T4 PROJECT

ENVIRONMENTAL ASSESSMENT

Prepared for Port Waratah Coal Services Limited | February 2012

Appendices - Volume 3

Appendix E	Groundwater assessment
Appendix F	Assessment of remediation options
Appendix G	Outline remediation action plan
Appendix H	Flooding assessment
Appendix I	Hydrodynamic assessment
Appendix J	Surface water assessment

EMM
EMGA Mitchell McLennan

PWCS

VOLUME 3

3

APPENDIX E

GROUNDWATER ASSESSMENT

E

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Report on Groundwater Assessment

Proposed Terminal 4 Project
Kooragang Island

Prepared for
Port Waratah Coal Services Limited

Project 49533.02-05
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Integrated Practical Solutions

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Executive Summary

This report presents the results of a groundwater assessment for the proposed Terminal 4 (T4) Project on Kooragang Island (KI). The work was carried out for Port Waratah Coal Services Limited (PWCS). A companion Contamination Assessment was undertaken and should be read in conjunction with this Groundwater Assessment. The T4 Project area includes the major portion of the Kooragang Island Waste Emplacement Facility, formerly used by BHP Billiton for disposal of waste materials from its steelmaking operations. The T4 Project area also includes the Delta EMD waste disposal area and the Fines Disposal Facility both currently owned by PWCS, plus wharf areas on both sides of the Hunter River (South Arm), adjacent to Tourle Street bridge. The south bank wharf area comprises part of the OneSteel facility and is assessed in a separate report.

The objectives of the investigation were as follows:

- Protection of the environment; and
- Protection of human health.

The environmental values to be protected are the quality of ground and surface water interacting with receptors that adjoin the T4 Project area, including the wetlands to the west and north of the T4 Project area and the Hunter River. This investigation included collation and review of previous geo-chemical testing and new investigations including boreholes, installation of groundwater monitoring wells and test pits. Soil, groundwater and surface water samples were also collected for chemical laboratory testing.

The primary objective of the groundwater assessment was to understand the implications of modifying the existing surface water and groundwater conditions and the impact of these modifications on the identified existing sites of ecological significance, as a result of the proposed T4 Project at KI.

The sites of ecological significance primarily comprise site surface water bodies and Office of Environment and Heritage (OEH) wetlands located west and north of the T4 Project area, BHPB Wetlands to the south of the T4 Project area and the Hunter River.

The groundwater assessment included collation of previous test information and new investigations including monitoring of groundwater and surface water levels and field parameters, development of a calibrated numerical groundwater flow and contaminant transport models for the T4 Project area. These models were used to assess potential groundwater related impacts and effectiveness of potential mitigation measures.

The following issues relating to groundwater were identified for the T4 Project at KI:

- Potential salinity impacts both on and off-site due to dredging;
- Potential mobilisation of contaminants and groundwater interactions at the former Delta EMD site during the dredging phase;
- Changes to water levels in the wetlands west and north of the T4 Project area;
- Impacts associated with changes to water levels and flow rates due to filling, preloading and subsequent capping the T4 Project area;
- Potential groundwater impact associated with tar waste in Pond 5;

- The potential for lead dust co-disposed with asbestos to come into contact with groundwater due to settlement under the T4 Project load;
- Free phase oil contamination at Bore B-01 in Site B;
- Potential mobilisation of contaminants (mainly hydrocarbons and metals) at the Fines Disposal Facility associated with settlement under the T4 Project load and a rise in the water table; and
- Groundwater interactions and potential contaminant pathways where the clay aquitard is penetrated by development.

The above groundwater issues would require appropriate management to mitigate the impacts on the environment, which have been identified in conjunction with the Contamination Assessment (Ref 23).

Groundwater modelling has assessed the risks of off-site migration of contaminants during and following Stages 1 to 3 construction, and compared them to the “no development” case. The Contamination and Groundwater reports provide the basis for the development and assessment of groundwater and contamination mitigation and management strategies for the T4 Project. These management and mitigation strategies are presented in a separate report titled “Assessment of Remediation Options” (Ref 26).

Table of Contents

Abbreviations

AHD	Australian Height Datum
AH	Aurecon-Hatch
BHP	Broken Hill Proprietary Company Limited
BHPB	BHP Billiton
BoM	Bureau of Meteorology
CBR	California Bearing Ratio
CFA	Continuous Flight Auger (pile)
CPT	Cone Penetration Test
CPTu	Piezocone (Cone Penetration Test with Pore Pressure Measurement)
CWR	Coal Washery Reject
DECCW	Department of Environment, Climate Change and Water
DMT	Marchetti Dilatometer Test
DNAPL	Dense Non-Aqueous Phase Liquid
DP	Douglas Partners Pty Ltd
DPC	Driven Precast Concrete (pile)
DSM	Deep Soil Mixing
EMD	Electrolytic Manganese Dioxide
EPL	Environment Protection Licence
FDF	Fines Disposal Facility
GCL	Geosynthetic Clay Liner
GPS	Global Positioning System
HDC	Hunter Development Corporation
HDPE	High Density Polyethylene
KI	Kooragang Island
KCT	Kooragang Coal Terminal
KIWEF	Kooragang Island Waste Emplacement Facility
LNAPL	Light Non-Aqueous Phase Liquid
NAPL	Non-Aqueous Phase Liquid
NEHF	National Environmental Health Forum
NCIG	Newcastle Coal Infrastructure Group
NHTG	Newcastle Harbour Tide Gauge
NPC	Newcastle Ports Corporation
OEH	Office of Environment and Heritage
PAH	Polycyclic Aromatic Hydrocarbons
PASS	Potential Acid Sulphate Soil
PQL	Practical Quantitation Limit
PWCS	Port Waratah Coal Services Limited
SCC	Specific Contaminant Concentration
SPT	Standard Penetration Test
SP1	Special Activities (Port and Industry) Zone
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
T4	Coal Export Terminal 4

Report on Groundwater Assessment
Proposed Terminal 4 Project
Kooragang Island

1. Introduction

1.1 Overview

Port Waratah Coal Services Limited (PWCS) proposes to construct and operate a new coal export terminal at the Port of Newcastle, New South Wales (NSW). PWCS owns and operates the Kooragang Coal Terminal (KCT) at Kooragang Island and Carrington Coal Terminal (CCT) at Carrington, both in the Port of Newcastle. The proposal, known as the Terminal 4 Project (T4 Project), is essentially an extension to KCT. The T4 Project would provide additional port capacity required to accommodate the projected future growth in coal exports from the Hunter Valley and broader NSW.

The T4 Project is proposed to include new rail tracks, coal stockyard, conveyors and ancillary facilities on Kooragang Island (KI), adjacent to KCT, and wharves, berths, ship loaders and ancillary facilities along the north and south banks will be constructed and operated within the Hunter River South Arm and along its northern and southern banks.

Approval for the T4 Project is being sought under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Commonwealth has accredited the Part 3A process as the appropriate Commonwealth assessment pathway for the T4 Project. An environmental assessment (EA) of the T4 Project is a requirement of the Part 3A approval process. Douglas Partners Pty Ltd (DP) has been engaged by PWCS to undertake components of the EA related to contamination, groundwater and remediation options assessments and to address the relevant Director General's Requirements (DGRs).

The assessment of site contamination for the T4 Project comprises the following reports:

- Contamination Assessment;
- Groundwater Assessment (this report);
- Site F – OneSteel Assessment;
- Assessment of Remediation Options; and
- Outline Remediation Action Plan.

The results of the contamination and groundwater assessments were utilised to determine requirements for remediation and options for mitigation measures to effectively manage site contamination during and following development. The Assessment of Remediation Options report represents the culmination of the first two reports, and includes Table A1 summarising where the DGRs are addressed within the set of reports.

This report presents the methods, results and conclusions of the groundwater assessment for the T4 Project at KI, and assesses the requirement for mitigation measures. The T4 Project area is shown on Drawing 5.01 in Appendix C.

The groundwater investigation comprised an initial assessment for the purpose of the prefeasibility engineering study (PES), followed by numerical and probabilistic modelling of specific groundwater matters, to provide a more detailed understanding of potential impacts to the KI site arising from the T4 Project development. Modelling was also used to assess the potential effectiveness of various proposed mitigation measures.

A parallel programme of geotechnical and contamination investigations of Sites A to D was also undertaken and was reported separately (Refs 25 and 23). The geotechnical investigation provided information for the models of site stratigraphy and hydrogeology presented in this report. The contamination investigation provided information on contaminants of concern in soil and groundwater, contaminant 'hot spots' and potential mobilisation pathways for identified contaminants, all of which has been utilised in the groundwater assessment.

Environmental and geotechnical investigations were also conducted within the Hunter River (South Arm) adjacent to the site associated with future dredging and wharf development (Ref 22).

The findings of the contamination assessment report together with this groundwater assessment report provided the basis for the proposed remediation options of existing contaminated land associated with the T4 Project at KI, presented in a separate report (Ref 26).

It is noted that there is no specific industry standard methodology for contaminant transport modelling in Australia. Therefore this groundwater assessment was undertaken with reference to the Murray-Darling Basin Commission *Groundwater Flow Modelling Guideline* (2000, Ref 38) which is the unofficial standard for groundwater flow modelling in Australia.

The groundwater assessment programme and this report has been the subject of peer review by Dr Noel Merrick, former Acting Director, National Centre for Groundwater Management, University of Technology, Sydney.

1.2 Proposed Development

The T4 Project is proposed to be located at the Port of Newcastle, in the Newcastle local government area, approximately 6 km north-west of the Newcastle central business district. The T4 project is primarily located on Kooragang Island (Sites A to E), adjacent to KCT and the Newcastle Coal Infrastructure Group (NCIG) coal terminal. Site F (within the OneSteel site) is located on the south bank of the Hunter River South Arm, at Mayfield North and includes a section of the Hunter River bed.

Mayfield North and the southern part of Kooragang Island, where the T4 Project area is located, is dominated by industrial, transport, distribution and port facilities, including KCT and NCIG. To the north and west of the Kooragang Island industrial and port area are estuarine wetlands, mangroves, saltmarsh and pastured and forested lands, subject to agricultural and conservation activities. This includes the Hunter Wetlands National Park, part of which is a Ramsar site. The nearest residential areas are at Fern Bay and Stockton 4.5km to the east and south-east, and Mayfield and Warabrook 1.7km to the south and south-west.

The T4 Project area is predominately reclaimed land which has previously been used for disposal of industrial waste and dredge material. It is a largely modified landscape dominated by bare ground, disturbed grassland and artificially constructed drainage depressions and ponds, which now support wetland communities. There is some remnant mangrove and saltmarsh vegetation along the north bank of the Hunter River South Arm, at the locations of the proposed wharves and berths, as well as to the north and west of the existing rail line.

The T4 Project is proposed to be developed progressively over an estimated 10 year timeframe in a nominal three stage program, in response to demand for increased coal export capacity. The maximum coal throughput capacity for the T4 Project will increase from 70 million tonnes per annum (Mtpa) in the first stage to a nominal 120 Mtpa at full development. All coal will be received by rail, stockpiled and then shipped to market. The T4 Project components include the following:

- Ground treatments, including pre-loading, to create suitable foundation conditions for development. Sand dredged from the Hunter River South Arm is proposed to be pumped to the proposed stockyard area, to provide pre-load and fill material for the project. This will be supplemented by engineering fill (sand and rock) trucked in from elsewhere;
- Relocation of some existing infrastructure and services, such as electricity transmission lines, gas lines, water lines, fibre optic cable, ship navigation aids, the existing KCT rail tracks and the Ausgrid wind turbine. Minor modification to local roads may also be required;
- Progressive construction and operation of rail receival infrastructure, generally located along the same alignment as the existing rail lines servicing Kooragang Island. At full development there will be up to eight arrival tracks leading up to four dump stations and on to eight departure sidings, which combine into a single departure track around the outside of the existing KCT rail loop;
- Progressive construction and operation of a coal stockyard, including coal stockpiles and yard equipment for stacking and reclaiming coal. At full development there will be up to seven stockpiles;
- Progressive construction and operation of coal conveyors, feeders and transfer stations that extend throughout the stockyard to deliver coal from the dump stations to the stockpiles, and to the wharves to deliver coal to the shiploaders, via buffer bins;
- Progressive construction and operation of wharf and berth facilities on both sides of the Hunter River South Arm, near the Tourle Street Bridge. At full development, up to five berths and four shiploaders are proposed, which accommodate vessels ranging from Handy size to Cape size;
- Development of water and wastewater management infrastructure including drainage works, water management ponds, pump stations and water tanks;

- Ancillary facilities, including electricity supply, dust suppression and fire fighting systems, fencing, amenities, landscaping, internal access roads, car parking areas and potentially, washdown facilities, refuelling facilities, administration and workshop buildings;
- Use of some existing KCT infrastructure, systems and workforce, including administration and maintenance facilities and environmental management and monitoring systems; and
- Habitat creation and enhancement.

The conceptual layout of the proposed T4 Project is shown on Drawing 5.16 Appendix C, which is based on drawing *KL 323170_A - Site Overview.dwg*, overlain on a site aerial photograph. The salient features, which will be refined during detailed design, are:

- Up to seven coal stockpiles of up to 1428 m in length;
- Up to eight machinery berms to carry yard equipment such as stackers, reclaimers, stacker/reclaimers and conveyors;
- T4 railway lines, mainly located in the SP1 zone outside the existing rail lines, except for a section inside Site A at Deep Pond;
- Dump Station located in the SP1 zone, just north of the boundary between FDF Cells 1 and 2; and
- Water treatment ponds located over Deep Pond.

Based on the conceptual stockyard levels, which range from RL 6.2 NHTG (5.2 AHD) to RL 11.0 NHTG (10.0 NHTG) the depth of filling would range from zero up to a maximum of about 8.5 m. The proposed depth of cut ranges up to about 3.5 m, mostly occurring in the central northern portion of the site in Area K7. Accordingly the quantity of cut will be relatively minor compared to the quantity of fill, so that the disturbance of existing contaminated soils is kept to a minimum. It is approximately estimated that the volume of ‘Level 3’ and/or hazardous waste will be in the order of 15,000 m^3 to 25,000 m^3; Soils that are excavated will be managed as discussed in Section 6.3 of the Remediation Options report (Ref 26).

The proposed machinery berms would have a level approximately 5 m above stockyard level. Final levels of the stockyard will be refined during detailed design.

The proposed T4 Project development would be undertaken in stages. The initial stage is proposed to include the construction of four coal stockpiles, three berths and associated infrastructure. Subsequent stages would be constructed while the first stage is in operation. Further details on the proposed T4 Project are provided in the EA, with further discussion of development features pertinent to this groundwater assessment included in Section 8.

1.3 Purposes and Objectives of the Assessment

The groundwater assessment was required for the following reasons:

- The proposed T4 Project would be a significant development that would have potential effects on the environment;

- Modelling of groundwater levels and movements related to the T4 Project would be required so that the potential effects could be assessed; and
- Assessment of the appropriate mitigation measures would be required and implemented to effectively manage site contamination and potential off-site groundwater migration.

The T4 Project area includes the major portion of the Kooragang Island Waste Emplacement Facility (KIWEF), formerly used by BHP Billiton (BHPB) for disposal of waste materials from its steelmaking operations. The T4 Project area also includes the former Delta EMD waste disposal area and the PWCS Fines Disposal Facility both currently owned by PWCS. PWCS have entered into an 'Agreement for Lease' with the state government for possible coal terminal development at the site.

Wastes dumped at KIWEF since the early 1970s included coal washery reject, blast furnace slag, granulated slag, coal fines, oil/tarry sludge, clayey silt filter cake, kiln wastes, cell scale (gypsum and manganese dioxide), lime sludge, asbestos, BOS flue dust and building rubble. As a result, various contaminants in soil and groundwater have been identified at elevated concentrations.

The proposed development presents an opportunity to reduce the environmental risks of the site, achieved by implementing strategies that manage and mitigate risks associated with the presence of contaminants, particularly to on-site and off-site receptors.

The overall objective of the groundwater assessment was to aid the environmental assessment of the T4 Project so that it could be constructed and operated in a manner that would:

- Protect the environment; and
- Protect human health.

The objectives of the groundwater assessment will be supported by completion of the following:

- Assess the groundwater flow regime and interconnections between groundwater, surface water ponds and drains located on and adjacent to the Site;
- Monitor surface and groundwater levels on a local scale for responses to rainfall and tidal variations;
- Develop numerical flow models for the site in its present state for use as a predictive tool to determine potential impacts arising from the T4 Project, namely: alterations in water levels, flow rates and potential salinity impacts during and after dredging;
- Determine potential impacts on the flux of contaminants from changes to the groundwater flow regime;
- Undertake a quantitative risk assessment of contaminant transport towards key off site receptors for a probable range of site conditions; and
- Model the effectiveness of potential mitigation measures to minimise impacts to receptors.

1.4 Environmental and Human Health Values

The environmental values that require protection during and following construction of the T4 Project are as follows:

- Wetlands in the Hunter Wetlands National Park located immediately to the north of the T4 Project area beyond the existing (and proposed) railway line (referred to as the 'OEH Wetlands');
- Hunter Estuary Wetlands Ramsar site located 600 m to the north and 1500 m north-east of the T4 Project area;
- The Hunter River (North Arm) located 1300 m north of the T4 Project area; and
- The Hunter River (South Arm) located 500 m to the south of the main T4 Project area (stockyards) and immediately adjacent the to the proposed T4 wharf areas.

The potential risk to these environmental receptors is associated with the potential for contaminant migration through groundwater movements and changes to groundwater levels.

The ponds that presently exist on both sides of the existing railway line are man-made, resulting from reclamation activities and construction of the railway embankment. These have since become important habitats that require protection, or where impacted, construction of compensatory habitats. The ponds are shown on Drawing 5.01 in Appendix C and are identified as follows:

- Deep Pond;
- Railway Pond;
- Rail Road Pond;
- Ponds 9, 10, 11 and 12;
- Easement Pond;
- BHPB Wetland and Blue Billed Duck Pond; and
- OEH Wetlands 1 to 3.

The T4 Project proposes to fill Railway Pond and Ponds 9 to 12, and water management ponds would be constructed within Deep Pond and Easement Pond.

The potential impact to off-site habitats is of key importance to this groundwater assessment. Several endangered flora and fauna species have been identified on the T4 Project site and surrounding area and a number of important Green and Golden Bell Frog (GGBF) habitats have been identified. These are: Rail Road Pond, OEH Wetland 1 and BHPB Wetland.

It is noted that the BHPB Kooragang Island Emplacement Cell (KIEC) is situated directly between the main T4 Project area and the Hunter River (South Arm). This facility comprises engineered fully-lined waste cells constructed to receive treated contaminated sediments from the Hunter River Remediation Project. It is also required that the T4 Project has no adverse impact on KIEC.

Human health would also require protection during construction of the T4 Project and subsequently during operation of the coal terminal. The main modes of protection would be:

- Construction: minimisation of exposure of workers to contaminants (through implementation of an environmental management plan); and
- Operation: prevention of access to contaminants by humans (through capping of the site) and implementation of a long term management plan.

There are no plans for beneficial use of the groundwater during construction or operation of the terminal.

The protection of these environmental and human health values can be achieved through consideration of the relevant policies and guidelines endorsed by the NSW Office of Environment and Heritage (OEH), by implementation of Data Quality Objectives (DQOs), and with reference to the National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (NWQMS, September 1995).

1.5 Environmental Strategy for the T4 Project

The primary project goal for the groundwater assessment of the T4 Project is to protect from unacceptable impacts the off-site receiving environment including adjacent landholdings, the South Arm of the Hunter River, wetlands of the Hunter Estuary National Park and the ecological attributes which characterise these areas. A secondary objective is to implement a land use option which effectively minimises exacerbation and reduces the long term risks posed by the contaminant legacies on the site, supports project approvals and minimises PWCS liability.

Development of the T4 Project provides an opportunity for PWCS to contribute to the responsible development of an area of Newcastle which is recognised as a heavily contaminated site which currently has no beneficial use. Understanding the contamination risks and identifying mitigation measures to prevent or minimise potential impact, facilitate safe use of the T4 Project area and protection of the environment.

The environmental strategies related to soil and groundwater contamination at the T4 Project area are based on the following:

- Existing (or surrendered) Environment Protection Licences for the Site;
- OEH approved capping measures for sections of the Site; and
- Additional measures for specific ‘hot spot’ areas where capping alone would be insufficient to meet environmental objectives. These measures would comprise mitigation strategies to manage potential contamination issues (remediation and/or management), as outlined in the Remediation Options report (Ref 26).

2. T4 Project Area Identification

The T4 Project area consists of six parcels of land. Four of these are within the former Kooragang Island Waste Emplacement Facility (KIWEF), designated Sites A, B, C and D (as shown on Drawing 5.01). The fifth parcel of land comprises the SP1 (Special Activities) zone (Site E), located to the west and north of the existing railway line, which is 100 m wide. The SP1 zone is essentially low-lying wetlands.

The sixth parcel of land (Site F) comprises part of the existing OneSteel site adjacent to the Hunter River (South Arm) where Wharves M8 and M9 are proposed. The assessment of groundwater contamination at the OneSteel site and mitigation options are presented in a separate report and this site is not discussed further in this report.

Site B is in two parts, which are separated by Cormorant Road. KIWEF is bounded by an existing railway line to the north and west, and the Hunter River (South Arm) to the south. The location and extent of these sites are shown on Drawing 5.01, and identified in Table 1.

Table 1: T4 Project Area Identification

Site	Name	Lot and DP	Area (ha)
A	KIWEF (north-west)	Lot 9, Lot 10 and Lot 11 DP 1119752	96.7
B	KIWEF (south-east) - River Waterfront / Cormorant Road	Lot 21 DP 1155723	37.6
C	Delta EMD Waste Disposal Site	Lot 121 DP 874949	25.4
D	PWCS Fines Disposal Facility	Lot 11 DP 841542	45.1
E	SP1 Special Activities - Rail and Dump Station	Part Lot 1 DP 126347	41.3
F	OneSteel - River Waterfront, South Bank	Part Lot 222 DP 1013964	9.2

PWCS have entered into an ‘Agreement for Lease’ with the State government (via Newcastle Ports Corporation) in relation to Sites A and B for possible coal terminal development.

The KIWEF area has historically been split into a number of distinct areas for reference purposes designated K1 to K13. The individual waste disposal cells or ponds were also numbered as they were constructed: called Ponds 1 to 39. These pond numbers are sometimes quoted with a ‘K’ prefix which could lead to confusion between Ponds 1 to 13 and the Areas K1 to K13. In this report the pond numbers are quoted without a prefix. The relationship between the T4 Project sites, areas and ponds is shown on Drawing 5.01.

Sites A, B North, C and Site D are or were licensed waste disposal facilities. The Environment Protection Licences were issued by the NSW Department of Environment, Climate Change and Water (DECCW), now OEH.

The site investigation area for this groundwater assessment is shown in Figure 1, which also indicates the approximate extent of Sites A, B, C, D and E, as well as the naming convention of surface water bodies.

Further details describing each of the Sites A to E are summarised in the following sections. Photographs of Sites A to E were taken with the approximate location and orientation of site photos are also shown on Drawing 5.26.

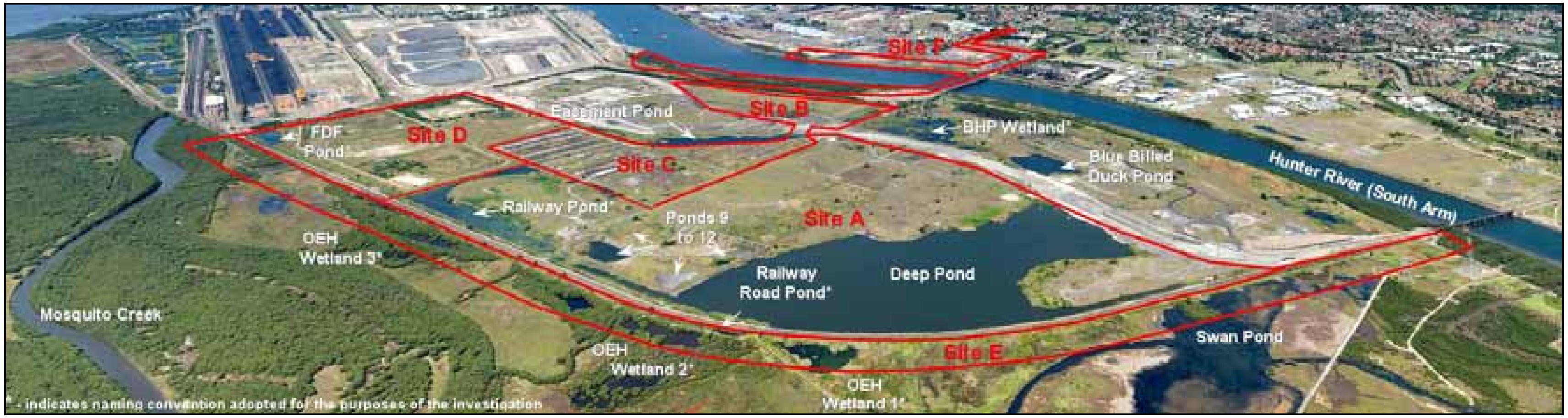

Figure 1: Site investigation area (Sites A, B, C and D) and surface water body features

3. Site Description

3.1 Site A (North-West KIWEF)

Site A is the largest portion of the T4 Project area and comprises the north-western part of KIWEF (Site A), bounded by the railway line to Kooragang Coal Terminal (KCT) to the west and north, by the PWCS Fines Disposal Facility (FDF) and Delta waste disposal sites to the east, and by the NCIG railway line to the south. Site A includes waste disposal Ponds 1 to 12 in Areas K5 and K6, an asbestos disposal cell in Area K7 (Photo 1 and Photo 2) and a large water body known as 'Deep Pond' (Area K4) (Photo 3). The remainder of Site A includes a general refuse dump (Area K3) (Photo 4 and Photo 5).

Photo 1: Site A – looking south (January 2011)

Photo 2: Site A - looking west (January 2011)

Photo 3: Site A - looking north to south-west towards Deep Pond (January 2011)

Photo 4: Site A - looking north to north-east from the navigation towers (January 2011)

Photo 5: Site A - looking west to south-west towards A-09 (January 2011)

Pond 5 has been identified as a hydrocarbon disposal area and previous investigations have shown this area contains elevated contamination (Photo 6 and Photo 7).

Photo 6: Site A - looking north to north-east across Pond 5 (January 2011)

Photo 7: Site A - looking south to south-east towards Bore A-06 and Pond 5 (January 2011)

Ponds 9 to 12 are partially filled, and contain differing proportions of surface vegetation and surface water (Photo 8 and Photo 9).

It is noted that the 200 litre drums present in some of the photos above contain excess drill cuttings from subsurface investigation which were removed and appropriately disposed upon completion of investigations.

Photo 8: Site A - looking north to north-east towards Pond 9 (January 2011)

Photo 9: Site A - looking south-west towards Pond 11 (January 2011)

The existing surface levels across Site A generally range from 4.0 NHTG to 10.5 NHTG. The ground surface levels in the western portion of Area A range from 4.0 NHTG to 5.5 NHTG, with levels in the asbestos disposal cell up to RL 13.0 NHTG (Photo 10).

Photo 10: Site A - looking north-west to south-west towards the Asbestos Area (January 2011)

3.2 Site B (South-East KIWEF)

Site B comprises two parts separated by Cormorant Road and the adjacent 'Long Pond'. These two parts are referred to in this report as Site B North and Site B South (Photo 11 and Photo 12).

Photo 11: Site B North - looking south towards Cormorant Road and Site B South from B-02 (January 2011)

Photo 12: Site B – looking north to north-west from Site B South across Cormorant Road towards Site B North and the mangroves along Swan Pond (January 2011)

Site B North includes all or part of Ponds 13 to 19, 21, 23 and 25. The ground surface level ranges from about 10.0 NHTG at the eastern end to 11.6 NHTG at the western end (Photo 13, Photo 14, Photo 15, and Photo 16).

Photo 13: Site B North - looking west along the southern boundary (January 2011)

Photo 14: Site B North- looking south-east (January 2011)

Photo 15: Site B North - looking west (January 2011)

Photo 16: Site B North - looking north towards monitoring well B-01 and the rail loop (January 2011)

Site B South comprises the waterfront strip between Tourle Street Bridge and the AusGrid wind turbine. The site largely consists of a low-lying mudflat with mangrove vegetation, with a ground surface level of 1.5 NHTG to 2.0 NHTG, rising at the eastern end to about 4.5 NHTG at the wind turbine site (Photo 17, Photo 18, Photo 19 and Photo 20).

Photo 17: Site B South - looking west to south-west (January 2011)

Photo 18: Site B South - looking east towards the AusGrid windmill (January 2011)

Photo 19: Site B South - looking east from the Tourle Street bridge (January 2011)

Photo 20: Hunter River (south arm) - looking east along the southern boundary of Site B South from the Tourle Street bridge (January 2011)

3.3 Site C (Delta EMD Waste Disposal Site)

The Delta EMD waste disposal site (Site C) is bounded to the north-east by the FDF with the remaining boundaries adjoining the larger KIWEF site (Site A) (Photo 21). The Delta EMD site currently comprises four landfill cells (Ponds 33 to 36), separated by bund walls.

Photo 21: Site C - looking north-east from the south-western corner of Site C (January 2011)

The internal cell areas are generally level, with previous stockpiles of soil/waste having been levelled out in 2010. The current ground surface levels in the range 3.5 NHTG to 6 NHTG (Photo 22 and Photo 23).

Photo 22: Site C - looking south-west from the north-eastern corner of Site C (January 2011)

Photo 23: Site C - looking west to north-west from the south-eastern corner of Site C (January 2011)

Photo 24: Site C - looking west to south-west from the eastern boundary of Site C (September 2010)

3.4 Site D (Fines Disposal Facility)

The PWCS FDF (Site D) currently comprises five ponds called Cells 1 to 5. The two southern cells (Cells 4 and 5) were formerly Ponds 37 to 39 of KIWEF. The FDF is bounded to the north by the railway line to KCT, to the west by Sites A and C, to the south by the NCIG railway line and Dump Station and to the east by an unnamed road. This road, which services the FDF and Pacific National essentially marks the boundary between the T4 Project and the two coal terminals to the east (KCT and NCIG).

The cell walls at the FDF are generally at RL 8.5 NHTG to 8.8 NHTG, while the ground surface within the cells varies from about RL 4.5 NHTG to 7.5 NHTG depending on the placement of waste in the cells (Photo 25, Photo 26 and Photo 27).

Photo 25: Site D - looking north-east to south-east from the north-western corner of Cell 1 in the FDF (January 2011)

Photo 26: Site D - looking north to north-east from the south-western corner of Cell 4 in the FDF (January 2011)

Photo 27: Site D - looking south-west from the northern boundary of Cell 2 in the FDF (January 2011)

3.5 SP1 Area

The SP1 Area comprises a corridor of land 100 m wide, located immediately west and north of the existing railway lines that service NCIG and KCT. SP1 is a zoning under the *State Environmental Planning Policy (Major Projects) Amendment (Three Ports) 2009*, designated 'Special Activities'.

The area consists of wetlands, gravel access tracks, overhead power lines, gas and water easements.

3.6 Surrounding Environment

The land adjoining and surrounding the T4 Project area comprises wetlands formed on partly reclaimed land and industrial development. The wetland areas are situated to the north and west of the site as follows:

- West: Kooragang Island Nature Reserve and National Park, including the 100 m wide SP1 Area described above. The site is low lying consisting of grassed areas and surface water bodies. The area is administered by OEH; and
- North: Hunter Wetlands National Park and Hunter Estuary Wetlands Ramsar site, including a 100 m wide SP1 zone adjacent to the existing railway line and a gas / water easement running east-west. The site is low lying consisting of grassed areas and surface water bodies. The area is administered by OEH.

The surface water bodies include Swan Pond, OEH Wetland 1 to 3 and Rail Road Pond.

Swan Pond is connected to the South Arm of the Hunter River and is subject to subdued Hunter River daily tidal variations, and is shown in Photo 28 below.

Photo 28: Swan Pond (July 2011)

OEH Wetlands 1, 2 and 3 are shown below in Photo 29 to Photo 31, notably with OEH Wetland 1 dry in January 2011.

Photo 29: OEH Wetland 1, observed dry (January 2011)

Photo 30: OEH Wetland 1 (July 2011)

Photo 31: OEH Wetland 3 (July 2011)

Rail Road Pond situated between the railway embankment filling and the northerly road running parallel to the railway and is shown in Photo 32 below.

