunter River (assumed to be a constant head boundary of 0 m AHD for the steady state simulation).
- Western extent defined by the groundwater divide and area of bedrock outcrop, while the eastern extent is just beyond the Kooragang RAMSAR wetland boundary. Eastern and western extents of the local hydrogeological flow domain are assumed to be no flow boundaries as groundwater flow is generally in a southerly direction.
- Material properties for the sand aquifer defined by previously published values (Woolley et al, 1995) and model calibration:
  - Sand hydraulic conductivity in the range 10 to 20m/d (refined by model calibration).
  - Vertical anisotropy (k_h/k_v) of 10.
  - Porosity of 0.3.
  - Specific storage and specific yield defined by model calibration.

Hydrological stress data includes the time varying hydrological data such as natural recharge, injection/extraction and other sources and sinks. These data have been sourced from the following:

- Average annual rainfall based on historical daily rainfall data from Raymond Terrace (Bureau of Meteorology station number 61031). The recharge coefficient has been defined by model calibration.
- Various infiltration scenarios (outlined in Section 2.1) have been assessed.

4.4.2 Model Assumptions

Since the hydrogeological model is based on limited data and is a simplified conceptualisation of the hydrogeological system, it was necessary to make assumptions. Assumptions and limitations are outlined as follows:

- The top and bottom elevations of the sand aquifer have been defined by relatively coarse contours (2 – 5 m intervals).
- There is no vertical seepage between the sand aquifer and underlying Medowie Clay.
- Aquifer material properties do not vary in time or space (horizontally or vertically) over the model domain.
- Groundwater divide was assumed to be in a fixed location, presented by Coffey Geotechnics (2011).
- The head level of the Hunter River and Fullerton Cove does not vary over time (0 m AHD). The potential impacts of climate change on water levels in the Hunter River have not been considered.
- The recharge coefficient does not vary in time or space over the model domain and incorporates the effects of evapotranspiration.
- Observed groundwater levels reported in March 2005 represent steady state groundwater conditions.
- No other sources or sinks, other than those already outlined, have been considered (such as creeks, streams or drains).

4.4.3 Model Construction

The conceptual understanding of the hydrogeological system in the vicinity of the site was used in developing a steady state three-dimensional MODFLOW numerical model of groundwater flow. MODFLOW is a finite difference flow model from the United States Geological Survey (USGS) and is one of the industry standard codes for numerical groundwater modelling. The model was built using the Groundwater Modelling System (GMS) software. GMS is a three-dimensional user interface for the MODFLOW groundwater modelling code.

The maximum east-west and north-south extents of the model grid are 5.4 km and 6.8 km respectively, divided into equally sized cells with dimensions 10 m × 10 m. The active modelling area (defined by boundaries outlined in Section 4.4.1) is composed of 186,588 cells and covers an area of approximately 18.7 km^2. The active modelling boundary is shown in Figure 4. The model consists of one layer (sand aquifer) with top and bottom elevations defined as outlined in Section 4.4.1.

4.4.4 Modelling Approach

Modelling of existing and proposed conditions was undertaken under steady state conditions. It is considered that a steady state simulation is sufficient for this assessment because the groundwater level is anticipated to rise as a result of the project (due to stormwater infiltration) and therefore the focus is on impacts to GDEs (rather than basic landholder rights and licensed extractions) which are impacted by long term change in groundwater quantity.

4.4.5 Model Calibration

A steady state groundwater model for existing conditions (ie without source and sink changes associated with the project site) was run and calibrated against observed groundwater levels from March 2005. Each cell (apart from constant head cells) was assigned a starting head of zero for the steady state simulation.

Best fit steady state modelled groundwater elevations for existing conditions are shown in Figure 5. Residuals between modelled and observed elevations were calculated and used to generate the following calibration statistics:

- Sum of residuals (0.5 weighting) = -0.04.
- Sum of Squares (SSQ) = 0.02.
- Root Mean Square (RMS) = 0.06.
- Scaled Root Mean Square (SRMS) = 5.1%.

According to the Murray-Darling Basin Commission (2000) Groundwater Flow Modelling Guideline, a SRMS in the order of 5% indicates that the ratio of error to total head differential is small and that errors are only a small part of the overall model response. Note that the model has been calibrated against observed data in the vicinity of the site (bores mapped in Figure 2) and therefore the degree of calibration at the model extents may not be as high.

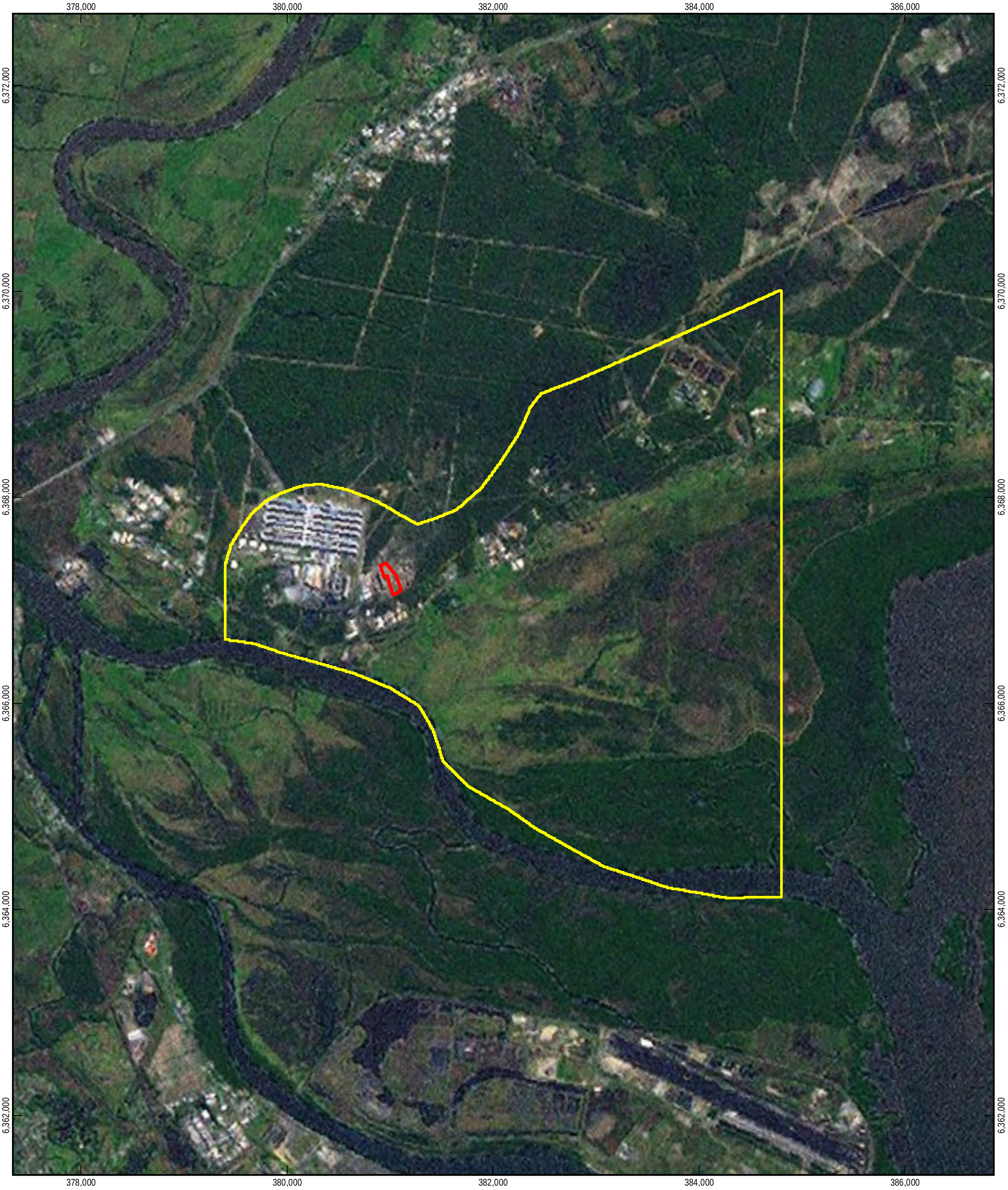
The calibrated parameter values are as follows:

- Horizontal hydraulic conductivity = 11 m/d.
- Aquifer specific storage = 0.00001.
- Aquifer specific yield = 0.05.
- Recharge coefficient = 10%.

Note that these calibrated parameter values have also been verified under transient conditions to ensure that the model appropriately responds to a range of storm events.

The water balance flows for the calibrated steady state model (existing conditions) are as follows:

- Inflow:
  - Recharge = 5,199 m^3/d.
  - Constant Heads = 213 m^3/d.
- Outflow:
  - Constant Heads = 5,412 m^3/d.



LEGEND

Site Boundary

Active Modelling Area MODFLOW

1:50,000 Paper Size A4

0 375 750 1,125 1,500

Metres

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

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Active Modelling Area of
MODFLOW Groundwater Model

Figure 4

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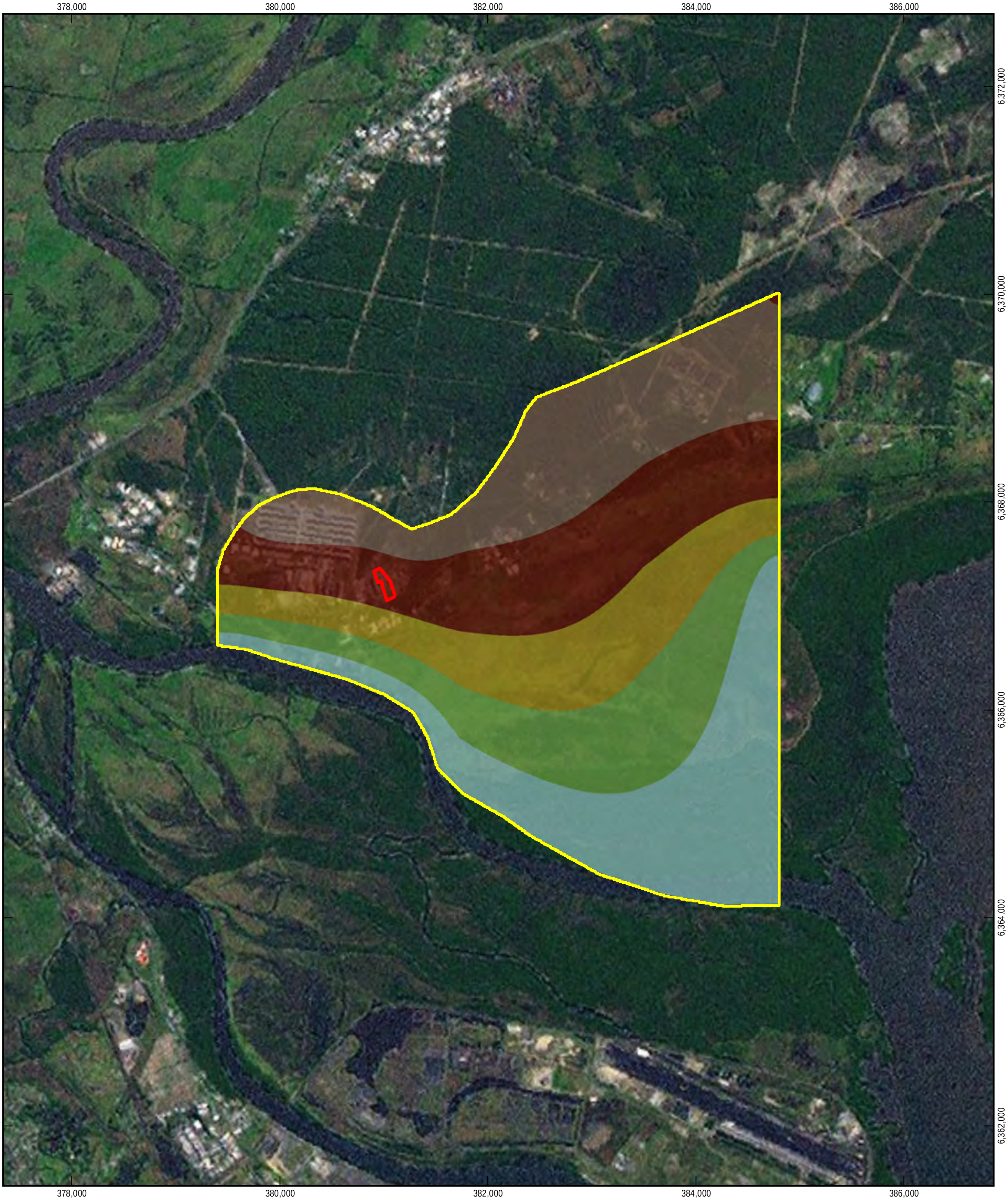
G:\22\15280\GIS\Maps\Working\NOW_Report_StuartGray\22_1528031_004_ActiveModellingAreaMODFLOW_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier



LEGEND
Site Boundary
Active Modelling Area MODFLOW

Steady State Groundwater Elevations
Elevation
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1

1:50,000 Paper Size A4
0 375 750 1,125 1,500
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Modelled Steady State Groundwater Elevations – Existing Conditions

Figure 5

G:\22\15280\GIS\Maps\Working\NOW_Report_StuartGray\22_1528031_005_SteadyStateGroundwaterElevations_RevA.mxd

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

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier

4.4.7 Model Predictions

Following calibration, the steady state model was run under proposed development conditions. Under these conditions, the following changes were made to model sources and sinks:

- The recharge coefficient over the project site was reduced to zero (although the same average annual rainfall was used).
- Infiltration wells were included throughout the proposed subsoil irrigation of treated wastewater and stormwater infiltration areas within the project site boundary. The following total infiltration scenarios (as outlined in section 2.1) were modelled:
  - Scenario 1: 60 m^3/d.
  - Scenario 2: 50 m^3/d.
  - Scenario 3: 40 m^3/d.
  - Scenario 4: 20 m^3/d.

Predicted changes to steady state groundwater elevations for each infiltration scenario are shown in Figure 6 to Figure 9. A rise in groundwater elevation is predicted in each case, ranging from a maximum rise of 0.05 m for 20m^3/d infiltration to 0.21 m for 60m^3/d infiltration. In each case, the maximum groundwater rise occurs at the project site, and the radius of influence extends over 2 km for the 50m^3/d and 60m^3/d infiltration scenarios.

The rise in groundwater elevation associated with site development is the result of an increase in rainfall run-off from the site from non-permeable surfaces (such as buildings, paths, roads and carparks) requiring recharge back into the aquifer system. Under pre-development (existing) conditions infiltrating rainfall is retained for longer periods on the ground surface and in the shallow unsaturated zone where it either evaporates, is taken up by vegetation or is retained within unsaturated pore spaces.

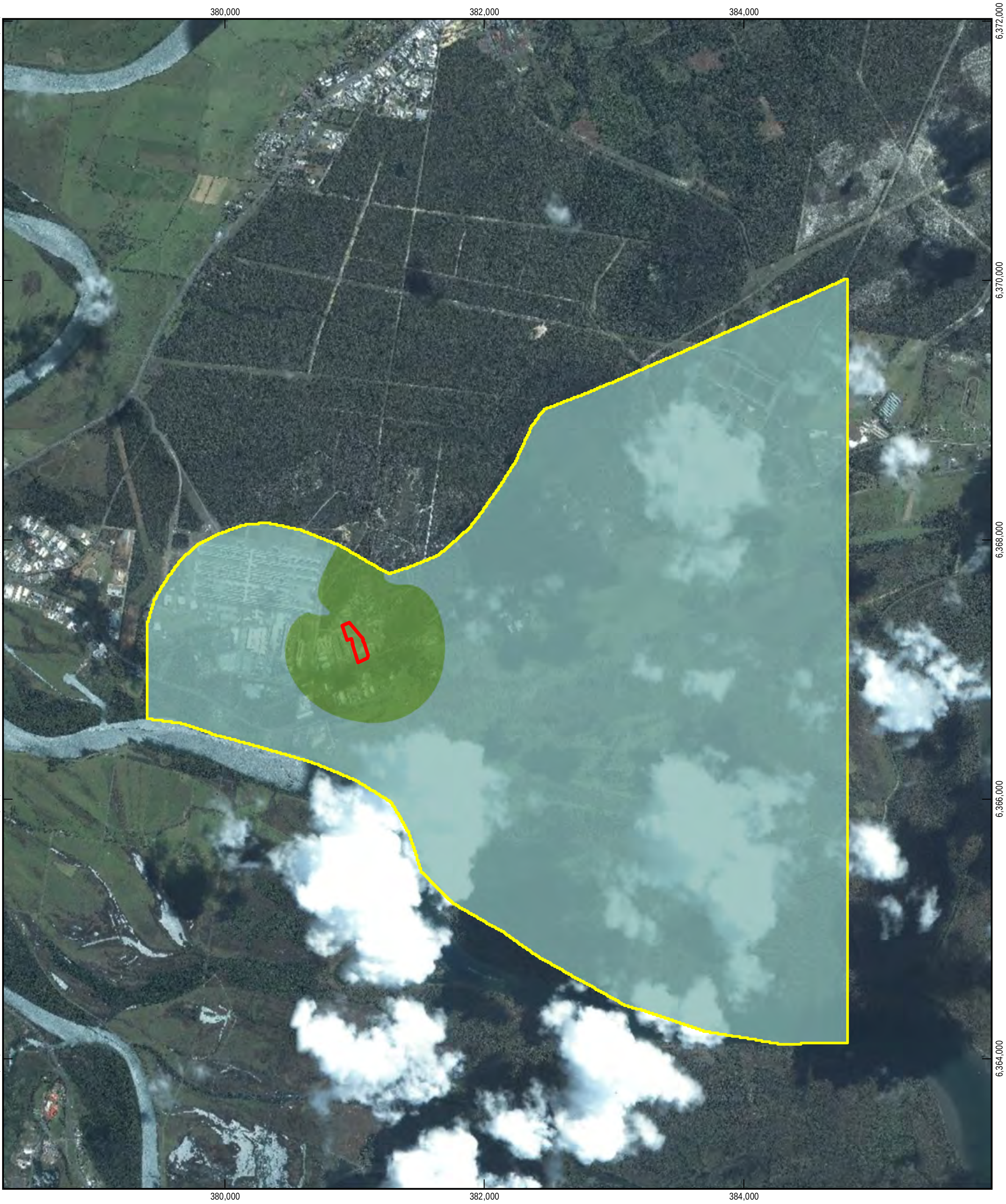
The water balance flows for the steady state model under proposed conditions (using figures from the 50m^3/d infiltration scenario) are as follows:

- Inflow:
  - Recharge = 5,188m^3/d (11m^3/d less than existing conditions).
  - Constant Heads = 204m^3/d.
  - Infiltration Wells = 50m^3/d.
- Outflow:
  - Constant Heads = 5,442m^3/d.

There is a net increase in water inflow to groundwater (approximately 30m^3/d for the infiltration of 50m^3/d scenario) within the model domain as a result of input from the infiltration system exceeding the reduction in rainfall recharge.

4.4.8 Assessment of Groundwater Quantity Impacts

Since an increase in groundwater elevation is expected throughout the modelling domain, there will not be a reduction in groundwater availability for basic landholder rights or licensed groundwater extraction in the vicinity of the project site. In addition, the relatively minor changes in groundwater elevation are not expected to adversely affect hydraulic gradients or groundwater velocity.



LEGEND

Site Boundary

Active Modelling Area MODFLOW

Change in Groundwater Elevation 20m3/d
Elevation

0.01 - 0.05

0.00 - 0.01

1:40,000 Paper Size A4

0 300 600 900 1,200

Metres

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

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Predicted Change in Steady State
Groundwater Elevation – Infiltration 20 m3/d

Figure 6

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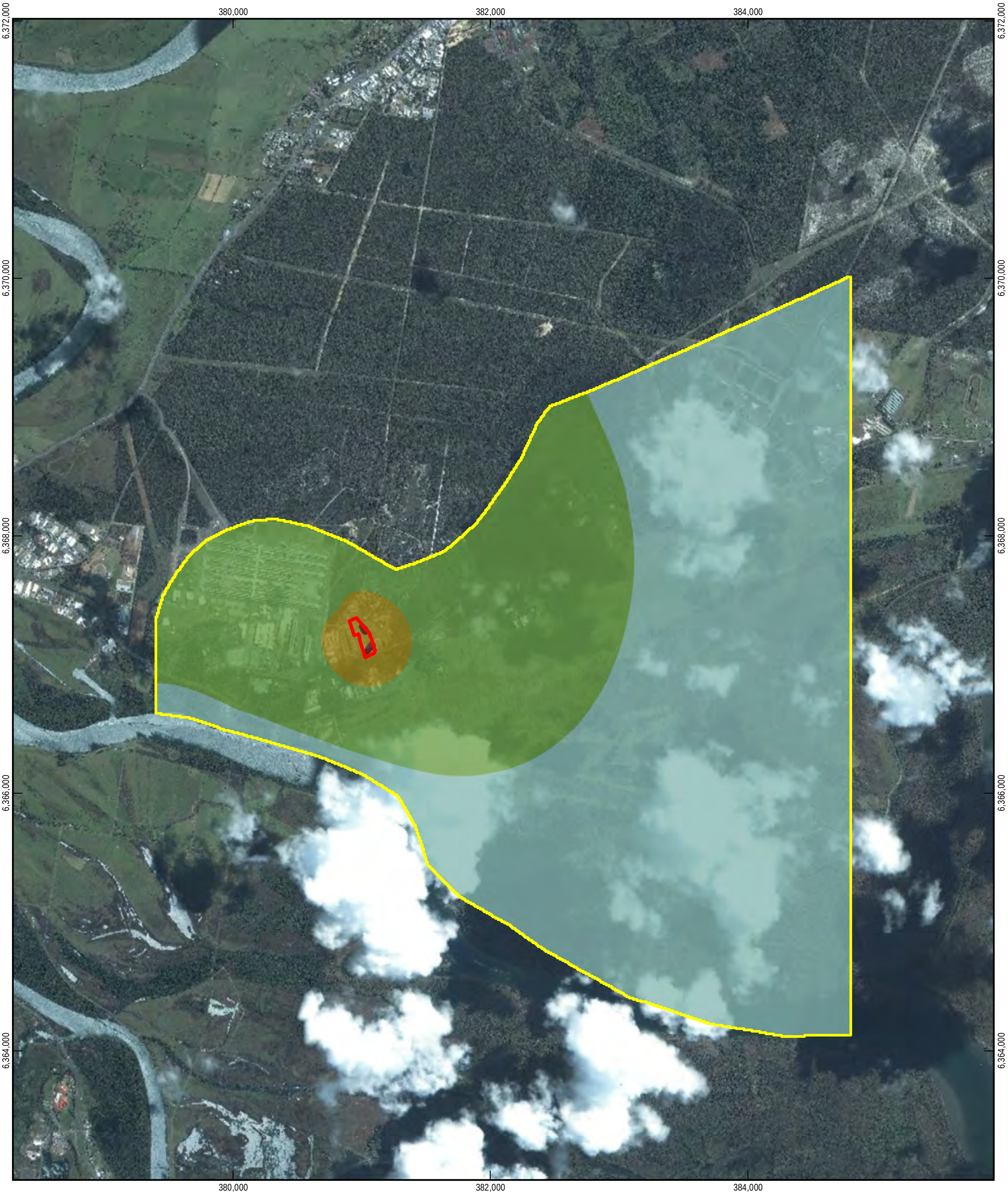

LEGEND

Site Boundary

Active Modelling Area MODFLOW

Change in Groundwater Elevation 40m3/d

Elevation

0.10 - 0.15

0.05 - 0.10

0.01 - 0.05

0.00 - 0.01

1:40,000 Paper Size A4

0 300 600 900 1,200

Metres

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

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Predicted Change in Steady State Groundwater Elevation – Infiltration 40 m3/d

Figure 7

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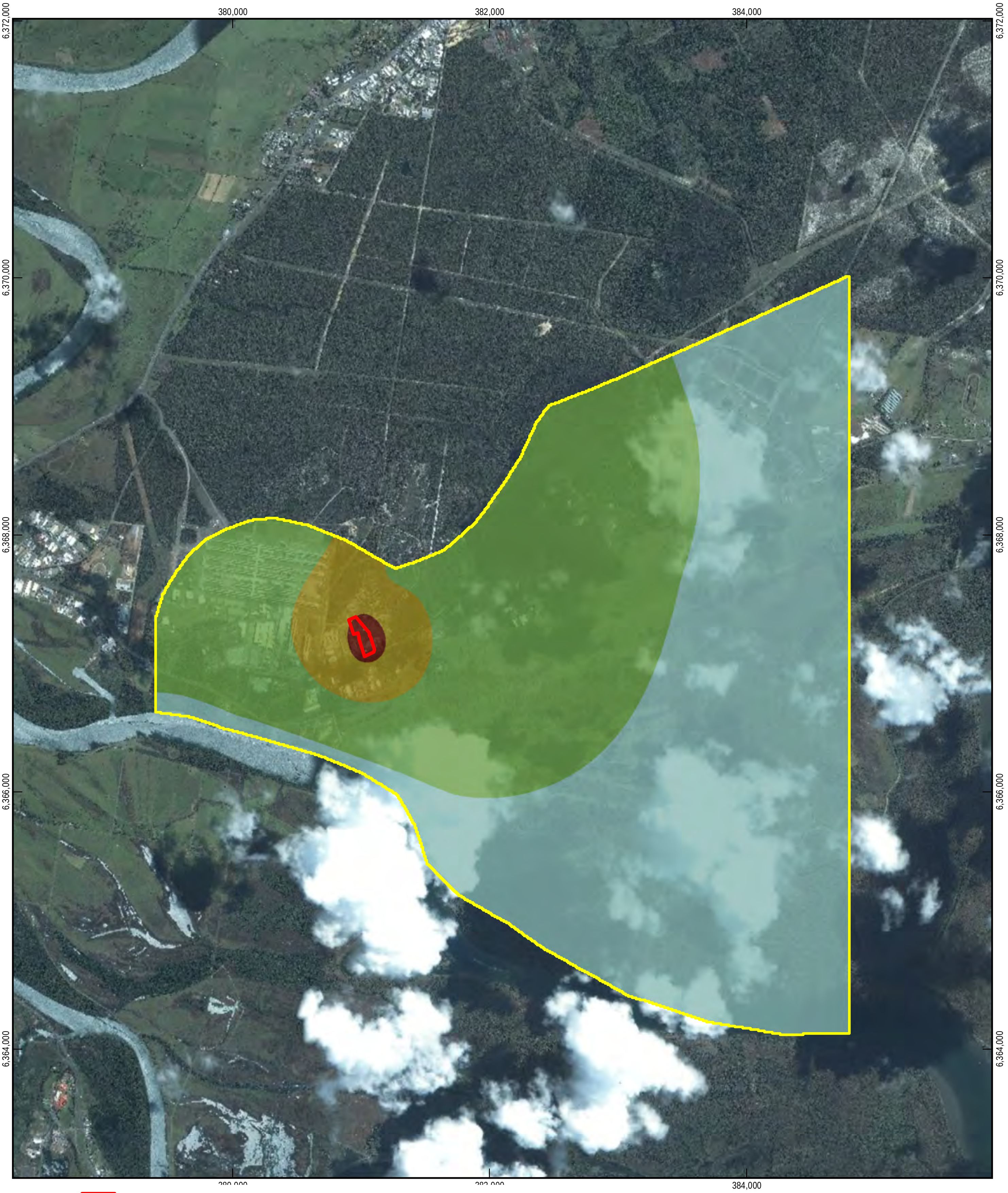
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier



LEGEND

- Site Boundary
- Active Modelling Area MODFLOW

Change in Groundwater Elevation 50m3/d

Elevation

- 0.15 - 0.20
- 0.10 - 0.15
- 0.05 - 0.10
- 0.01 - 0.05
- 0.00 - 0.01

1:40,000 Paper Size A4

0 300 600 900 1,200

Metres

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

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Predicted Change in Steady State Groundwater Elevation – Infiltration 50 m3/d