Photo 32: Rail Road Pond (July 2011)

Industrial development adjoining the T4 Project area is as follows:

- East: Kooragang Coal Terminal and NCIG Coal Terminal. These sites are highly developed industrial facilities which are currently under expansion to fully occupy the respective sites;
- South-East: The NCIG Rail loop, which encompasses former KIWEF waste ponds, lies to the south of T4 Project Sites C and D, and north of T4 Project Site B. Cormorant Road bisects Site B, and the Hunter River (South Arm) is located further south, adjacent to the proposed T4 Project wharf area; and
- South-West: the BHPB Kooragang Island Emplacement Cell (KIEC) is situated immediately south of Site A. It comprises three lined cells constructed to receive treated contaminated sediments from the Hunter River. The construction of the cells is complete with final capping currently near completion. The Hunter River (South Arm) lies to the south of KIEC.

4. Background Information

4.1 Introduction

The review of background information for the T4 Project was undertaken for the following:

- General site history of the T4 Project area and Kooragang Island area;
- The current Geotechnical and Contamination Assessment Reports (Refs 25 and 23);
- Existing geo-environmental reports by others;
- T4 Project Geology and Stratigraphy;
- Current site levels and topography;
- Results of existing hydraulic conductivity and coefficient of consolidation testing; and
- Groundwater bore search.

4.2 Site History

The KIWEF is located in an area of reclaimed channels, mudflats and shallow islands, and was originally used for agricultural purposes as shown on Drawing 5.05, Appendix C. Reclamation of the general area commenced in the late 1950s using materials dredged from the Hunter River. In the 1970s BHP (now BHPB) purchased 310 ha of land between the river and the future railway line, and commenced construction of waste emplacement ponds. This area became the Kooragang Island Waste Emplacement Facility (KIWEF).

By 1974 the eastern part of the T4 Project Site A, comprising Ponds 1 to 8 had been formed, using coal washery reject and blast furnace slag to construct the bund walls of these ponds. Ponds 9 to 12 were completed in 1978 and construction of additional ponds to the east commenced (Ponds 13 to 32). Ultimately Ponds 33 to 36, forming the current Delta EMD site (Site C), and Ponds 37 to 39, now FDF (Site D) Cells 4 and 5, was constructed by BHP.

The ponds were used for the disposal of various waste by-products from the BHP Steelworks and BHP subsidiaries, including Commonwealth Steel, Tubemakers, BHP Wire Rope Works, Koppers, BHP Refractories and BHP research laboratories (Ref 30). The waste included general refuse (bricks, timber, cardboard, earth, tyres), coal reject waste (fine and coarse), fly ash, blast furnace slag, granulated slag, BOS flue dust, steel slag (Brecketts), lime and dolomite sludges, asbestos, oil sludges, tarry waste and acidic sludges (Ref 33). Drawing 5.09 shows the reported types of wastes disposed in the various cells (based on a Dames & Moore Plan, Ref 18937-001-70, Fig 11 and GHD Plan, Ref 33).

The electrolytic manganese dioxide (EMD) plant, located on the southern side of the Hunter River, adjacent to Tourle Street, was constructed by BHPB in 1988-1989. The plant was operated by the Australian Manganese Company Limited (AMCL), a subsidiary of BHPB. It is therefore likely that Site C (EMD Waste Disposal site) commenced receiving the EMD by-products waste from about 1989 onwards. Further details on the Delta EMD operations and waste disposal are given in the DP review reports undertaken for the site (Refs 17 and 18).

In 1993 PWCS purchased from BHPB the land that now forms the FDF (Site D), the southern part of which comprised Ponds 37 to 39, now FDF Cells 4 and 5 (see Drawing 5.01).

Filling operations at Site A and B ceased in 1999 with the closure of the former BHP Steelworks at Mayfield. Filling operations at Site C ceased in 2008 with the closure of the Delta EMD Plant, with only minor waste disposal activities continuing to late 2009 as the Mayfield plant site was decommissioned in preparation for sale (Ref 19). Site D (FDF) continues to periodically receive waste materials originating from river dredging activities, which included cement modified sediment from BHPB's current Hunter River Remediation Project. The historical emplacement of waste over the site is summarised on Drawing 5.09 in Appendix C.

4.3 Current Geotechnical / Contamination Assessments

Subsurface investigation conducted as part of the current phase of combined geotechnical, contamination and groundwater assessment was undertaken over Sites A to D, using a combination of methods, namely test bores, cone penetration tests (CPT), test pits and push cores.

- 44 bores by site investigation drilling rig;
- 47 cone penetration tests (22 standard and 25 piezocone);
- 46 test pits by backhoe;
- 8 push cores (in Deep Pond); and
- Installation of 24 environmental grade monitoring wells and 15 standpipes.

Further details of the geotechnical and contamination assessments are provided in References 23 and 25, respectively. The test locations are shown on Drawing 5.02, Appendix C.

4.4 Previous Investigations

This groundwater assessment was designed to complement pre-existing geotechnical and contamination information on the T4 Project site. Information from previous investigations has been reviewed and relevant results or findings have been incorporated in this report where appropriate. The principal sources of additional information are listed in Table 2.

Table 2: Principal Background Documents for T4 Project

Date	Title	Author [1]	Ref
Jun 1975	Preliminary Site Investigation Report, Newcastle Works Development to 3 MTPA	DP (as GT)	35
May 1988	Environmental Impact Statement (EIS)	BHP-UTAH	5
May 1988	Environmental Impact Statement (EIS) Doc 2 Waste Management Study	BHP-UTAH	4
Jul 1990	Installation of a Groundwater Monitoring Network at the Delta site	EES	28
1996	Kooragang Island Management Plan	Unknown[2]	40
Mar 2000	Area K10 Groundwater Flow Assessment	RCA	42
Jun 2001	Geotechnical Assessment, BHPB Emplacement Land, Kooragang Island	DP	10
Jun 2001	Geotechnical Investigation Hunter River South Arm	DP	11
Dec 2002	Geotechnical Investigation, Austeel Port and Transport Corridor, Kooragang Island	DP	12
Aug 2003	Geotechnical Investigation, Waste Emplacement Ponds, Kooragang Island	DP	13
Nov 2004	Area K10 Permeability Assessment	RCA	44
Jun 2007	Draft Baseline Contamination Assessment Site A and Site D, Kooragang Island, Newcastle	EES	29
Dec 2008	Baseline Contamination Study, Conceptual Model and Sampling and Analysis Plan for Site A and Site D, Kooragang Island	EES	30
Aug 2009	KIWEF Revised Final Landform and Capping Strategy	GHD	33
Apr 2010	Geotechnical and Geo-Environmental Assessment - Concept Stage, Proposed Terminal 4, Kooragang Island	DP	20

Notes to Table 2:

1. See References in Section 14 for full names of Authors / Companies
2. The author of this report was most likely BHP Co Ltd

4.5 Geology

The geology at the site comprises Permian aged Tomago Coal Measures overlain by Quaternary alluvium. The Tomago Coal Measures comprise shale, siltstone, sandstone, conglomerate and coal.

The overlying alluvium comprises fine to medium grained estuarine sediments with some gravel zones, overlain by fluvial sands with further fine grained estuarine deposits at the top of the natural profile.

The 1:100 000 scale regional geology map for Newcastle (Newcastle Coalfield Regional Geology, Sheet 9321, NSW Department of Mineral Resources) indicates that there are no recorded geological faults directly beneath the site. There are two “normal” faults (position approximate) shown traversing Kooragang Island in a north-south orientation. One fault lies about 700 m to 800 m east of the site and the southern end of the plotted position stops about 500 m north of the railway bridge. The second fault is shown about 1300 m west of the rail line, crossing the western end of Kooragang Island.

The region is an area of low to moderate seismicity and lies within an intra-plate area. A significant earthquake occurred in December 1989 (‘’the Newcastle Earthquake’’) which registered approximately 5.6 on the Richter Scale, and was assessed to have a return period of about 500 years.

The acid sulphate soil risk map for Newcastle indicates that there is a high probability of occurrence of acid sulphate soils within estuarine sediments of the Hunter River. The land area associated with the T4 Project development is indicated as disturbed terrain due to reclamation.

4.6 Stratigraphy

A general geotechnical model for the site was developed from the previous investigations. DP has adopted similar terminology for the various soil units, as defined in previous investigations, for purposes of continuity and consistency.

Based on the previous work, the site stratigraphy in the vicinity of the site can generally be divided into the units described below and represented in Figures 5.17 to 5.22.

Unit 1: Filling

Fill levels within the site are up to RL 13 NHTG, but typically less than RL 10 NHTG comprising large areas of loosely dumped refuse and fill (generally comprising blast furnace slag, coal washery reject and refuse), with water ponding in low-lying areas at less than RL 3 NHTG. Pond 5 of Site A contains oil and tar sludge.

The filling forms an unconfined groundwater aquifer, as described in Section 9.

Contours of the base of the Unit 1 filling across the proposed emplacement pond are presented on Drawing 5.10 in Appendix C.

Unit 2: Upper Soft Soil

The filling is generally underlain by a soft to firm compressible natural clay unit, designated Unit 2. The thickness of the unit typically varies from approximately 1 m to 4 m across Site A Ponds 1 to 6 and increases to 14 m in the north western corner of Area A in Deep Pond. Unit 2 thickness in Sites B, C and D are generally between 0.0 m and 5.5 m with zones of up to 7 m thick in Site B South. This unit may be further divided into low plasticity sandy clay/clayey sand and medium plasticity clay/silty clay.

Isopachs of clay thickness across this area are presented on Drawing 5.13 in Appendix C.

Unit 3: Lower Sand

The Unit 2 clay is underlain by sand, which generally ranges from medium dense, becoming dense to very dense with depth. There is occasionally a thin transition zone of loose to medium dense silty sand near the top of the unit. This unit can vary from several metres, to up to approximately 30 m thick and in places there seems to be discontinuous layers of Unit 4 Clay within the unit.

The lower sand forms the confined estuarine aquifer. Contours of the base of the lower sand layer (top of stiff clay level) are presented on 5.14 in Appendix C.

Unit 4: Deep Clay

The dense sand is generally underlain by a "deep clay" unit. Where encountered, the unit ranges in thickness from about 10 m to 35 m and generally comprises stiff medium to high plasticity clay and occasionally lower plasticity sandy clay. In places, deep clay contains interbeds of dense to very dense sand and gravel layers.

Unit 5: Bedrock

The alluvial soils are underlain by bedrock comprising siltstone, sandstone and coal. The depth to bedrock varies substantially across the site, occurring as shallow as about -5 NHTG in south-westerly areas, to as deep as -62 NHTG outside the site. The top of the bedrock is generally extremely to highly weathered and very low to low strength, becoming medium to high strength and slightly weathered with depth. Contours of the bedrock level are presented on Drawing 5.15 in Appendix C.

A geotechnical summary spread sheet was prepared, comprising a list of current and previous tests (bores, CPTs, test pits, etc), and showing coordinates, levels and basic stratigraphic information, where known. This 'database' of tests formed the basis of various contour plans prepared for this report, and is included in Appendix A as Table A1.

4.7 Surface Levels

The current site survey levels were provided by Monteath and Powys (project surveyors) in a 10 m grid format. The grid was derived from a digital terrain model (DTM) based on an aerial survey undertaken by AAMHatch on 7 March 2009 (Ref Volume 15781A02NOM, 24 May 2009).

The tidal flats to the north of the site were not included in the above survey. Information on site levels for the tidal flats was based on a site survey plan by Connell Hatch (Ref HW00-00-C-61-600, dated 29 March 2006), however, it is noted that limited survey information for this area was available and is at lower resolution.

4.8 Hydraulic Conductivity

A number of previous studies on the site have estimated the hydraulic conductivity of the various strata as outlined below. Hydraulic conductivity, commonly referred to as ‘permeability’, is a quantitative measure of how easily water flows through the pore spaces in a soil.

4.8.1 Area K2

Investigations undertaken by EES (Ref 29) in 2007 included rising head testing in piezometers. A summary of the results from these investigations is presented in Table 3.

Table 3: Estimated Hydraulic Conductivities (Ref 29)

Aquifer	Number of Tests	Range		Average	
		m/s	m/day	m/s	m/day
Fill – Sandy	6	$1x10^{-5}$ to $2.1x10^{-4}$	0.84 to 18.1	$1x10^{-4}$	8.6
Fill – Clay	1	$1.2x10^{-4}$	10.4	NA	NA
Fill - Coal Washery Fines	1	$6.8x10^{-9}$	$5.9x10^{-4}$	NA	NA
Estuarine – upper	14	$7x10^{-5}$ to $3x10^{-4}$	6.1 to 25.9	$1.7x10^{-4}$	14.7
Estuarine – lower	6	$1.2x10^{-5}$ to $2.2x10^{-4}$	1.0 to 19	$6.3x10^{-5}$	5.4

The results of falling head tests from subsequent investigations by DP (Ref 16) are presented in Table 4.

Table 4: Estimated Hydraulic Conductivities (Ref 16)

Aquifer	Number of Tests	Range		Average	
		m/s	m/day	m/s	m/day
Fill - Slag and Coarse Coal Reject	20	$8x10^{-6}$ to $1.5x10^{-3}$	0.69 to 130	$2.5x10^{-4}$	21.6
Estuarine	25	$1.7x10^{-5}$ to $4.6x10^{-4}$	1.5 to 39.7	$1.4x10^{-4}$	12.1

4.8.2 Area K10

Rising head testing undertaken in Area K10 by RCA in 2000 (Ref 43) indicated the following average hydraulic conductivities:

- Fill: $1.9x10^{-6}$ m/s;
- Shallow Estuarine Aquifer: $1.7x10^{-4}$ m/s (15 m/day); and
- Deep Estuarine Aquifer: $2.1x10^{-4}$ m/s (18 m/day).

The results of subsequent shallow permeameter testing of the fill (Ref 44) are presented in Table 5.

Table 5: Estimated Hydraulic Conductivities (Ref 43)

Aquifer	Range		Average	
	m/s	m/day	m/s	m/day
Coal Washery Reject	$6x10^{-7}$ to $1x10^{-4}$	0.05 to 8.64	$3x10^{-5}$	2.6
Cemented Slag	$5x10^{-7}$ to $2x10^{-4}$	0.04 to 17.3	$1x10^{-5}$	0.86
BOS Dust	$8x10^{-7}$ to $3x10^{-5}$	0.069 to 2.6	$3x10^{-6}$	0.26

4.8.3 Kooragang Coal Terminal (east of the T4 Project)

Pumping tests undertaken for investigations of dump stations within KCT, to the east of the T4 Project indicated the following typical hydraulic conductivities (Ref 15):

- Fill Aquifer (silty sand): $1x10^{-5}$ to $2.5x10^{-5}$ m/s; and
- Estuarine Aquifer: $2.5x10^{-4}$ to $4.5x10^{-4}$ m/s.

4.8.4 Particle Size Distribution Testing

Particle size distribution testing was undertaken on estuarine sand as part of the geotechnical and contamination assessments (Refs25 and 23) for the T4 Project. The results indicate the material is a fine to medium grained sand and the pertinent results as well as estimated range of hydraulic conductivities (K) based on Hazen's method are presented below in Table 6.

Table 6: Results of Particle Size Distribution Tests – Estuarine Sand

Location	Depth (m)	D_{10} (mm)	K low (m/s)	K high (m/s)
R-01	8.65-9.1	0.19	2.89×10^{-04}	4.33×10^{-04}
R-01	16.3-16.75	0.0075	4.50×10^{-07}	6.75×10^{-07}
R-02	6.1-6.55	0.17	2.31×10^{-04}	3.47×10^{-04}
R-03	8.3-8.75	0.31	7.69×10^{-04}	1.15×10^{-03}
R-03	13.7-14.15	0.16	2.05×10^{-04}	3.07×10^{-04}
R-04	7.55-8	0.18	2.59×10^{-04}	3.89×10^{-04}
R-04	13.85-14.3	0.18	2.59×10^{-04}	3.89×10^{-04}
R-05	13.3-13.75	0.17	2.31×10^{-04}	3.47×10^{-04}
R-06	7.75-8.2	0.17	2.31×10^{-04}	3.47×10^{-04}
R-08	5.0-5.45	0.17	2.31×10^{-04}	3.47×10^{-04}
R-08	9.0-8.45	0.17	2.31×10^{-04}	3.47×10^{-04}
R-10	4.9-5.35	0.17	2.31×10^{-04}	3.47×10^{-04}
R-10	12.45-12.9	0.2	3.20×10^{-04}	4.80×10^{-04}
A-02	13-13.45	0.17	2.31×10^{-04}	3.47×10^{-04}
A-06-1	11.5-11.95	0.15	1.80×10^{-04}	2.70×10^{-04}
A-11	9.8-10.15	0.15	1.80×10^{-04}	2.70×10^{-04}
Average (m/s)			2.55×10^{-04}	3.82×10^{-04}
Average (m/day)			22.0	33.0

Notes to Table 6:
'R' prefix denotes soil sample collected from the South Arm of the Hunter River
'A' prefix denotes sample collected from 'Site A'
D_{10} – particle size for which 10% of particles are smaller

4.8.5 Rising Head Tests – Areas A and B

Additional rising head testing was undertaken by DP in monitoring wells in Areas A and B in May 2011. The results of this testing is summarised in Table 7.

Table 7: Estimated Hydraulic Conductivities

Aquifer	Range		Mean	
	m/s	m/day	m/s	m/day
Fines Areas A and B	9×10^{-9} to 7×10^{-6}	8×10^{-4} to 6.5×10^{-1}	6×10^{-7}	5×10^{-2}
Slag Inclusions in Area A	1.9×10^{-5} to 4.4×10^{-4}	1.6 to 38	1.7×10^{-4}	15
Area C Fill	1.5×10^{-6} to 3.5×10^{-6}	0.13 to 0.30	2.5×10^{-6}	0.2
Estuarine clayey sand immediately below Unit 2 clay	4×10^{-6} to 1.2×10^{-4}	0.35 to 1.0	2.0×10^{-5}	1.8
Estuarine Sand	2.1×10^{-4} to 8.5×10^{-4}	18 to 74	3.5×10^{-4}	30

4.9 Coefficient of Consolidation

The coefficient of consolidation (c_v), which is a critical parameter for assessment of consolidation required for geotechnical assessment, has been assessed for the fine grained soils as part of the geotechnical assessment for the T4 Project. The coefficient of consolidation is used to assess the time it takes for consolidation settlement to occur. This is closely related to hydraulic conductivity.

This parameter can be determined from laboratory odometer tests, however experience indicates that laboratory values under-estimate c_v for field conditions due to the small sample size. It is therefore reasonable to multiply laboratory values by a factor of 4 to estimate field values.

Piezocone pore pressure dissipation tests provide an in-situ (field) estimate of the horizontal coefficient of consolidation (c_h). The ratio of c_h/c_v depends on soil anisotropy and is equivalent to the ratio of horizontal to vertical permeability (k_h/k_v). This ratio typically ranges from 1 to 5 with a value of 2.5 being adopted for the T4 Project geotechnical assessment.

Figure 2 shows the estimated vertical coefficient of consolidation values from all available laboratory and field tests from the T4 Project site and for each principal soil unit.

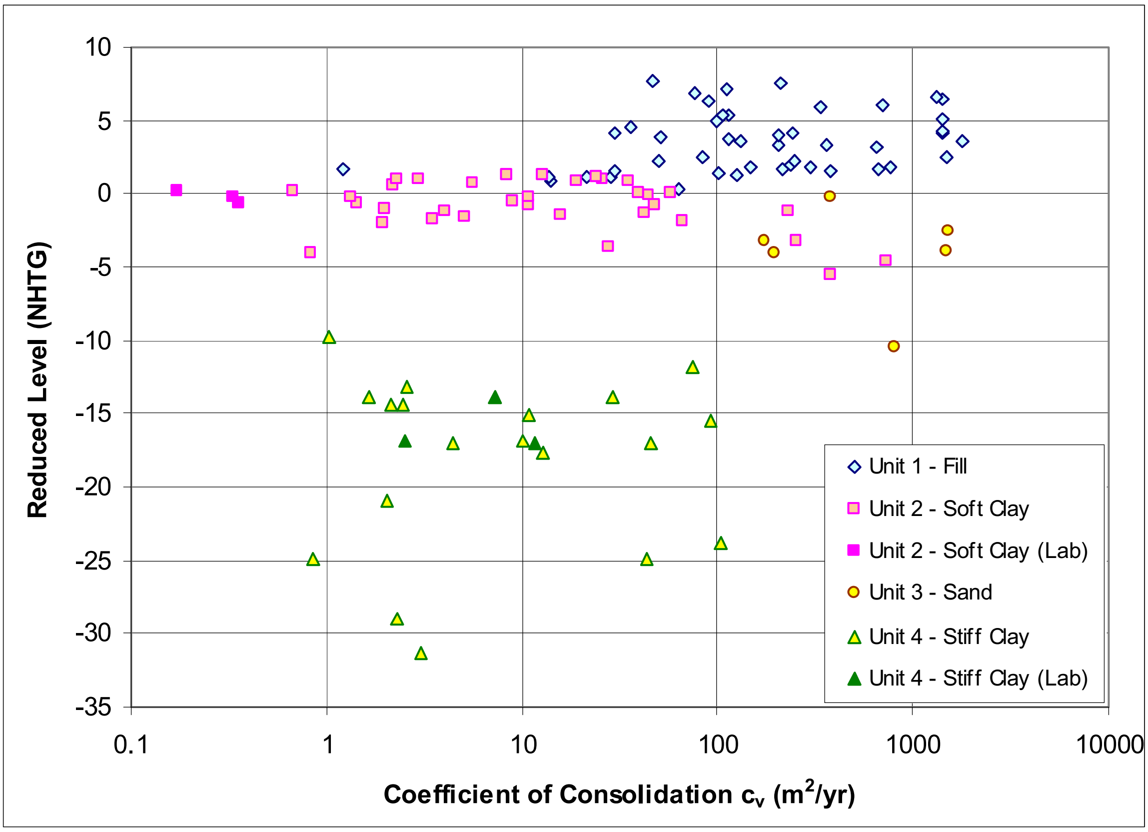

Figure 2: Combined Results for Coefficient of Consolidation

Figure 2 illustrates a wide range of results. However, statistical analysis indicated that the results for each unit fit a log-normal distribution. For the geotechnical assessment a 5% percentile was used for design to reduce the risk of underestimating the settlement times. For groundwater modelling, the vertical flow through the layer is the critical issue as the clay layers are stratified and testing indicates the c_v/K varies with depth. Therefore the vertical flow is likely to be controlled by lower permeability sublayers and the representative permeability is likely to be based on a value within the range of the 5^{th} and 50^{th} percentile c_v. Table 8 presents the results of the statistical analyses of c_v.

Table 8: Statistical Analysis of the Vertical Coefficient of Consolidation

Unit	Description	Log-Normal Distribution of Coefficient of Consolidation (m^2/yr)		
		Fit - R^2 (Correlation Coefficient)	Median (50th Percentile)	5th Percentile
1.1	Mainly Coal Fines, Some Clay	0.95	483.1	40.6
2	Soft Clay (alluvial)	0.98	64.4	3.4
4.1	Stiff Clay (estuarine)	0.94	2.30	1.0
4.2	Stiff Sandy Clay (estuarine)	0.93	52.0	11.4

The relationship of hydraulic conductivity to c_v is shown in Equation 1 below:

$$k = m_v \times c_v \times \gamma_w \qquad \text{(Equation 1)}$$

where: m_v = coefficient of compressibility (vertical)

- (design value adopted = 1.5 m^2/MN for Unit 1 and 1.0 m^2/MN for Unit 2)
- c_v= coefficient of consolidation (vertical) (m^2/day)
- γ_w = density of water

The resulting estimated hydraulic conductivities are presented in Table 9.

Table 9: Estimated Hydraulic Conductivities

Correlated Hydraulic Conductivities	Unit 1.1 Coal Fines / Sediment		Unit 2 Soft Silty Clay		Unit 4.1 Stiff Clay		Unit 4.2 Stiff Sandy Clay	
	m/s	m/day	m/s	m/day	m/s	m/day	m/s	m/day
5th Percentile vertical	1.9×10^{-8}	1.6×10^{-3}	9.3×10^{-10}	8.0×10^{-5}	1.6×10^{-11}	1.4×10^{-06}	9.3×10^{-11}	8.0×10^{-06}
5th Percentile horizontal	4.7×10^{-8}	4.1×10^{-3}	2.3×10^{-9}	2.0×10^{-04}	3.9×10^{-11}	3.4×10^{-06}	2.3×10^{-10}	2.0×10^{-05}
50th Percentile vertical	2.3×10^{-7}	2.0×10^{-2}	2×10^{-8}	1.7×10^{-03}	3.6×10^{-11}	3.1×10^{-06}	4.8×10^{-10}	4.1×10^{-05}
50th Percentile horizontal	5.6×10^{-7}	4.8×10^{-2}	5×10^{-8}	4.3×10^{-03}	8.9×10^{-11}	7.7×10^{-06}	1.2×10^{-09}	1.0×10^{-04}

4.10 Groundwater Water Bore Licensing

An online records search of licensed groundwater bores with the NSW Office of Water (NOW,) indicated that there are three registered groundwater wells on Kooragang Island. Bores GW200456 and GW053226 are located approximately 1.5 km south-east of the eastern T4 Project site boundary and are respectively licensed for industrial irrigation purposes and industrial purposes. Bore GW200485 is situated approximately 2.3 km east of the site and is licensed for industrial purposes. The location of the wells are shown in Figure 3.

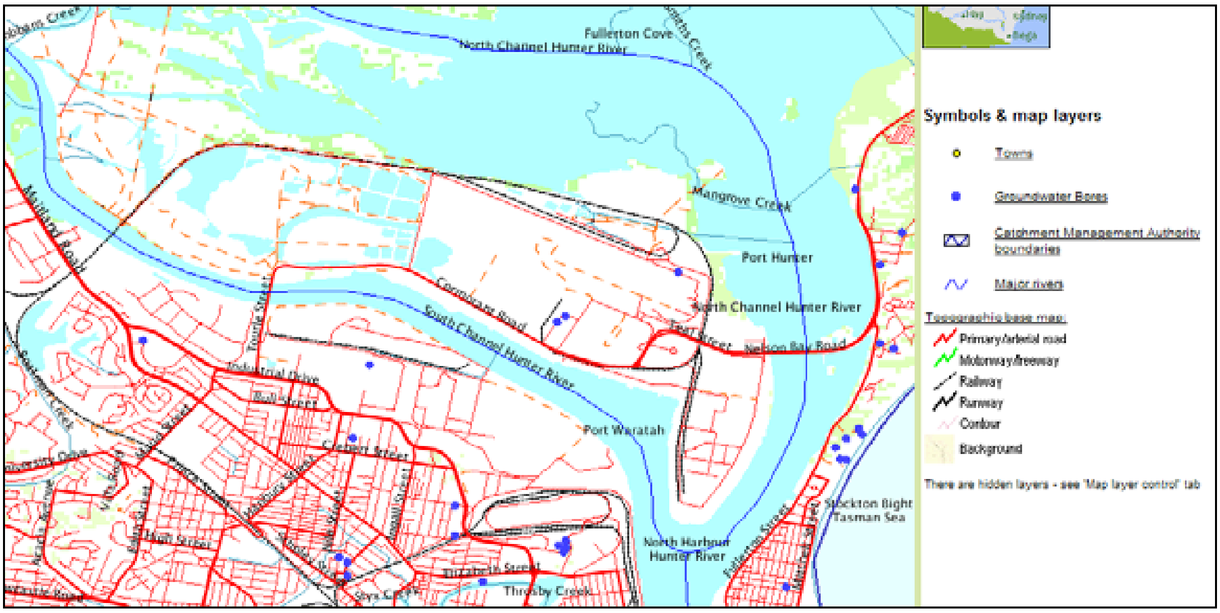

Figure 3: NSW Natural Resource Atlas Licensed Groundwater Bore Mapping

5. Scope of Groundwater Assessment

5.1 Overview

A substantial amount of information exists on the type and extent of soil and groundwater contamination as well as geotechnical information within the T4 Project area and overall KIWEF. The scope of work was devised to complement this information.

The groundwater assessment was undertaken in a number of stages as outlined in the following sections. The main issues requiring assessment included:

Impacts on Adjacent Wetlands

The proposed dredging, preloading and T4 Project construction could impact on the salinity of adjacent wetlands, surface water bodies, water levels and water flows.

Ponds 5 and 7 Tar Waste

Ponds 5 and 7 in Site A contain large volumes of non-aqueous phase liquid (NAPL) tar waste to depths of approximately 8 m. The tar is generally in the form of a viscous sludge. Groundwater impact has also been recorded above ANZECC criteria (Ref 3) in wells immediately surrounding Ponds 5 and 7. The groundwater impact is primarily in the upper fill aquifer, with some elevated concentrations also recorded in the underlying estuarine aquifer.

Lead Dust / Asbestos Area

The asbestos burial pits are known to contain lead dust, co-disposed with the asbestos in polyethylene bags. Some of the asbestos and lead dust burial pits are expected to come into permanent or frequent contact with groundwater following settlement induced by preloading and subsequent T4 development. The lead dust is expected to be highly leachable when in contact with groundwater hence elevated concentrations of lead could potentially reach the wetlands to then north of the disposal area.

LNAPL Contamination Site B North

Free-phase hydrocarbon impact, comprising Light Non-aqueous Phase Liquid (LNAPL) was encountered in groundwater collected from the upper fill aquifer monitoring well B-01-U. The apparent thickness of floating product in Bore B-01-U was found to be 2.15 m, when dipped in June 2011. Fingerprint analysis of the free product found that the sample was degraded mineral lubricating oil with trace amounts of diesel. The report concluded that the oil was not a recent release and may have been used in diesel engines. The monitoring well locations are shown on Drawing 5.02 in Appendix C.

Fines Disposal Facility

Groundwater levels within the FDF are artificially low due to the existing leachate collection system – generally about RL 1.8 to 2.0 NHTG. This is approximately the same level as the base of the dredged spoil placed in the FDF, hence to date materials with elevated contaminant levels have been essentially above the water table.

Groundwater levels would be elevated during dredging and preload stages. The existing leachate collection system is expected to continue functioning during dredging. Following dredging, however, the elevated head of water in the sand fill (now overlying the FDF) would increase vertical infiltration through the dredge spoil and potentially mobilise contaminants. Preload and site development are expected to induce settlements which may impact on the leachate collection system. Further, the base of the emplaced dredge spoil would settle and is expected to come into contact with groundwater.

Delta EMD Site

The former Delta EMD site principally contains manganese waste and localised hydrocarbon contamination. The Contamination Assessment reported exceedances of the landuse criteria and *Waste Classification Guidelines* for General Solid Waste for metals, TRH and PAH. The ground conditions comprise a thinner and more permeable Unit 2 aquitard below fill materials compared to elsewhere on site. This presents a risk of migration of contamination into the estuarine aquifer, and increased groundwater effects on nearby surface water bodies, particularly during dredging.

The main areas of contamination identified within the T4 Project area at KI are shown on Drawing 5.27 in Appendix C. Drawing 5.31 in Appendix C also indicates the main areas of contamination in relation to the proposed development.

5.2 Desktop and Field Investigation

The first stage of the groundwater assessment comprised the following:

- Detailed walk over of the site by a senior groundwater engineer and an environmental engineer to assess the following:
  - Interconnections between various ponds and drains;
  - Evidence of surface flows or seepage; and
  - General condition of various ponds and measurement of key field parameters, pH and Electrical Conductivity (EC).
- Measurement of groundwater levels in a total of 150 existing serviceable wells and ponds within an eight hour period to provide a detailed 'snapshot' of groundwater and surface water levels across the site;
- Installation of water level data loggers in three pairs of deep/shallow wells as well as several surface water ponds over a period of eleven months to provide information on how the surface water and groundwater interact on a local scale, in particular in response to rainfall and tidal variations. A total of 13 loggers were installed over the period, at 15 locations;
- Collection of selected soil samples from bores (Refs 23 and 25) which were tested for Total Organic Carbon (TOC) to determine coefficients for contaminant transport modelling; and
- Review of data collected from the current Geotechnical and Contamination Assessments (References 25 and 23) and incorporation of this data into an overall data set to provide a conceptual flow model for the T4 Project area.