Figure 8

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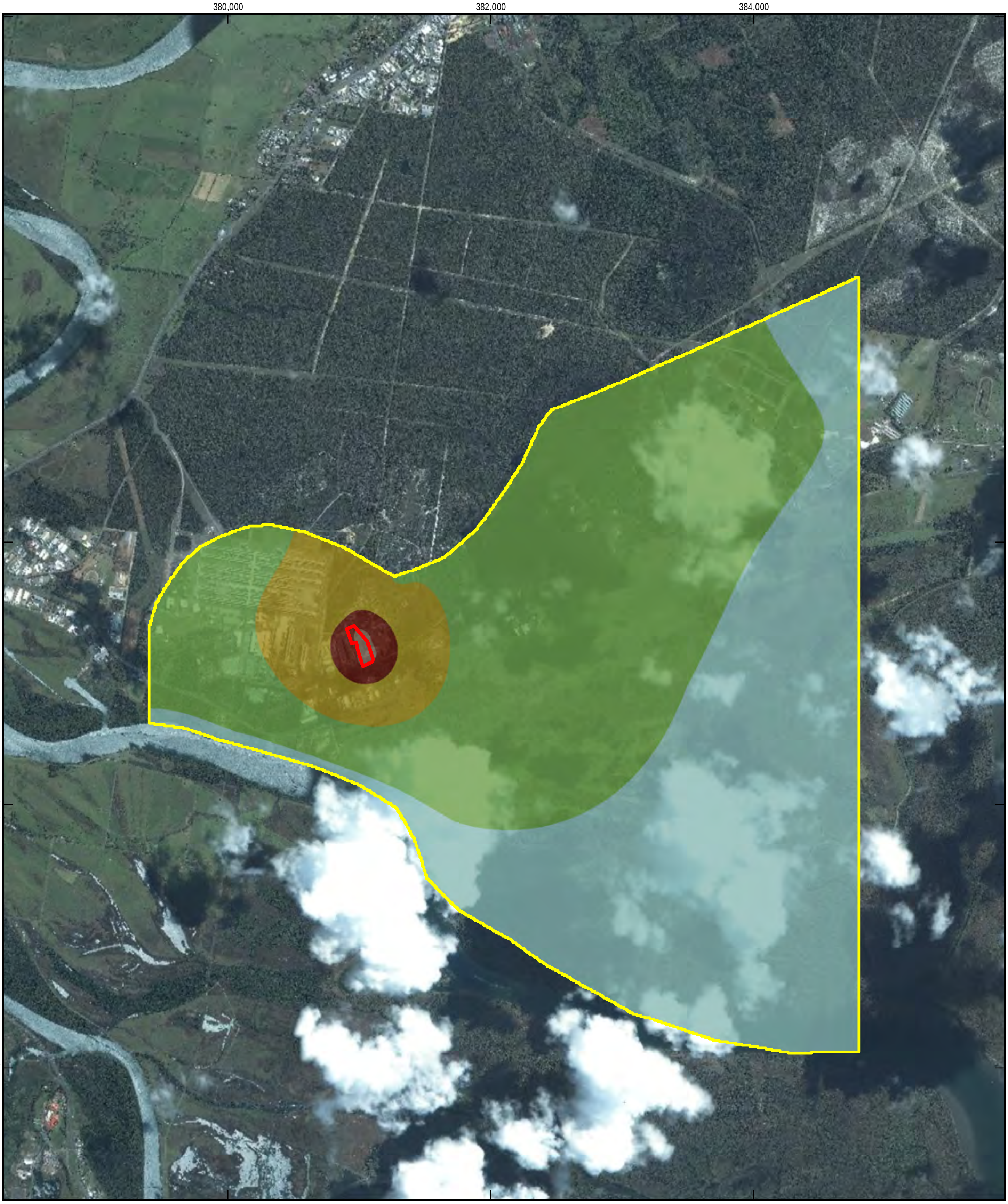

LEGEND

Site Boundary

Active Modelling Area MODFLOW

Change in Groundwater Elevation 60m3/d

Elevation

0.20 - 0.25
0.15 - 0.20
0.10 - 0.15
0.05 - 0.10
0.01 - 0.05
0.00 - 0.01

1:40,000 Paper Size A4

0 300 600 900 1,200

Metres

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

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Predicted Change in Steady State Groundwater Elevation – Infiltration 60 m3/d

Figure 9

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G:\22\15280\GIS\Maps\Working\NOW_Report_StuartGray\22_1528031_009_ChangeSteadyStateGrndwtrInfil60md_RevA.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier

Should temporary excavations made during the construction phase be likely to intercept groundwater, they are unlikely to have any far reaching or long term effects. Nevertheless, the NOW would be consulted to confirm whether a licence is required under the Water Management Act 2000. Where possible, excavations should be scheduled to avoid interaction with the fluctuating groundwater level.

The assessment of impacts of groundwater elevation changes on GDEs and critical thresholds are included in Section 5.

4.5 Groundwater Quality Impact Analysis

The existing quality of groundwater underlying the site is generally fresh and slightly to moderately acidic. It is anticipated that petroleum hydrocarbon compounds are not currently present in the groundwater and that heavy metal concentrations are representative of the variable and often elevated concentrations throughout the Tomago Sandbeds.

Potential impacts to groundwater quality may result from:

- Accidental spills/leaks of fuels and oils and general runoff of petroleum hydrocarbons and subsequent injection into the groundwater system.
- Long term changes to pH and EC.

Section 3.3 indicates that wastewater will be treated to an advanced secondary level and then used for subsurface irrigation. During detailed design, the irrigation system will be refined to ensure compliance with Council's guidelines and the Environmental Guidelines fo Reuse of Effluent by Irrigation (2003). Details regarding the surface area of the irrigation zone and the type of vegetation will be confirmed to ensure that there is sufficient nutrient uptake to minimise the potential for eutrophication due to the project.

As outlined in Section 3.4.2, stormwater will pass through a GPT prior to discharge via the infiltration system. It is anticipated that groundwater quality impacts would be minimal and not result in a need for remediation if the following controls are in place:

- Emergency spill response plan, as outlined in Section 3.4.
- Bunded areas for fuel and oil storage and vehicle refuelling.
- Vehicle inspection and maintenance.
- Preparation and implementation of environmental management plans for the construction and operation of the project.
- Monitoring of stormwater prior to discharge to the infiltration system.
- Monitoring of groundwater bores down gradient of the project site (as detailed in Section 4.6).

4.6 Groundwater Monitoring Plan

A Groundwater Monitoring Plan (GMP), incorporating a response plan, should be prepared prior to construction and detail monitoring requirements pre-construction, during construction and during the operation of the facility. Considering the existing hydrogeological environment and the levels of impact determined in this assessment, the GMP design should be as follows:

4.6.1 Monitoring Locations and Frequency

Groundwater monitoring should be undertaken at a location up gradient of the project site and at two locations down gradient of the site and down gradient of the infiltration areas. It may be possible to utilise existing TAC bores, at least for the up gradient monitoring location. The monitoring bores should be screened within the unsaturated zone and across the groundwater surface so that light petroleum based compounds (that are lighter than water) will be detected. Note that water supply works approvals (Water Management Act 2000) will be required for new monitoring bores.

It is considered that monthly monitoring is sufficient, considering the rate of groundwater flow (in the order of 2 m per month).

4.6.2 Parameters

pH, EC and depth to groundwater should be monitored monthly, while quarterly monitoring is sufficient for total petroleum hydrocarbons (with silica gel cleanup[3]). Monitoring of major cations/anions and dissolved heavy metals would be triggered by trend analysis of pH and EC data.

Due to the on site subsoil irrigation, the groundwater will also be monitored quarterly for total nitrogen (including ammonia and nitrates) and total phosphorus (including reactive phosphorus). This monitoring should be undertaken within the existing monitoring bore network and commence during construction of the facility so that baseline concentration data can be established.

4.6.3 Trigger Values and Response

It is expected that pH and EC values will remain within the range previously reported in the vicinity of the site (Table 6). However, an annual review of pH, EC and nutrient data should be undertaken and non-parametric trend analysis should be carried out. Based on the results of this annual review, a trigger and response plan should be implemented as follows:

- If a statistically significant decreasing trend in pH is evident, undertake quarterly monitoring for dissolved heavy metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Hg, Ni, Zn) until the cause is identified.
- If a statistically significant increasing trend in EC is evident, undertake major cation and anion monitoring on a quarterly basis until cause is identified.
- If a statistically significant increasing trend in nutrients is evident, the nutrient balance and performance of irrigation system should be reviewed.

In addition, should petroleum based compounds be detected in groundwater, the source and likely volume of leak/spill should be identified. If dissolved concentrations exceed 600 µg/L (Dutch intervention level for mineral oil in groundwater (MHSPE, 1994)), undertake natural attenuation modelling to assess whether natural attenuation processes are sufficient to remediate spill.

[3] A silica gel clean up removes natural polar compounds in the sample extract, allowing only non polar petroleum based compounds to be analysed by the Gas Chromatograph – Flame Ionisation Detector (GC-FID).

Groundwater hydrographs should be reviewed annually to verify that actual groundwater elevation changes are consistent with predicted changes in this assessment. Should increases in groundwater elevation be greater than expected, impacts on GDEs should be reassessed.

5. Groundwater Dependant Ecosystems

5.1 NSW State Groundwater Dependant Ecosystems Policy 2002

The *NSW State Groundwater Dependant Ecosystems Policy 2002* defines the planning, regulatory and practical context for identifying, assessing, managing and monitoring GDEs. This policy framework has been adopted by NOW, and forms the purpose of GHD's assessment.

There are five principles stated in the policy that are used to consider GDEs within the context of other competing demands for groundwater, these being:

1. GDEs have scientific, aesthetic, ecological and economic values, including threats and species management requirements, to ensure the protection of vulnerable and valuable systems.
2. Groundwater extractions must be sustainable within the context of biological systems dependant on the related groundwater aquifers.
3. Supply of groundwater resources to protect known GDEs must be maintained particularly those under a high degree of threat from extraction activities.
4. Apply the precautionary principle to protect GDEs where there is limited scientific certainty.
5. Planning, approval and management of development should aim to minimise impacts on GDEs by maintaining existing GDEs, avoiding the pollution of groundwater resources and rehabilitating degraded groundwater systems.

5.2 Background

A GDE is an ecosystem where the species composition and natural ecological processes are entirely or partly determined by groundwater (Department of Land and Water Conservation, 2002), and is therefore reliant on groundwater for at least some of its water requirements. GDEs include wetlands and red gum forests, some terrestrial vegetation communities, ecosystems in streams fed by groundwater, limestone cave systems, springs, and hanging valleys and swamps. For such ecosystems, access to groundwater can be critically important to the maintenance of ecosystem viability and biodiversity.

Surface GDEs can be considered in two classes. The first class is reliant on the surface expression of groundwater and includes swamps, wetlands and rivers, while the second class relies on the availability of groundwater below the surface but within the rooting depth of the vegetation (Eamus, 2009).

The dependency upon groundwater of these ecosystems varies, with obligate and facultative dependent ecosystems recognised (DLWC, 2002). Obligate GDEs are highly dependent and groundwater forms a critically important water source in the hydrological regime of the ecosystem. In addition to water supply reliance on groundwater may include a dependence on water pressure, chemistry, or temperature requirements either seasonally or intermittently (eg during drought). However the term 'obligate' does not necessarily mean that the ecosystem is totally dependent upon, or requiring of, continuous access to groundwater (Howe and Prichard, 2007).

Facultative groundwater dependence refers to an ecosystem where the presence or absence of groundwater is not crucial to the presence of species within an ecosystem. Biota is facultative groundwater dependent if groundwater maintains their habitat conditions in some locations but not others. Other environmental factors such as landscape position, geology, hydrology, and climate, may be of greater importance to the species composition of the ecosystem.

5.3 Potential Impacts on Groundwater Dependent Ecosystems

The recognised threats to GDEs (Sinclair Knight Merz, 2001) include:

- Groundwater resource development.
- Changes in land use – particularly from native vegetation to agriculture or agriculture or native vegetation to plantation forestry.
- Activation of acid sulphate soils in coastal areas by drainage, dredging or groundwater extraction.
- Dewatering or water resource development associated with mining.
- Commercial, urban or recreational developments.

GDEs exposed to these threats may respond by changes in vegetation structure, ecological function and/or biota composition of the ecosystem. It is noted that impacts associated with lowered water tables upon GDEs can take place over an extended time and can lead to decline in growth, recruitment and enable invasion by exotic species (Eamus, 2009).

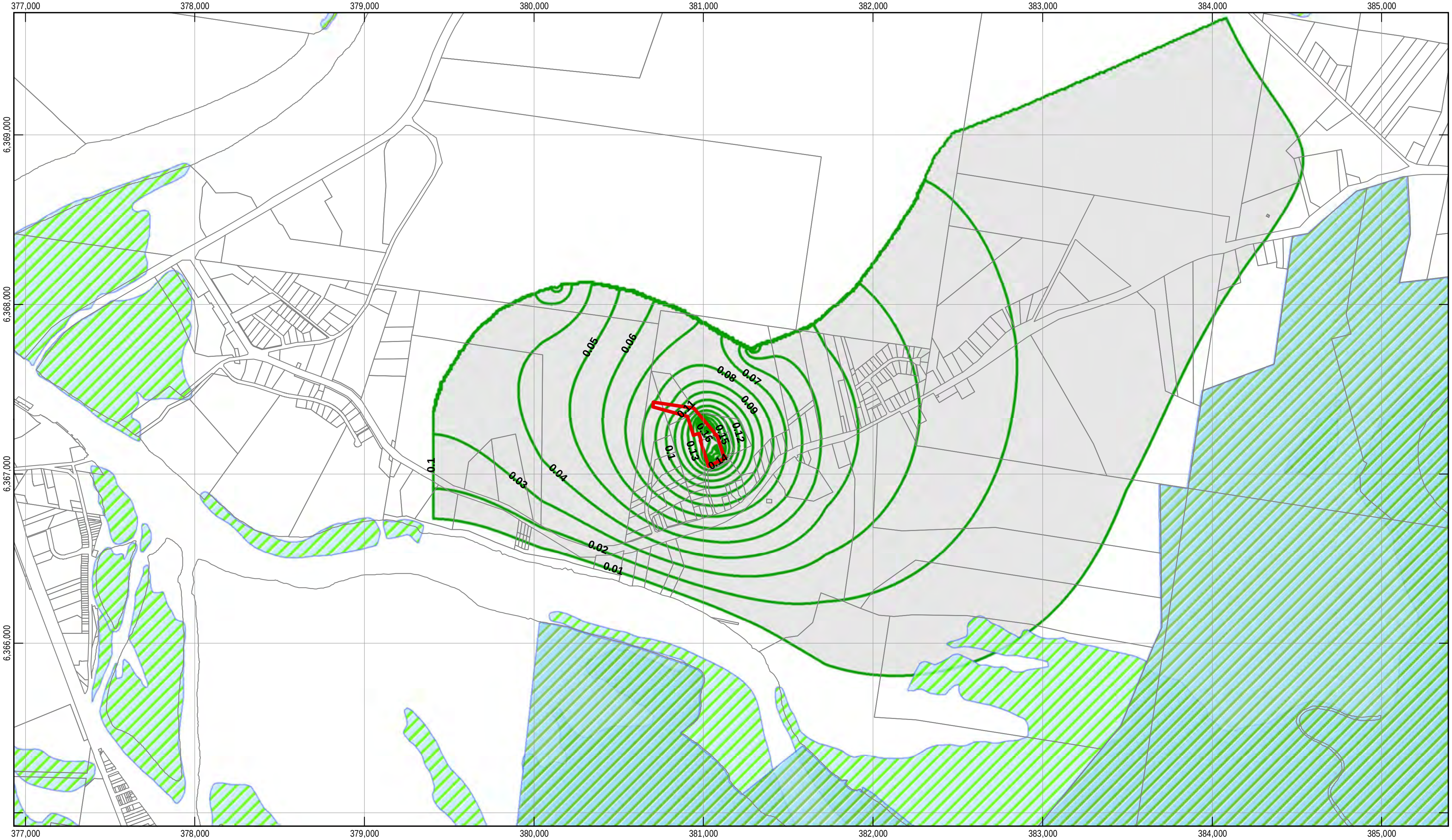
Two threats that may impact on GDEs in the project area are groundwater extraction or mounding resulting in changes to groundwater level or changes to water quality. The potential impacts from these threats form the basis of this assessment.