5.3 Numerical Flow Modelling

The second stage of the groundwater assessment used the information collected from the desktop and field investigations, as well as DP's current Contamination and Geotechnical Assessments (References 23 and 25) to develop numerical flow models capable of simulating pre-development site conditions and the potential impacts associated with the development of the T4 Project.

Computer modelling was then undertaken using the well-recognised computer modelling software MODFLOW-SURFACT with Groundwater Vistas Version 6 as an interface. The following numerical flow modelling was undertaken:

- Development of a three layer Steady State model, calibrated using the 'snapshot' groundwater level data and average annual climatic data;
- Development of a three layer Transient model, calibrated to rainfall, evapotranspiration and Newcastle Harbour tide data and the four month period of logged groundwater and surface water levels collected; and
- Steady State and Transient simulations of the three stages of the T4 Project, namely:
  - Stage 1: Progressive placement of dredged sand over the Sites A, C and D, and preloading of Stage 1;
  - Stages 2 and 3: Progressive preload, construction and capping of Sites A, C and D; and
  - Final capping of the site following completion of Stages 1 to 3.

The potential T4 Project groundwater impacts to the sites of ecological significance were considered in terms of the following:

- Variations in pre development, construction and post development water levels and fluctuations in surface water bodies;
- Variations in pre development, construction and post development groundwater levels and associated hydraulic gradients and flow rates, which may affect the rate of transport of contamination from the site to sensitive receptors; and
- Potential for saline dredge waters to impact on sensitive receptors during and after dredging.

The above models also considered the use of various mitigation measures to minimise the potential effects of development.

5.4 Contaminant Transport Modelling

The flow modelling described in Section 3.3 was used to assess the potential changes to groundwater levels and flow rates associated with construction and operation of the T4 Project, which may impact on the flux of contaminants from the site to sensitive receptors.

Potential impacts on the flux of contaminants from changes to the groundwater flow regime included:

- Possible increases in the height of the water table resulting in saturation of contaminants formerly located above the water table; and
- Short term increases in flow rates potentially leading to increased flux of existing contaminants.

There is also potential for off-site migration of existing on site contamination, in particular Pond 5/7 under existing groundwater flows and levels or under potential reduced groundwater flows and levels.

A probabilistic approach was conducted for contaminant transport modelling, due to the variability in distribution of contamination in soil and groundwater and potential future flow rates and water levels, as well as uncertainty in key contaminant transport parameters.

The computer program ConSim, developed for the UK Environment Agency for quantitative risk assessment of controlled water, was used for assessing the probable range of contaminant concentrations at key off site receptors for a probable range of site conditions. The program uses a stochastic (probabilistic) approach using Monte-Carlo style simulation to account for uncertainty.

6. Field Work and Field Monitoring Results

6.1 Site Walk Over

A detailed site walk over was undertaken on 8 November 2010 by a senior groundwater engineer and an environmental engineer to assess the following:

- Interconnections between various ponds and drains;

- Evidence of surface flows or seepage; and
- General condition of various ponds and measurement of the field parameters pH and EC.

Key observations associated with surface water/groundwater interactions included the following:

- There is a narrow open unlined drainage channel running from the FDF Pond into the Railway Pond;
- There are localised ponds within the south west corner of K7, north of Site C, which are not directly connected through to the Railway Pond;
- The Railway Pond drains to Deep Pond though an unlined drainage channel;
- Deep Pond drains to Area K1 via a series of concrete culverts at the southern end of a drainage channel along the eastern side of the rail line. The invert level is 2.46 NHTG;
- Easement Pond South drains into the BHP Wetland which then drains to Blue Billed Duck Pond which then drains to Deep Pond via concrete pipes;
- Easement Pond receives runoff via a surface drainage swale from the railway line. There are two 0.2 m diameter PVC pipes which enter the pond from the north eastern end of the pond. The invert level of the pipes is RL 2.38 NHTG and it seems that these are low flow discharge pipes. Information from Aurecon Hatch indicates that the discharge point is east of the NCIG dump station, and comprises concrete pipes with an invert level of 2.4 NHTG;
- Long Pond wraps around the southern and eastern sides of Site B and is separated from the Hunter River tidal flats by a fill embankment associated with Cormorant Road, with no culverts observed through the road. Surface water has been observed to overspill the road following significant rainfall events;
- Swan Pond is connected to the South Arm of the Hunter River via two sets of culverts. The culverts are at about or above mean tidal levels and allow tidal transfer during the high part of the daily tidal cycle only. Swan Pond has interconnections which span the majority of the area to the western side of the site. There was no connection observed to the northern tidal flats;
- Rail Road Pond is located immediately between filling associated with the railway embankment and filling associated with a road embankment to the north of the rail embankment and thus was formed artificially. The pond has a clayey base and seems to have no direct connection to other surface water features;
- OEH Wetland 1 was dry at the time of the walk over assessment and was observed to comprise a shallow depression with a clay base. There is a filled road embankment which forms the northern side of the pond, preventing drainage to the north and allowing water to pond in the area following rainfall. It is unlikely that water would have collected in this location to the same extent prior to construction of the road embankment and there was no visual evidence of the pond in aerial photos prior to construction of the road embankment;
- OEH Wetlands 2 and 3 are located immediately to the north of filling associated with the rail embankment as well as a road embankment which runs to the north of the rail embankment. The ponds are surrounded by mangrove vegetation and there are minor surface channel features at the northern end of the ponds which seems to provide an intermittent connection to the northern tidal flats; and

- There are areas of low lying ground (about RL 1.8 NHTG) which are grassed and extend from 50 m to 200 m to the north of the OEH Wetlands 2 and 3, separating them from an area of low lying mangroves which seem to be subject to daily tidal movements. The ground in this area comprises silty clay and contains numerous crab holes. These tidal flats extend all the way to the North Arm of the Hunter River, about 1 km to the north of the site, however also include various smaller creeks, the most significant of which is Mosquito Creek. These creeks are expected to be subject to the full range of daily tidal movement and extend along and sub-parallel to the full length of the northern site boundary.

6.2 Well Gauging

Measurement of groundwater and surface water levels was undertaken on 25 November 2010 within an eight hour period as follows:

- Well gauging of a total of 150 groundwater monitoring wells and piezometers (both existing and those installed for the T4 investigation) using a Heron oil-water interface meter capable of detecting free floating product. The wells are situated within the main site area with selected wells accessible around the perimeter of the site also gauged; and
- Measurement of surface water levels of selected ponds and surrounding surface water bodies using a differential GPS unit as shown in Table 10.

Table 10: Measured Surface Water Levels on 25 November 2010

Surface Water Feature	Reduced Water Level (NHTG)
Hunter River South Arm	1.96
Deep Pond	2.28
Easement Pond	2.56
BHP Wetland	2.97
Swan Pond	1.50
OEH Wetland 1	Dry
OEH Wetland 2	1.74
OEH Wetland 3	1.97

The results of groundwater gauging for wells and piezometers are presented in the data summary table in Appendix A. Contours of groundwater head in the Fill Aquifer and Estuarine Aquifer, based on these measurements, are presented in Drawings 5.07 and 5.08, Appendix C. Descriptions of the aquifers are provided in the subsections below.

6.3 Data Loggers

Six hydraulic data loggers have been installed at the location of three paired upper and lower aquifer groundwater monitoring wells since 26 November 2010 (refer Drawing 5.02, Appendix C) as follows:

- Well A-04-U (Fill Aquifer) and Well A-04-L (Estuarine Aquifer);
- Well C-05-U (Fill Aquifer)and Well C-05-L (Estuarine Aquifer);
- Well A-05-U (Fill Aquifer) and Well A-05-L (Estuarine Aquifer).

Seven hydraulic data loggers have been installed at a total of eight surface water body locations since 7 December 2010:

- Easement Pond, SWDP4;
- Deep Pond, SWDP2;
- Pond 11, SWDP3;
- Swan Pond, SWDP5;
- OEH Wetland 1, SWDP7A (9 February to 1 March 2011) and SWDP8;
- OEH Wetland 2, SWDP7 (3 February to 8 February 2011);
- OEH Wetland 3, SWDP6; and
- FDF Pond, SWDP1 (until 8 February 2011).

The results from the data loggers for groundwater and surface water are presented in Figure 4 and Figure 5 respectively, together with BoM recorded daily rainfall at Williamtown and Nobby's Stations and KCT recorded daily rainfall. Newcastle Port Corporation provided measured tidal variations for Newcastle Harbour for the period 1 November 2010 to 1 March 2011.

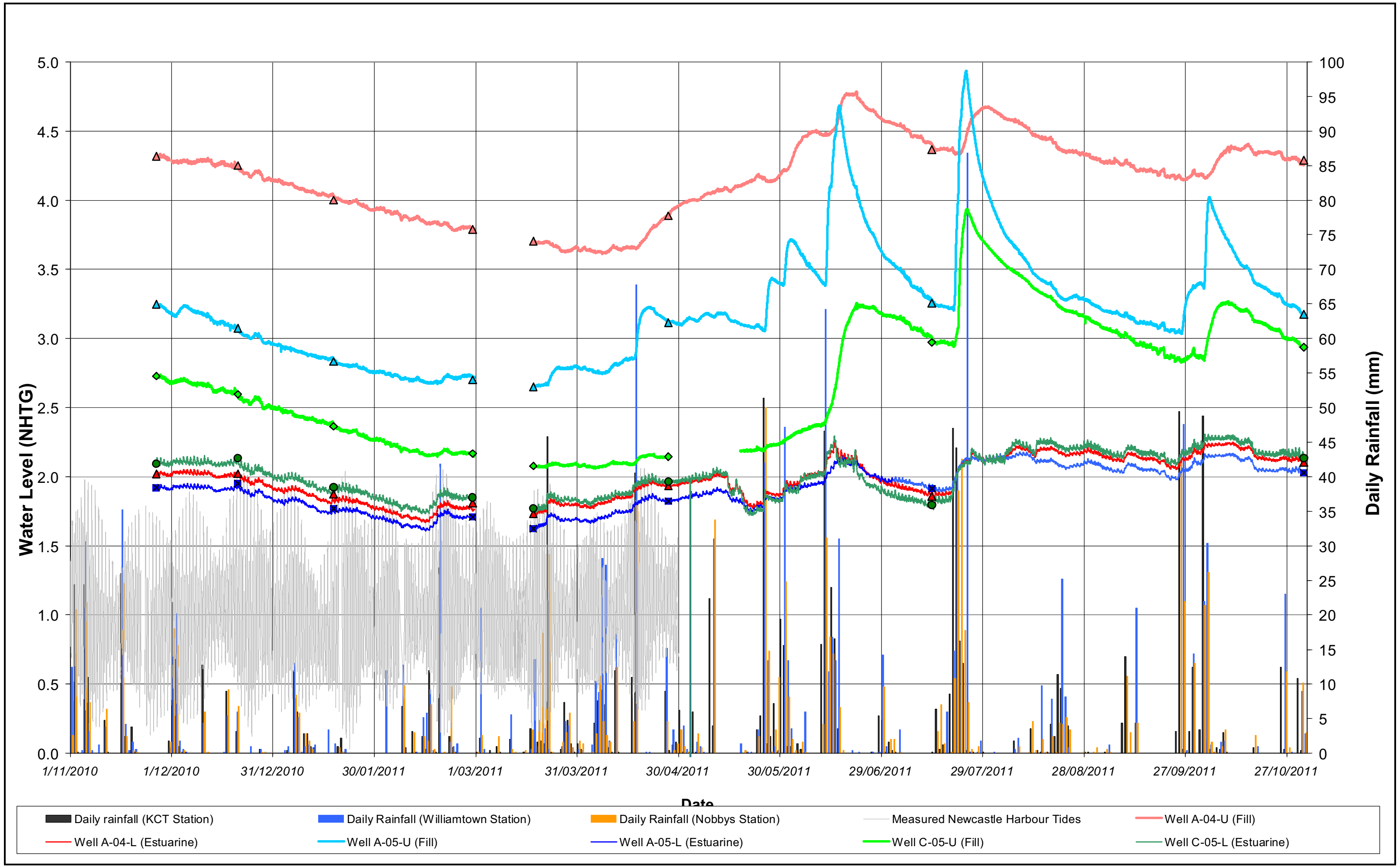

Figure 4: Measured Groundwater Levels and Newcastle Harbour Recorded Tides versus Rainfall – 1 November 2010 to 1 November 2011

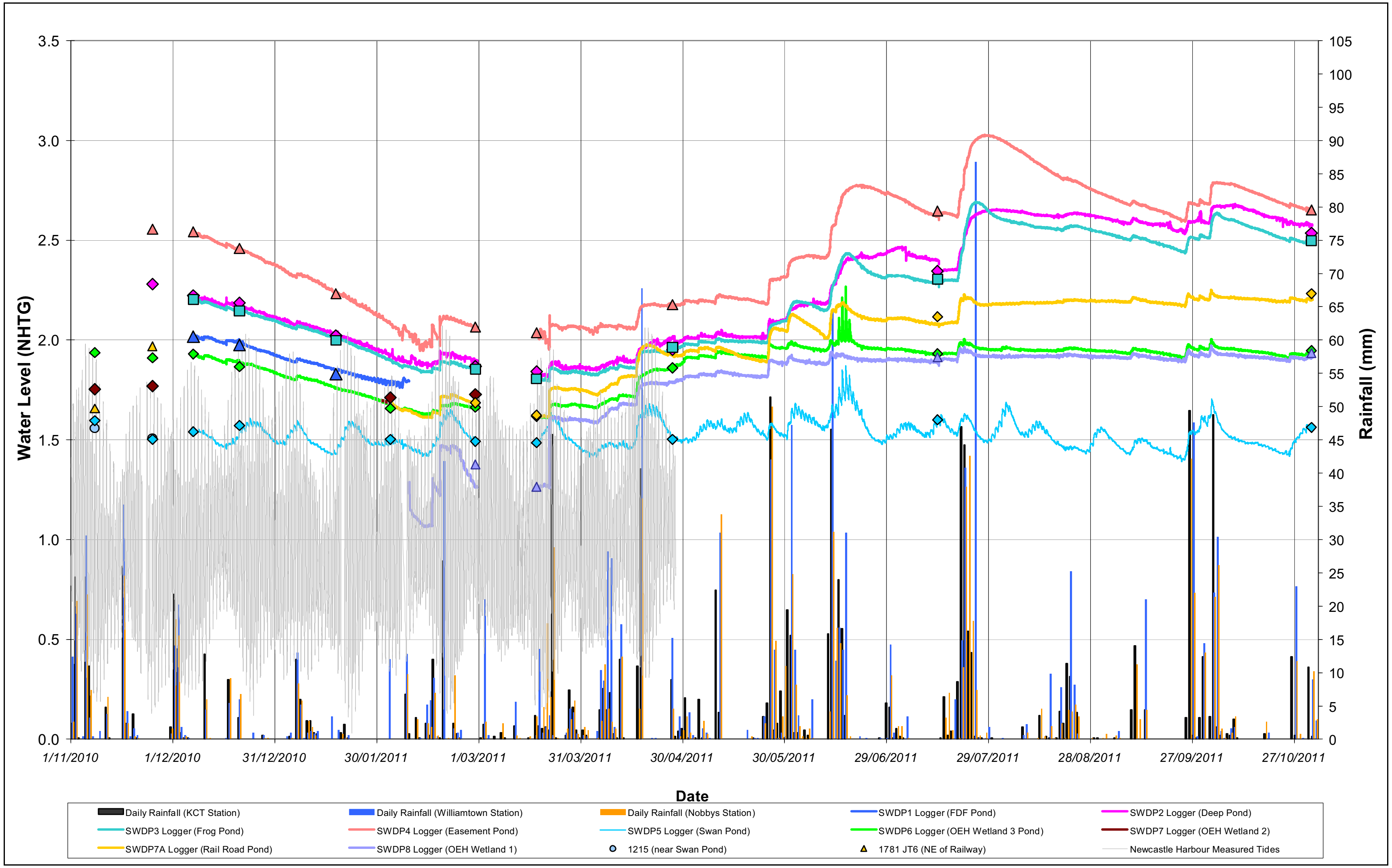

Figure 5: Measured Surface Water Levels and Newcastle Harbour Recorded Tides versus Rainfall – 1 November 2010 to 1 November 2011

Figure 4 and Figure 5, indicate the following:

- **Fill Aquifer**
  - High response to rainfall, particularly high rainfall events;
  - Initial fast recession immediately following rainfall events, becoming near linear over time; and
  - Minor sub-daily fluctuations.

- **Estuarine Aquifer:**
  - Generally less response to rainfall than for Fill Aquifer;
  - Recession rate is slower than for the Fill Aquifer;
  - Sub-daily fluctuations occur in response to tidal fluctuations in river;
  - Monthly variations in groundwater levels occur in response to rolling average tidal levels;
  - Some responses to minor rainfall events are evident, more so than for the Fill Aquifer with a clear response to the rainfall in February (this is expected to be partly due to changes in the Hunter River level due to the rainfall); and
  - The increased tidal response compared to the Fill Aquifer is due to the Estuarine Aquifer being confined and having a significantly lower storage. The Estuarine Aquifer also has a more direct hydraulic connection to the river.

- **Surface Water**
  - Swan Pond levels show a response to daily tidal fluctuations as well as a longer term response to monthly variations in maximum daily tide levels. This is because the culverts connecting to the river have limited hydraulic capacity and prevent flows at lower tidal levels, attenuating and truncating the response and therefore maintaining water levels at between about RL 1.5 NHTG and 1.6 NHTG;
  - There is generally no tidal response in any of the other recorded levels for surface water. This is because the outlet controls, whether they be drains, culverts or natural weir features are all above the maximum tidal levels for the recording period. An exception to this occurs in OEH Wetland 3 for a short period in May 2011 when the wetland is overtopped due to high river levels;
  - OEH Wetland 2 contained a logger for a brief period in early February 2011 which did not indicate tidal fluctuations within this wetland. However, based on the measured outlet level of around 1.8 NHTG, it is expected that sub monthly inundation of the wetland occurs during peak monthly tides. Occasional gauging of the water levels was undertaken over the period that indicated no recession of levels due to evaporative effects, further suggesting that the water level in this wetland is regularly topped up by tidal flushing;
  - Increases in pond levels were generally proportional to the magnitude of rainfall, with greater responses occurring in ponds which received more run-off from surrounding areas, in particular, Easement Pond, OEH Wetland 1 and Rail Road Pond;
  - In times of relatively high rainfall and low evaporation, such as from May 2011 to September 2011, most of the surface water bodies were near full capacity and truncated rainfall response is noted in OEH Wetland 1 and 3 and Railway Pond, indicating overspilling of water levels has occurred. Recession of water levels between rainfall events in these ponds is low due to low evaporation;

- Easement Pond also recorded an increased rate of recession compared to the other ponds. The contours of groundwater level in the Fill Aquifer indicate that Easement Pond is a groundwater sink and the increased rate of recession compared to the other ponds suggests an increased rate of leakage through the Clay Aquitard. This is also evident from elevated heads in the underlying Estuarine Aquifer. The increased rate of leakage is due to increased permeability of the Clay Aquifer which may be due to the presence of a former creek through this part of the site (Refer Drawing 5.05 and 5.06) or possibly the extensive use of Gypsum on Site C (Former EMD plant) leading to cation exchange and increasing the permeability of the clay;
- The levels in Deep Pond and Pond 11 are similar indicating a strong hydraulic connection, probably through the fill bunds; and
- OEH Wetland 1 was dry for much of March 2011. The data logger was installed in a sump below the base of the wetland in order to measure the groundwater levels and when rainfall did occur results showed an exaggerated response to rainfall due to filling of the sump. When levels were above the base of the pond the logger provided information on the surface water level in the actual pond.

6.4 Water Quality Testing

In-situ measurements of pH and EC were undertaken for selected surface water bodies using a calibrated hand-held meter during various site visits. The results of this testing are summarised in Table 11.

Table 11: Surface Water Body Field Parameters

Surface Water Body	8/11/2010		3/2/2011		28/2/2011		12/5/2011		1/11/2011	
	pH	EC (mS/cm)	pH	EC (mS/cm)	pH	EC (mS/cm)	pH	EC (mS/cm)	pH	EC (mS/cm)
Swan Pond	7.6-8.4	22.9-43.7	7.9-8.1	67.9-76.2	8.0-8.7	68.4-73.4	8.4	56	8.1	25.5
Deep Pond	7.8	1.02	-	-	8.6	9.3	8.1	5.5	8.3	2.1
BHP Wetland	7.8	1.01	-	-	-	-	-	-	-	-
Pond 10	-	-	-	-	-	-	8.2	-	-	-
Pond 11	8.5	1.72	-	-	9.2	3.8	8.6	1.9	8.8	0.8
Pond 12	-	-	-	-	-	-	8.3	11	-	-
Ponds (Site A/C)	8.4-9.7	0.5-1.36	-	-	-	-	-	-	-	-
Easement Pond	7.6-8.4	0.95-1.89	-	-	8.9	3.8	8.8	2.2	7.5	1.5
FDF Pond	7.9	4.9	-	-	-	-	7.9	10	-	-
Railway Pond	10.1	2.18	-	-	-	-	8.8	3.3	-	-
Rail Road Pond	-	-	8.6	14.2	-	-	-	-	8.0	2.5
OEH Wetland 1	8.4	11.0	7.4	48.0	7.8	15.6	8.7	5.5	7.5	1.5
OEH Wetland 2	7.3-8.0	1.87-4.86	7.4-8.3	34.0-48.3	8.1	49.2	8.3	30	-	-
OEH Wetland 3	7.7-7.9	1.76-8.54	7.4-8.1	29.8-43.6	8.4	34.7	7.6	17	7.6	5.05
Hunter River, South Arm (upstream)	-	-	7.6	57.6	8.1	56.2	-	-	-	-
Hunter River, South Arm (downstream)	9.0	50.8	-	-	-	-	-	-	-	-
Mosquito Creek (Moscheto Channel)	7.8	10.6	7.5-7.6	42.0-44.5	-	-	-	-	-	-
Ponds in Between Railway and OEH Wetlands	7.6-8.0	1.83	7.8-7.9	6.44-47.7	8.8	6.4	-	-	-	-

Notes to Table 11:
EC – Electrical Conductivity (mS/cm)
Where ranges are presented these are for measurements taken at different locations around the perimeter of the water bodies.
- Not Tested

Variations of EC over the investigation period shown in Table 11 indicate the following:

- The EC in the Hunter River is typically about 57 mS/cm;

- Swan Pond initially had an EC substantially less than the Hunter River and then increased to greater than the Hunter River. The likely reason for this is because the first reading was taken after recent rainfall which would have diluted the EC. The first reading was also taken near the surface and which may have been a fresher lense above more saline water. Over time tidal flushing and the added effect of evaporation on this shallow pond has led to the salinity increasing to above that of the Hunter River;
- For OEH Wetlands 2 and 3 there was also a significant increase in the salinity during the initial monitoring period (December to January), although it was less marked than for Swan Pond. It is likely that the initial readings were also affected by rainfall and the influence of a lens of fresh water at the surface. Review of the data logger records for OEH Wetland 3 indicate that no tidal flushing occurred during this initial period so the increase in salinity was probably due to vertical mixing with more saline water at depth which was remnant from a previous tidal flush. The increase in salinity in OEH Wetland 2 is more likely to have been related to tidal flushing;
- The salinity in OEH Wetland 1 also varied substantially with a peak recorded when the pond was near empty, however the salinity dropped substantially following rainfall and was lower than OEH Wetlands 2, 3 and Swan Pond. This wetland is expected to be, rarely if ever subject to tidal fluctuations as the road embankment separates it from the tidal flats to the north. Therefore salinity that is present in this wetland may be due to remnant salinity prior to construction of the road embankment, or could be due to cumulative evaporative effects. If this is the case the average salinity in this wetland could be expected to continue to increase slowly over time; and
- The salinity of Deep Pond, Easement Pond and Pond 11 were all substantially lower than the OEH Wetlands and Hunter River. Salinity in these water bodies is likely to be to the result of leaching of soils from rainfall recharge. The salinity increased slightly over the period to March 2011, probably due to vertical mixing and evaporative effects and decreased to May 2011 following higher than average rainfall for May 2011.

7. Laboratory Testing

7.1 Total Organic Carbon Testing

Selected soil samples from bores in References 23 and 25 were tested to determine the Total Organic Carbon (TOC) in Units 1, 2 and 3. TOC is a measure used to determine the partition coefficient (K_d), which can provide an indication of aquifer adsorption/retardation behaviour of selected contaminants. The testing was undertaken to assist with contaminant transport modelling.

Seven soil samples were tested for TOC by Envirolab Services Pty Ltd (Envirolab), a laboratory registered with the National Association of Testing Authorities, Australia (NATA) for the test. The results of laboratory testing for TOC are shown in Table 12. Drawing 5.02 highlights the test locations listed in Table 12.

Table 12: Laboratory Results of Total Organic Carbon Testing

Unit	Test Location	Depth (m)	Description	Total Organic Carbon (%)
1	A-04	3.5	Pale pink, silt (gypsum) filling, trace to some sand	0.18
	A-05	4.0-4.45	Red-brown, sandy clay filling, some gravel	0.65
2	A-06	8.5-8.95	Grey clay, trace shell fragments	18
	A-03	7.0-7.45	Grey, sandy clay	1.2
	A-07	8.5-8.95	Grey silty clay, some gravel and sand	1.8
	A-01	7.0-7.45	Dark grey clay, with thin shell lenses	2.3
3	A-01	10.0-10.45	Grey, slightly clayey sand	1.0

8. Development Features Pertinent to Groundwater

8.1 General

The conceptual layout of the proposed T4 Project is shown on Drawing 5.16 Appendix C, which is based on drawing *KL 323170_A - Site Overview.dwg*, overlain on a site aerial. The salient features (which will be refined during detailed design) pertinent to groundwater are:

- Up to seven coal stockpiles of up to 1428 m in length, with coal up to 24 m height;
- Up to eight machinery berms to carry stacker/reclaimers, stackers, reclaimers and conveyors;
- T4 Project railway lines, mainly located in the SP1 buffer zone (Site E) outside the existing rail lines, except for a section inside Site A at Deep Pond;
- Dump Stations located in the SP1 zone, just north of FDF Cell 1; and
- Water management ponds within Deep Pond, Easement Pond and FDF Pond.

Based on the proposed stockyard levels (indicative), which range from RL 6.2 NHTG to RL 11.0 NHTG, the depth of filling required to raise site levels would range from zero up to a maximum of about 8.5 m. The proposed depth of cut ranges up to about 3.5 m, mostly occurring in Area K7, which includes the 'asbestos' disposal area. The proposed machinery berms would have a level approximately 5 m above the stockyard level. Final levels for the stockyard will be refined during detailed design.

Components of the T4 Project development which have been identified to have the potential to impact the existing groundwater/surface water regime comprise the following:

- Deposition of dredged sediments on the site;
- Changes in surface levels (increase or decrease), including alteration of existing drainage paths;
- Changes in surface characteristics, including provision capping;

- Ground improvements are required to reduce post development ground settlement to tolerable levels. Ground improvements currently considered to be appropriate for the site include preloading and deep soil mixing. Potential impacts on the groundwater associated with these proposed ground improvements comprise:
  - 'squeezing' of pore water from the clay soils during the pre-loading;
  - Changes in bulk hydraulic conductivity of soils due to ground improvements.
- Impaired performance of the existing leachate collection system below the existing FDF site.

8.2 Dredging

Details of the proposed dredging strategy are outlined in the Aurecon Hatch (AH) *"T4 Prefeasibility Engineering Study" Report* (2011, Ref 2). The AH *Reclamation Strategy Plan* (Drawing No. KL283732-Rev B) which summarises the dredging strategy, the location of stockpiles and the order of filling.

The proposed dredging strategy includes the placement of an estimated total of about 4,000,000 m^3 of dredged material for the stockyard pad and pond embankments. Dredge sequence and volumes required will be refined during the detailed design phase. The proposed dredging strategy is summarised as follows:

- Step 1: A low permeability bund (6.5 NHTG) north of Easement Pond would be constructed, extending the southern FDF cell wall alignment and connecting the elevated areas of Site A;
- Step 2: A bund wall of dredged sand (8.5 NHTG) extending west of the northern FDF cell to Deep Pond would be constructed;
- Step 3: The height of the low permeability bund wall would be increased with dredged sand to a height of 8.5 NHTG;
- Step 4 and 5: Internal bunds would be constructed of dredged sand along the berm alignments for Stockpiles 1 and 2 and then filled with dredged sand;
- Step 6: Steps 4 and 5 would be repeated for Stockpiles 3 and 4, Stockpiles 5 and 6 and lastly Stockpile 7. The result would be an overall relatively level fill area;
- Step 7: Remaining sand would be stockpiled in required preload areas.

The placement of the seven stockpile strips from east to west would enable the westerly flow of tail water towards Deep Pond which would act as a settlement pond for collection of dredge fines. Excess water from Deep Pond would then be piped and discharged to the Southern Arm of the Hunter River.

8.3 Earthworks and Site Levels

8.3.1 Coal Stockyards

The proposed bulk earthworks for the coal stockyard would comprise minor cut and large-scale filling of the site. The fill material would predominantly be dredged sand from the South Arm of the Hunter River. Information on this material is provided in the Geotechnical Investigation report for the South Arm (Report 49533.02-03, Ref 22). Note that all earthworks and site levels presented below will be subject to detailed design and project refinements.

The proposed base level of the stockyard ranges from approximately RL 6.2 to 11.0 NHTG with the depth of filling would range from zero up to a maximum of about 8.5 m. The proposed depth of cut ranges up to about 3.5 m, mostly occurring in Area K7. The proposed machinery berms would have a level approximately 5 m above stockyard level and are expected to be constructed of cement-stabilised dredged sand.

OEH capping / closure requirements for Sites A, C and D may have some impact on earthworks depending on the timing of construction. A revised capping strategy for the Delta site (Site C) was approved by OEH in 2009. The details of the revised capping strategy are provided in the ENSR document *Technical Specification, Kooragang Island EMD Facility Capping Works* (Ref 27). The approved capping strategy involves cut and fill of the existing landform, compacting a "sealing bearing layer" using site material, and then placing a Geosynthetic Clay Liner (GCL) topped by a pavement hardstand.

The adjacent KIWEF site has also been the subject of a revised final landform and capping strategy, which was prepared by GHD on behalf of NPC (Ref 33). This strategy also has the approval of OEH who have issued an "Approval of the Surrender of a Licence" for KIWEF and placed a deadline of 28 March 2013 for implementation of the approved landform and capping strategy.

The earthworks for the T4 Project would therefore need to take account of these approved capping strategies as well as the objectives of OEH Benchmark 28 of the Solid Waste Landfill Guidelines (Ref 39). Further discussion on capping strategies in relation to OEH requirements and environmental considerations is presented in the Contamination Assessment Report (49533.02-02, Ref 23), and the Remediation Options Report (Ref 26).

8.3.2 Railway Embankment

The railway embankment would be constructed over very soft to soft soils in Deep Pond and the land areas outside (west and north of) the existing railway line. Construction over these areas would require an initial bridging layer of sand or other granular material to create a working platform. This may require the use of geofabric to assist in preventing 'mud waves'.

8.3.3 Water Management Ponds

The water management ponds would also be constructed over very soft to soft soils in Deep Pond, with bund walls constructed at a nominal RL of 3.8 NHTG, based on preliminary designs. This would involve filling of about 2.2 m above the current pond base level which is approximately RL 1.6 NHTG. As with the railway embankment, the construction of bund walls would require an initial bridging layer of sand or other granular material to create a working platform. It is anticipated that the bund walls would not be sensitive to settlement and hence ground improvement under the pond walls may not be required.

Permanent batter slopes of pond walls should be 1V:2.5H to 1V:3H for stability purposes. Lining of the ponds would also be undertaken to retain water, allow minimal seepage and prevent inflow of groundwater from adjacent areas.

8.4 Ground Improvement

8.4.1 Ground Improvement Options

Various methods of ground improvement to reduce post construction settlements have been considered for the T4 Project area as part of the Geotechnical Assessment Report (49533.02-01, Ref 25), namely the following:

- Preload (without Wick Drains);
- Deep Soil Mixing;
- Stone Columns;
- Wick Drains with Preload;
- Piled Earth Raft;
- Excavate and Replace;
- Dynamic Replacement;
- Compression Grouting;
- Dynamic Compaction; and
- Vacuum Consolidation.

The geotechnical assessment indicated that the favoured ground treatment method for the T4 Project stockyard area is preload with some deep soil mixing (Ref 25). A brief overview of the Preload and Deep Soil Mixing options are provided in Table 13. Final options for geotechnical treatments of the site will be refined during detailed design phases of the project.

Table 13: Ground Treatment Options Considered

Rank	Technique	Principle	Comment
1	Preload (without wick drains)	Application of a load to the foundation which is usually greater than the final loads after construction.	The load is usually applied in the form of additional fill material which is later removed. This method is one of the simplest ground treatment methods but requires sufficient time and excess fill material.
2	Deep Soil Mixing	Mixing of lime and/or cement with the soft soils (coal fines and natural clay) to form a column of treated soil. Usually done in a panel or cell arrangement.	Reduces the plasticity and compressibility of the soil. Highly specialised equipment is required to effectively mix the lime and/or cement with the soil. Can have the added benefit of immobilising contaminated soil.

Ground improvements are common and preloading has been undertaken successfully for various stages of previous development on adjacent site. Additional details regarding the proposed soil improvement methods with respect to potential groundwater impacts are described in the following sections.

8.4.2 Preload

For Stage 1 it is proposed to preload the majority of the coal stockyard area. The preload period would be about 5 months to allow for consolidation to occur, with each area being preloaded consecutively. The estimate of primary consolidation during preload varies between areas and is in the range of 0.5 m to 1.2 m.

Preloading may also be undertaken in future stages of the development and although no detailed design has been undertaken, similar magnitudes and times of settlement are expected.

Preloading would lead to squeezing of pore water from the various soil units, most significantly the Unit 1 Fines and Unit 2 Clay. This would lead to a temporary increase in flow rates in the Fill and Estuarine Aquifers.

Preloading would also increase soil density, potentially decreasing the soil permeability, in particular, that of the Unit 2 Clay.

For the purposes of determining potential increased flow rates and water levels, the modelling of project development phases has assumed preloading over the proposed stockpiles areas as detailed in Section 11.3.

8.4.3 Deep Soil Mixing

Deep soil mixing (DSM) involves the addition of cementitious material to the soil in columns. A variety of additives are used including lime, cement, slag products and flyash.

It is anticipated that the columns would be in the order of 0.8 m diameter and placed at 2.0 m to 2.5 m spacings. This would result in a replacement ratio of about 20% to 30% of the horizontal cross section, being subject to treatment.

The impact of the deep soil mixing on vertical permeability of the Unit 2 Clay Aquitard material would be limited as the methodology retains the clay in-situ. Overall it is expected that the disturbance of the soil and addition of various calcium based additives would lead to an overall slight increase in the permeability of the in situ material.

8.4.4 Post-Construction Settlements

Following ground treatment there would still be some post construction settlements. The long term settlements for each treatment area for Stage 1 have been estimated in the geotechnical assessment (Ref 24) and are summarised in Table 14.

Table 14: Estimates of Post-Construction Settlement

Ground Improvement Area*	Treatment	Estimated Post-Construction Settlement at 25 years (mm)
1	DSM	300 – 350
2	DSM	250 – 300
3	Preload 5 Months	220 – 280
4	DSM	200 – 250
5	Preload 5 Months	160 – 210
6	Preload 5 Months	350 – 400

Notes to Table 14:

Post construction, these settlements would occur over a significantly longer time than the preload. Impacts on the aquifer flows due to expulsion of pore water over this longer time period are likely to be insignificant over this time period.

8.5 FDF Closure

The existing FDF facility (Site D) has a leachate collection system with a drainage level set at about RL 1.6 NHTG. The differential settlement occurring between stages of preloading could possibly permanently impair the performance of the existing drainage system and potentially lead to an increase in groundwater levels in the location of the FDF.

9. Conceptual Groundwater Model

9.1 General

9.1.1 Aquifers

Groundwater beneath the site is present in two principal aquifers: an upper unconfined aquifer within the fill strata (Fill Aquifer), and a deeper confined aquifer within the estuarine sediments (Estuarine Aquifer). The upper soft natural clays form a ‘leaky’ aquitard that separates these aquifers. Previous investigations by others (Ref 29) suggest the Unit 2 Clay Aquitard may be absent in localised areas, however, no specific evidence of this was found from the current investigation (see Drawing 5.13 titled “Isopachs of Soft Clay”) in Appendix C. The main sand layer (Unit 3) is therefore generally confined and forms the Estuarine Aquifer. There are further layers of sand within the stiff estuarine clay (Unit 4), but the data indicate that these layers are hydraulically linked and chemically similar to the Estuarine Aquifer.

The aquifers and aquitard are described in the following sub-sections. Contours of groundwater head in the Fill Aquifer and Estuarine Aquifer are presented in Drawings 5.07 and 5.08. The contours are based on the water level gauging of 150 wells, as well as several surface water features, undertaken on 25 November 2010.

9.1.2 Fill Aquifer (Unit 1.1 Waste Filling)

The Fill Aquifer is at the surface and is therefore unconfined. This means the water table fluctuates within the thickness of the aquifer, and groundwater is free to drain to the surface where the water table intersects the surface, such as at drains, ponds or wetlands.

In the waste ponds the fill comprises various wastes (Unit 1.1). The waste has typically been placed within slag bunds. The permeability of the waste is variable, however would typically be low to moderate, with moderate to high permeability material originally used to construct the bunds.

The Fill Aquifer is recharged primarily by rainfall. Groundwater flow within the fill is primarily sub-horizontal, generally flowing towards the closest surface drainage features, however some vertical leakage occurs through the underlying clay aquitard.

There site has a number of surface drainage features, which form the boundaries around several prominent mounds of the water table, as evident on Drawing 5.07. Groundwater mounds, which represent areas of localised groundwater recharge, are evident in Site A to the east of Deep Pond (up to about RL 5.5 NHTG), in Site C (up to about RL 4.0 NHTG) and Site B (up to about RL 6.5 NHTG) and are generally in areas of elevated ground surface levels. The surface drainage features around these mounded areas generally drain either to the south arm of the Hunter River or to the wetlands to the north of the site. There is an absence of any significant groundwater mounding below Site D (FDF) as the groundwater levels here are likely to be controlled by the FDF's leachate collection system. Surface water and groundwater interactions are discussed in more detail in Section 9.1.6 below.

9.1.3 Clay Aquitard (Unit 1.2 Fines and Unit 2 Clay)

The Clay Aquitard primarily consists of Unit 2 clay, however in places includes an overlying layer of Unit 1.2 fines (coal fines or dredged fines placed in the waste ponds, such as at the FDF). The total thickness of the aquitard ranges from less than 1 m to over 15 m. The aquitard is thought to be absent at some locations, providing a degree of localised connectivity between the aquifers. The permeability of the aquitard is relatively low, however still sufficient to allow some vertical flow from the Fill Aquifer to the underlying Estuarine Aquifer.

9.1.4 Estuarine Aquifer (Unit 3 Sand)

The Estuarine Aquifer is generally confined, which means that there is no free water table within the layer, and the phreatic surface (the height at which a water table would form in a bore connected only to the estuarine aquifer) is above the base of the overlying clay aquitard. The phreatic surface is however below the water table in the Fill Aquifer, thereby allowing vertical flow from the Fill Aquifer to the underlying Estuarine Aquifer. The sand in the Estuarine Aquifer is of moderate to high permeability.

Drawing 5.08 in Appendix C shows that groundwater heads in the Estuarine Aquifer form a north-south ridge line below the western parts of Site C, with a smaller ridge line oriented east-west across Site C. Groundwater flows are generally from the ridge lines to the North, West and South where the groundwater is expected to drain to the Hunter River and associated tidal wetlands to the north, the tidal wetlands to the west and the south arm of the Hunter River, respectively. Groundwater flow within the Estuarine Aquifer on the eastern parts of the site is expected to be primarily north on northern parts of the site and south on southern parts of the site, approximately parallel with the eastern T4 Project area boundary.

The location of the groundwater mounding below Site C does not correspond to any groundwater mounding in the overlying Fill Aquifer and is likely to be mostly due to Site C being relatively centrally located between the northern, western and southern flow boundaries. However, it may also be due to locally thinner or more permeable areas of the Unit 2 aquitard in Site C.

Seepage rates in the Estuarine Aquifer are estimated to be in the order of 15 m to 20 m/year.

9.1.5 General Conceptual Groundwater Flow Model

Figure 6 shows a section typical of conditions in Sites A, B or C to illustrate the conceptual groundwater flow model, which is summarised as follows:

- Rainfall leads to vertical infiltration into the Fill Aquifer;
- Mounding of the water table occurs within the Fill Aquifer with sub-horizontal flow towards the drainage features, typically at the toe of the berms;
- Vertical percolation occurs through the Clay Aquitard from the Fill Aquifer to the Estuarine Aquifer; and
- Sub-horizontal flow occurs within the Estuarine Aquifer, draining towards the tidal wetlands to the north and west, and the Hunter River (South Arm) to the south.

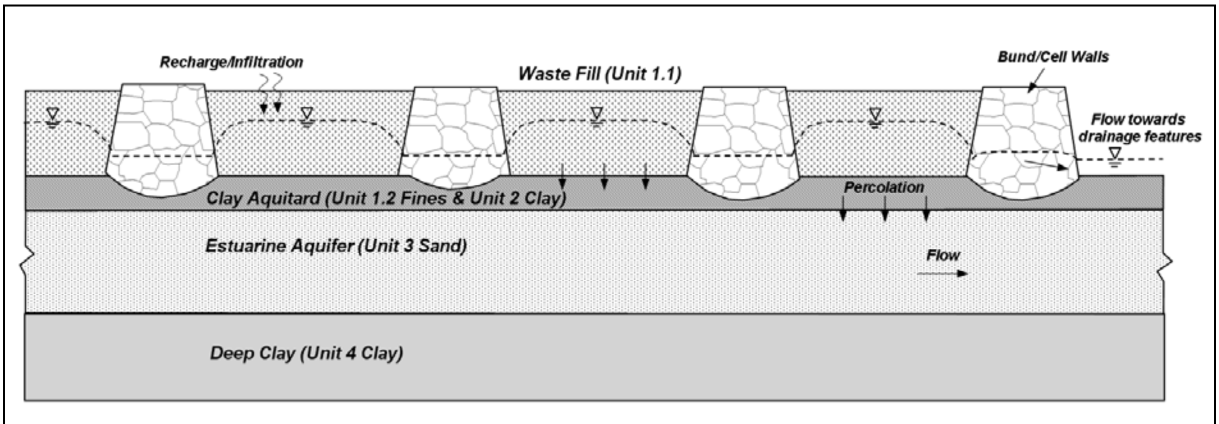

Figure 6: Typical Vertical Section in Sites A, B North and C

9.1.6 Groundwater – Surface Water Interactions

There are several ponds and drains present across the site and adjacent to the site which interact with the groundwater, primarily groundwater within the Fill Aquifer. The ponds are shown on Drawing 5.01 and the results of surface water field monitoring of pH and EC measurements are presented in Table 15. The table also includes comments on how the surface water feature is likely to interact with the groundwater.

A conceptual diagram of groundwater, surface water, recharge and evapotranspiration processes for the site is shown in Figure 7.

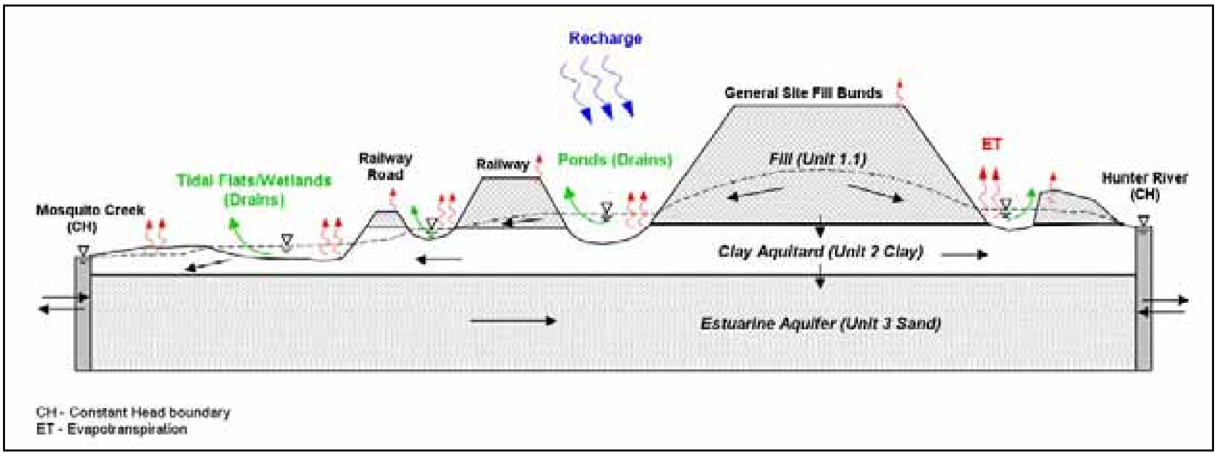

Figure 7: Conceptual Diagram of Groundwater, Surface Water Recharge/ Evapotranspiration Process for the Modelled Site

Table 15: Surface Water Features and Groundwater Connectivity

Surface Water Feature	Comments
Hunter River South Arm	The Hunter River represents the southern boundary for discharge of groundwater from the Estuarine Aquifer as well as the southern fringes of the Fill Aquifer. Groundwater head in the Estuarine Aquifer at the edge of the river is likely to be slightly higher than mean tidal level due to head losses in the river bed and because the average discharge point is somewhere past the bank in the river bed. Groundwater head in the Fill Aquifer at the edge of the river is likely to be closer to mean high tide level due to the tidal action on the sloping beach face ‘pumping’ the water table above mean tidal level.
Swan Pond	This pond is located to the west of the site and is connected to the South Arm of the Hunter River by several drains. However the pond receives an attenuated and truncated tidal response with water levels generally fluctuating between about RL 1.5 NHTG and RL 1.6 NHTG. This pond is expected to represent a western boundary for discharge from the Fill Aquifer. Limited groundwater recharge can be expected to the Estuarine Aquifer, which discharges to the river to the south of this pond.
Mosquito Creek (Mocheto Channel)	Mosquito Creek, a tributary of the North Arm of the Hunter River probably represents the closest potential discharge boundary for groundwater flow from the Estuarine Aquifer below the site. However due to the thickness of clay in this area, hydraulic connectivity is likely to be limited. Water levels in the creek are primarily controlled by surface water flows associated with the river, with groundwater discharges below the site having a minor contribution to surface water conditions.
Tidal Flats and Hunter River North Arm	The main North Arm of the Hunter River is expected to be the primary northern discharge boundary for flow from the Estuarine Aquifer. Water levels in the tidal flats are expected to be controlled primarily by rainfall and evaporation with occasional tidal inundation in more elevated areas and primarily tidal fluctuations in lower areas.
Rail Road Pond	Rail Road Pond is situated between the railway embankment filling on the northern site boundary and the Rail Road which runs parallel to the railway. The pond has a clayey base and seems to have no direct surface connection to other nearby surface water features, namely OEH Wetlands 1 and 2, and Deep and Railway Ponds. Some groundwater flow could be expected to occur through the rail embankment from Deep Pond, however this is expected to be limited due to the presence of significant siltation in the base of both ponds.

Table 15: Surface Water Features and Groundwater Connectivity (Continued)

Surface Water Feature	Comments
OEH Wetland 1	OEH Wetland 1 is located just to the north west of the site and receives recharge from rainfall. Groundwater seepage from Deep Pond is expected to be limited as at the time of the site walk over OEH Wetland 1 was dry with no signs of seepage from Deep Pond, although the water levels in Deep Pond were relatively high. Discharge from this wetland is likely to comprise evaporation, as well as overland flow across natural surface water drainage lines to the south/west; however this would only occur in times of higher water levels. Periodic inundation of this wetland during high tides could occur, however, it will be much less often than inundation of the other OEH wetlands due to the presence of road fill and did not occur during the monitoring period. Survey of OEH Wetland 1 indicated base pond levels were fairly uniform, at levels of RL 1.6 NHTG to 1.8 NHTG. This wetland is confined to the south-east by Rail Road at about 2.6 NHTG, the railway embankment at about 4.0 NHTG and to the north-east by an access road at about 3.4 NHTG.
OEH Wetland 2	OEH Wetland 2 is located to the north of the western end of the site. The drainage level of this pond was surveyed as RL 1.6 NHTG to 1.7 NHTG, therefore this pond receives fairly regular saltwater inundation during times of higher tides in the monthly tide cycle. There is some recharge to this wetland from groundwater seepage from Deep Pond and Railway Pond as well as direct recharge. Discharge from this wetland is likely to comprise evaporation, as well as overland flow across natural surface water drainage lines, however this will only occur in times of higher water levels. The regular inundation of the wetland is expected to keep the surface levels close to or slightly below the drainage level of RL 1.7 NHTG.
OEH Wetland 3	Wetland 3 has a slightly higher surface water level than Wetland 2 and a higher drainage level, about RL 2.0 NHTG. Additional groundwater interaction can be expected in this wetland, as tidal inundation is expected to occur less often and was only observed once during the 11 month period of water level monitoring.
Ponds 9 to 12 and Area K7 Ponds	The ponds within the site are located within a local area of groundwater mounding of the Fill Aquifer in Sites A and C and receive groundwater recharge from upstream Site A. The ponds are ‘windows’ to the groundwater system and will fluctuate with groundwater levels, direct rainfall and evaporation. A strong correlation is apparent between water levels in Deep Pond and the ponds in this part of the site, suggesting a strong hydraulic connection.
Railway Pond	Railway Pond is likely to receive rainfall runoff from parts of the FDF to the east as well as from the immediate batter slopes to the north and south, locally recharging groundwater levels and then overflowing into Deep Pond. Groundwater seepage from the Ponds 9 to 12 / Railway Pond is generally expected to occur through the filling associated with the railway line and then towards the OEH Wetlands 2 and 3 north of the site.

Table 15: Surface Water Features and Groundwater Connectivity (Continued)

Surface Water Feature	Comments
FDF Pond	FDF Pond is in the very north-eastern corner of the site and is likely to act in a similar manner to Railway Pond, by intermittently discharging to Railway Pond through a drainage channel, and hence probably receiving less flushing than Railway Pond.
Deep Pond	Deep Pond is also controlled by an intermittent surface discharge control; a set of culverts located at the south-west corner of the pond, which run below the rail loop and into tidal wetlands along the edge of the South Arm of the Hunter River. This pond receives surface runoff and Fill Aquifer groundwater inflows from most of Site A. In times of no flow through the culverts significant evaporation occurs across the surface area of the pond. Limited groundwater seepage also occurs from Deep Pond through the fill below the rail line towards the OEH Wetlands 1, 2, 3, Rail Road Pond and Swan Pond.
Easement Pond	Inspection indicates that Easement Pond receives runoff from the NCIG rail line to the south, via numerous diversion drains. There were surface discharge drains observed during the inspection comprising a number of small PVC pipes at the eastern end, therefore this pond would be expected to be a groundwater sink. Substantial vertical leakage through the base of this pond may be occurring into the Estuarine Aquifer.
BHPB Wetland and Blue Billed Duck Pond	These wetlands receive runoff from the surrounding ground and have intermittent discharge from Easement Pond (South) via a set of culverts passing under the main site access road at invert levels between 3.06 NHTG and 3.07 NHTG. Water through these wetlands is then permitted to pass through a set of culverts at invert levels between 2.36 NHTG and 2.51 NHTG into Deep Pond. The ponds, however, are generally expected to be windows to the groundwater system and receive groundwater inflows from Site A to the north.
Long Pond	Long Pond has no obvious surface water connection to the South Arm of the Hunter River, apart from following prolonged/heavy rainfall when the surface flow overtops the road and discharges to the river. During normal times Long Pond receives Fill Aquifer groundwater flow from Site B and groundwater flow occurs out of the pond through the filling below the road.

The various surface and groundwater flow processed described in Table 15 are summarised in Figure 8.

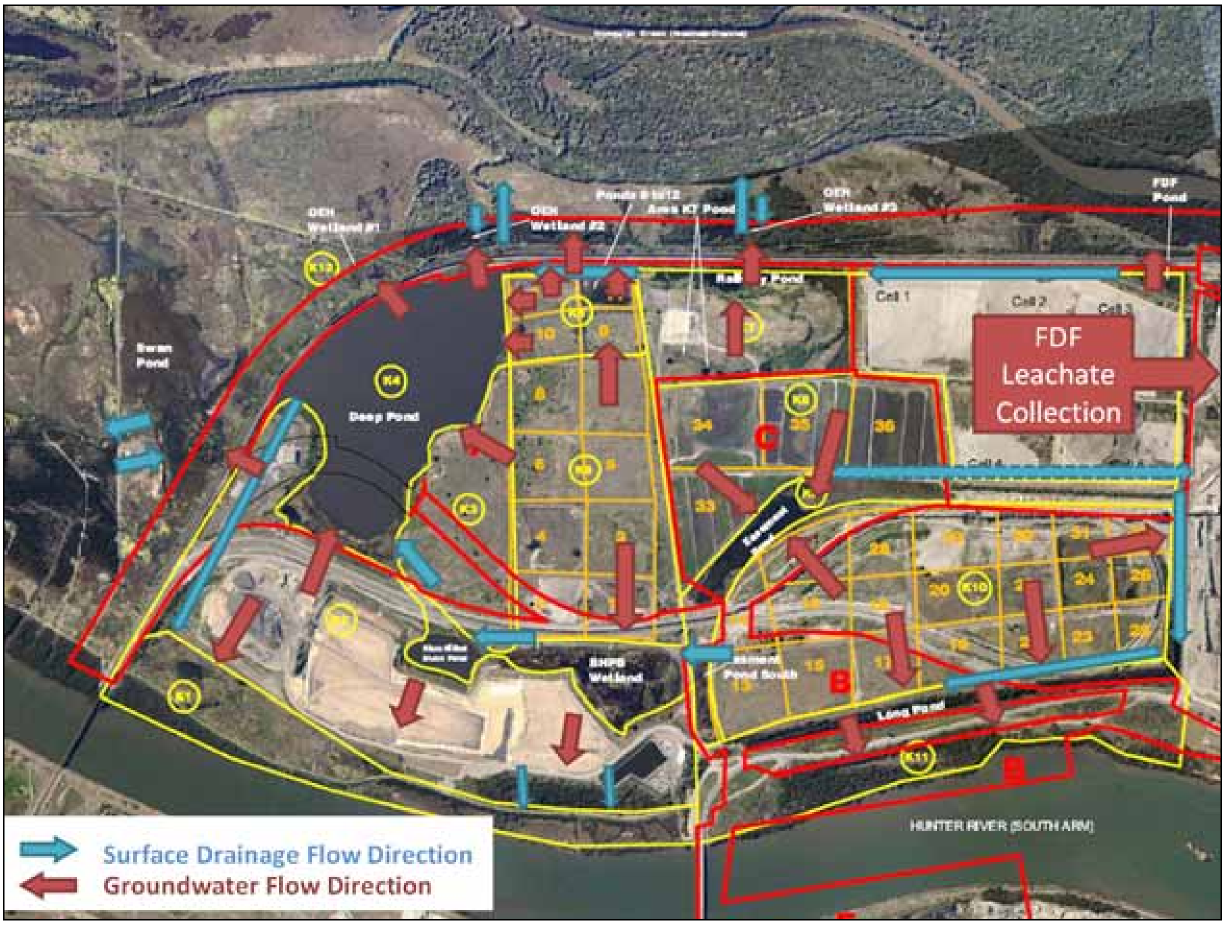

Figure 8: Groundwater and Surface Water flow for the T4 Project area

9.2 Potential Groundwater Effects

9.2.1 General

Potential impacts to groundwater related to the T4 Project development will be experienced both during construction and after construction. The impacts during construction would include the effects associated with dredging, loading and 'squeezing' of the soft soils and surface water management. The impacts following construction would include the effects on the groundwater regime associated with the capping system and penetrations of the clay aquitard. These effects are discussed qualitatively in the following sections. Numerical modelling has also been used to provide a more quantitative estimate of effects and is presented in Section 11.

9.2.2 Dredging and Surface Water

The dredging of sand from the river and placement onto the site would introduce significant volumes of saline water to the site. Dredged slurries are typically pumped at a solids content of around 30% to 35% and hence comprise 70% to 65% estuarine/saline water.

Based on conceptual dredging planning, which will be refined in the detailed design phases, placement of dredged slurries over the site would be undertaken progressively within confining bund walls within the proposed fill area. The estuarine/saline dredge return water would be directed towards Deep Pond which would act as a settling pond for dredge fines.

Placement of dredged slurries would be undertaken over existing site fill materials including coal washery reject and slag fill materials which are moderately permeable. The imposition of large volumes of saline water would initially increase the head of water within the fill aquifer and promote flow of saline water into adjacent surface water bodies. It could take some time for this saline water to be flushed from the system.

9.2.3 Regrading and Capping

Filling of the site with relatively high permeability sand would temporarily increase rainfall recharge, and filling of the existing low lying areas would potentially lead to an increase in groundwater levels.

The subsequent construction of coal stockyards, berms and pavements would generally create a low-permeability cap over the site that would then reduce rain water infiltration which drives the groundwater flows on site. It is expected that appropriately designed surface capping would reduce groundwater flows substantially.

Increases in groundwater levels have the potential to increase leaching of existing contamination from soils as well as increasing the flux of existing contaminants in the groundwater towards sensitive receptors such as offsite wetlands. Conversely lowering of the water table, as may occur following capping, would tend to decrease the flux of contaminants.

9.2.4 Squeezing

The process of filling the site both during dredging as well as for subsequent pre-loading would lead to short term increases in groundwater flow rates. This is due to the process of 'squeezing' the soil profile, in particular compressible material such as Unit 1.1 coal fines, Unit 1.2 fines and Units 2 and 4 clays, due to application of load from placing additional fill at the surface. Loading of the soil profile leads to consolidation and squeezing of pore water from the compressible layers. The water squeezed from the compressible layers would generally flow into both the Fill Aquifer and the Estuarine Aquifer, leading to a temporary increase in groundwater flow rates and temporary increase in flux of contamination.

9.2.5 Penetration of Unit 2 Clay Aquitard

It is expected that over most of the site the two aquifers are separated by the Unit 2 Clay Aquitard, which reduces the hydraulic connection between the Fill Aquifer and the Estuarine Aquifer.

If penetration of the Unit 2 aquifer occurred due to the use of stone columns, piles or dump station construction for the development, then the connection could lead to reduced groundwater levels in the Fill Aquifer and increased groundwater heads and flow rates in the Estuarine Aquifer, leading to potential transfer of contamination from the Fill Aquifer to the Estuarine Aquifer and increased flux of existing contamination in the Estuarine Aquifer.

9.2.6 Excavations in SP1 Area

It is proposed to relocate existing buried gas and water mains, construct the rail receival dump station and conveyor tunnels north to the existing railway lines in the SP1 zone. This would involve excavations and penetration of the clay aquitard. From a contamination and groundwater perspective it would be undesirable to form a permanent connection between the surface of the wetlands and the estuarine aquifer.

It is proposed to construct the relocated gas main using horizontal directional drilling techniques, subject to appropriate geotechnical conditions being confirmed, with localised open cuts at pipeline tie-ins. It is proposed to construct the relocated water main using open trench techniques. Such excavations will be likely to extend below the water table and therefore some form of groundwater control will be required during the construction works to prevent the excavations filling with water. In this case impacts on groundwater levels over the short period required for installation of the pipes would be expected to be minimal.

For the Dump Station, which will be excavated through the clay aquitard and into the Estuarine Aquifer, conventional methods of construction would involve the installation of dewatering wells and abstraction of significant volumes of groundwater to achieve the required depth of dewatering. Such conventional dewatering would lead to significant drawdown of surrounding groundwater levels with potential impacts on any adjacent sensitive habitats.

Excavations and dewatering in the SP1 zone are expected to disturb potential acid sulphate soils (PASS). The management of acid sulphate soils is discussed in the Contamination Assessment report (Ref 23).

10. Assessment Criteria

10.1 General

The potential impact to off-site habitats is of key importance to this groundwater assessment. Several endangered flora and fauna species have been identified on the T4 Project site and surrounding areas and a number of important Green and Golden Bell Frog (GGBF) habitats have been identified. The following provides an explanation of the criteria used to assess potential impacts on these habitats.

10.2 Contamination

The ANZECC (2000) *“Australian and New Zealand Guidelines for Fresh and Marine Water Quality”* (Ref 3) are used to assess groundwater quality. The protection of slightly to moderately disturbed aquatic ecosystem guidelines (marine) are considered to be relevant to the site assessment due to the proximity of the T4 Project to the Hunter River (i.e. receiving waters). These trigger values generally provide 95% protection level.

The receiving waters for the T4 Project are considered to be an Estuarine Aquatic Ecosystem. In ANZECC 2000 the Estuarine Aquatic Ecosystem is a sub-set of the Marine Aquatic Ecosystem (Figure 3.1.3 of ANZECC 2000). Quantitative ANZECC Guidelines for estuary waters are only provided for pH, chlorophyll, total phosphorus, total nitrogen, oxides of nitrogen, ammonium and dissolved oxygen (Table 3.3.2 of ANZECC 2000). The Estuarine trigger values have been adopted for pH, however, since there are no Estuarine criteria for the main parameters of concern it is necessary to adopt the Marine values. In the absence of Marine values it is common practice to refer to available Fresh water criteria to at least provide some sort of benchmark for comparison purposes.

10.3 Salinity

There is limited information available regarding the specific tolerance of GGBF to potential contamination, however some studies have been undertaken with regard to tolerance to salinity.

Christy & Dickman (2002, Ref 6) assessed the effect of salinity on tadpoles of GGBF. They found that salinity above 5.5% seawater (about 2,000 mg/L) significantly decreased growth rates and increased mortality. Salinity in the range 10% to 15% (about 3,500 to 5,000 mg/L) can be tolerated for short periods (up to 3 weeks) before significant weight loss and mortality resulted.

GGBF are known to be vulnerable to the chytrid virus and unpublished research completed by the University of Newcastle suggests that the salinity levels that are beneficial due to their retarding effect on chytrid are about 3,000 mg/L to 4,000 mg/L, resulting in a decreased infection load of the host (frog) and increased host survival (Leu (2011), personal comment).

Therefore, although low salinity is required to prevent mortality in tadpoles (less than 2,000 mg/L), some level of salinity is required to retard the effects of the chytrid fungus (3,000 to 4,000 mg/L) and a balance is required between the two. It is understood from sampling undertaken by the University of Newcastle that salinity in habitat ponds near the T4 Project area can range from 531 to 11,920 µS/cm (about 370 mg/L to 8,350 mg/L). This variability is consistent with measurements undertaken by Douglas Partners as part of this groundwater assessment, which indicated salinity ranging from 1,500 µS/cm to 48,000 µS/cm (about 1,000 mg/L to 34,000 mg/L) in OEH Wetland 1 and 2,500 µS/cm to 14,000 µS/cm (1,800 mg/L to 10,000 mg/L) in Rail Road Pond over time. The salinity levels are highly variable, depending on prevailing rainfall versus evaporation conditions.

Therefore adoption of a single upper tolerance salinity level for GGBF has not been adopted, rather the suggested mitigations to salinity potential salinity impacts from dredging have been aimed at maintaining a range of variation in salinity levels, in identified GGBF habitat, similar to that which already occurs.

11. Numerical Modelling

11.1 General

11.1.1 Software

Based on the conceptual groundwater flow model, summarised geotechnical information and the groundwater-surface water interactions within and surrounding the T4 Project area, steady-state and transient groundwater flow models were developed using the following software:

- MODFLOW with Groundwater Vistas, Version 6.04 Build 17 for pre/post processing;
- MODFLOW-SURFACT, Version 4.0 numerical engine using PCG5 solver; and
- PEST for preliminary parameter estimation.

11.1.2 Model Layers

The existing system was represented by three model layers as follows:

- Layer 1 was set as a Type 3 Unconfined Aquifer:
  - Generally comprising Unit 1 fill (Fill Aquifer), where present;
  - Where surface water ponds were present within the filling they were assumed to be directly underlain by the Clay Aquitard and were generally represented as a high permeability material in Layer 1 only;
  - On the northern tidal flats, where there is currently no filling present, in order to allow extension of Layer 1 to the limits of the model, Layer 1 represented the upper 1 m thickness of the Unit 2 Clay. In areas where surface water ponds were present in the northern tidal flats (OEH Wetlands 2 and 3), this layer was set to high conductivity materials to replicate the ponds.
- Layer 2: Represented the Unit 2 Clay Aquitard and was set as Type 3 Unconfined Aquifer; and
- Layer 3: Represented the Estuarine Aquifer and was set as Type 2 Confined Aquifer.