5.4 Groundwater Elevation Contours and Flow

Groundwater elevation contours modelled from measured groundwater levels in sample bores of the locality are shown in Figure 5. Based on these contours, groundwater is flowing in a southerly direction through the site towards the Hunter River.

5.5 The Study Area

Modelling worst case infiltration rates at the site resulted in the delineation of an irregularly bounded study area extending north, east, south and west from the site as shown in Figure 10. This boundary is mutually exclusive to the mapped boundary of the Hunter Estuary Nature Reserve or RAMSAR site, however, SEPP 14 wetlands were noted within the south eastern boundary of the study area.



Paper Size A4

0 125 250 500 750 1,000

Metres

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

N

LEGEND

- Extent of Works
- Cadastre
- Change60 Contours (m)
- Change60 Greater than 0.1m

NSW Ramsar Wetlands

- Kooragang Island
- Myall Lakes National Park
- SEPP14

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Date	26 Jul 2011

The Study Area for Groundwater Dependant Ecosystems

Figure 10

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier

5.6 GDEs within the Study Area and their Importance

Vegetation cover identified within the Hunter River – Tomago sand beds that may classify as a GDE include:

- Dry sclerophyll woodlands.
- Wallum heathlands.
- Swamp Sclerophyll Forest on Coastal Floodplains.
- Swamp Oak Floodplain Forest.
- Coastal wetlands.
- Mangrove Woodlands.
- Saltmarsh.

The importance of vegetation cover that classify as GDEs within the study area is discussed in the following sections.

5.6.1 International Importance

Vegetation cover contained within the Hunter Estuary Nature Reserve is associated with a RAMSAR site listed on the EPBC Act. Some of this vegetation cover is likely to classify as an obligate wetland GDE. The study area boundary is mutually exclusive to the mapped area of the RAMSAR wetland. As such is predicted that the Project would not have a measurable impact on any GDEs within this RAMSAR wetland.

5.6.2 National Importance

Areas of Smooth-barked Apple – Red Bloodwood shrubby open forest located within the study area that are known to be utilised by the New Holland Mouse (*Pseudomys novaehollandiae*) are regarded as facultative GDEs of national importance. The New Holland Mouse is a mammal species listed as vulnerable on the EPBC Act. It is a species reliant on dry heathy native vegetation formed on coastal sand beds. Wet heathy woodlands, shrublands and heath on coastal sands are generally unsuitable for the New Holland Mouse with such vegetation generally supporting other native rodent species (eg Swamp Rat). Changes in depth to groundwater have the potential to influence vegetation diversity hence habitat suitability (Fox and Fox, 1978).

5.6.3 State Importance

SEPP 14 wetlands 815 (Siddon's Swamp), 816 (Blind Harry's Swamp) and 835 (part of the Hunter Estuary Wetland complex) occur adjacent too but outside the study area boundary. Part of SEPP 14 wetland no. 817 occurs within the study area near its southeastern corner and as such will be considered in this assessment.

Two TSC Act listed endangered ecological communities classified as 'obligate wetland or seasonal inundation GDEs' (Swamp Mahogany Swamp Forest and Swamp Oak Swamp Forest), which are not mapped as SEPP 14 wetlands, occur within the study area (ie access to groundwater is critical for their survival). A description of these GDEs is provided as follows:

Broadleaved Paperbark - Swamp Mahogany Swamp Forests

The canopy of this community is dominated by *Melaleuca quinquenervia* (Broadleaved paperbark) and to a lesser extent *Eucalyptus robusta* (Swamp Mahogany) up to 15 m tall and dense projected crown cover estimated to range between 30-50%. The occasional *Casuarina glauca* (Swamp Oak) may occur, particularly along edges where this vegetation merges with cleared lands. Bell and Driscoll (2006) identify a number of floristic variants within the study area including Paperbark Swamp Forest, Swamp Mahogany Forest, Paperbark-Mahogany Low Swamp Forest and Fringing Paperbark Forest.

The midstorey is generally described as moderately sparse and dominated by *Glochidion ferdinandi* (Cheese Tree), *Trema tomentosa* (Native Peach) and *Acacia longifolia* (Coastal wattle). The ground layer is dominated by a large number of ferns, were sedges and rushes forming a patchily dense groundcover. The dominant and most common species include *Gahnia clarkei* (Saw-sedge), *Blechnum indicum* (Water Fern), *Pseudoraphis paradoxa, Lomandra longifolia and Schoenus brevifolius*. Forbs including *Hydrocotyle peduncularis* (Pennywort) and *Viola hederacea* (Native Violet) were infrequently present and not dominant, with the majority of the forest floor comprising mainly ferns and dead organic matter. Weed occurrences were largely restricted to Crofton Weed (*Ageratina adenophora*) and Lantana (*Lantana camara*).

Bell and Driscoll (2006) identify this vegetation type to be an obligate GDEs with depth to groundwater locally ranging between 0.9 and 1.0 m.

Swamp Oak Forest

Casuarina glauca (Swamp Oak) dominates the canopy cover of this community; however, there are occasional inclusions of *Melaleuca quinquenervia* (Broadleaved paperbark) and to a lesser extent *Eucalyptus robusta* (Swamp Mahogany). This community also extended to a canopy height of approximately 15 m. The projected crown cover was less than the adjoining vegetation type, typically ranging between 50% and 75%. Almost no weed occurrences were noted in this vegetation type aside from occasional occurrences of *Hydrocotyle bonariensis*.

The midstorey contrasts substantially with the Broadleaved paperbark - Swamp Mahogany forest. A variety of ferns dominate this vegetation community with sedges and rushes forming lesser constituents. Forbs including *Hydrocotyle peduncularis* (Pennywort) and *Viola hederacea* (Native Violet) are characteristic groundcover species along with a variety of other soft stemmed herbs.

5.6.4 Local Importance

The Smooth-barked Apple – Red Bloodwood shrubby open forest is classified as a facultative GDE (ie partial seasonal reliance on groundwater). This vegetation is not listed as an endangered ecological community on either the TSC Act or EPBC Act. Areas where this vegetation does not support the New Holland Mouse classify as a GDE of local importance. A description of this GDE is provided as follows:

Angophora costata (Smooth-barked Apple) and *Corymbia gummifera* (Red Bloodwood) co-dominate as the tree canopy species of this free draining dry sclerophyll heathy woodland. This vegetation is widespread throughout the Tomago sand beds where the canopy is known to include *Eucalyptus pilularis* (Blackbutt) as a third co-dominant. However, local examples of this vegetation type do not support Blackbutt in the canopy stratum, with the absence of this canopy co-dominant potentially linked to localised groundwater conditions (Bell and Driscoll, 2006).

Locally, the midstory is characterised by dense stands of *Monotoca elliptica* with *Banksia serrata* also occasionally frequent. Several taller shrub species including native peas are common (e.g. *Bossieae heterophylla*, *Bossieae rhombifolia* subsp. *rhombifolia, Dillwynia retorta, Aotus ericoides*) together with *Monotoca scoparia*, *Leptospermum trinervium, Eriostemon australasius*, *Pimelea linifolia* and *Amperea xiphoclada* var. *xiphoclada*. The groundcover stratum is generally sparse, particularly beneath areas with a dense midstory. Species observed include *Gonocarpus teucrioides, Lomandra lngifolia, Lomandra glauca, Dianella caerulea, Billardiera scanden, Schoenus ericetorum and Hypolaena fastigata.* Two orchid species were observed including *Acianthus fornicata* and *Pterostylis longifolia*.

Locally, Bell and Driscoll (2006) report the depth to groundwater for this vegetation type being between 3.0 and 3.1 m.

5.7 Predicted Impacts on Groundwater Resources

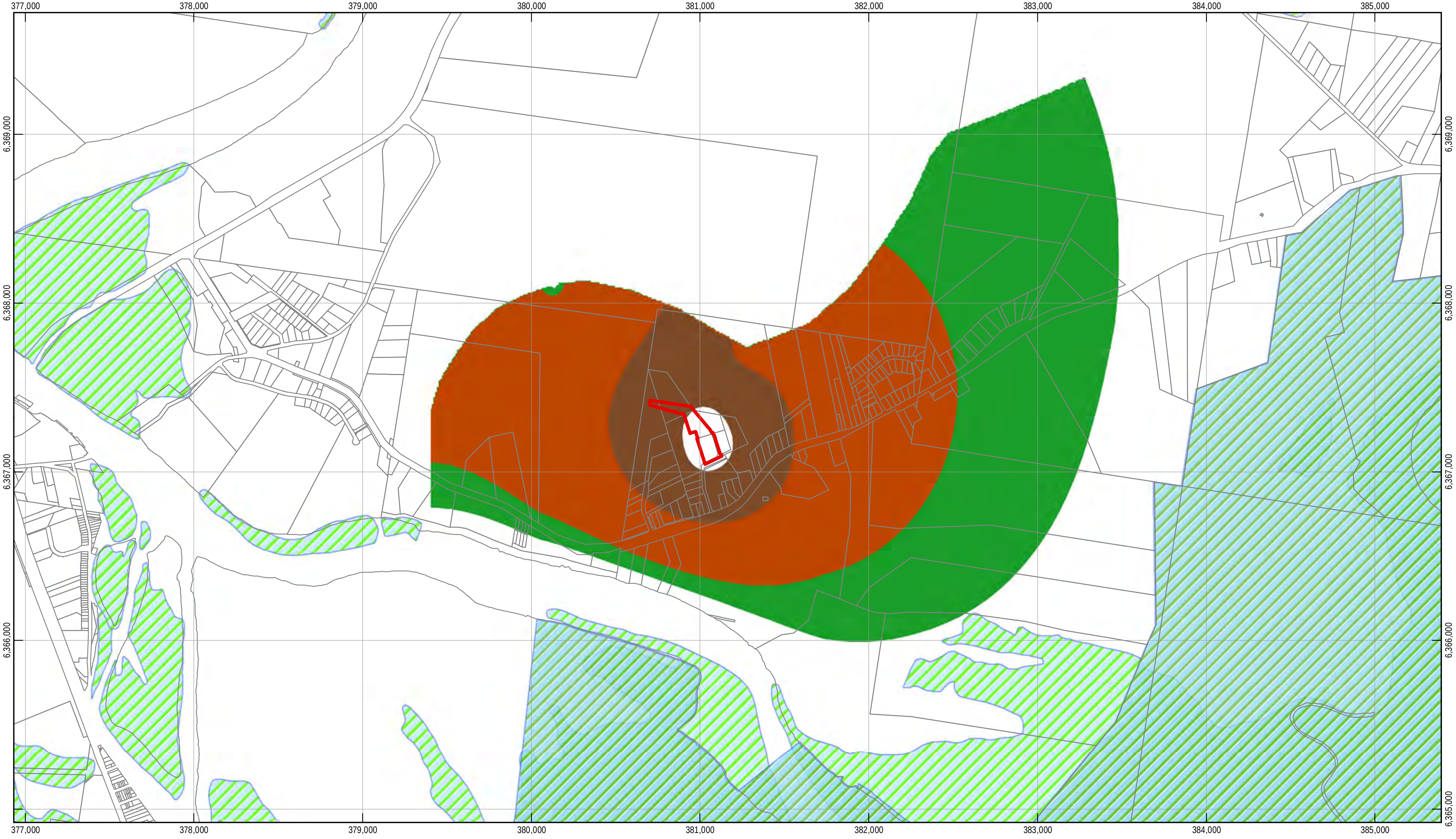
5.7.1 Groundwater Elevations

Predicted for the worst case water infiltration rate scenario (scenario 1) is a net change in steady state depth to groundwater of between 0.01 to 0.16 m. (see Figure 10). The midpoint increase in depth to groundwater (0.08 m) occurs up to 300 m from the site boundary with the greatest distance for detectable change (ie 0.01 m) being approximately 4 km to the northeast of the site. The majority of change occurs within approximately 600 m of the site (0.05 m decrease in depth to groundwater).

Alternative scenarios (ie scenario 2, 3 and 4) show substantial contraction in groundwater mounding beyond the site boundaries. This is evident in modelling for scenario 2 where the horizontal effect of groundwater mounding has contracted by up to 1.5 km as shown in Figure 11. All scenarios show the area of affectation to be greatest within the site and its immediate surrounds.

5.7.2 Groundwater Salinity

Salinity intrusions have the potential to have substantial adversely impacts on GDEs not adapted to saline or brackish environments. These include obligate GDEs such as freshwater wetlands and forested wetlands to facultative GDEs including dry sclerophyll forests. The likelihood of a salinity intrusion is greatest when a groundwater drawdown is predicted. In the case of the Project a groundwater mound with origin centred on the site is predicted. Such predicted groundwater conditions are not likely result in the generation of a salinity intrusion into the underlying aquifers and on that basis it is considered that there would be no impacts on GDEs arising from increased groundwater salinity.