The base of the model was set at the top of the stiff clay as the Unit 4 Clay and Unit 5 Rock were considered to be of sufficiently low permeability that their contribution to flow in the system would be insignificant.

The surface level of the model was based on grid data from the DTM and additional survey information as outlined in Section 4.7. As the DTM could not provide surface elevations for the site surface water bodies, elevations were estimated from existing contours, site observations and surveyed culvert/weir levels. Contours of the top of Layer 1 as imported into the model are shown in Figure 9.

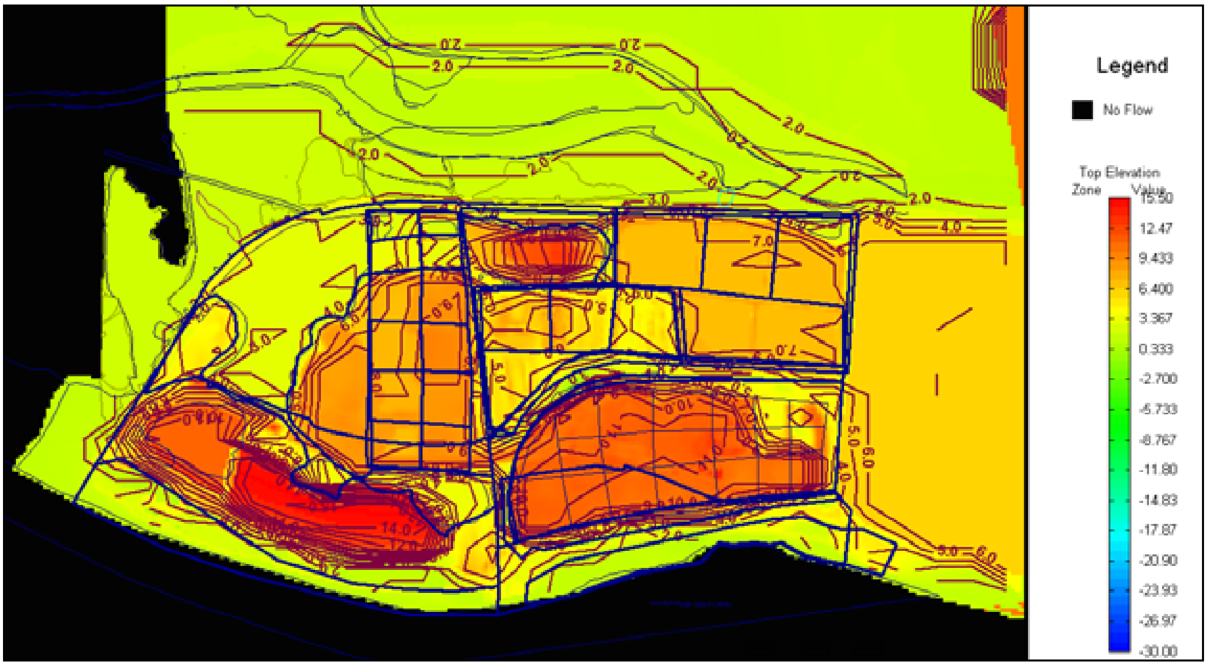

Figure 9: Contours of the top of Layer 1 imported into the Model (RL (m) NHTG)

The base of Layers 1, 2 and 3 were imported as the surfaces defined by the contours presented on Drawings 5.10 to 5.14. In some instances smoothing of the base of Layer 1 was required to prevent localised high spots leading to model instability.

11.1.3 Model Extent and Boundary Conditions

The extent of the model was set to boundaries which could be reasonably well defined as follows:

- The model was extended to the western side of Swan Pond. The results of data logger monitoring of Swan Pond indicated that the levels were primarily controlled by a truncated tidal connection to the South Arm of the Hunter River at about RL 1.5 NHTG. Therefore the boundary along the western side was set to a constant head of 1.5 NHTG on the outer edge of the pond where it was present. There was a small section of the boundary to the north of the pond and this was set as no flow;
- The southern extent of the model was set at the northern bank of the South Arm of the Hunter River. This bank has a sloping beach face and therefore the boundary condition in Layers 1 and 2 was set to the approximate average high tide level of RL 1.5 NHTG as the tidal action on sloping beach faces tends to ‘pump’ the groundwater level up above the average tide level;
- For Layer 3, a general head boundary with reduced boundary conductance was used to represent limited connectivity between the Estuarine Aquifer and the river, due to presence of lower permeability material on the river bed. The head at this boundary was set at measured tidal levels, in the case of the steady state model the rolling average measured heads over the two day period for the time of the simulation and for the transient the rolling average head over a two day period;

- The northern end of the model was extended to the north arm of the Hunter River. Mosquito Creek is tidally influenced; however review of the Unit 2 clay thicknesses indicated that this is unlikely to be directly connected to the Estuarine Aquifer. Therefore for Layers 1 and 2 constant head boundaries were set at both Mosquito Creek and the north arm at a level of RL 1.5 as per the south arm. For the Estuarine Aquifer (Layer 3) a single general head boundary was set at the north arm of the river as per the southern boundary (at average measured tide levels); and
- To the east of the site flow is generally in an approximate north-south direction and therefore this boundary was set as a no-flow boundary to replicate that flow condition. The boundary was extended approximately 650 m to the east of the site to reduce any effects that the boundary might have on the site flow.

The model was set up in world coordinates at a rotation angle of -9 degrees, to allow alignment of the grid with the site ponds/bund walls.

The overall extent of the model was 4900 m from east to west and 3550 m from north to south, portioned into a uniform grid of 392 columns and 284 rows, each 12.5 m wide. The size of the grid increments was selected to allow representation of the bund walls around the various landfill ponds, which typically range in width from 10 to 15 m at the base.

The extent of the active model (i.e. excluding no flow cells) was 3713 m from east to west and 3063 m from north to south.

11.1.4 Drain and River Packages

Groundwater flows in the Fill Aquifer are largely controlled by the presence of various surface drainage features. These were incorporated into the model as ‘drain packages’ with the drainage levels generally set at the surveyed height of the relevant overflow control such as culverts or weirs. For the northern tidal flats and Mosquito Creek tidal flats, drains were applied at the surface level to represent the free draining surface conditions.

The drainage areas are shown in yellow on Figure 10, with the adopted levels summarised as follows:

- Deep Pond: 2.6 NHTG;
- Easement Pond: 2.55 NHTG; (with low conductance to replicate very limited flow capacity);
- Railway Pond: 2.30 NHTG;
- FDF Leachate Collection system: 1.6 NHTG;
- BHPB Wetland and Blue Billed Duck Pond: 3.08 NHTG;
- Northern Tidal Flats: surface level 1.5 NHTG;
- Mosquito Creek Tidal Flats: surface level 2.0 NHTG;
- FDF Pond: 3.3 NHTG;
- Long Pond: 3.6 NHTG;
- OEH Wetland 1: 2.0 NHTG;
- Rail Road Pond: 2.0 NHTG;

- OEH Wetland 2: 2.0 NHTG;
- OEH Wetland 3: 2.0 NHTG; and
- North-eastern Railway Ponds: 2.1 NHTG.

Figure 10: Drain Packages (yellow) and 'River' Packages (green)

Swan Pond was modelled using the head-dependent river boundary condition which permits the modelling of groundwater inflows in Layer 1, in-line with the tidal influence of the Hunter River. The river feature was set to 1.5 NHTG and is shown in green in Figure 10. Similarly OEH Wetland 1 was converted to a river boundary at RL 1.7 NHTG to reflect the regular tidal inundation.

It is noted that the drain modules are only active when the water levels reach the drain levels and in this instance they do not receive recharge. When the drains are inactive (groundwater levels below drain level) the model cells are free to accept recharge and evapotranspiration.

11.1.5 Material Zones

As indicated on Drawing 5.09, various types of filling have historically been placed over the site. This drawing has been used as the basis for zoning of materials in Layer 1 of the model, with the various adopted hydraulic conductivities shown below in Figure 11.

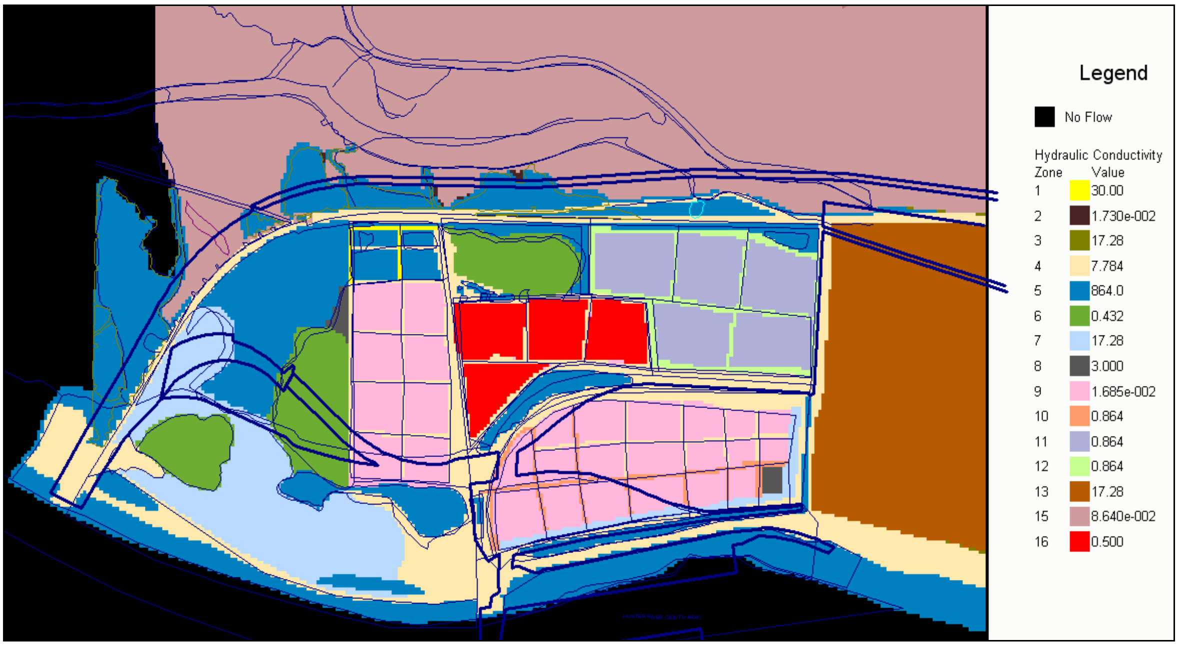

Figure 11: Hydraulic Conductivities (m/day) in Layer 1

The majority of Layer 2 was assigned as a single clay material, with the exception of two areas in which permeability of the clay was increased as a result of the calibration process, as shown in Figure 12.

Figure 12: Hydraulic Conductivities (m/day) in Layer 2

Layer 3 was assigned as a single material zone.

11.1.6 Recharge and Evapotranspiration

Daily rainfall data from the adjacent KCT Meteorological Station was provided by PWCS for the period 1 November 2010 to 30 April 2011 and was utilised in the adoption of rainfall recharge rates.

The Bureau of Meteorology (BoM) annual mean rainfall data for Nobby's Station and mean annual pan evaporation data for Williamtown Station (nearest available data) were used to assign typical climatic conditions. The BoM data for local weather stations is shown in Table 16.

Table 16: Annual Mean Rainfall and Pan Evaporation for Newcastle Weather Stations

BoM Station	Approximate Distance and Direction from the T4 Project (km)	Mean Annual Rainfall (mm)	Mean Annual Pan Evaporation (mm)
Nobby's	8 km, south-east	1134.5	-
Williamtown	13 km, north-east	1121.2	1725.0
Maryville*	5 km, south-east	1112.4	1512.3

Notes to Table 16:
* Maryville Station ceased monitoring 31 January 1993
- No data

11.1.7 MODFLOW-SURFACT Options

Variably saturated flow options were implemented in MODFLOW-SURFACT, with details and parameter values presented in Table 17.

Table 17: MODFLOW-SURFACT Saturation

Variably Saturated Flow Options	
Unsaturated Modelling Option	1 - van Genuchten for water flow
Relative Permeability Option	0 - Upstream Weighting
Unsaturated Flow Constants	
Alpha	0.01
Beta	5
Residual Saturation	0.1

11.2 Calibration

Model calibration was undertaken concurrently in both the steady state conditions using the target heads measured during the dip round on 25 November 2010, as well as transiently using target heads from data loggers installed over the period 26 November 2010 to 27 April 2011. The results were iterated until both models had matching hydraulic parameters and recharge and evapotranspiration multipliers.

The transient calibration was undertaken to simulate the aquifer responses to climatic variations in tide, evapotranspiration and rainfall. The calibration was undertaken in two stages as follows:

1. Response of piezometric heads in the estuarine aquifer to sub daily tidal variations. This allowed calibration of the tidal boundary conditions as well as the storativity of the estuarine aquifer.
2. Response of surface water and groundwater heads to daily variations in tide, evapotranspiration and rainfall. The water level data collected during the period 26 November 2010 to 27 April 2011 were used as targets for this calibration.

The resulting head distributions for the Fill Aquifer and Estuarine Aquifers are presented on Figure 13 and Figure 14. The figures also include the magnitude of residuals at target points, which are the difference between the observed head at monitoring wells and the computed heads from the model. Where residuals are negative/red the observed head was lower than the computed head and where residuals are positive/blue the observed head was higher than the computed head.

The calibrations are discussed in more detail in Appendix B.

Overall the calibrations, both steady state and transient are considered to provide good representations of the groundwater system on the T4 Project site and are considered suitable for the purposes of assessing the sensitivity of the groundwater system to changes induced by the proposed T4 Project development.

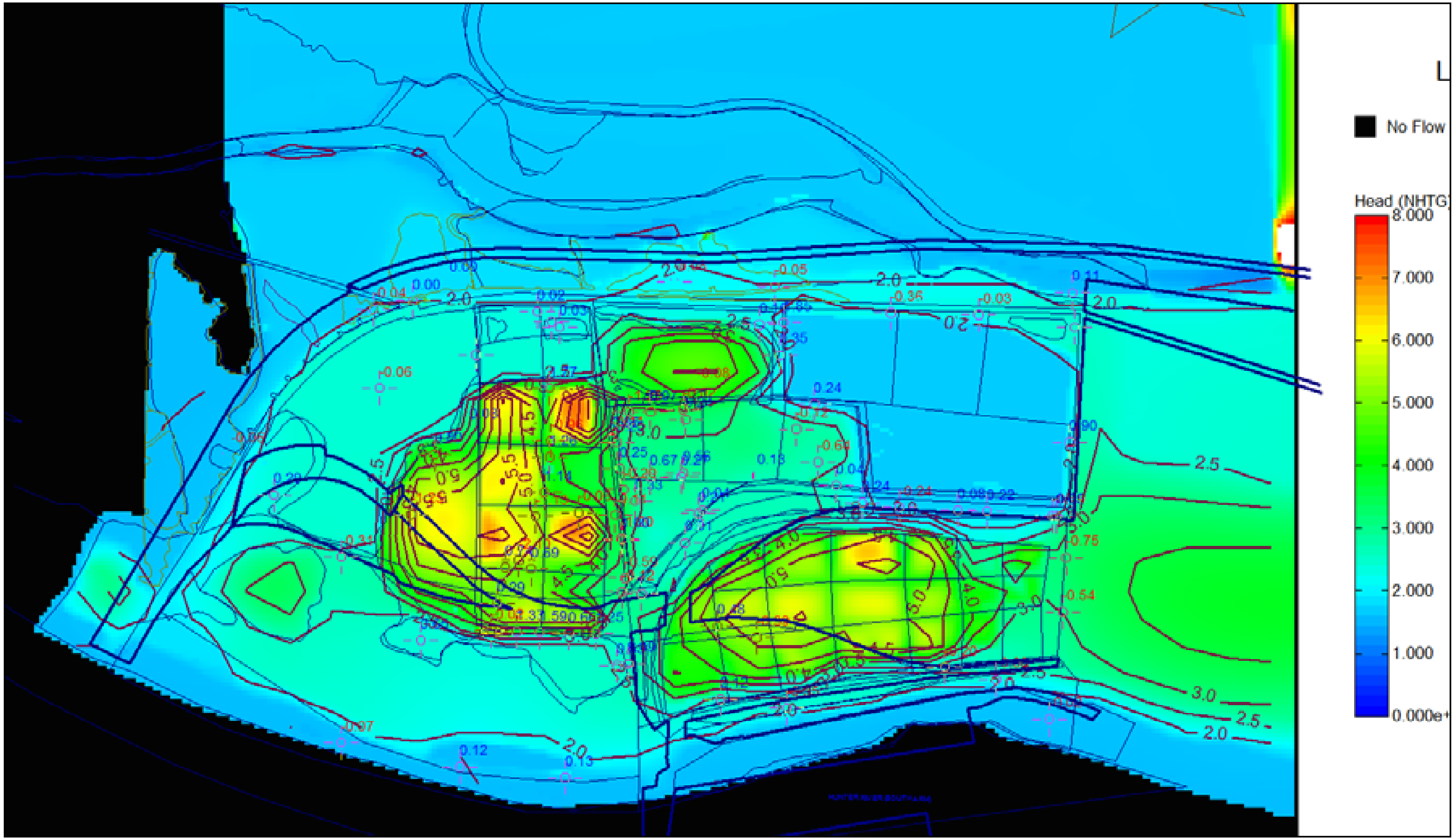

Figure 13: Computed Contours and Colour Flood of Groundwater Head in Layer 1 (Fill Aquifer), 0.5 m NHTG Contour Intervals

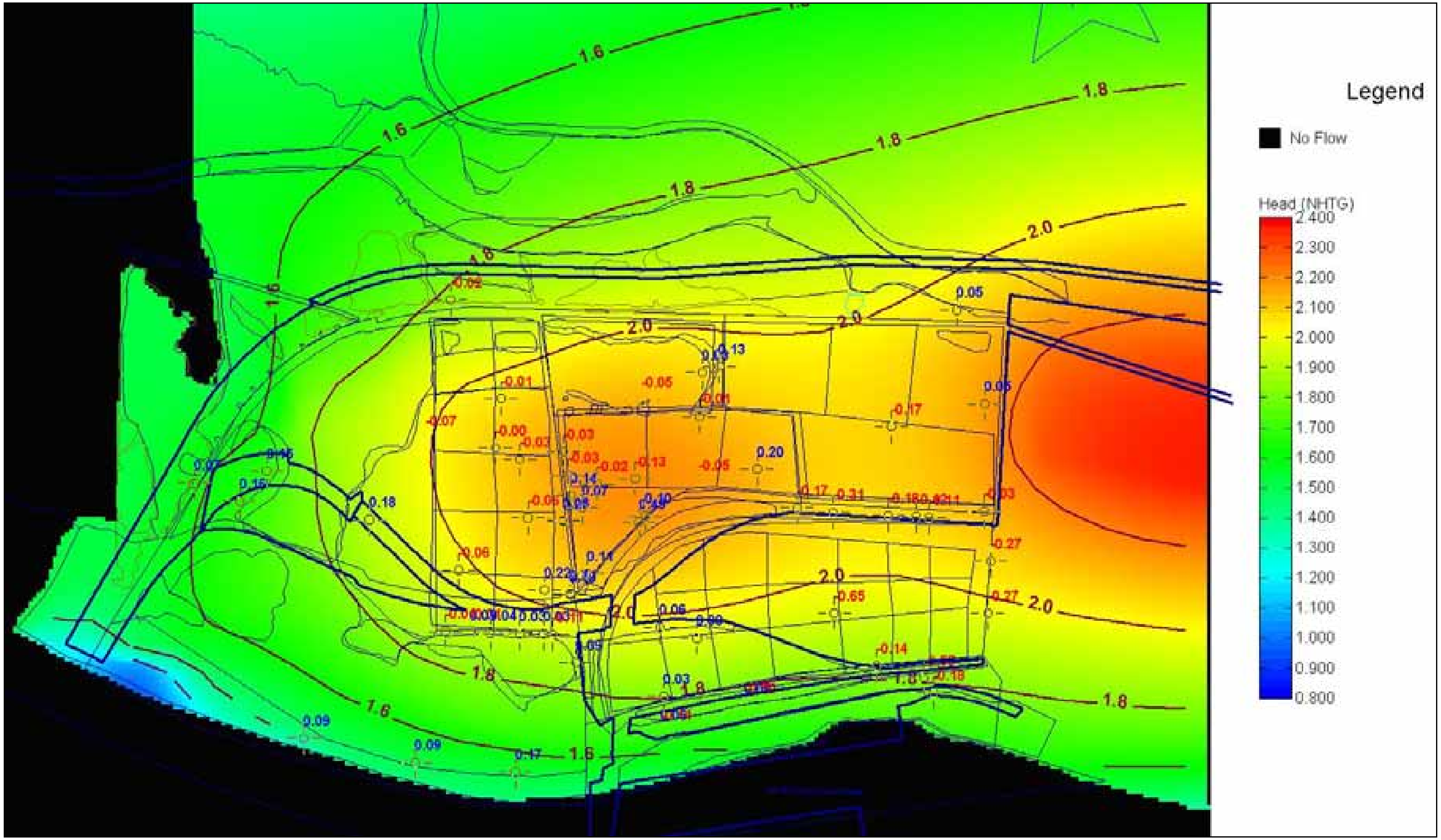

Figure 14: Computed Contours and Colour Flood of Groundwater Head in Layer 3 (Estuarine Aquifer), 0.2 m NHTG Contour Intervals

11.3 Impacts Associated with Groundwater from the T4 Project Development

11.3.1 Cumulative Impacts and Interactions with Other Developments

The following sections describe how the calibrated groundwater model has been used to provide prediction of the impacts of the proposed T4 Project on groundwater. The model also incorporates other existing and proposed developments on and adjacent to the site.

This proposed T4 Project is located adjacent to existing development including the following:

- PWCS existing facilities to the east of Area D (FDF);
- BHPB treated sediments area to the south of the site; and
- NCIG facilities to the south east of the site.

The extent of the groundwater model includes the BHPB treated sediments area to the south of the site. Key elements of this development with regard to groundwater comprise the low-permeability landfill cell, which will limit infiltration to groundwater, as well as the BHPB Wetlands and Blue Billed Duck Pond. These elements have all been incorporated into the model, as discussed in Section 11.1 and Appendix B (Numerical Model Calibration).

The existing PWCS and NCIG facilities are generally located to the east of the site. The model extends slightly onto these sites to allow for edge affects from the sites, however the sites are essentially cross-gradient of the T4 development and will have limited effect. Key elements of these developments with regard to groundwater which have been incorporated into the model (described in Section 11.1 and Appendix B) include the following:

- Existing wick drains through Clay Aquitard below westerns sections of PWCS development; and
- Rail loop associated with NCIG site, which passes immediately to the south of the T4 development including effects of run-off from the rail line into Easement Pond.

As well as these existing developments, as part of the closure plan for existing landfill cells in Sites A and B, capping these sites is proposed to be completed by the end of 2013, independent of the T4 Project. The placement of this capping will have an impact on groundwater levels, surface water levels, flow rates and contaminant fluxes independent of the T4 Project.

The groundwater modelling described in the following sections accounts for the above described elements of other developments on the groundwater. The modelling has been undertaken in stages, representing the various proposed stages of construction of the T4 Project and therefore provides an assessment of the cumulative impacts of the T4 Project as well as other development, including capping that will be undertaken independent of the T4 Project.

The modelling has been also undertaken for the scenario with no T4 Project development, however still including the proposed capping in Sites A to C. This provides a measure of the net impact of the T4 Project.

11.3.2 Stage 1 Including Dredging

Based on current concept designs, initial filling of the site for the T4 Project comprises hydraulic placement of dredged sand from east to west over the footprint of the seven proposed stockpiles. The final approach for land reclamation will be refined during the detailed design phase, however placement of sand is expected to be undertaken as follows with additional details provided in Section 9.2:

- Installation of a low permeability bund on southern extent of the T4 Project area between FDF and Deep Pond;
- Placement of sand in seven east-west strips, starting at the northern end of the T4 Project area;
- Each strip would be formed by placing initial bunds of sand to contain subsequent sand that would be placed between the bunds from east to west, the decanted water would flow to Deep Pond at the eastern end; and
- Overflow from Deep Pond would then be piped to the South Arm of the Hunter River.

The dredging of the site for Stage 1 of the proposed T4 Project was modelled as follows:

- Three stages of dredging, each comprising two or three east-west strips;
- Each stage was then subdivided into areas of similar height of sand filling to be placed;
- Where ponds were previously present these were replaced with sand and any associated drainage controls were removed, to represent the ponds being filled with sand;
- The sand dredging is estimated to require about a year and a half to complete and therefore each stage was modelled as a separate stress period, each of 6 months duration;
- For the actual dredging process the head of water within the sand would initially be at the surface of the sand when the sand is first placed, with the remaining water flowing overland to the west of the placement front at quite a shallow depth. As the placement front moves to the west the sand previously placed would drain by infiltration into the underlying and adjacent strata. Therefore the average head over each stage would be between the previous surface level and the new surface level of the sand, probably slightly below the half height of the sand fill. For the purpose of the model, the head within each sub-area was simulated with General Head Boundaries set with a head at half the height of the sand fill;
- The volume of water entering each stage for each stress period from the general head boundaries was calculated using zone budgets. The balance of water was then applied to Deep Pond as a recharge rate to replicate the flow of water decanted from the sand filling process;
- The Drain boundary condition for Deep Pond was increased from 2.46 NHTG to 3.0 NHTG for the dredge water receival area and was applied only at the centre of the pond to allow the saline recharge water an opportunity to mix with the pond water around the perimeter of the pond;
- The process of placing the fill would lead to consolidation (squeezing) of the underlying Unit 2 Clay which would result in a volume of water (in m^3/m^2) equivalent to the amount of settlement (m) being expelled from the Unit 2 Clay. Estimates of predicted settlement calculated in the DP Geotechnical Report (Ref 25) have been utilised in this Groundwater Assessment, taking into account progressive filling of the stockpile areas, variable proposed fill heights and varying clay thicknesses;

- The expulsion of water was simulated using an array of wells, on a 12.5 m by 12.5 m grid, within Layer 2. As the sand fill would be placed progressively over the period of each stage of filling, the flow rate was applied at a uniform rate over each stress period representing a stage of filling. The expected settlement and volume of water applied within each zone is summarised in Table 18;
- As the dredging progresses the preloading of Stage 1 would follow in areas where dredging was complete. The preloading of Stage 1 has been assumed to be undertaken in two 6 month sub stages (Stockpiles 1 and 2 and Stockpiles 3 and 4). This has been modelled in a similar manner to the 'squeezing' with flow rates presented in Table 18.

Table 18: Indicative Stages and timing of Placement of Sand Fill and Associated Settlement and 'Squeezing' Flows

Modelled Stage of Dredging	Stages of Construction	Description	Average Height of Fill (m)	Expected Settlement due to placement of dredged Fill (m)	Daily Flow Rate (m^3/m^2 per 12.5m^2 model cell)	Length of Period (days)	Year
Stress Period 1	Dredge Fill Stockpiles 1 and 2	FDF	1.9	0.241	0.238	182	Mid 2013 to Late 2013
		Railway Pond, north of FDF	8.6 to 8.9	0.743 to 0.766	0.735 to 0.758		
		Area K7	1.9	0.160	0.158		
		Ponds 9 to 12	8.4	0.829	0.820		
		Deep Pond (partial)	7.9	0.596	1.535		
Stress Period 2	Dredge Fill Stockpiles 3 and 4	FDF	1.9	0.740	0.186	182 (364)	Early 2014 to Mid 2014
		Site C	3.4	0.329	0.829		
		Ponds 7, 8, part Pond 6	1.9	0.379	0.956		
		Deep Pond (partial)	7.9	1.387	3.496		
	Preload Stage 1 over Stockpiles 1 and 2	Former Drains, Ponds 9 to 12, Area K7 and FDF	8	0.43 to 0.64	0.158 to 1.535		
Stress Period 3	Dredge Fill Stockpiles 5 to 7	FDF	1.9	0.185	0.419	182 (546)	Mid 2014 to Late 2014
		Site C	3.9	0.401	0.909		
		Pond 6	0.9	0.322	0.729		
Stress Period 4	Preload Stage 1 over Stockpiles 3 and 4	Former Drains, Ponds 9 to 12, Area K7 and FDF	1.9-7.9	0.286 to 0.705	0.245 to 0.605	182 (728)	Early 2015to Mid 2015
Stress Period 5	Capping of Stockpiles 1 to 4, Stage 1	Dissipation of Heads Following Filling and Capping	NA	NA	NA	550 (1278)	Mid 2015 to End 2016

- To model the impact of the application of saline water to the T4 Project area a TDS concentration of 35,000 mg/L was applied at each general head boundary as well as the recharge into Deep Pond, to replicate the approximate expected salinity of the dredge water. The initial concentration of the pond was set at 35,000 mg/L to replicate the surface water mixing which would be expected to lead to high salinity levels in the pond within the first few days of dredge water entering Deep Pond;

- MODFLOW-SURFACT was run in transport mode to simulate the migration of salinity and assess potential impacts on the T4 Project area surface water bodies;
- Longitudinal dispersivity was estimated using “US EPA On-Line Tools for Site Assessment Calculation” based on a typical flow path length of 500 m. Calculated dispersivities for various flow path lengths are presented in Table 24. For the purposes of modelling salinity, a dispersivity of 50 m was used, based on 10% of the flow path as this was slightly more conservative in terms of salinity travel distance than the method of Xu and Eckstein (1995 – Ref 46).

Table 19: Longitudinal Dispersivity Estimates for Various Plume Lengths

Plume Length	10% plume Length (m)	Approx. Lower Limit (m)	Xu and Eckstein (Ref 46) (m)	Approx. Upper Limit (m)
3	0.3	-	0.139	6.5
12.5	1.25	0.0019	1.04	66
100	10	0.2	4.42	600
500	50	0.82	9.12	2500
1000	100	1.5	11.8	4500

Contours of concentration, for the case of discharge of saline water directly into Deep Pond are presented in Figure 15 for the end of dredging and Figure 16 for the end of Stage 1 construction (two years following completion of dredging).