1:30,000 Paper Size A4

0 250 500 750 1,000

Metres

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

N

LEGEND

Site Boundary

Cadastre

Net Change in Groundwater (m)

- 0.01 - 0.02m
- 0.02 - 0.05m
- 0.05 - 0.10m
- 0.10 - 0.15m

Wetlands

- Hunter Estuaries Wetland Ramsar Site
- SEPP14 Wetlands

CLIENTS | PEOPLE | PERFORMANCE

Midal Cables International Pty Ltd
Tomago Rod and Conductor Manfacturing Facility

Job Number	22-15280
Revision	B
Date	17 Aug 2011

Net Change in Steady State Groundwater - Scenario 2

Figure 11

G:\22\15280\GIS\Maps\Working\22_15280_01_MidalGroundwaterFig2_RevB.mxd

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

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:mabarnier

5.7.3 Groundwater Temperature

Groundwater temperature can affect biological activity and potentially ecological diversity. An increased infiltration of surface waters harvested from within the site into the groundwater is likely to have some influence on the existing thermal character of the underlying aquifer. Infiltration rates will be governed by gravity feed, thus limiting the potential for rapid changes in groundwater temperatures at the site and throughout the study area. Tangible changes in thermal gradients in the study area's groundwater resources are likely to be localised to the site and are unlikely to have any measurable impacts on sensitive GDEs located within the study area.

5.7.4 Acid Sulfate Soils

Water quality affected by Acid Sulfate Soils (ASS) can significantly alter the suitability of swamp environments for native plants and is known to be a hostile environmental factor resulting in the simplification of floristic variability and cover. The generation of ASS is only likely to occur in cases where groundwater drawdown is predicted. The infiltration of water into the groundwater aquifer will not result in any groundwater drawdown. The generation of ASS as a consequence of the Project is considered unlikely.

5.7.5 Nutrient loading

The nutrient design calculations show that the site will have a net negative organic loading (BOD) and nitrogen balance and a positive phosphorus balance. Based on a conservative sorption capacity of the imported soil, the irrigation system is expected to last for 86 years before the phosphorus capacity of the soil may be reached.

When a storm event occurs at the site where infiltration will occur (on the assumption that a 5mm rain event will result in infiltration to groundwater, this would happen once at least every 3 months based on the last 30 years of historical data), oxygenated water will come through to oxidise the soil and dilute/flush the system through. Any accumulation in this period that is not dealt with by the nutrient balance with the planted flora, the sorption with the soil or the bio-degradation in the soil would only be in the area immediate to the treatment unit at the site and would not impact GDE's further away.

5.7.6 Summary

The Projects impacts on the groundwater resources are likely to be restricted to a rise in groundwater elevations (ie decrease in depth to groundwater). The predicted impacts are widespread; however, the greatest impacts are largely restricted to vegetation nearby the site where greatest change in depth to groundwater is predicted.

5.8 Impacts on GDEs

No predicted impacts have been identified for RAMSAR, as shown in Figure 10. As such no assessment is required to ascertain the impact on GDEs within this internationally significant area. However, impacts are predicted on obligate GDEs (ie Broad-leaved Paperbark Swamp Mahogany Swamp Forest and Swamp Oak Swamp Forest), SEPP 14 wetland no. 817 and a facultative GDE (ie Smooth-barked Apple Red Bloodwood shrubby open forest). The following sections discuss the Project related impacts on relevant GDEs identified within the study area.

5.8.1 Worst Case Scenario

Scenario 1 or the worst case scenario, as defined by Figure 10 (ie infiltration of the first 30 mm of daily rainfall), predicts the Project to have a small impact on SEPP 14 Wetland 817 (approximately 0.01 m rise in groundwater).

A reduction in the steady state depth to groundwater of 0.01 to 0.03 m is also predicted to occur for the obligate GDEs identified, these being Broadleaved Paperbark – Swamp Mahogany Forest and Swamp Oak Forest. These impacts are likely to result in small measurable changes in plant species diversity although most of these predicted changes are likely to be within the expected variation for these vegetation communities. Predicted reductions in steady state depth to groundwater for facultative GDEs (ie Smooth-barked Apple – Red Bloodwood shrubby open forest) are between 0.01 to 0.10 m, with the majority predicted change occurring between 0.01 and 0.08 m.

5.8.2 Preferred Scenario

Lesser impact scenarios were modelled to examine the effects of reduced infiltration into the groundwater (scenarios 2, 3 and 4). All of the alternative scenarios showed no predicted impact on SEPP 14 wetland 817 assuming a 0.01 m cutoff. As such no assessment is required to determine the impacts on any GDEs within the SEPP 14 wetland areas.

Scenario 2, which involved the infiltration of the first 15 mm of daily rainfall, showed a substantial contraction in offsite groundwater mounding whilst maintaining a reasonable capacity for the management of surface waters captured within the site. Scenarios 3 and 4 also showed incremental decreases in offsite groundwater mounding although these options substantially limited the management of surface waters intercepted by the Project. On this basis scenario 2 has been adopted as the preferred scenario for assessment.

Obligate GDEs

Under scenario 2 obligate GDEs such as the Broad-leaved Paperbark – Swamp Mahogany Forest and Swamp Oak Forest are likely to experience a reduction in depth to groundwater of between 0.02 to 0.05 m (ie 2-5 % decrease). This net change is considered to be within natural variation although small permanent changes in floristics and vegetation structure are expected within ecotonal areas (GHD, 2010).

For the Broad-leaved Paperbark – Swamp Mahogany Forest changes are likely to be minimal although a successional change toward vegetation classed by Bell and Driscoll (2006) as 'Coastal Wet Sand Cyperoid Heath' is predicted (ie median depth to groundwater range of 0.5 to 0.8 m). However, a substantial change towards Coastal Wet Sand Cyperoid Heath is unlikely as this would require a substantially greater decrease in depth to groundwater (ie exceeding 0.1 m). Predicted changes to Swamp Oak Forest are likely to be limited to a small decrease in floristics with no successional change in vegetation type predicted.

Facultative GDEs

It is predicted that the facultative GDE 'Smooth-barked Apple Red Bloodwood shrubby open forest' is likely to experience a similar percentage net change in depth to groundwater as predicted for the obligate GDEs. Net change in steady state depth to groundwater coincident with this facultative GDE is predicted to range between 0.01 to 0.10 m or < 3% across the study area, with the majority of the predicted change ranging between 0.01 and 0.08 m or <2.5%.

Predicted reductions in depth to groundwater of up to 0.1 m within this GDE is likely to drive successional change towards a similar vegetation type described as Peppermint – Apple – Bloodwood Forest' (Bell and Driscoll, 2006). A noticeable reduction in plant species diversity and heathness would occur if the current vegetation were to experience a depth to groundwater change exceeding 0.10 to 0.20 m. Changes of such magnitude are not widely anticipated and are likely to be restricted to vegetation located immediately south of the site and north of Tomago Road.

Facultative GDEs providing suitable habitat for the New Holland Mouse are also predicted to experience a decrease in depth to groundwater. An adverse impact by the Project would occur for the New Holland Mouse should a substantial decrease in steady state depth to groundwater eventuate. Fox and Fox (1978) identified a strong relationship between New Holland Mouse biomass and plant species diversity/ heathness, with reduced plant species diversity and percent plant heathness harming habitat suitability. Areas of known space utilisation by the New Holland Mouse (ie north of the site) are coincident with predicted changes in depth to groundwater ranging from 0.05 to 0.10 m, which is likely to result in a small reduction in habitat suitability for this species. However, these predicted changes are localised and small when considered within the context of mitigation strategies including the use of fire and seeding of areas regenerating from prior sand mining using heath plant species (GHD, 2011).

5.9 Monitoring

Monitoring would be conducted coincident with the surface water/ groundwater monitoring program to maximise the discovery of any unpredicted trends or changes. In this respect matters such as water quality and seasonal groundwater variation should be examined in greater detail within the context of vegetation cover, where possible. A Before After Control Impact (BACI) monitoring program should be designed in connection with the data collected for this analysis to evaluate the predictions presented in this report. This will provide an ongoing feedback mechanism enabling a timely response to any unforseen changes in site vegetation.

5.9.1 Trigger and Response Plan

The following plan is recommended:

- Implement the Trigger and Response Plan as outlined below. Trigger levels are at this stage linked to depth to groundwater. Variation of < 0.1 m is expected to result in a tolerable change consistent with the predicted impacts outlined this assessment (ie partial successional change between vegetation types). However, a net change exceeding 0.1 m has the potential to adversely impact obligate GDEs such as Broad-leaved Paperbark – Swamp Mahogany Forest and Swamp Oak Forest. An exceedence of this magnitude has the potential to result in substantial successional change between vegetation types.
- The locations of the trigger measurements will be selected on the basis of where the impacts of the project can be reliably measured. Therefore the monitoring will be from around the site, including areas immediately southwest and north of the site.

Table 8 Trigger and Response Plan

Trigger[(a)]	Response
0 – 0.1 m groundwater level mounding after accounting for natural variation	Continue ongoing monitoring program with no change.
0.1 – 0.15 m groundwater level mounding after accounting for natural variation	Establish whether groundwater changes are associated with site activities or an unrelated off-site activity. Generate a new drawdown map and compare with the BMPM. Should on-site activities be the likely reason for change then consult with ecologist for guidance.
> 0.15 m groundwater level mounding after accounting for natural variation	Undertake full floristic analysis in combination with detailed predictive groundwater modelling. Remedial measures to limit groundwater mounding (such as reducing surface water infiltration to groundwater) may need to be investigated.
Detection of dissolved petroleum compounds	Identify source and likely volume of leak/spill. If dissolved concentrations exceed 600 ug/L (Dutch intervention level for mineral oil in groundwater), undertake natural attenuation modelling to assess whether natural attenuation processes are sufficient to remediate spill. Otherwise other remediation measures may need to be investigated.

(a) Groundwater mounding (between monitoring sites and controls sites or outside natural variation determined over two years) must be observed for at least four months of a six month period.

6. Conclusions

The integrated consideration of surface water management and groundwater impacts has been undertaken to address the water related DGRs and associated NOW requirements for the Project. The assessment has included a scenario based analysis of impacts of the proposed infiltration system on groundwater and GDEs relevant to the Project.

The project site is situated near the south western extent of the Quaternary unconsolidated sand deposit known as the Tomago Sandbeds. Groundwater in the vicinity of the project area is generally fresh and slightly to moderately acidic. It is anticipated that petroleum hydrocarbon compounds are not currently present in the groundwater at this location and that heavy metal concentrations are representative of the variable and often elevated concentrations throughout the Tomago Sandbeds. In the vicinity of the site, the steady state groundwater elevation is approximately 3.3 to 3.8 m AHD, which represents a depth to groundwater of approximately 3.2 m below ground level (bgl) at the north western corner of the site (closest to TAC) to 1.2 m bgl at the southern end of the site.

The Project is located within the catchment of several GDEs that are of local, State, national and international importance (ie Ramsar wetlands).

A preliminary steady state hydrogeological numerical model was developed and calibrated against observed groundwater level data to assess the impact of the proposed project on groundwater levels within the unconfined sand aquifer based on the four infiltration scenarios outlined in Section 2.1. A rise in groundwater elevation is predicted for each scenario, ranging from a maximum rise of 0.05 m for 20m3/d infiltration to 0.21 m for 60m3/d infiltration. Since an increase in groundwater elevation is expected throughout the modelling domain, there will not be a reduction in groundwater availability for basic landholder rights or licensed groundwater extraction in the vicinity of the project site.

The GDEs were considered within the context of the four infiltration rate scenarios with scenario 2 selected as having the optimal compromise between surface water management demand and impacts on GDEs. It is predicted that scenario 2 would not result in a measurable impact on the following:

- Internationally listed Ramsar wetlands and migratory species that occupy these wetlands.
- State listed SEPP 14 Coastal Wetlands.

Minor tolerable impacts on State listed endangered ecological communities that are classified as obligate GDEs have been identified for scenario 2, however, these impacts are regarded as negligible (ie within natural variation). Impacts on facultative GDEs are also predicted, with habitat changes affecting the New Holland Mouse also considered. These impacts are considered tolerable and unlikely to have any lasting adverse impacts Groundwater quality impacts are anticipated to be minor with the implementation of specific environmental controls and the establishment of a Groundwater Monitoring Plan (GMP). The GMP, incorporating a response plan, should be prepared prior to construction and detail monitoring requirements pre-construction, during construction and during the operation of the facility.

Of the surface water infiltration rate considered, scenario 2 (15 mm of rainfall) was identified as having a tolerable impact on groundwater and associated GDEs. Residual surface water not directed into the groundwater aquifer is proposed to be directed south from the site into an existing drainage easement connected with the site.

Potable water for plant construction and operation will be serviced from the HWC potable water network, The 150 mm potable water service line adjacent to the site is expected to be able to supply the flow and pressure demands throughout the life of the proposed project.

As there is no sewage system in the area, sewage from the site will be treated through an onsite sewerage treatment system. The treated wastewater will substitute potable water for on-site landscaping requirements, and any surplus will be allowed to infiltrate into the subsoil. The irrigation system will be designed to ensure that there is sufficient area and appropriate vegetation to remove the nutrients in the wastewater.

7. References

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Appendix A
Site Visit Photos

Northern Site Boundary - looking at the upstream neighbouring property

North west corner of the site boundary – looking east at the north fence line

North west corner of the site boundary – looking south east at the site.