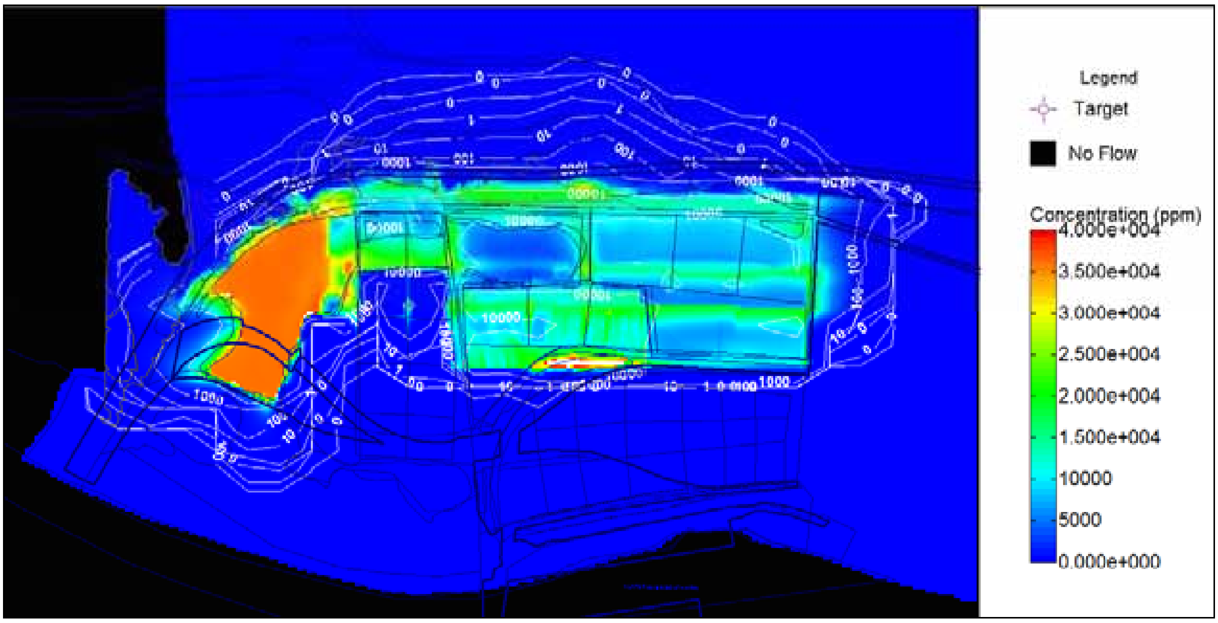

Figure 15: Logarithmic Contours of Salinity Concentration (mg/L) at the Completion of Dredging

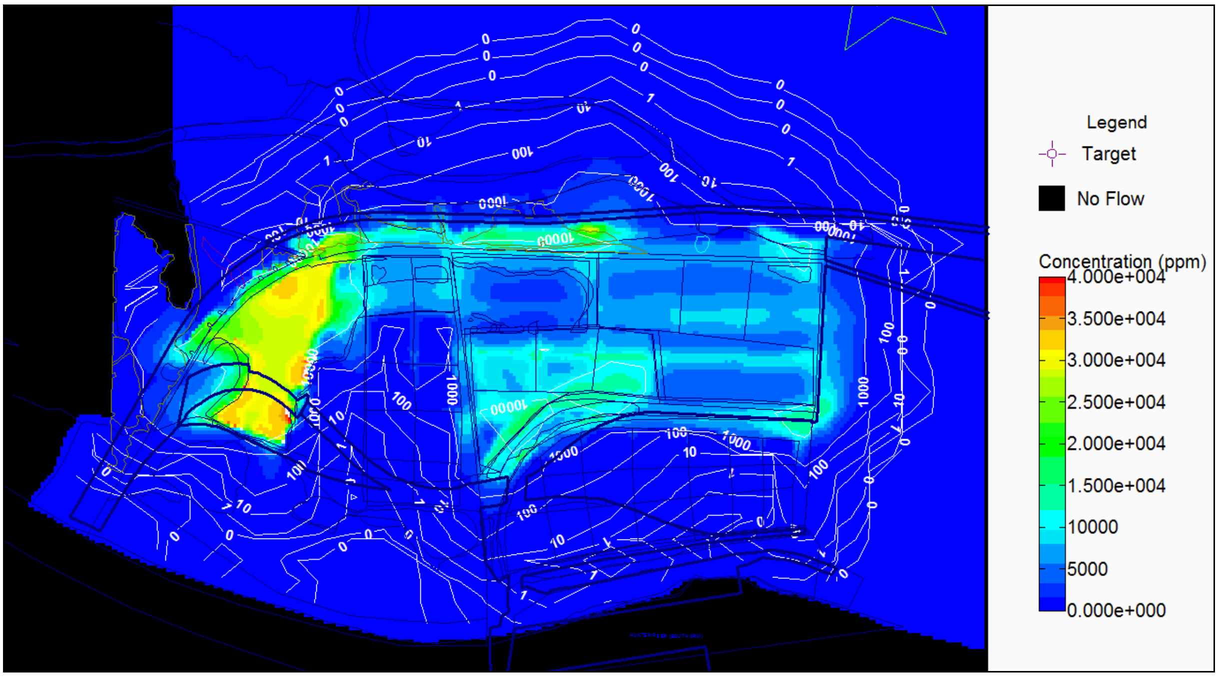

Figure 16: Logarithmic Contours of Salinity Concentration (mg/L) at the Completion of Stage 1 Construction

Contours of salinity concentration in Figure 15 indicated salinity above 10,000 mg/L at the completion of dredging in the following areas:

- Site C;
- Easement Pond;
- Filled Ponds 9 to 12 and Railway Pond;
- Deep Pond and extending up to about 50 m to the south and west;
- Rail Road Pond;
- Beneath the rail embankment to the north of Deep Pond, in OEH Wetlands 2 and 3; and
- North of Area D between the railway line and northern access road.

Modelled impacts on the Blue Billed Duck Pond are less than 100 mg/L, which would be less than background salinity concentration.

Contours of salinity for two years following completion of dredging as presented in Figure 16 indicated that concentrations had generally dissipated further, however the overall extent of salinity greater than 10000 mg/L had increased slightly in some places, in particular to the south of Area C, towards BHPB Wetland.

Impact associated with other potential groundwater contaminants are discussed in Section 11.3.5.

Figure 17 presents contours of head in the Estuarine Aquifer at the completion of dredging and indicates that there would be significant leakage into the Estuarine Aquifer, sufficient to increase heads to greater than RL 3.5 NHTG, compared to normal RLs of about 2.1 NHTG. This would effectively increase flow rates by more than three times for the period of the dredging. This increase would be mostly due to leakage through the more permeable zone under Site C.

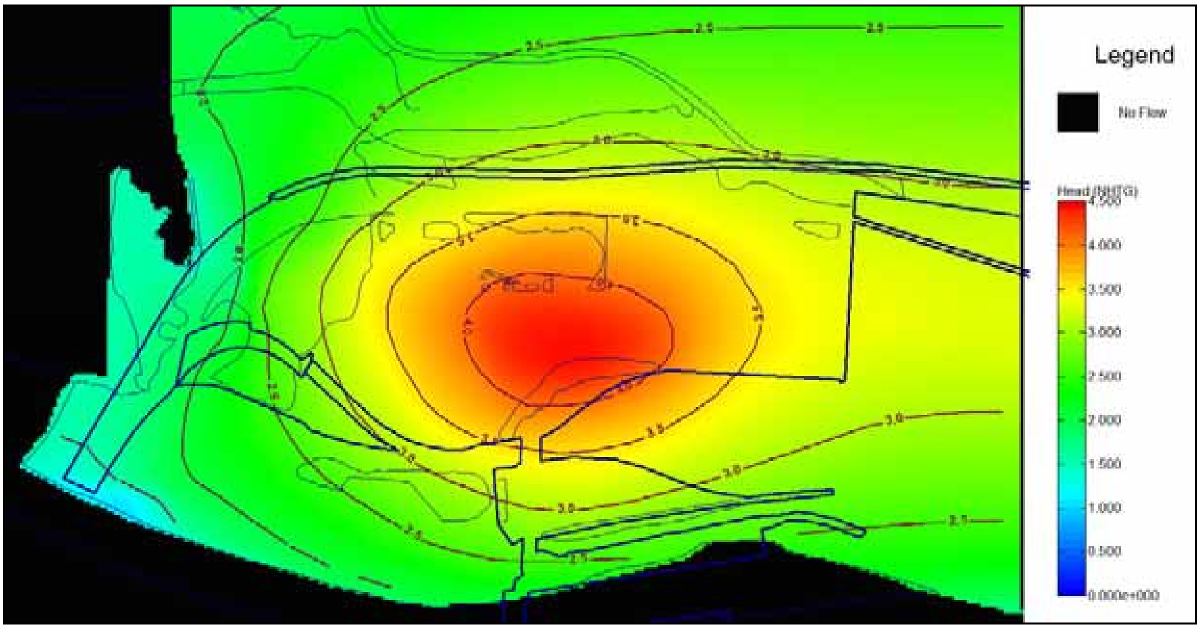

Figure 17: Contours of head in the Estuarine Aquifer at the Completion of Dredging (0.5 m NHTG contour intervals)

The model was re-run with the following mitigation measures to reduce potential impacts from salinity and increased flows in the Estuarine Aquifer:

- Placement of a low permeability liner (GCL and/or HDPE) on the fill batters around the perimeter of Deep Pond, thereby separating the saline water from pathways towards sensitive receptors (OEH Wetland 1 and Rail Road Pond). A conceptual section of the liner is show in Figure 18; and
- Placement of a GCL liner (or similar) in Site C prior to dredging. The GCL liner was modelled as a 5 mm thick material with a hydraulic conductivity of $3x10^{-11}$ m/s. Leakage through the liner was modelled by applying a recharge rate of 0.002 m/day based on a typical head on the liner of 4 m being dissipated across the liner.

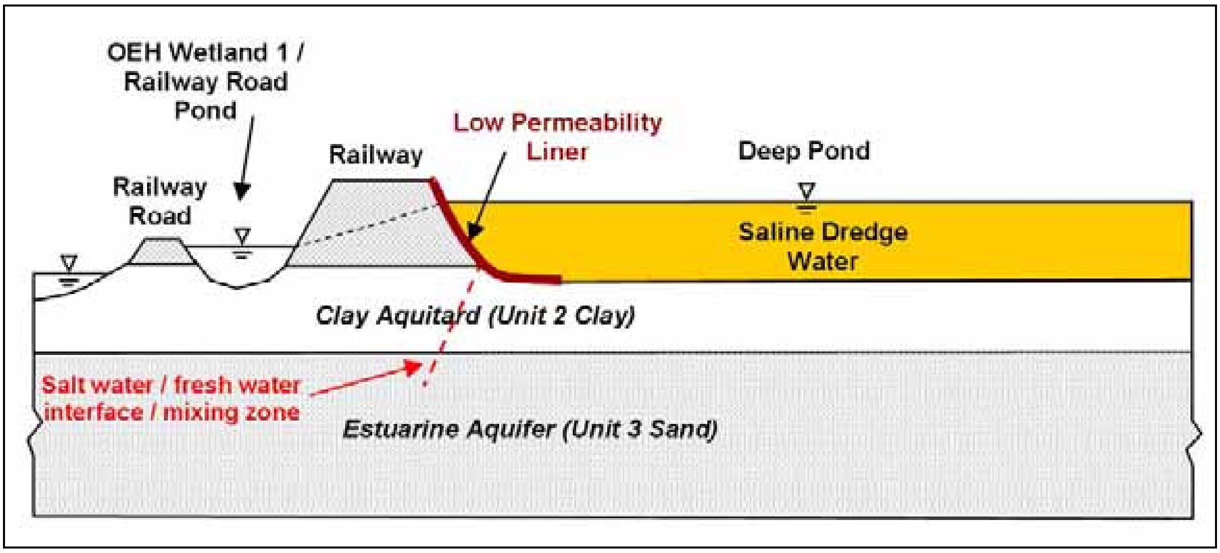

Figure 18: Conceptual Section showing Low Permeability Liner

The resulting contours of salinity concentration, with the mitigations in place are presented in Figure 19 for completion of dredging and Figure 20 for two years following completion of dredging.

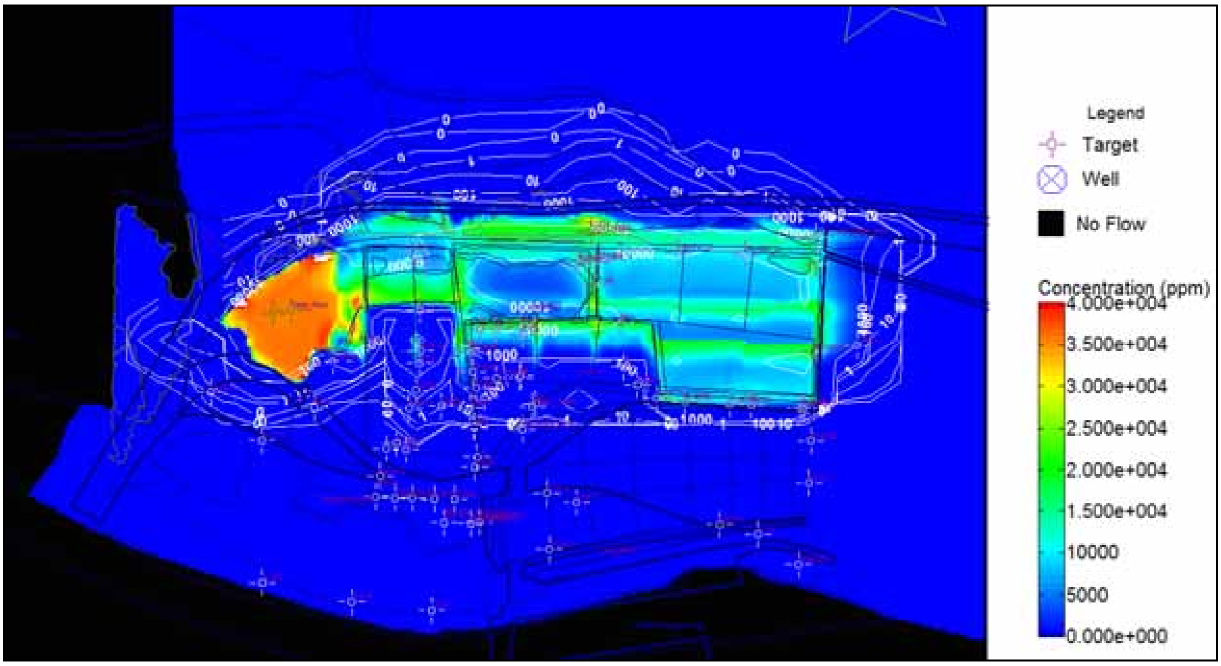

Figure 19: Logarithmic Contours of Salinity Concentrations (mg/L) with Mitigations at the Completion of Dredging

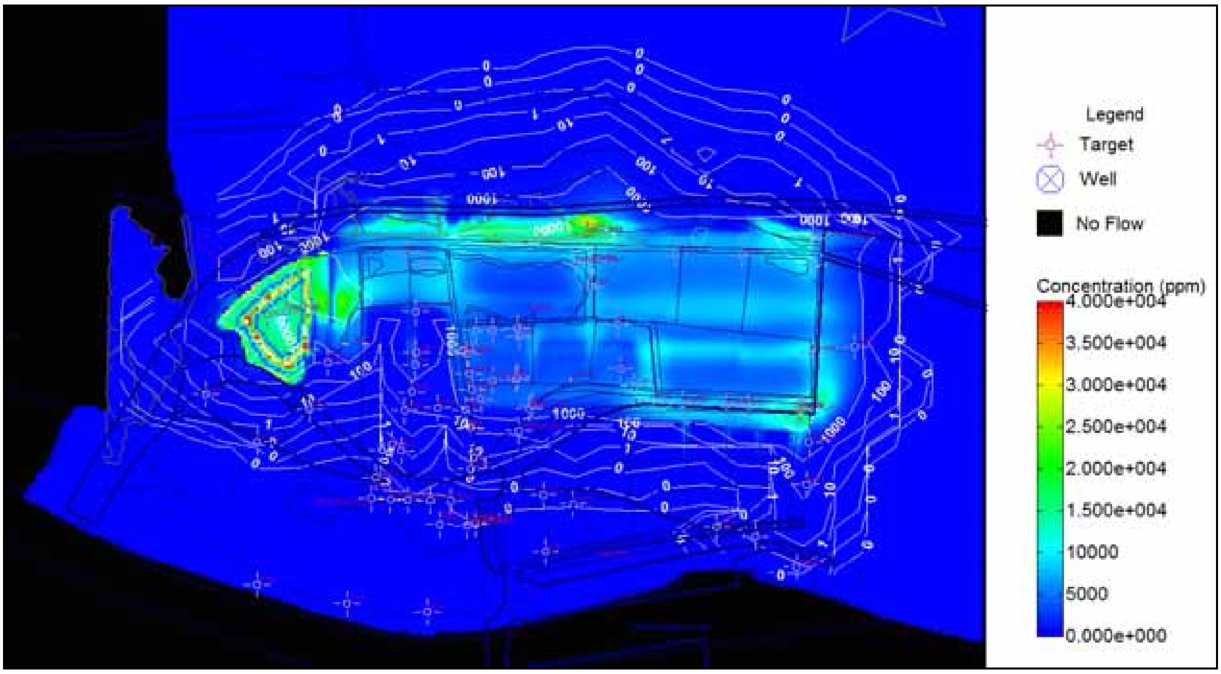

Figure 20: Logarithmic Contours of Salinity Concentrations (mg/L) with Mitigations at the Completion of Stage 1 Construction

Figure 19 and Figure 20 indicates salinity concentration impacts of about 1,000 mg/L or less in OEH Wetland 1 and Rail Road Pond. Such concentrations are at the lower range of background groundwater concentrations. The encroachment of salinity to the south of Deep Pond towards Blue Billed Duck Pond would be reduced, reducing the risk of elevated concentrations reaching this pond along preferential flow paths not replicated by the model.

The predicted salinity concentrations presented in Figure 19 and Figure 20 represent potential net increases in salinity of groundwater and do not take into account the transient variations in salinity which will occur in the Wetlands and ponds due to cycles of rainfall and evaporation. Field measurements indicate that salinity concentrations in the wetlands/ponds vary over a range from about 1,500 mg/L to greater than 10,000 mg/L due to these natural cycles.

Overall the results of the modelling indicate that with appropriate mitigations in place, the net impact on salinity concentrations would be insignificant, provided that fluctuations in pond levels due to rainfall and evaporation are maintained in a similar manner to what currently occurs.

It is considered however that potential exists for preferential flow paths through the slag bunds towards the Blue Billed Duck Pond which are not necessarily reflected in the model. This could be mitigated by placement of lining materials over high permeability slag bunding in the vicinity of Ponds 5 to 8 during the dredging.

Heads in the Estuarine Aquifer with the above mitigation measures implemented would be substantially reduced, especially by the use of a GCL liner or similar, with peak heads over Site C reduced to about 3.0 NHTG.

11.3.3 Completion of Stage 1

11.3.3.1 General

The potential impacts associated with groundwater of the completed Stage 1 of the T4 Project, in particular with respect to the ponds and OEH Wetlands were modelled both in Steady State as well as a full Transient simulation using variable climatic conditions.

The completed Stage 1 model included the following assumptions:

- The removal of drain conditions below areas subject to placement of sand fill and the replacement of high permeability zones representing these drains and ponds with sand fill. Removal of drains associated with the leachate collection system below the FDF as these may no longer be operational after filling (as per dredging scenarios);
- The proposed rail embankment is present, including widening of the rail line to the south through Deep Pond and then transitioning to the North of Stage 1 as it continues to the east. The rail embankment was modelled with a hydraulic conductivity equivalent to a typical compacted sand (20 m/day);
- A bund or liner is constructed within Deep Pond for purposes of controlling saline dredge waters;
- The presence of Stormwater Ponds with a base level of RL 1.5 NHTG and a typical water level set at RL 3.5 NHTG with a GCL liner in the base of the ponds. Leakage through the base of the ponds was simulated by applying a recharge equivalent to a head of 2.0 m on the GCL liner at 0.001 m/day. The walls of the ponds were simulated by a single cell width (12.5 m) set with a hydraulic conductivity of 0.011 m/day equivalent to compacted clay;
- The remaining sections of Deep Pond outside of the stormwater ponds were left unchanged compared to the pre-development situation, including receiving run-off equivalent to about 50% of the surface areas (recharge multiplier of 1.5); and
- Stage 1 of the development, as well as sections of Areas A and B proposed to be capped by OEH were subject to reduced recharge to simulate the capping proposed in these areas. A recharge multiplier of 5% was used for these areas.

11.3.3.2 Steady State

The model was initially run in steady state to provide an indication of typical Stage 1 T4 Project site conditions and how water levels below the site would compare to the pre-development (calibration) conditions.

The resulting head distribution in the Fill Aquifer and Estuarine Aquifer are presented in Figure 21 and Figure 22.

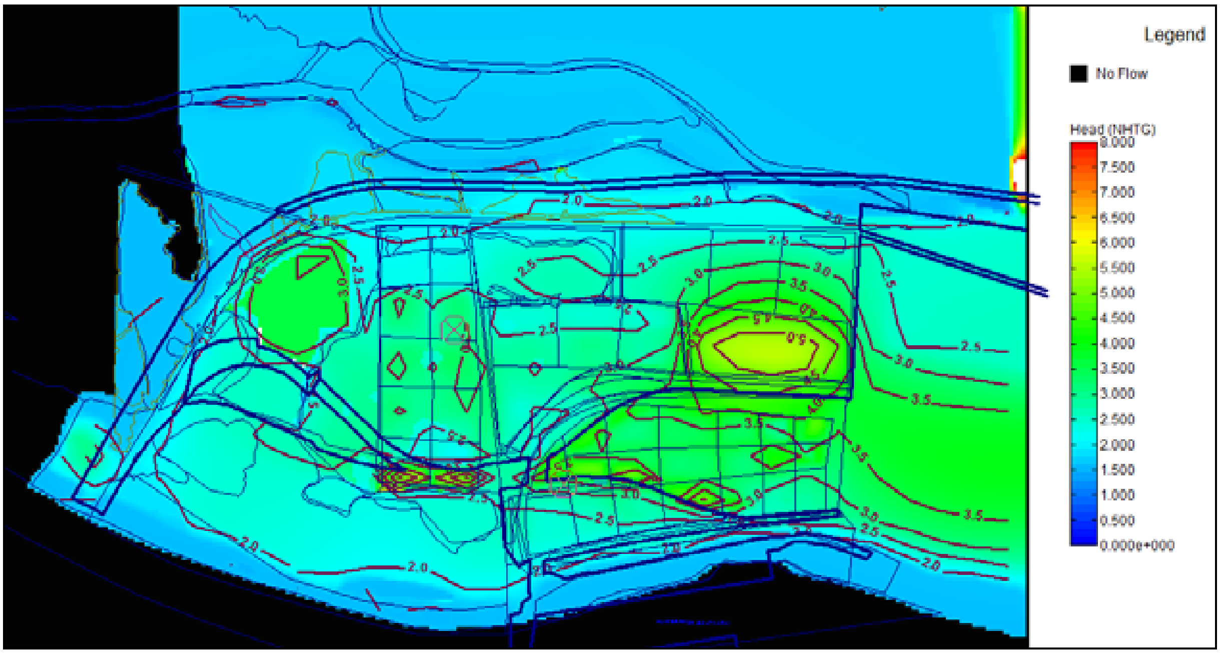

Figure 21: Steady State Post Stage 1 Development - Contours of head in Layer 1 (0.5 m intervals)

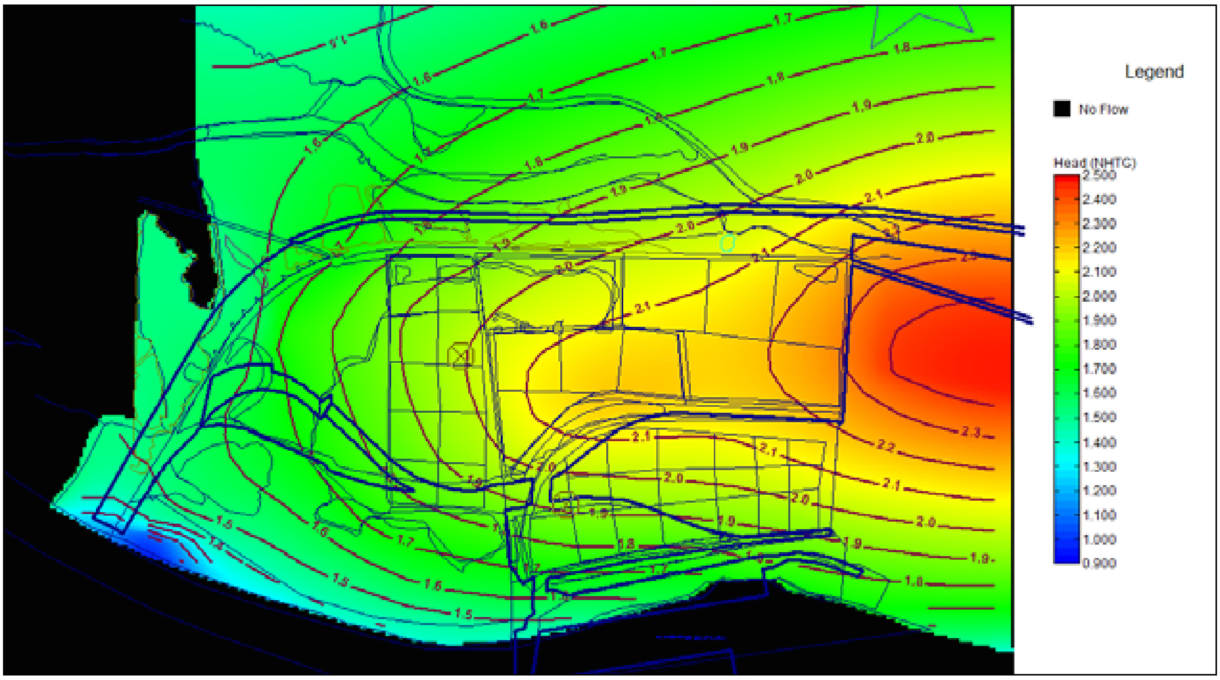

Figure 22: Steady State Post Stage 1 Development - Contours of head in Layer 3 (0.1 m intervals)

The results of steady state modelling shown in Figure 21 and Figure 22 indicate the following:

- Removing the leachate collection system controls over Site D (FDF) would cause mounding of groundwater over the central part of the T4 Project area in the Fill Aquifer, increasing heads from RL 2.0 NHTG to 6.0 NHTG;
- Increased heads and flows are apparent for the Estuarine Aquifer, in particular Site D, with the resultant heads now similar to those for Site C;
- The heads in the Estuarine Aquifer below Site D would be increased from RL 2.0-2.1 NHTG pre-development to 2.1-2.2 NHTG post-development;
- Heads in the Estuarine Aquifer on the remaining parts of the T4 Project area would generally be slightly lower; and
- There would be no significant changes to the north of the T4 Project area for both the Fill and Estuarine Aquifers.

11.3.3.3 Transient

The steady state model was then used as starting heads for a transient model. The climatic data set for the four month calibration period was then used to simulate changes in the response of the model post T4 Project development compared to the pre-development calibration. A comparison of the calculated heads at each of the surface water target locations pre and post development are presented in Figure 23.

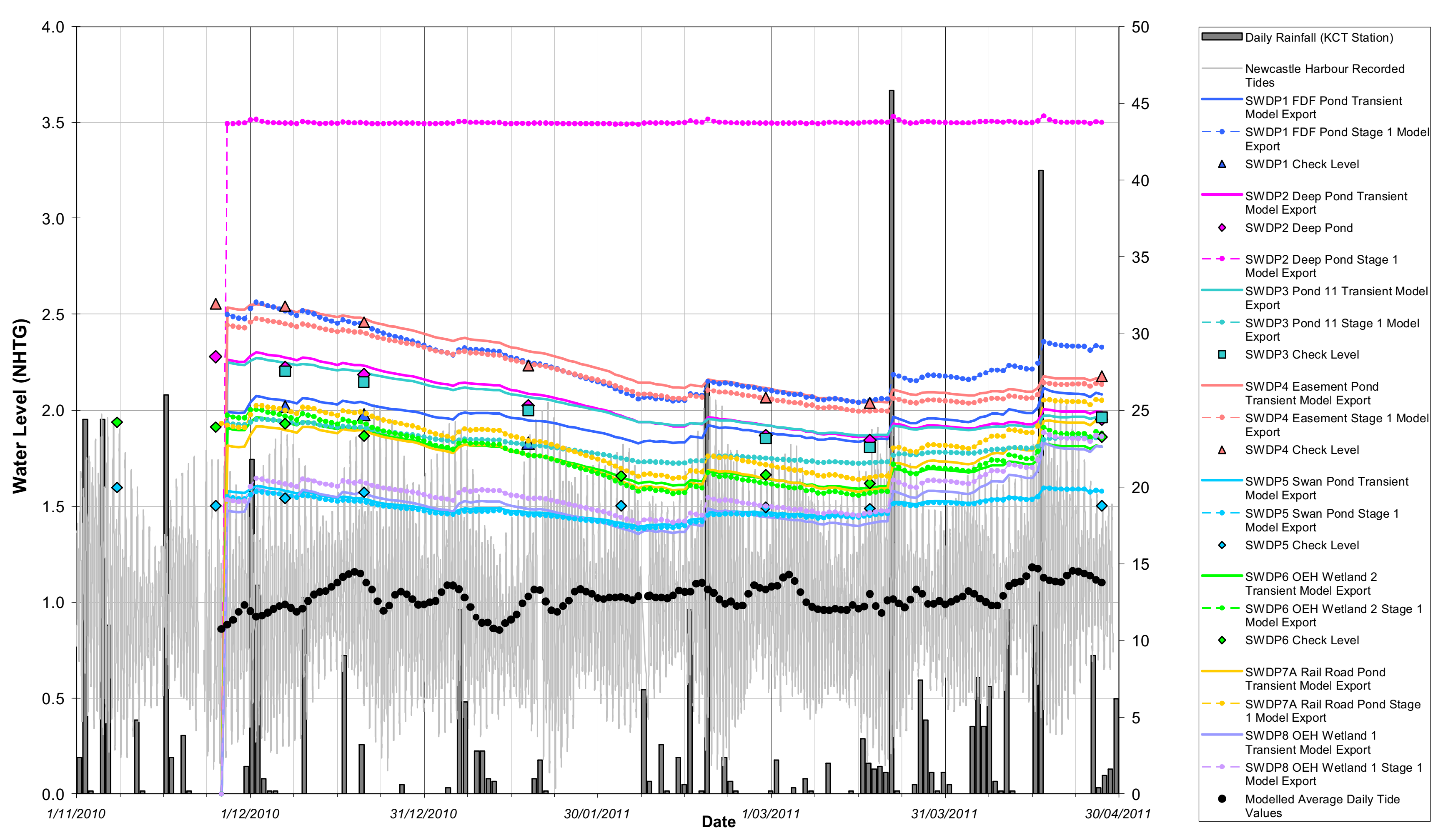

Figure 23: Calculated Surface Water Levels Pre and Post Stage 1 Development

Figure 23 indicates the following with respect to T4 Project surface waters:

- The level in Deep Pond would increase to a constant of 3.5 NHTG as controlled by the proposed stormwater detention ponds in this area;
- There would be a slight change in level of the OEH Wetlands (less than about 0.05m). The change is generally consistent across the hydrograph, indicating the fluctuations are controlled by rainfall and evaporation rather than leakage from Deep Pond. This is because, although there is some groundwater leakage from Deep Pond though the Unit 2 clay, the leakage rate is very low compared to evaporative and rainfall events. Furthermore, if the section of Deep Pond immediately upstream of the railway embankment is retained, this would further limit impacts. The observation that the wetland dries out when Deep Pond is still at relatively high levels is further evidence of this limited connection. Therefore changes to Deep Pond are not expected to significantly affect OEH Wetland 1, however changes to the amount of run-off received by OEH Wetland 1 from the rail line would have an effect;
- Similarly with the Rail Road Pond, there would be a slight increase in water level (about 0.1 m), probably due to removal of the drain between Deep Pond and Railway Pond leading to slightly increased leakage through this section of the rail embankment. The impacts of the T4 Project development would be limited due to the limited hydraulic connection through the railway embankment especially if Deep Pond is retained immediately upstream of the Rail Road Pond, thereby maintaining the same driving head. As with OEH Wetland 1, variations in levels in the pond would be sensitive to changes in run-off from the railway line. and to a more limited extent to variation in the levels of the remnant Deep Pond, which in turn would be dependent on maintaining similar ratio of run-off to the existing situation;
- FDF pond levels would increase due to filling part of the pond and removal of any associated drainage to Deep Pond; and
- Water levels in Pond 11 would increase as the pond would have been filled with sand.

11.3.4 Cumulative Impacts from Future Stages of Development

The potential impacts of future Stages of the T4 Project were also modelled. Future stages will be determined by coal export demand however for the purposes of this assessment potential Stages 2 and 3 of the T4 Project construction were modelled as a Transient simulation using Steady State climatic conditions, following on with starting heads from the completed Stage 1 development.

The proposed T4 Project Stages 2 and 3 developments would include the following:

- Progressive pre-loading of the stockpiles, from northern to southern stockpiles, grouped into:
    - Stage 2: Stockpile Areas 5 and 6; and
    - Stage 3, Stockpile Area 7.
- Consecutive construction and capping of the stockpile areas following preloading of each of the above stages.

The modelling of Stages 2 and 3 included the following elements:

- One stress period for each preloading stage, subdivided into areas of similar expected settlement;

- One stress period for each stage of general construction and capping, following preloading;
- A fifth and final stress period to model the final capped site;
- The process of pre-loading would lead to consolidation ('squeezing') of the existing Layer 1 filling/Stage 1 dredged sand and underlying Unit 2 Clay which would result in a volume of water (in m^3/m^2) equivalent to the amount of settlement (m) being expelled from Layers 1 and 2. The expulsion of water was simulated using an array of wells separately screened in Layers 1 and 2, on a 12.5 m by 12.5 m grid, with the flow rates based on a proportion of the total expected settlement. The flow was uniformly applied over the stress period for the corresponding stage of the development. The settlement due to preloading is assumed to be complete at the completion of each stage of pre-loading, therefore the wells were made inactive at this time;
- Consolidation settlement would be due to loss of water from the pore spaces and not compression of the soil phase. Therefore the flow rates are not factored according to the porosity;
- Settlement estimates are based on the loads applied by filling the T4 Project area and preloading to levels commensurate with the completed stockyard; consolidation parameters were based on the results of the geotechnical investigation; and
- General construction and capping of each stage following progressive pre-loading was simulated over Stress Periods 2, 4 and 6, with recharge multipliers of 5% imposed to simulate the expected recharge through the final landform.