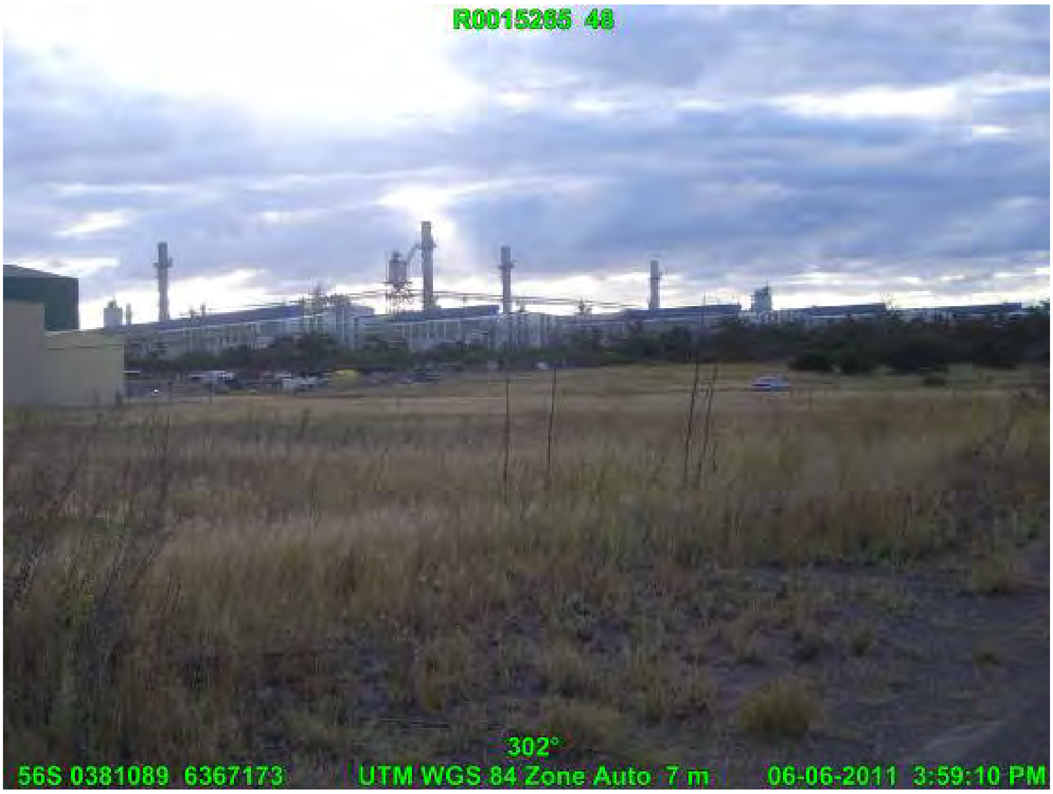
North west corner of the site boundary – looking south at the west fence line.

Example of the existing paved areas which cover the site.

Example of the existing paved area which cover the site.

Existing Shed and paved areas on site

Easter side corner of the site boundary – looking north west at the site and Tomago smelter in the background.



South west corner of the site boundary – looking north at the west fence line

South west corner of the site boundary – looking north east at the site

South west corner of the site boundary – looking east at the south boundary. A stormwater channel/bern was identified on the northern side of the road, diverting any stormwater to a culvert located near the closest visible power pole.

The entry point of the identified culvert from the site. The culvert was in disrepair and overgrown with vegetation.

The exit point from the identified culver from the site.

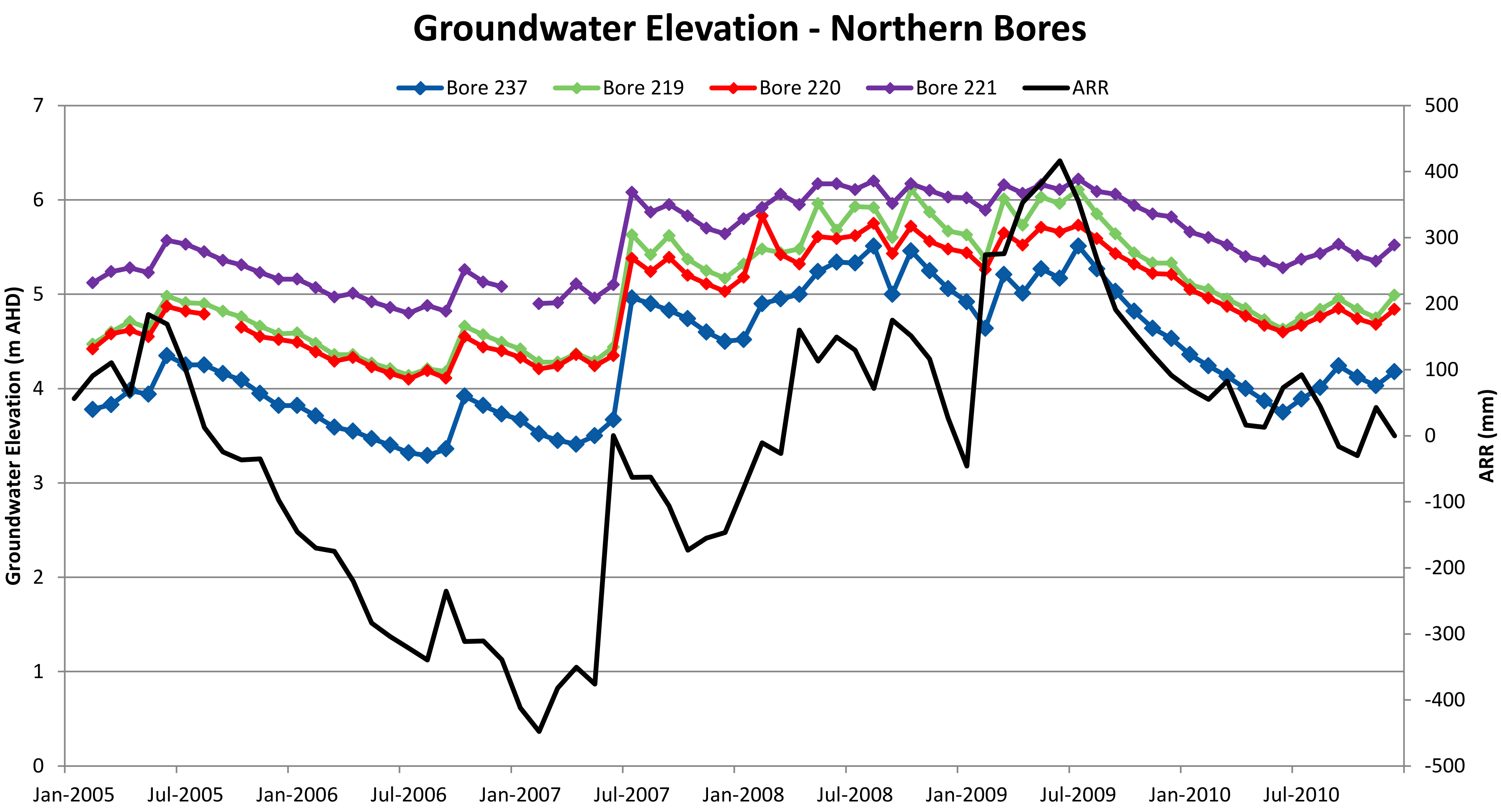
The identified shallow stormwater channel across the easement of the potable water trunk main.

The identified area where any stormwater would discharge too if there was any stormwater surface flows from the site and if it did not infiltrate on the way in the potable water trunk main easement area.

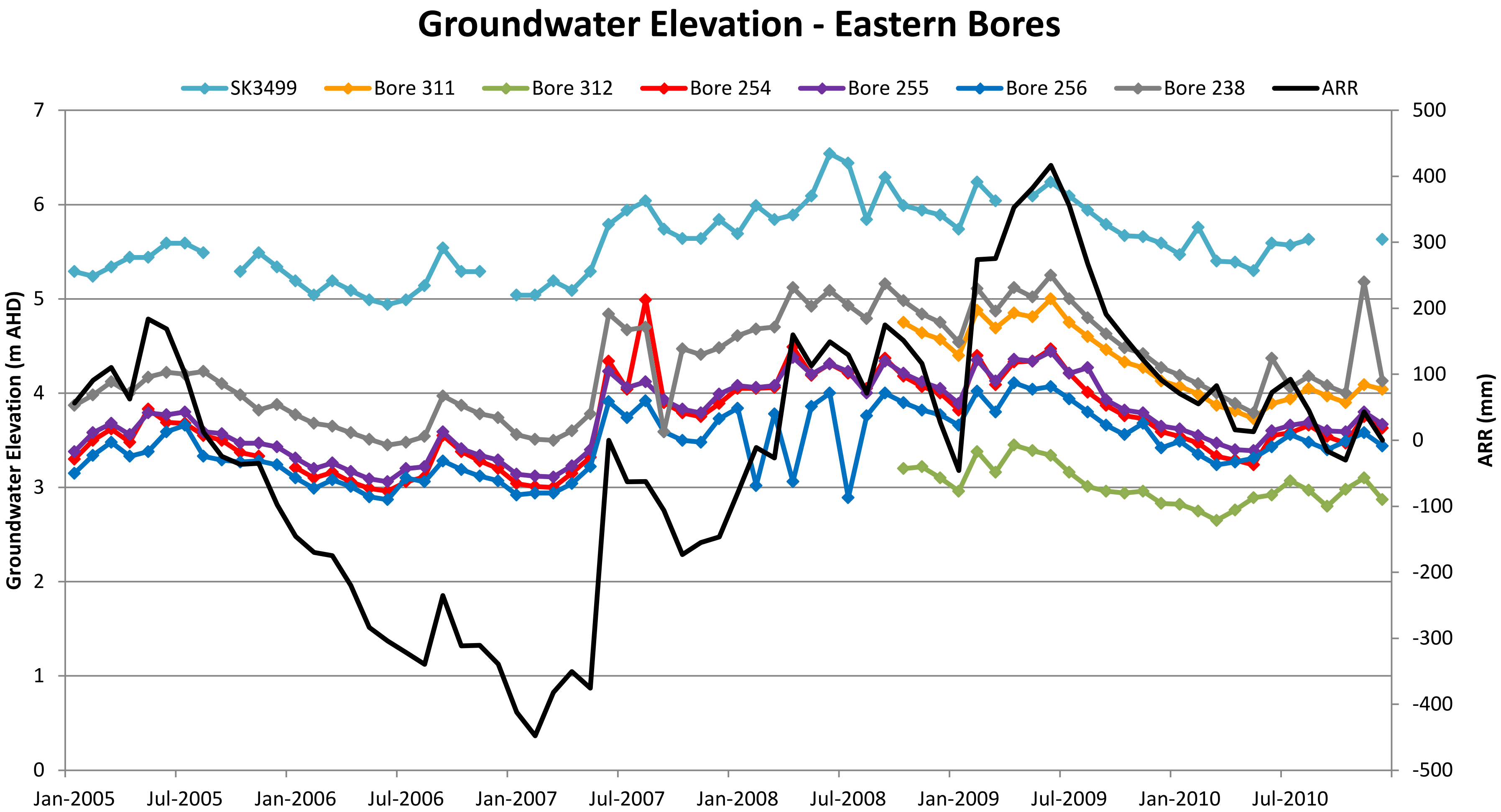
The start of an alternate stormwater channel currently utilised by neighbouring industries.

Appendix B

Groundwater Time Series Graphs



Groundwater Elevation - Northern Bores
Bore 237
Bore 219
Bore 220
Bore 221
ARR
Groundwater Elevation (m AHD)
ARR (mm)
7
6
5
4
3
2
1
0
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jan-2005
Jul-2005
Jan-2006
Jul-2006
Jan-2007
Jul-2007
Jan-2008
Jul-2008
Jan-2009
Jul-2009
Jan-2010
Jul-2010


Groundwater Elevation - Eastern Bores
SK3499
Bore 311
Bore 312
Bore 254
Bore 255
Bore 256
Bore 238
ARR
Groundwater Elevation (m AHD)
ARR (mm)
7
6
5
4
3
2
1
0
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jan-2005
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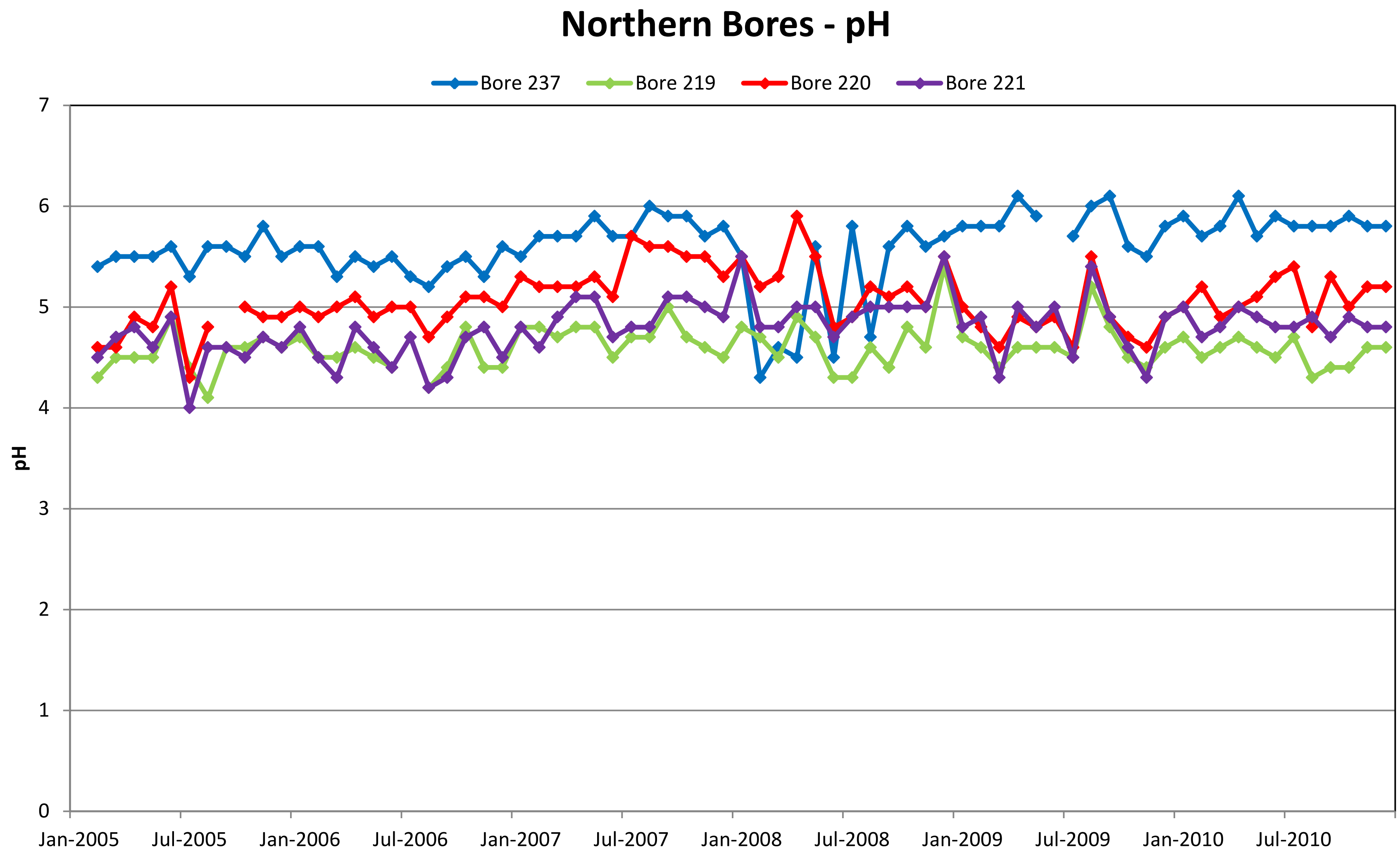
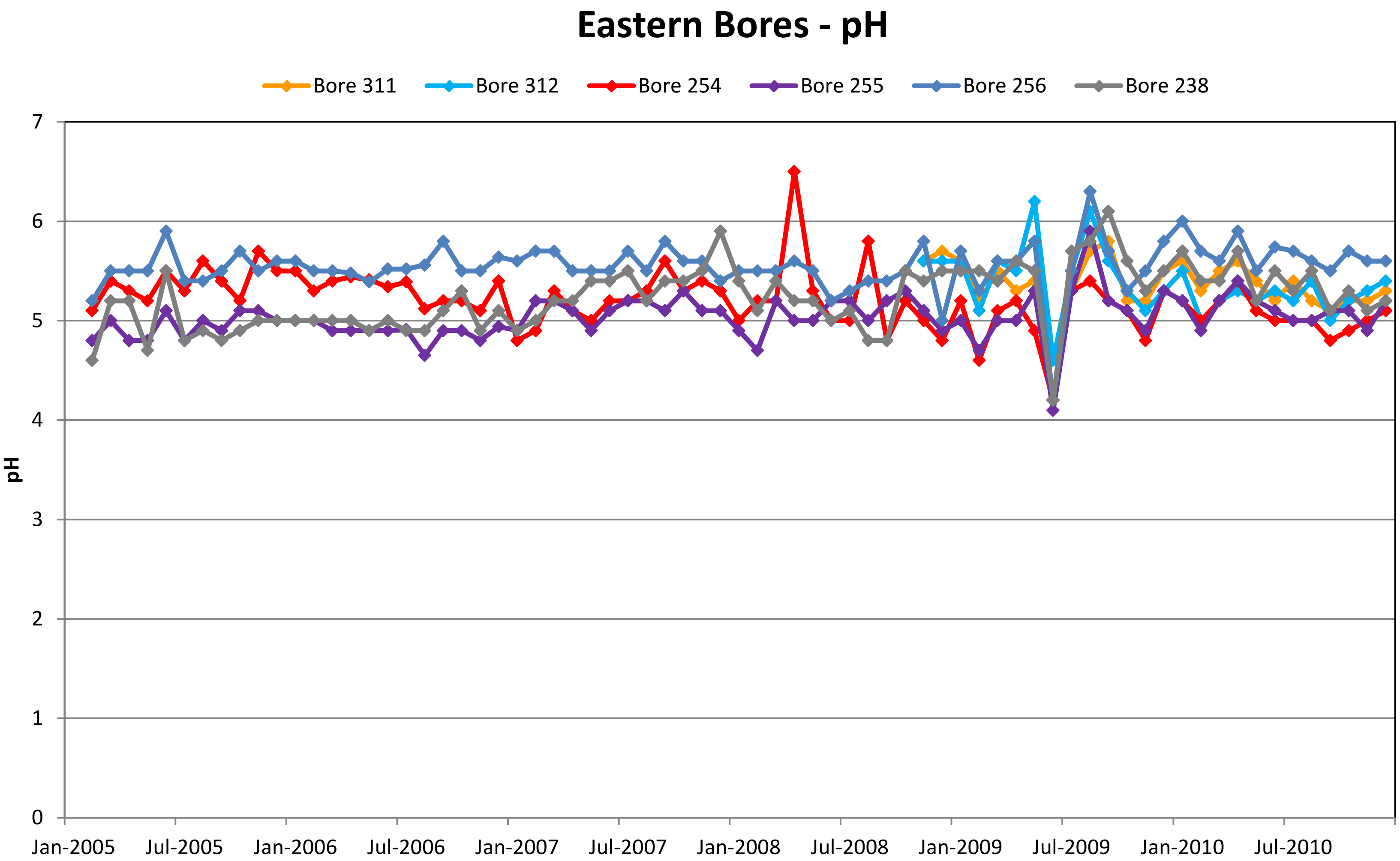
Jul-2009
Jan-2010
Jul-2010



Northern Bores - pH
Bore 237
Bore 219
Bore 220
Bore 221
pH
7
6
5
4
3
2
1
0
Jan-2005
Jul-2005
Jan-2006
Jul-2006
Jan-2007
Jul-2007
Jan-2008
Jul-2008
Jan-2009
Jul-2009
Jan-2010
Jul-2010


Eastern Bores - pH
Bore 311
Bore 312
Bore 254
Bore 255
Bore 256
Bore 238
pH
7
6
5
4
3
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1
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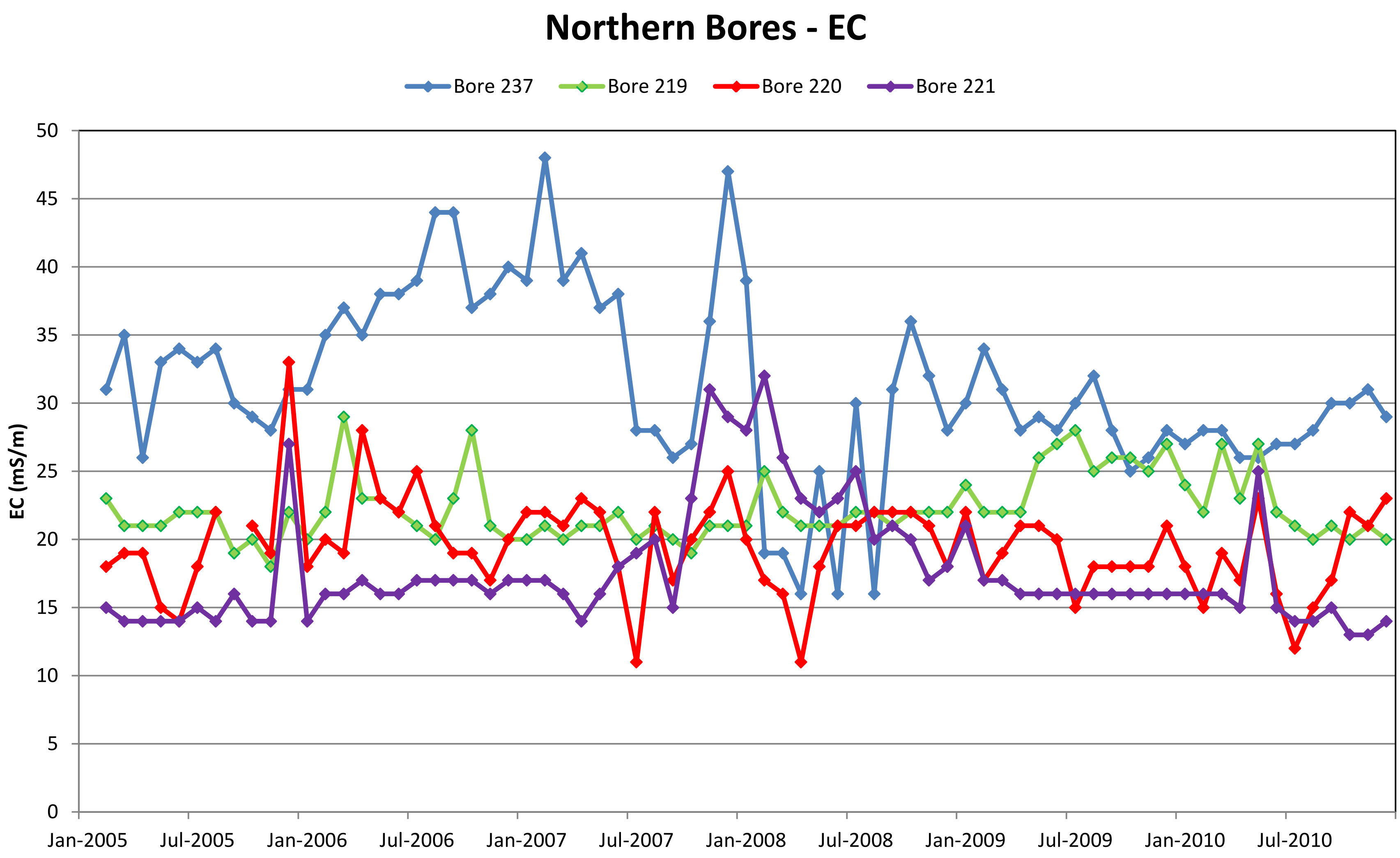
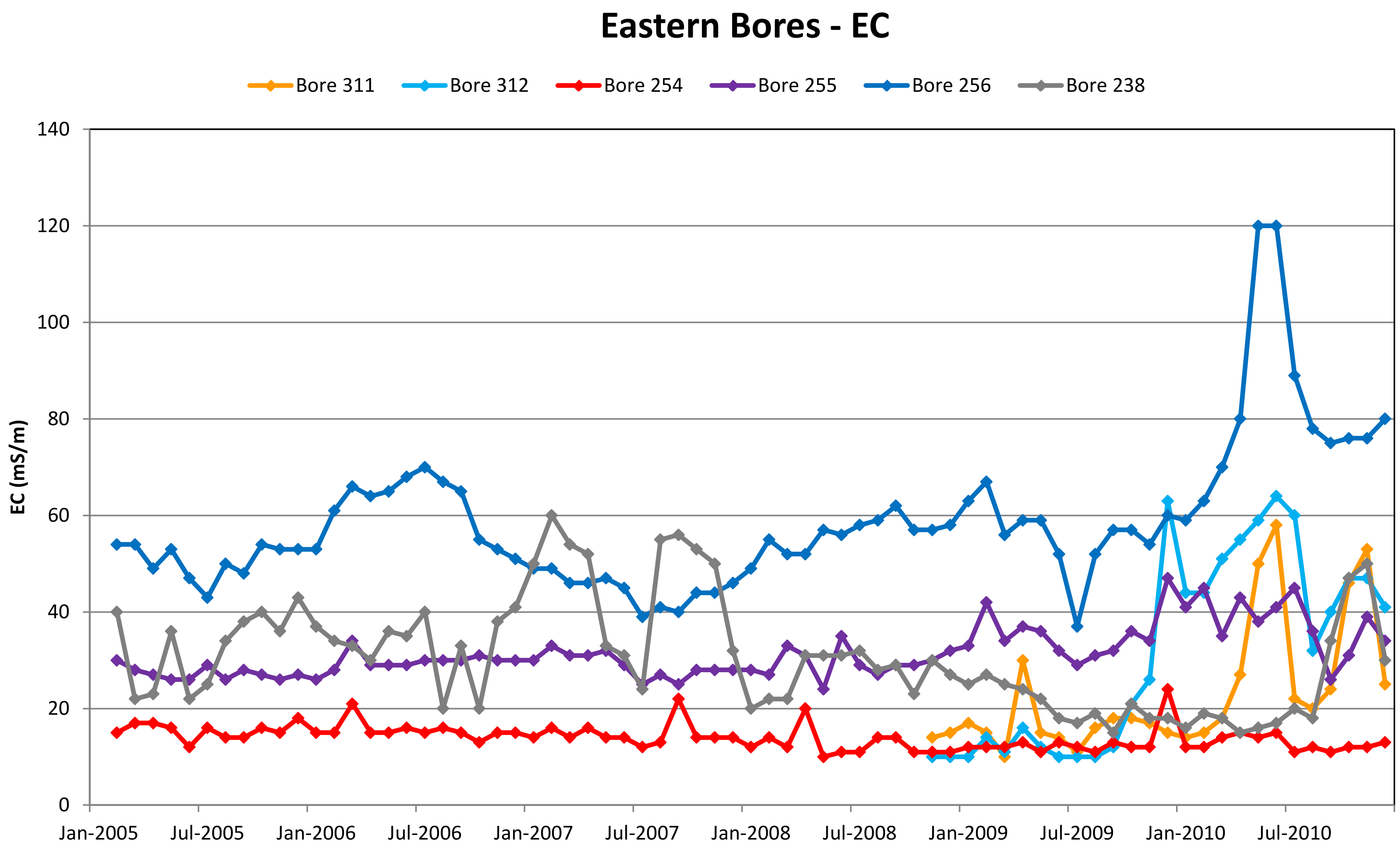
Jul-2009
Jan-2010
Jul-2010


Northern Bores - EC
Bore 237
Bore 219
Bore 220
Bore 221
EC (mS/m)
50
45
40
35
30
25
20
15
10
5
0
Jan-2005
Jul-2005
Jan-2006
Jul-2006
Jan-2007
Jul-2007
Jan-2008
Jul-2008
Jan-2009
Jul-2009
Jan-2010
Jul-2010