The expected settlement and volume of water applied within each zone and layer is summarised in Table 20.

Table 20: Indicative Stages and Timing of Placement of Sand Fill and Associated Settlement and 'Squeezing' Flows

Modelled Stage of Dredging	Stages of Construction	Description	Expected Settlement – Preloading (m)		Daily Flow Rate (m^3/m^2 per $12.5m^2$ model cell)		Length of Period (days) (1)	Year
			Layer 1	Layer 2	Layer 1 Fill	Layer 2 Clay		
Stress Period 1	Placement of Stage 2 Preload	Stockpile Area 5 and 6	0.241 to 0.268	0.311 to 0.318	0.207 to 0.230	0.267 to 0.273	182 (1460)	Early to Mid 2017
Stress Period 2	Stage 2 General Construction and Capping		NA	NA	N/A	N/A	912 (2372)	Mid 2017 to Late 2019
Stress Period 3	Placement of Stage 3 Preload	Stockpile Area 7	0.241 to 0.268	0.311 to 0.318	0.207 to 0.230	0.267 to 0.273	182 (2554)	Early 2020 to Mid 2020
Stress Period 4	Stage 4 General Construction and Capping		NA	NA	N/A	N/A	912 (3466)	Mid 2020 to End 2022
Stress Period 5	Final Capped Surface	Dissipation of Heads Following Filling	NA	NA	N/A	N/A	365 (3831)	Start 2023 to End 2023

Notes to Table 20:

1. Value in brackets is cumulative days from start of dredging

Groundwater hydrographs for the Fill and Estuarine Aquifers were exported from the model at five critical locations across the T4 Project area which have been identified as potential contamination hot spots (see Drawings 5.27, 5.28 and 5.29), namely:

- Pond 5 ('Pond 5 Upper' / 'Pond 5 Lower');
- Pond 7 ('Pond 7 Upper' / 'Pond 7 Lower');
- Area K7 ('Area K7 Upper' / 'Area K7 Lower'); and
- Two locations within the FDF ('FDF Upper' / 'FDF Lower' and 'FDF2 Upper' / 'FDF2 Lower').

The exported water levels pre and post development, over the 4,195 day / 11.5 year modelling period are shown in Figure 24 to Figure 29. The water levels show on these figures represent 'average' conditions and do not take account of fluctuations due to variations in rainfall and evaporation which occur which can occur on a daily basis. The figures provide a comparison of long term water levels changes due to the Project T4 development compared to a no development case, assuming identical climatic conditions for each scenario. The no development case includes HDC capping of Sites A and B proposed to be completed by the end of 2013 independent of the T4 Project. It has been assumed that Site C would also be capped at this time.

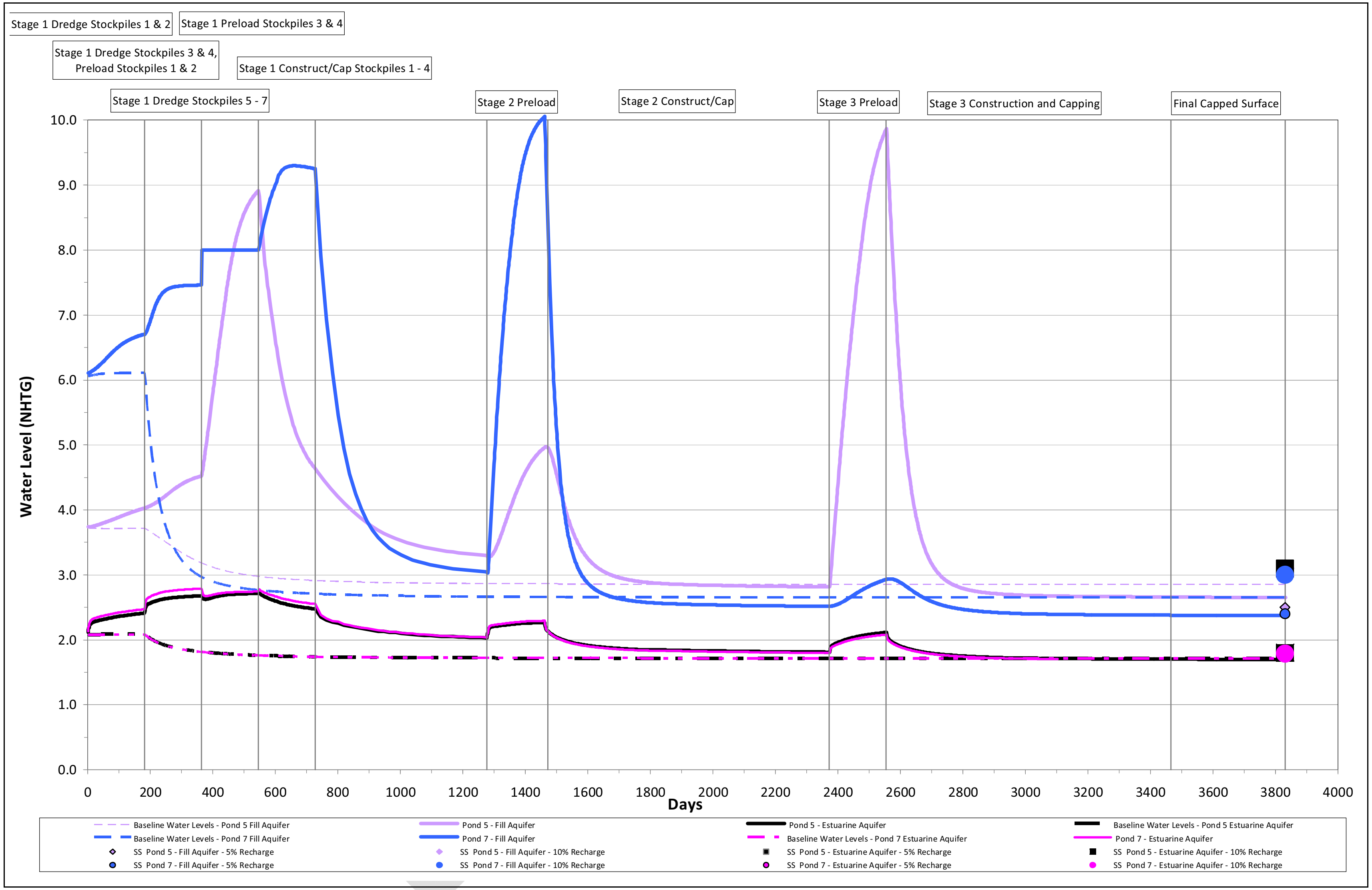

Figure 24: Baseline and Post Development Water Levels in Ponds 5 and 7 (Site A) – Indicative staging presented

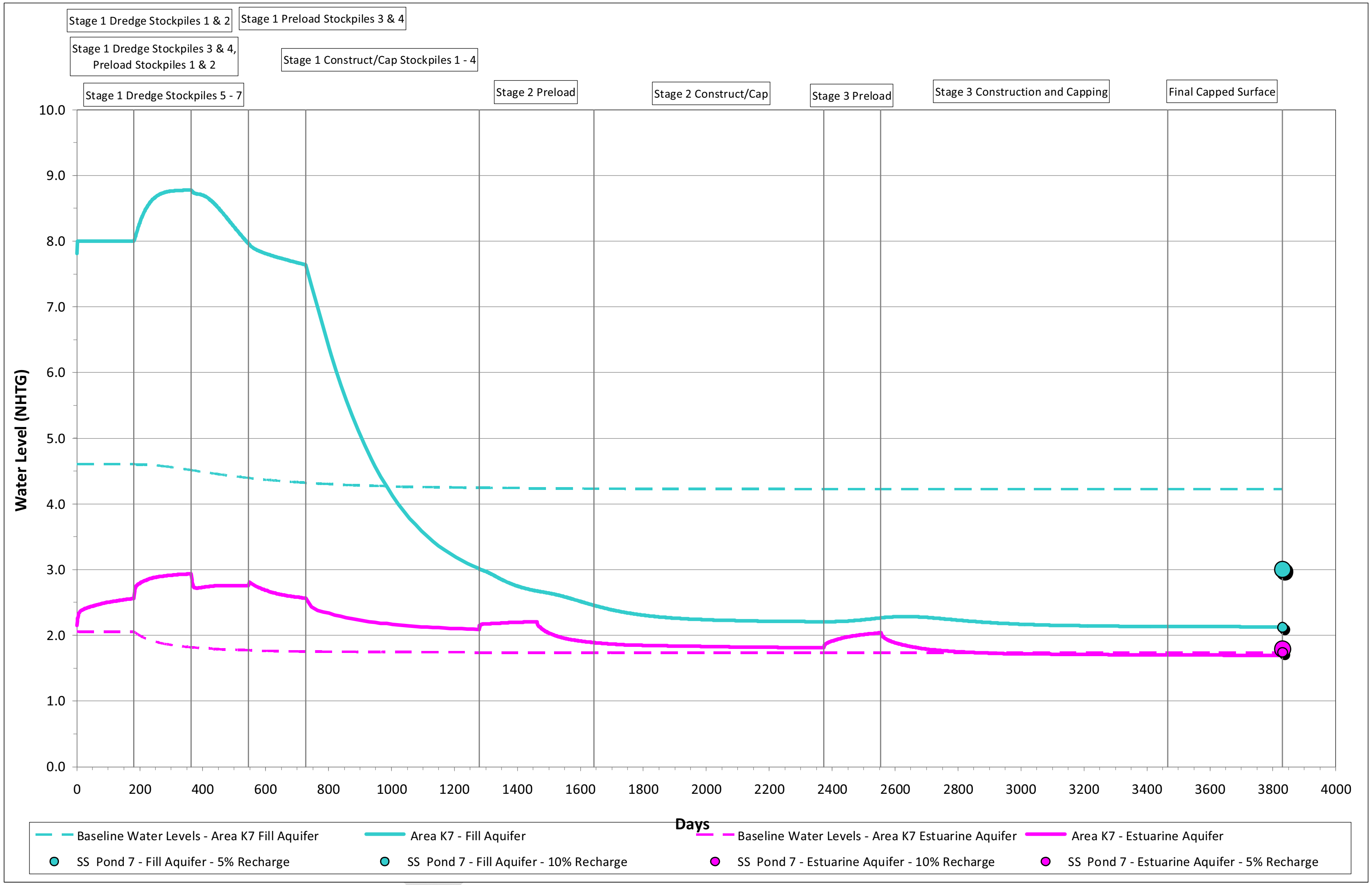

Figure 25: Baseline and Post Development Water Levels in Area K7 (Site A) – Indicative staging presented

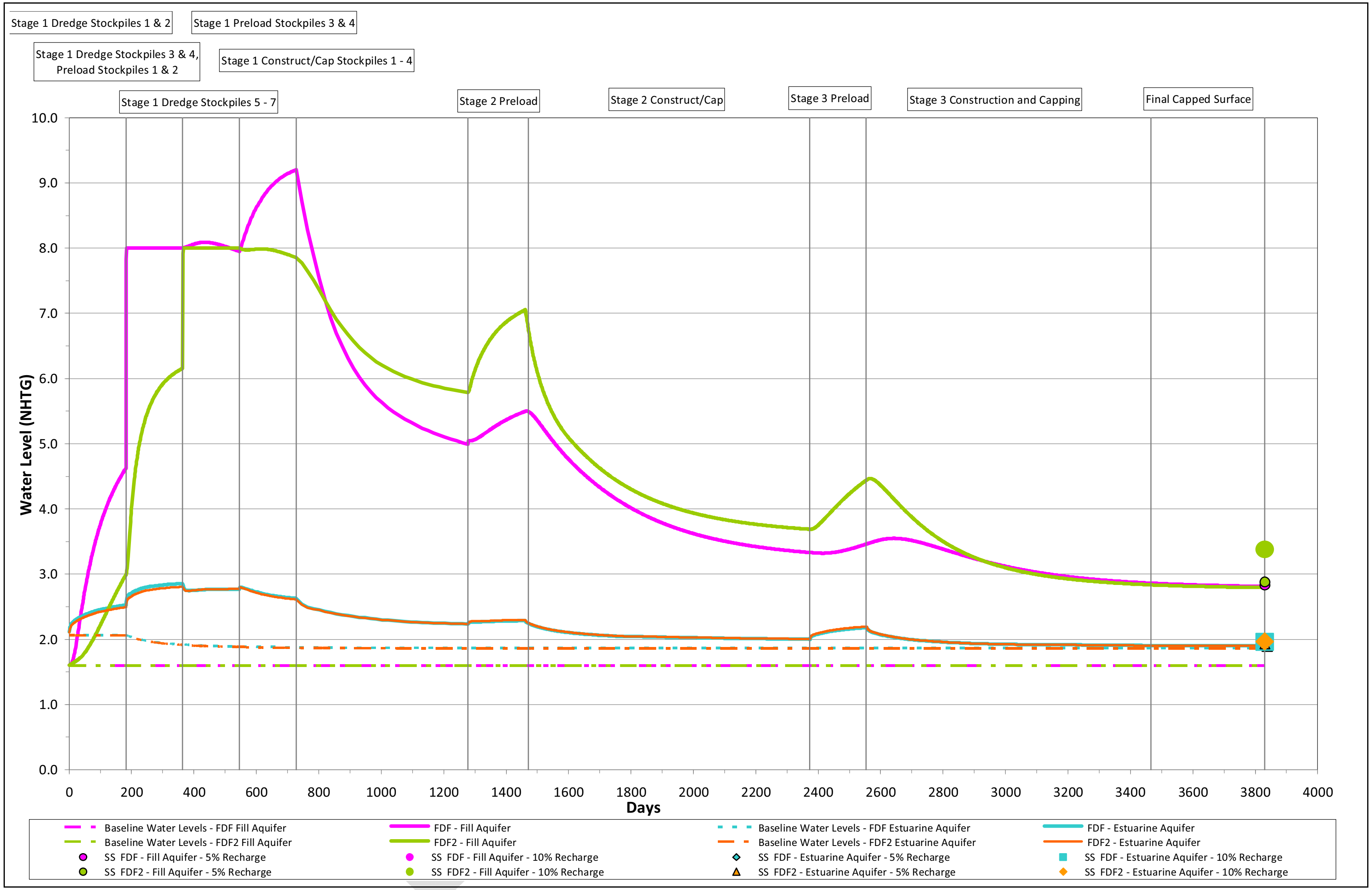

Figure 26: Baseline and Post Development Water Levels in Site D – Indicative staging presented

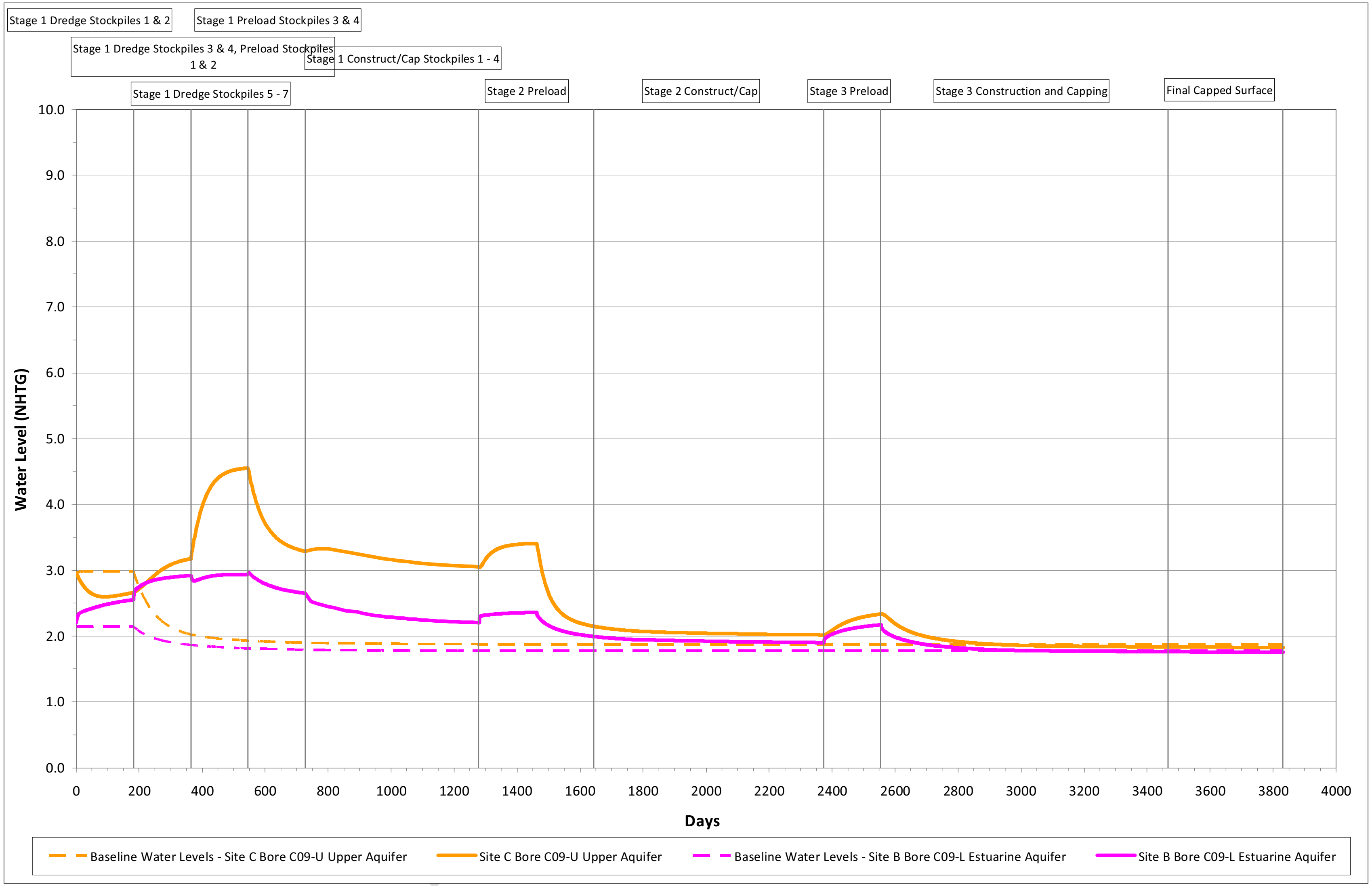

Figure 27: Baseline and Post Development Water Levels in Site C – Indicative staging presented

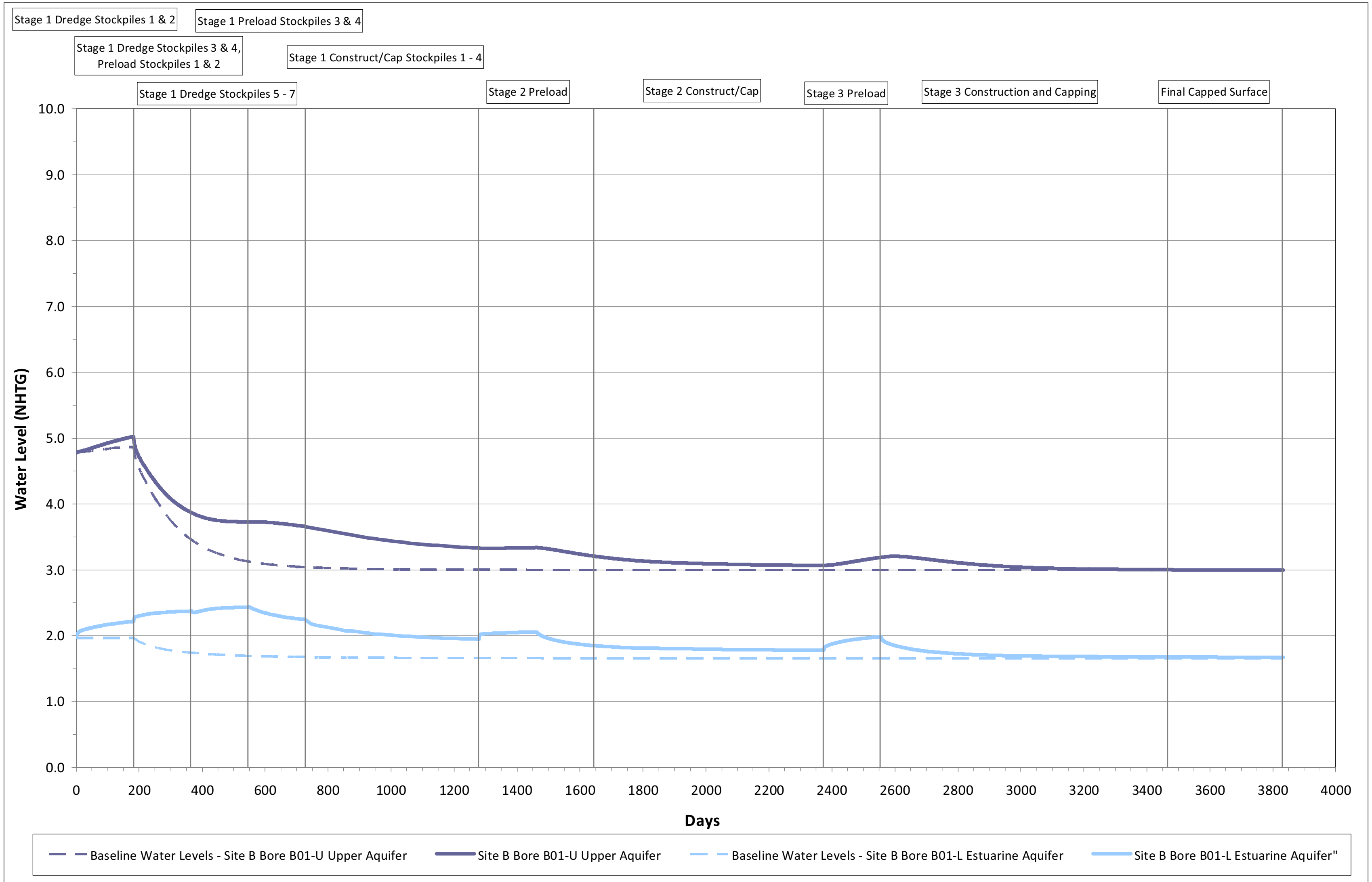

Figure 28: Baseline and Post Development Water Levels in Site B – Indicative staging presented

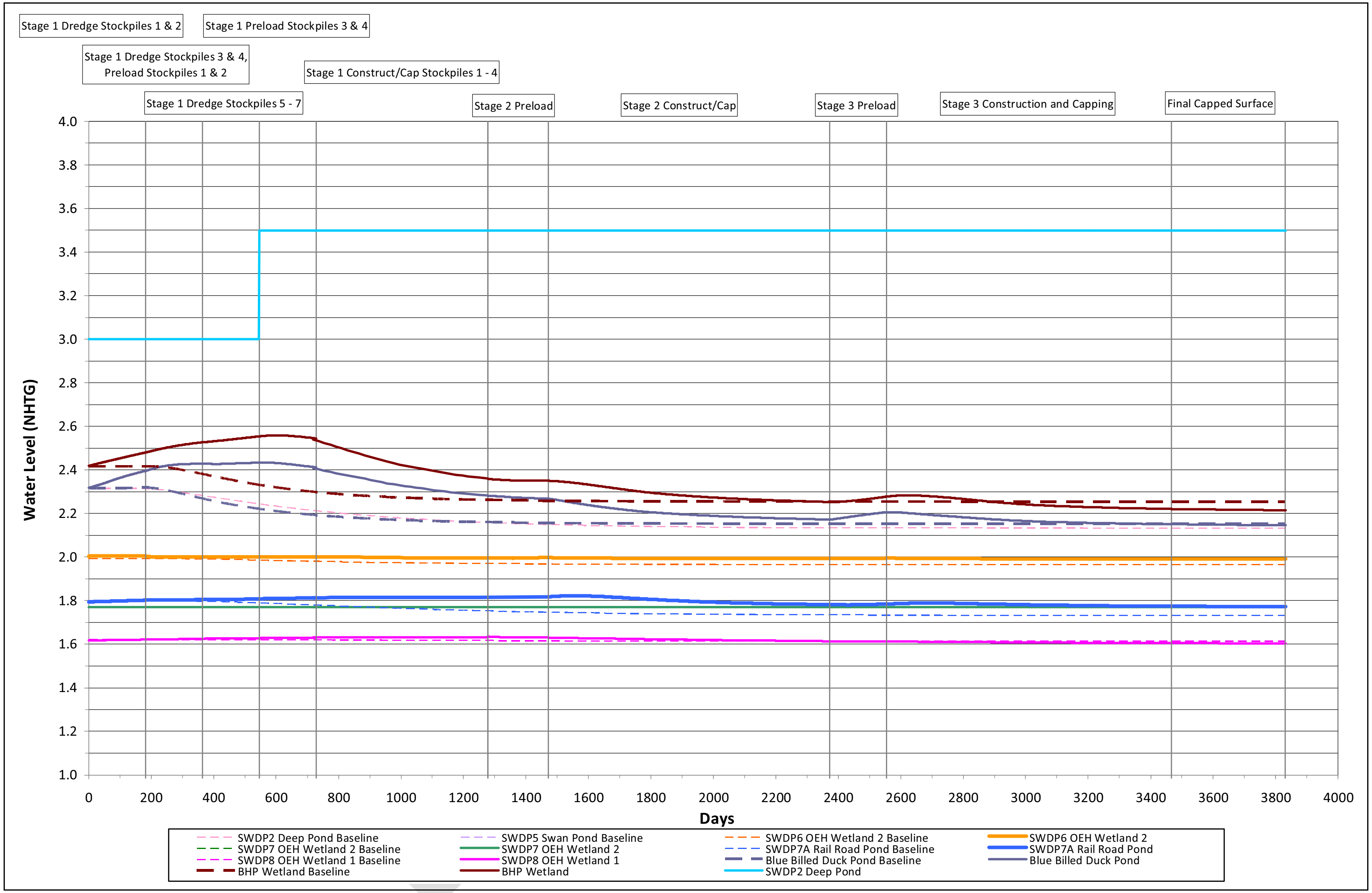

Figure 29: Baseline and Post Development Water Levels for Surface Water Bodies – Indicative staging presented

Figure 24 indicates the following with respect to groundwater levels at Ponds 5/7:

- Average groundwater levels in the Fill Aquifer pre development are in the range RL 3.5 to 4.5 in Pond 5 and 3.5 to 6.0 NHTG in Pond 7. Flow from Pond 5 is towards the east at a hydraulic gradient of about 0.1. Flow from Pond 7 radiates out from the centre of the pond towards the surrounding bunds at a gradient of about 0.04 with hydraulic gradients in the bunds of about 0.004. Flow velocities are difficult to estimate due to the variability of the soil, however could be expected to be in the order of about 0.2 m per year in the fines and 40 metres per year in the coarse slag material;
- For the Estuarine Aquifer pre development flow from below Pond 5 and 7 are generally expected to be in a westerly and north-westerly and south-westerly direction with a typical hydraulic gradient of about 0.0004 and a seepage velocity of about 15 m/year;
- There would be a temporary increase in average heads to about RL 8 NHTG to 9 NHTG for the Fill Aquifer and RL 3.0 NHTG for the Estuarine Aquifer during dredging and Stage 1 preload for a period of about two years or less for much of the area. The increase heads would lead to increased flow rates, mostly towards Deep Pond, however also possibly towards Blue Billed Duck Pond;
- Hydraulic gradients under average conditions in the Fill Aquifer would be expected to increase to about 0.015 with flow rates of the order of about 0.3 m per year in the fines and 150 metres per year in the coarse slag material. However this increase in flow rates would occur for about two years and therefore the incremental increase in travel distance over this time would be about the travel distance that would occur in about eight years under normal conditions. Hydraulic gradients in the Fill Aquifer, provided that a liner is placed in the base of Site C, would be expected to increase to about 0.001, with a seepage velocity of about 40 m per year, with an incremental increase in travel distance over this period equivalent to about five years normal travel distance;
- Capping of the Stage 1 site and adjacent areas including Ponds 5 and 7 would lead to reduced average water levels of about RL 3 NHTG to 4 NHTG in the Fill Aquifer and below pre development levels in the Estuarine Aquifer;
- For subsequent stages of construction the ongoing capping of the site as part of the T4 Project development would lead to an ongoing decrease in typical heads in both the Fill and Estuarine Aquifers, to below pre development levels. Preloading of Stages 2 and 3 would result in temporary (estimated to be 20 weeks) increases in the heads ranging from about RL 5 NHTG to RL 9 NHTG in the Fill Aquifer. In the Estuarine Aquifer heads increase to about 0.1 m to 0.3 m above pre-development levels, representing a very slight temporary increase in flow rates; and
- Overall, over the duration of construction the short term increases in heads and flows due to dredging and preloading would be offset by subsequent decreases in heads and flow rates due to subsequent capping of the site. This is expected to lead to average water levels in both aquifers and therefore the flow rates and associated flux of contamination to be overall lower than pre development. Post development this trend would continue with capping associated with the development expected to lead to a net decrease in flows and water levels and therefore a net reduction in the flux of existing contamination from the T4 Project area. Final average hydraulic gradients in the Estuarine Aquifer are expected to be about 0.0003 with flow velocities of about 10 m/year.

Figure 25 indicates a similar trend in Area K7, where buried lead dust has been reported. For the dredging and Stage 1 preloading with water levels in the Fill Aquifer rising to about RL 8 NHTG to 9 NHTG for about a two year period. Once this part of the site is capped as part of Stage 1 development the levels are expected to drop to about RL 3.0 NHTG, well below pre-development water levels and also below water levels expected to be achieved from the HDC capping alone.

Figure 26 represents predicted water levels in the FDF assuming the site is not fully capped until Stage 4 of the T4 Project development is complete and that the existing leachate collection system fails, both worst case scenarios. If the leachate collection system stops working then both construction and long term water levels are expected to remain above pre development levels in the Fill Aquifer, potentially leading to increased mobilisation of contamination. For the Estuarine Aquifer the water levels would be higher during dredging and pre-loading, however the levels drop slightly to near pre development water levels once the site is fully capped. Potential implications of failure of the leachate collection system are discussed in Section 12.

Figure 27 represents the predicted variations in ground water levels in Area C. The modelling indicates lesser impacts in the Fill Aquifer from preloading compared to Ponds 5/7 and the FDF, as this part of the site contains less fines in the Fill Aquifer and a liner is proposed to be placed prior to dredging. Similar variations in the Estuarine Aquifer head occurred to those below Ponds 5/7 and the FDF.

Figure 28 represents the predicted ground water levels in Area B, which is remote from both the dredging and the preloading. The figure indicates slightly subdued increases in Estuarine Aquifer heads when compared to Ponds 5/7 and the FDF. The plots also indicated a slight increase in head in the Fill Aquifer when compared to the no development/HDC capping case. It is considered that this is due to the indirect effect of increases in the Estuarine Aquifer heads leading to reduced leakage from the Fill Aquifer to the Estuarine Aquifer.

Figure 29 represents the predicted variations in surface water levels. The figure indicates that the variations in surface water levels for OEH Wetlands 1 to 3 and Rail Road Pond, to the north of the site are less than 0.1 m for both the case with HDC capping only, and with the T4 Project as well. The figure indicates that for BHPB Wetland and Blue Billed Duck Pond, water levels are expected to drop by about 0.15 m due to the HDC capping (dashed line). This is considered to be mainly due to reduction in heads in the Estuarine Aquifer, increasing vertical leakage, as well as some reduction in flow from the Fill Aquifer to the north. When the impacts of the dredging and preloading a superimposed (solid line) there is a temporary increase in water levels of about 0.15 m, flowed by a decrease in water levels due to the effects of the capping. The impacts during dredging would be less if dredge water is diverted to the North of Ponds 5/7 and/or lining of permeable bund materials. The net long term difference in water levels between HDC capping and the T4 Project is predicted to be less than 0.05 m, this is because the extent of capping in the vicinity of the BHPB Wetland and Blue Billed Duck Pond is similar for both cases.