Eastern Bores - EC
Bore 311
Bore 312
Bore 254
Bore 255
Bore 256
Bore 238
EC (mS/m)
0
20
40
60
80
100
120
140
Jan-2005
Jul-2005
Jan-2006
Jul-2006
Jan-2007
Jul-2007
Jan-2008
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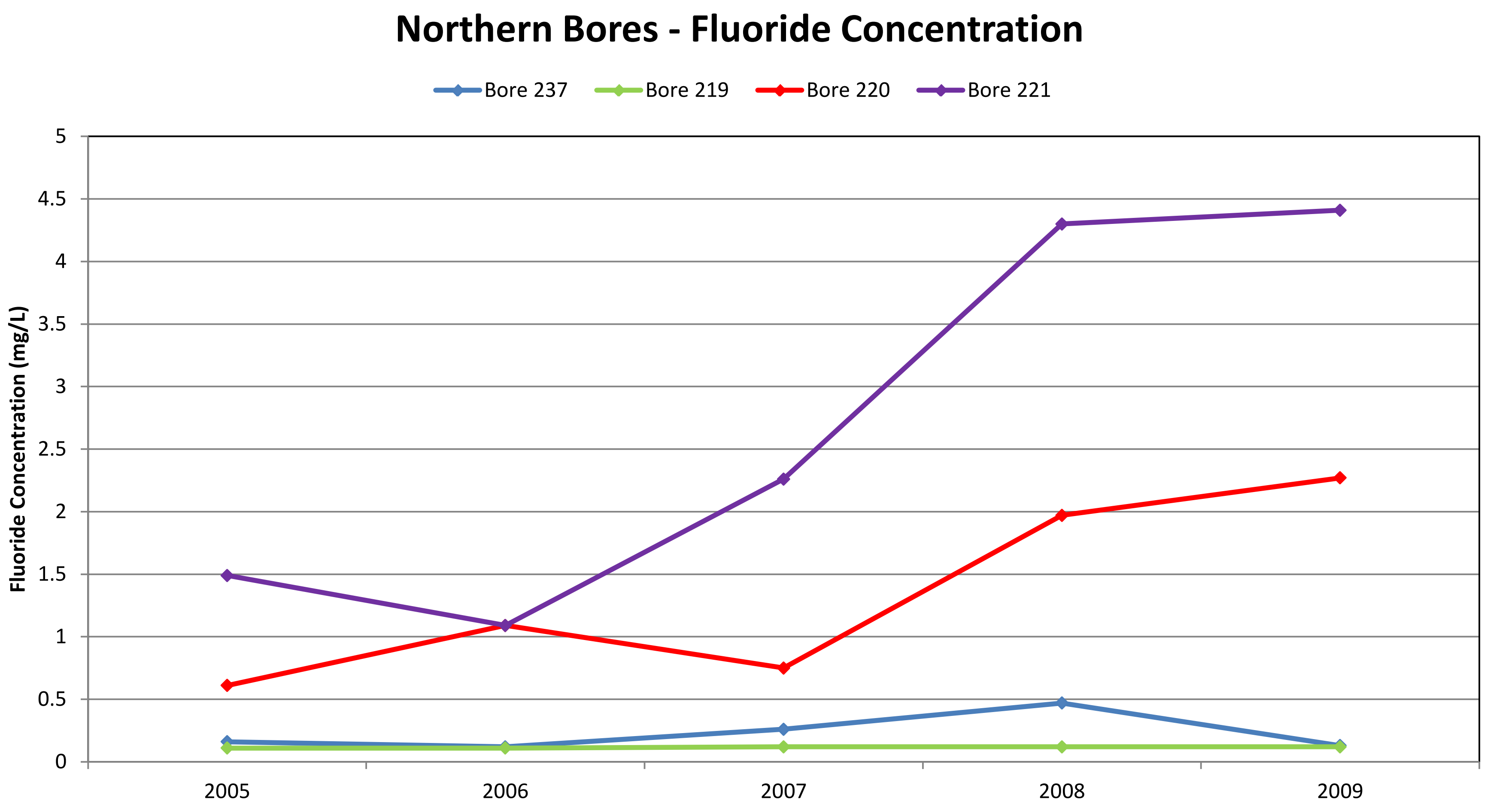
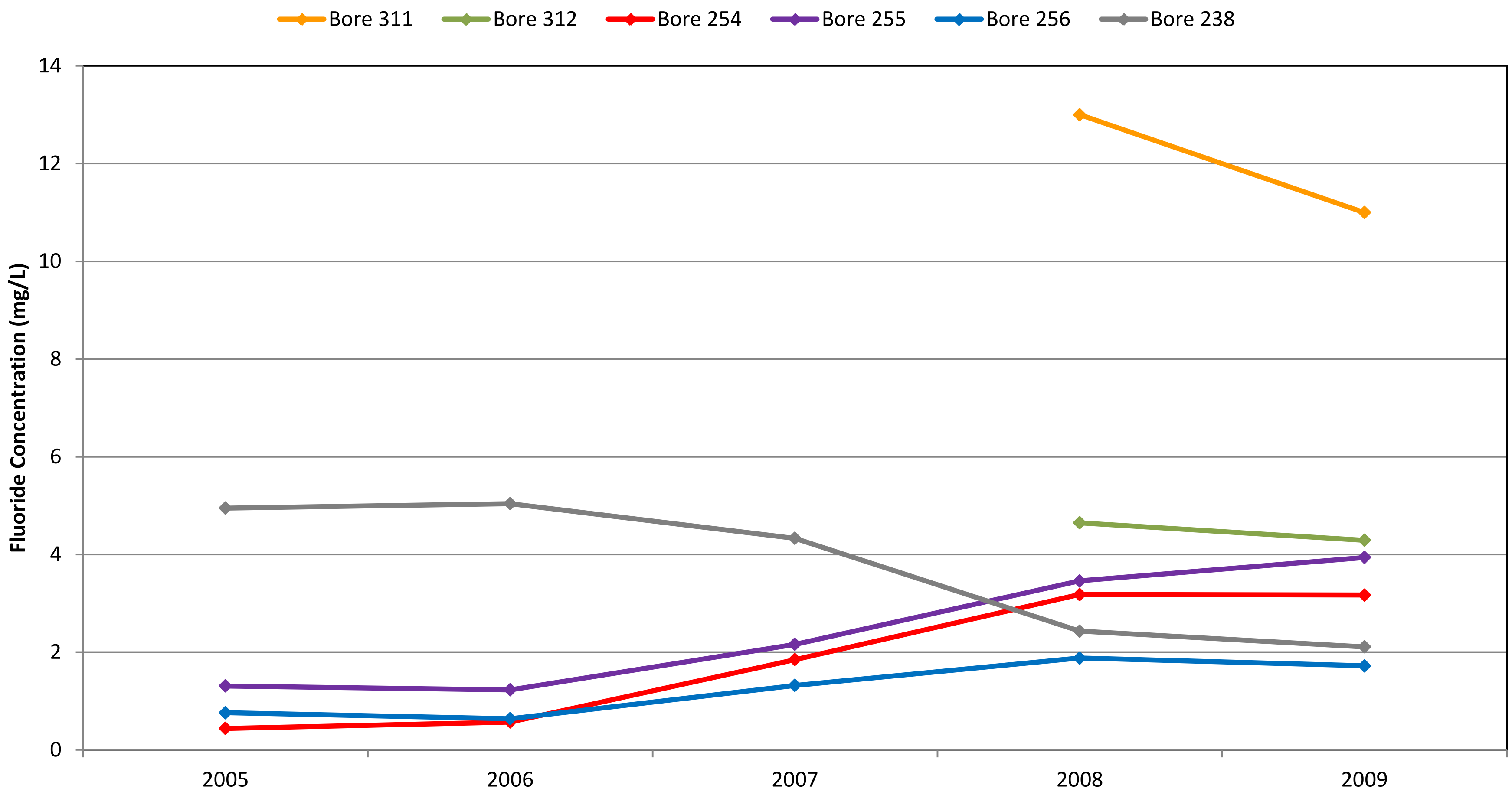
Jan-2010
Jul-2010

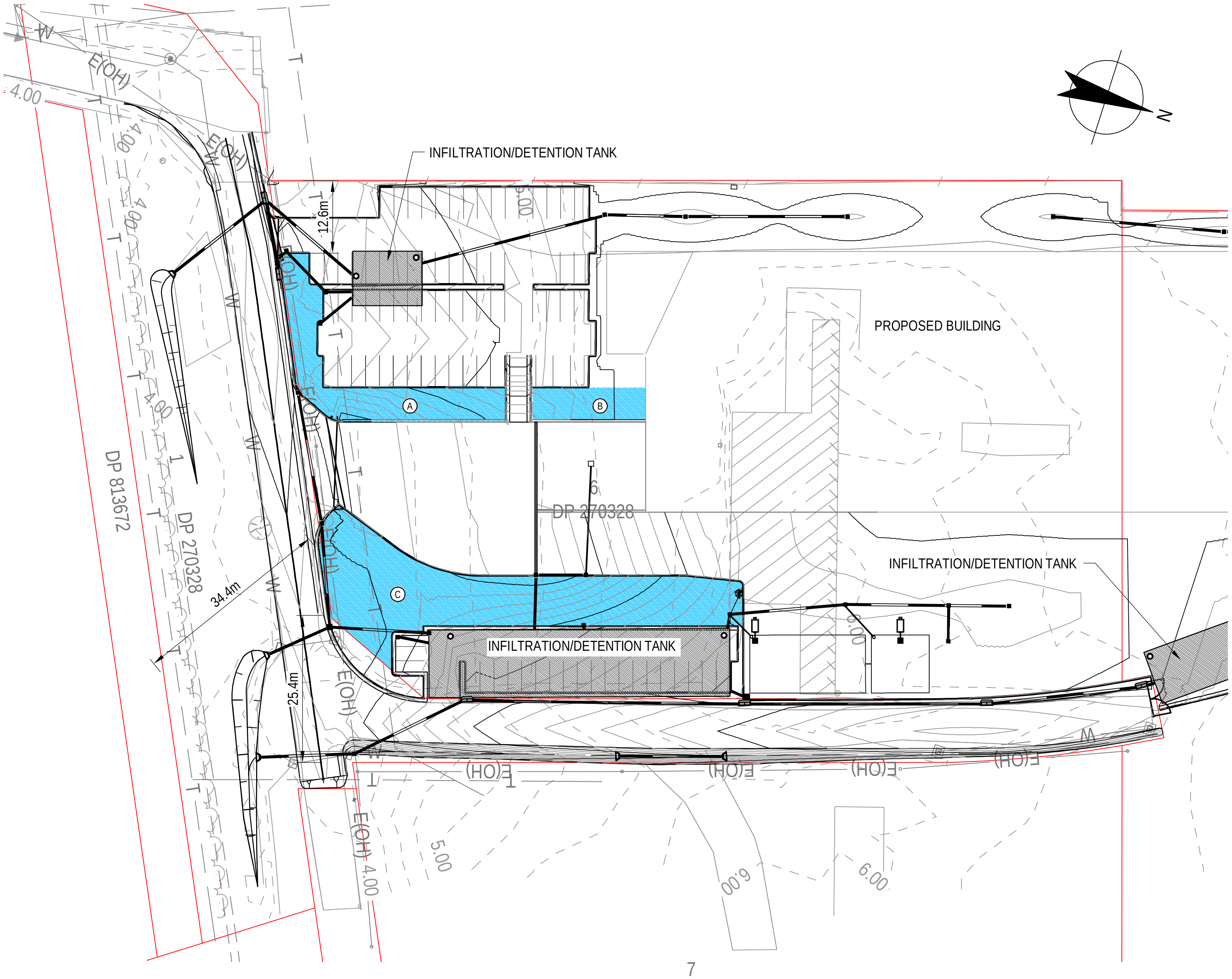


Northern Bores - Fluoride Concentration
Bore 237
Bore 219
Bore 220
Bore 221
Fluoride Concentration (mg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2005
2006
2007
2008
2009

Eastern Bores - Fluoride Concentration



Appendix C
Sub Soil Irrigation Area Details



LEGEND

- SUBSURFACE IRRIGATION AREA
- PROPERTY BOUNDARY
- PROPOSED PIPE AND PIT

SUBSURFACE IRRIGATION AREAS	
AREA	AREA SIZE (m²)
A	315
B	108
C	797
TOTAL	1220

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

GHD

MIDAL CABLES INTERNATIONAL
TOMAGO ROD AND CONDUCTOR FACILITY
SUBSURFACE IRRIGATION

Job Number	22-15280
Revision	A
Date	FEB 2012

Figure C01

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

Plot Date: 8 February 2012 - 3:19 PM Plotted by: Rebecca J Cocks/Newcastle/GHD/AU Cad File No: G:\22\15280\CADD\Drawings\SKETCHES AND FIGURE\22-15280-FIG03.dwg

Appendix D

Sub Soil Irrigation Hydraulic Balance

Hydraulic Balance

Crop Factor

Month	Pasture
Jan	0.70
Feb	0.70
Mar	0.70
Apr	0.60
May	0.50
Jun	0.45
Jul	0.40
Aug	0.45
Sep	0.55
Oct	0.65
Nov	0.70
Dec	0.70

Flowrate	4.5	kl/d weekday
	3.6	kl/d weekend
	4.2	kl/d average week
Land Area	1,000	m2

Monthly Balance

Mth/ Units	No. of Days	Inflow m3/mth	Av. Rainfall mm/mth	Total Rainfall m3/mth	Pan Evap. mm/day	PanEvap. mm/mth	EvapoTrans. m3/mth	Balance m3/mth	Percolation mm/week	Net Balance Check m3/month
Jan	31	132	96	96	7	214	150	78	18	0.0
Feb	28	119	121	121	6.2	174	122	118	29	0.0
Mar	31	132	120	120	4.9	152	106	145	33	0.0
Apr	30	127	106	106	3.8	114	68	165	38	0.0
May	31	132	115	115	2.7	84	42	205	46	0.0
Jun	30	127	120	120	2.4	72	32	215	50	0.0
Jul	31	132	74	74	2.6	81	32	173	39	0.0
Aug	31	132	76	76	3.6	112	50	157	35	0.0
Sep	30	127	61	61	4.7	141	78	110	26	0.0
Oct	31	132	75	75	5.5	171	111	96	22	0.0
Nov	30	127	82	82	6.3	189	132	77	18	0.0
Dec	31	132	80	80	7.2	223	156	55	12	0.0
Annual	365	1,549	1,124	1,124	57	1,725	1,080	1,593	367	
								Average	**30.6**	

Appendix E

Sub Soil Irrigation Nutrient Balance

OnSite Subsoil Irrigation Annual Nutrient Balance

Treated Effluent Characteristics

Flowrate	4.5	kl/d weekday	
	3.6	kl/d weekend	
Biological Oxygen Demand	10	mg/l	
Total Nitrogen (TN)	25.0	mg/l	
Total Phosphorus	5.0	mg/l	

Nutrient Uptake Calculations for Crop Type

Crop Type: Kikuyu (or equivalent grass)		100%	Harvested
Average Grain Yield	20	20	(t/ha dry matter)
Nitrogen	2.6%	2.6%	
		0.52	t N/ha
		520	kg N/ha
		52	kg N/year
Phosphorus	0.3%	0.3%	
		0.06	t P/ha
		60	kg P/ha
		6.0	kg P/year
Organic Loading Rate	1500	kg/ha/m	Effluent Irrigation Guidelines recommended value

Area of Irrigation

Area of Irrigation	1000	m2	0.100	ha

Nutrient Balances

Inflow Data			Total Nitrogen Balance			Uptake Phosphorus Balance			Organic Loading Rate		
	No.of	Flowrate	Intake	Uptake	Net	Intake	Uptake	Net	Intake	Uptake	Net
Balance	Days	m3/mth	kg N/m	kg N/m	kg N/m	kg P/m	kg P/m	kg P/m	kg BOD/m	kg BOD/m	kg BOD/m
Annual	365	1,549	39	52	-13.3	7.7	6.0	1.7	15	1,800	-1,785

P sorpotion Capacity (critical) for most soils	1500	kg/ha	(this is a conservative value)
For the site this equates to	150	kg	
Years of use before some leaching of P may occur	86		

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