It is noted that the wetlands to the north of the development are less sensitive to the capping and T4 development than the wetlands/ponds located in fill to the south of the T4 Development. There are several reasons for this as follows:

- The thickness of the Unit 2 clay is about 13 m below OEH Wetland 1 and Rail Road Pond, however only about 1.0 to 1.5 m thick below the BHPB Wetland and Blue Billed Duck Pond;
- OEH Wetland 1 and Rail Road Pond are more heavily controlled by run-off;

- Variations in the head of Deep Pond, which provides some recharge to OEH Wetland 1 and Rail Road Pond are limited by the overflow controls. Variations in the Fill Aquifer levels to the, which provide some recharge in BHPB Wetland and Blue Billed Duck pond are not as constrained and will be more influence by the capping; and
- OEH Wetlands 2 and 3 are controlled by rainfall evaporation and tidal inundation.

11.3.5 Final Capped Site and Sensitivity Analyses

The final developed landform of the T4 Project is expected to include:

- Stabilised sand berms of low permeability;
- Areas of graded and sealed pavements and hardstands;
- Buildings; and
- Coal Stockpiles with lined and drained bases.

The T4 Project area would be essentially capped with run-off coefficients for such style of development typically being in the range 80% to 90%. The T4 Project area is also expected to be graded to prevent ponding of water occurring at the surface. Mass balance calculations indicate that for typical conditions, the added effect of evaporation from the near impervious surfaces would result in infiltration of less than about 5%.

The final capped state was modelled in steady state with 5% annual recharge set over the final capped areas to model the long-term reduced water levels. The plot of the final capped site and Steady State groundwater heads are shown in Figure 30 for the Fill Aquifer and Figure 31 for the Estuarine Aquifer.

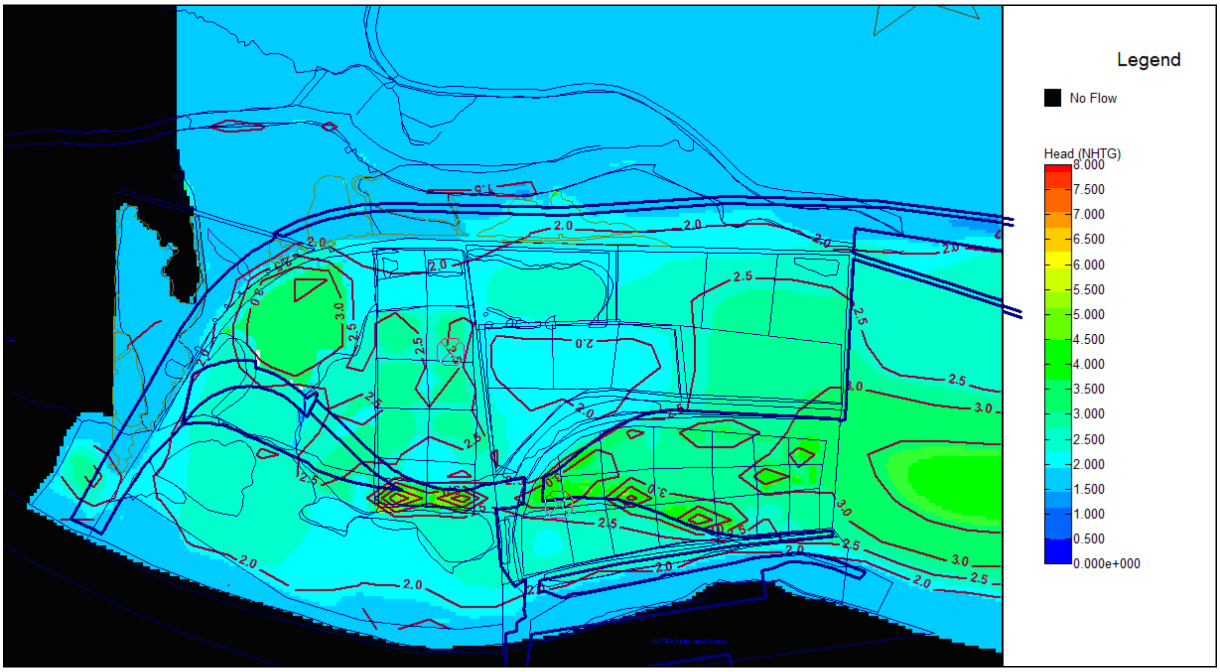

Figure 30: Steady State Fill Aquifer Heads for the Final Capped Site – 5% Annual Rainfall (0.5 m NHTG Contours)

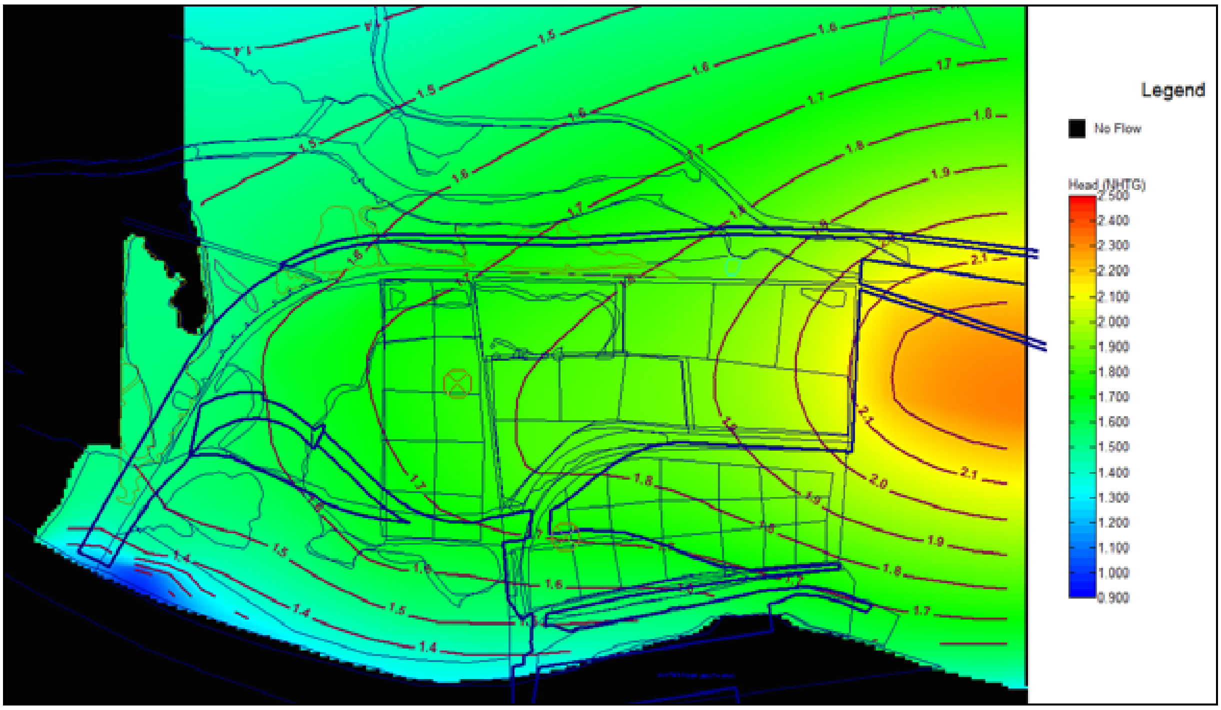

Figure 31: Steady State Estuarine Aquifer Heads for the Final Capped Site – 5% Annual Rainfall (0.1 m NHTG Contours)

The final capped situation with 5% of rainfall recharge indicates substantially reduced heads in both the Fill Aquifer and the Estuarine Aquifer, with the only exception being Site D (the location of the former FDF). This result is based on the assumption that the existing leachate collection system becomes ineffective.

There is some uncertainty regarding the actual infiltration which would occur through the capping. It is also possible that the flow calibration may slightly over-estimate the hydraulic conductivity of the Estuarine Aquifer and leakage through the Clay Aquitard, thereby slightly over-estimating the effects of the capping. Therefore the sensitivity of the water levels by changes to the rates of inflation of the capping was checked by doubling the infiltration rate to 10% of rainfall. The resulting head distributions for the Fill and Estuarine Aquifers are presented in Figure 32 and Figure 33.

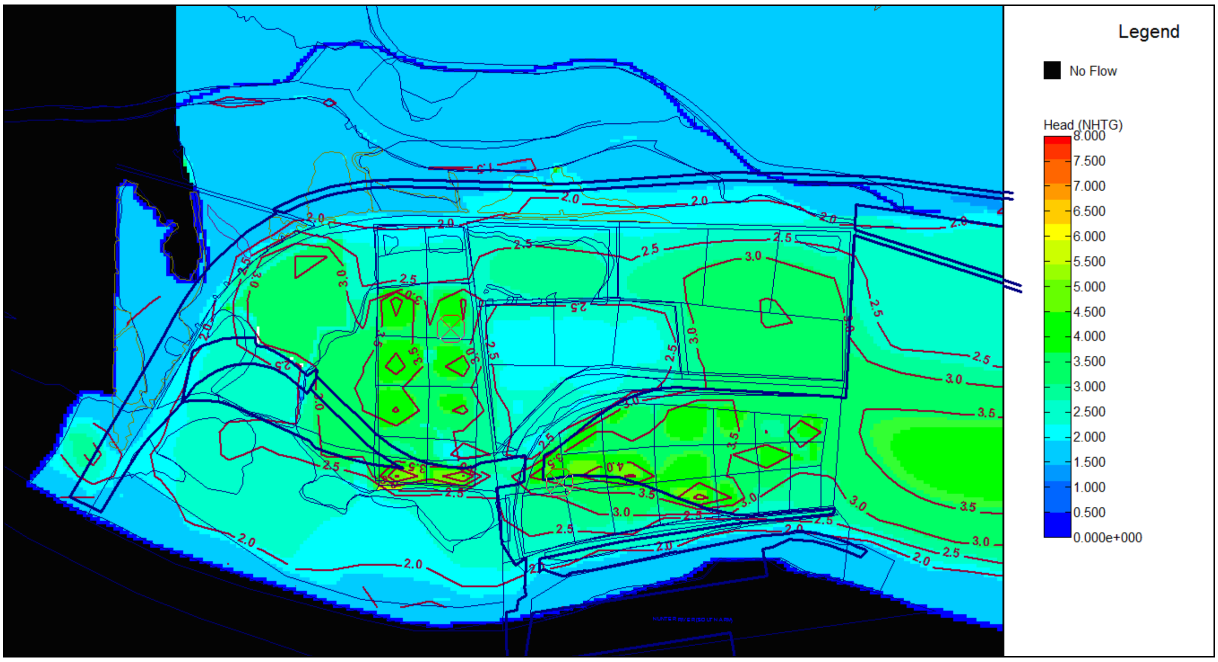

Figure 32: Steady State Fill Aquifer Heads for the Final Capped Site – 10% Annual Rainfall (0.5 m NHTG contours)

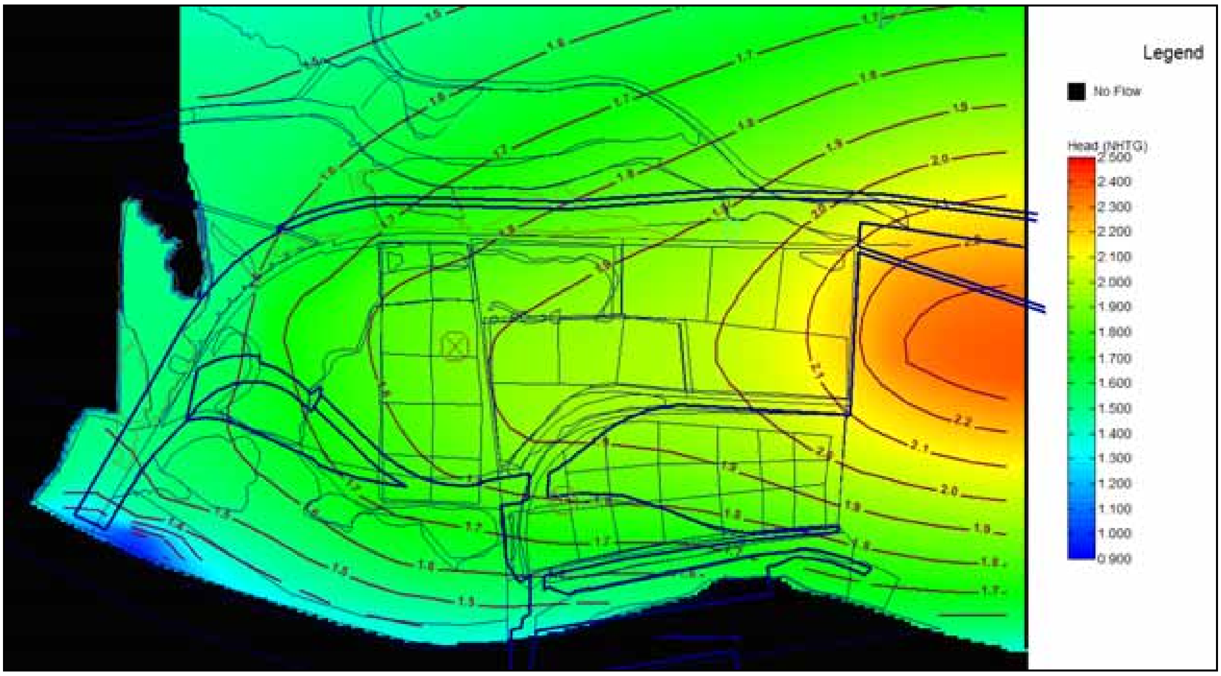

Figure 33: Steady State Estuarine Aquifer Heads for the Final Capped Site – 10% Annual Recharge (0.1 m NHTG contours)

The results indicated a slight increase in heads compared to the 5% case, however still significantly lower than the pre development case. Overall flow rates and therefore flux rates of existing site contamination would be less than for pre-development.

It is also possible that dredging of the Hunter River to the east of Tourle Street Bridge may lead to removal of low permeability sediments on the base of the river and possible increased flow to the South Arm in this location. This possible effect was assessed by increasing the conductivity of the General Head Boundary representing the river at this location. The resulting distribution of head in the Estuarine Aquifer is presented in Figure 34 below and indicated an overall reduction in heads below the site. The north-south groundwater divide was predicted to move slightly to the south which would increase the risk of southerly flows from the Estuarine Aquifer below Pond 5 towards the BHPB Emplacement Cell to the south, however overall gradients on the T4 Project development site would not change significantly.

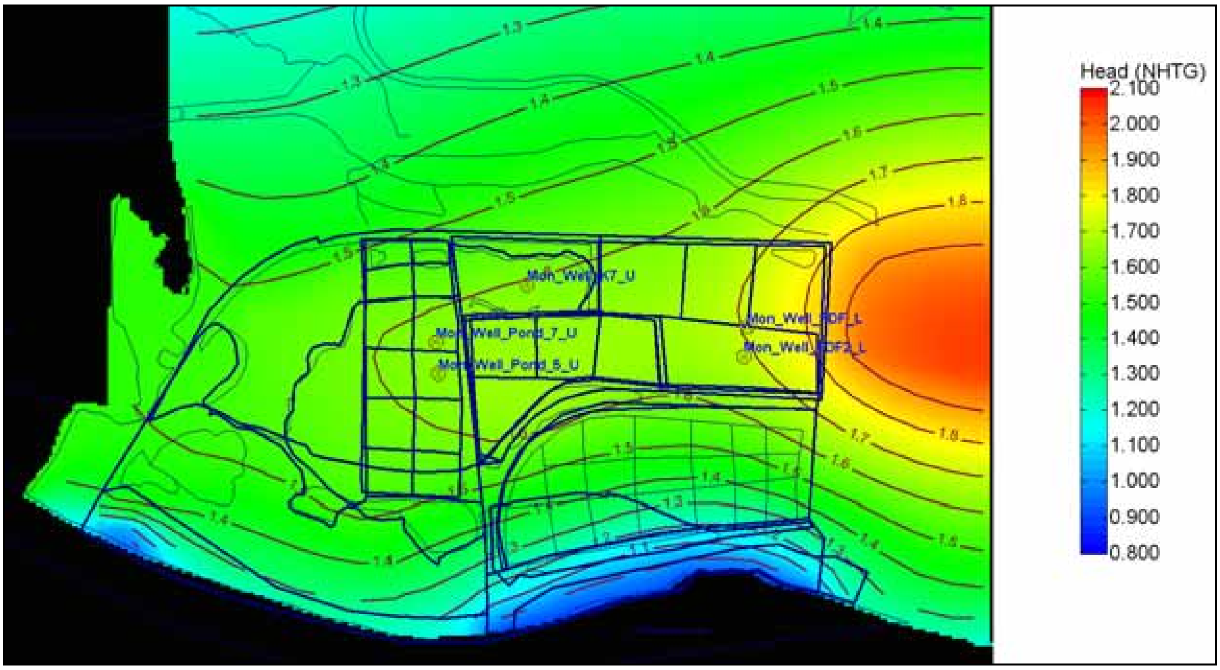

Figure 34: Groundwater Heads in the Estuarine Aquifer with Increased Hunter River General Head Boundary Conductance – 5% Annual Recharge (0.1 m NHTG contours)

11.3.6 Contaminant Transport

11.3.6.1 General

This section identifies the potential contaminants and the existing contaminant concentrations that may be released as a result of the construction and operation of the T4 Project. Section 11.3.5.3 discusses the potential contaminant pathways, identifies the potential receptors that may be impacted by contaminants. Section 12 assesses the extent and implications of these potential impacts.

Key parts of the T4 Project area which have been identified with elevated concentrations of soil and groundwater contamination, as identified in DP's Contamination Assessment report (Ref 23), comprise the following areas:

11.3.7 Fines Disposal Facility

The FDF is located in the north-eastern corner of the proposed T4 Project development and comprises five disposal cells over a total area of about 600 m by 800 m. The cells were constructed over the Unit 2 clay by placing a layer of sand filling about 2 m thick which contains a leachate collection system with drainage at a level of about RL 1.6 NHTG. The cells have berms constructed of gypsum with clay facing, and have typically been filled with inter bedded layers of sand and dredged fines. The most recent material placed in the cells is cement modified dredge sediments which have been continued to near the top of the current bunds at about RL 7.5 NHTG.

Groundwater is monitored around the perimeter of the FDF and indicated groundwater levels in the Fill Aquifer in the range RL 1.0 to 2.0 NHTG, which is expected to be controlled by the leachate collection system.

The results of soil and groundwater sampling and testing from the FDF have been subject to statistical assessment of the mean and standard deviation of total, leachable (ASLP) and groundwater concentrations for key chemical parameters. The statistical results are presented against the Australian and New Zealand Environment and Conservation Council (ANZECC) *Guidelines for Fresh and Marine Water Quality* (2000 - Ref 3) in the case of protection of aquatic ecosystems in Table 21.

Table 21: Soil and Groundwater Statistics at the FDF

Parameter	Soil Total (mg/kg)		Soil Leachable (mg/L)		Fill Aquifer (mg/L)		Estuarine Aquifer (mg/L)		ANZECC (Ref 3) (mg/L)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Anions									
Ammonia (NH_3) as N	-	-	-	-	4.42	10.2	10.6	7.48	0.91
Metals									
Aluminium (Al)	16065	5710	2.26	1.66	0.0140	0.0275	0.0375	0.1327	0.055
Arsenic (As)	8.65	3.75	0.0074	0.0093	0.0035	0.0024	0.0040	0.0055	NC
Cadmium (Cd)	0.893	0.532	0.0005	0.0009	0.0001	0.0001	0.0002	0.0004	0.0007
Cobalt (Co)	-	-	-	-	0.0009	0.0007	0.0012	0.0009	0.001
Chromium (Cr)	36.0	18.8	0.0052	0.0105	0.0012	0.0010	0.0049	0.0088	0.0044 (1)
Copper (Cu)	29.1	14.7	0.0108	0.0232	0.0021	0.0024	0.0025	0.0028	0.0013
Iron (Fe)	31300	10500	0.902	2.03	1.39	2.25	8.60	8.56	NC
Manganese (Mn)	781	1700	0.0071	0.0122	1.25	1.58	1.38	1.21	1.9
Nickel (Ni)	23.1	10.6	0.0181	0.0184	0.0017	0.0013	0.0020	0.0018	0.007
Lead (Pb)	117	76.1	0.0424	0.134	0.0009	0.0008	0.0025	0.0028	0.0044
Zinc (Zn)	746	500	0.314	0.927	0.0320	0.0558	0.0665	0.285	0.015
Selenium (Se)	-	-	-	-	0.0034	0.0040	0.0068	0.0099	NC
Mercury (Hg)	0.119	0.112	0.00010	0.00010	0.00012	0.00018	0.00011	0.00015	0.0001 (2)
Cyanide									
Total Cyanide	-	-	-	-	0.0045	0.0056	0.0081	1.66	0.004
TRH									
C_6 - C_9	6.53	2.40	-	-	0.0163	0.0225	49.6	70.2	NC
C_{10} - C_{36}	1170	879	-	-	4.03	7.81	0.0654	0.112	NC
BTEX									
Benzene	0.165	0.0805	-	-	-	-	-	-	0.5
Toluene	<0.5	0.0	-	-	-	-	-	-	0.18 (L)
Ethyl Benzene	<0.5	0.0	-	-	-	-	-	-	0.08 (L)
Xylene	<0.5 <1.5	0.0	-	-	-	-	-	-	NC
PAHs									
Total PAHs	99.0	247	0.1115	0.0834	0.0013	0.0015	0.0011	0.0011	NC
Naphthalene	45.8	121	0.0417	0.0416	0.0001	0.0001	0.0001	0.0002	0.05
Acenaphthylene	1.13	3.55	0.0005	0.0002	0.0001	0.0000	0.0001	0.0001	NC
Acenaphthene	5.98	11.1	0.0516	0.0374	0.0001	0.0000	0.0001	0.0001	NC
Fluorene	3.33	7.15	0.0115	0.0082	0.0001	0.0000	0.0001	0.0001	NC
Phenanthrene	9.80	27.5	0.00595	0.00594	0.0001	0.0001	0.0001	0.0001	0.0006 (L)
Anthracene	3.18	9.14	0.00103	0.00080	0.00005	0.00000	0.00008	0.00012	0.00001 (L)
Fluoranthene	8.89	22.8	0.00181	0.00078	0.0001	0.0001	0.0001	0.0001	0.001 (L)
Pyrene	7.33	17.8	0.0015	0.0007	0.0001	0.0001	0.0001	0.0001	NC
Benzo[a]anthracene	2.53	5.76	0.0002	0.0002	0.0001	0.0000	0.0001	0.0001	NC
Chrysene	2.09	4.34	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	NC
Benzo[b,k]fluoranthene	3.01	8.46	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002	NC
Benzo[a]pyrene	2.64	5.28	0.00024	0.00033	0.0003	0.0002	0.0001	0.0001	0.0001 (L)
Indeno[123-cd]pyrene	1.36	2.46	0.0002	0.0002	0.0001	0.0000	0.0001	0.0001	NC
Dibenzo[ah]anthracene	0.280	0.517	0.0002	0.0002	0.0001	0.0000	0.0001	0.0002	NC
Benzo[ghi]perylene	1.63	2.59	0.0002	0.0002	0.0001	0.0000	0.0001	0.0001	NC
Total Phenols	-	-	-	-					

Notes to Table 21:

NC – No Criteria

(L) – Low reliability criteria

(1) – Chromium (VI) criteria

(2) – Mercury (inorganic)

Shaded result indicate exceedances of ANZECC (Ref 3) criteria

Table 21 indicates the following:

- Mean soil leachable concentrations are greater than ANZECC (2000, Ref 3) criteria for the following: Al, Cr, Cu, Pb, Zn, Hg, Phenanthrene, Anthracene, Fluoranthene and Benzo(a)pyrene. The leachable concentrations were obtained from ASLP testing which is an aggressive test, involving tumbling for 18 hours, and is expected to provide higher leachable concentrations that would occur in-situ. Standard deviations for Cd, Cr, Cu, Pb are high relative to the means because of a small number of high results;
- Mean groundwater concentrations in the Fill Aquifer are generally significantly less than the soil leachable means, however still exceed ANZECC criteria for NH_4, Cu, Zn, Hg, Total Cyanide, Anthracene and Benzo(a)pyrene. Samples for leachability testing were retrieved from within the cells, however groundwater wells are generally located on the bunds around the perimeter of the cells and groundwater may be intercepted by the leachate collection system before it gets to the groundwater wells. Therefore the groundwater concentrations may not provide a true indication of the leachable potential of the cell filling;
- Mean groundwater concentrations in the Estuarine Aquifer are generally similar and sometimes higher than the Fill Aquifer for metals, however are lower and generally non-detectable for organics, with the exception of Anthracene.

Proposed dredging would result in up to about 2 m of saturated sand filling being placed over the existing surface of cement modified fines. However this would be placed at the upstream end of the dredging disposal area and would be expected to drain relatively quickly. The FDF has been subject to similar disposal of saturated material in the past with no significant impacts observed from groundwater monitoring.

Stage 1 preloading would occur over the northern parts of the T4 Project area and result in up to an average of about 520 mm of settlement. Subsequent Stage 2 preloading is predicted to lead to an average of 490 to 590 mm of settlement. This degree of settlement would likely lead to the lower layers of filling in the cells becoming permanently saturated. Also, the differential settlement occurring between Stages 1 and 2 of preloading could potentially impair the performance of the drainage system. For the purposes of the groundwater modelling discussed in the above sections it has been assumed that the leachate collection system becomes inoperable, in which case the water table could temporarily rise to about abut RL 6.0 NHTG between Stages 1 and 2 of the preload if uncapped sand fill was left sitting over the existing cells. This would lead to a head of water sitting on the existing cell fill material (within the sand fill). In the long term, once the sand fill over the FDF is capped the water levels would be expected to drop to about 3 NHTG. If the capping of the sand was brought forward to occur at the same time as Stage 1 construction then the heads would drop much sooner and head of RL 6.0 NHTG would be unlikely to ever occur. Similarly if the leachate collection system remains in functional then heads would be expected to remain at about RL 1.6 NHTG to RL 2.0 NHTG.

Increases in water levels below the FDF would have the potential to lead to increased leaching of contaminants within the FDF cells and possible adverse impacts to potential receptors. The increase in leaching would be primarily a function of the rate of recharge through the material, which is directly related to the capping used over the FDF.

The results of groundwater modelling have allowed identification of two key potential pathways for contaminated leachate to reach key environmental receptors as follows:

1. Vertical leaching through the unsaturated material above the water table.

2. Leaching of material in the base of the cells which becomes saturated by subsidence from preload and possible rising water table.
3. Vertical flow in to the sand blanket below the FDF cells:
    1. Horizontal flow in the sand towards the OEH Wetland 3 to the north of the rail line.
    2. Vertical leakage from the sand and through the Unit 2 clay and then mixing with the Estuarine Aquifer and subsequent horizontal flow towards the north with key receptors being the northern site boundary and then the north arm of the Hunter River.

The above key potential contaminant pathways are illustrated in Figure 35.

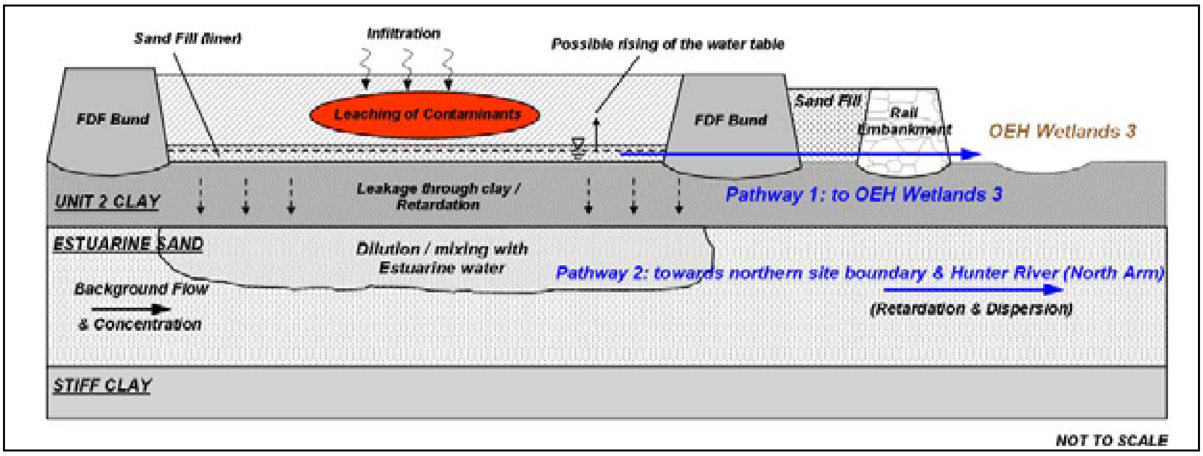

Figure 35: Key Potential Contaminant Flow Paths at Site D

Pond 5 and Adjacent Pond 7

Pond 5 is located near the centre of the T4 Project area and has been historically used for the disposal of tar waste. The current contamination and geotechnical investigations (Refs 23 and 25) have also encountered tar waste in the southern parts of the adjacent Pond 7, the extent of which is shown on Drawings 5.27 and Drawing 5.28 in Appendix C. These ponds were formed by placement of granular bunds (typically cemented slag) and then filling between the bunds. Historical aerial photography also suggests that mini sub-cells were formed within the main cells to receive coal fines and other wastes such as tars and therefore the cells contain a mix of fine and coarse materials. Cone penetration tests within the cells also indicates some vertical sub-layering, and also indicates the presence of a natural clay base ranging in thickness from about 2 m to 3 m. Pond 5 has been capped with a GCL overlain by compacted coal fines with a graded surface which would be expected to limit infiltration and potential leaching of contamination in Pond 5. The adjacent Pond 7 has no such capping and significantly greater infiltration is expected to occur in Pond 7.

Groundwater monitoring indicates groundwater levels in the Fill Aquifer in and around Ponds 5 and 7 is highly variable both spatially and temporally, typically in the range RL 4 NHTG to 5 NHTG. Groundwater heads in the underlying Estuarine Aquifer are typically in the range RL 2.0 NHTG to 2.2 NHTG with a flow direction towards the north-west.

Potential pathways for leaching of contamination from the Ponds 5 and 7 comprise the following:

- Vertical leaching through the unsaturated material above the water table (more infiltration and potential leaching in Pond 7 due to absence of GCL liner);
- Leaching of saturated material in the cells:
  1. Horizontal flow though the cell material to the surrounding slag bunds:
     - Seepage at the toe of the eastern batter along the adjacent road shoulder;
     - Flow to the north towards the currently near empty Ponds 9 to 12 and possibly continuing towards Deep Pond; and
     - Flow to the West towards Deep Pond.
  2. Vertical flow through the Unit 2 Clay into the underlying Estuarine Aquifer and subsequent horizontal flow towards the north with key receptors being the northern site boundary and then the north arm of the Hunter River.

The above key potential pathways are shown in Figure 36.

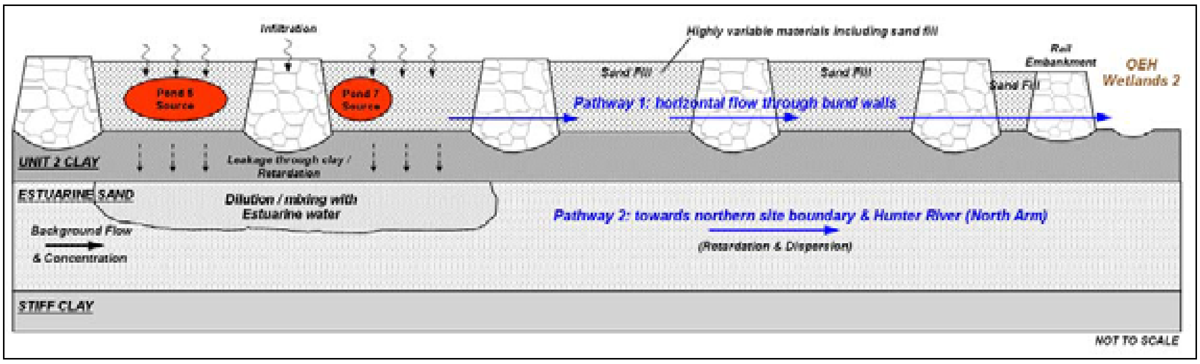

Figure 36: Key Potential Flow Paths for Ponds 5 and 7

The results of soil and groundwater sampling and testing at Pond 5 and Pond 7 have been subject to statistical assessment and the mean and standard deviation of total, leachable and groundwater concentrations for key chemical parameters are presented in Table 22.

Table 22: Soil and Groundwater Statistics at Pond 5, Pond 7 and Immediate Surrounds

Parameter	Soil Total (mg/kg)		Soil Leachable (mg/L)		Fill Aquifer (mg/L)		Estuarine Aquifer (mg/L)		ANZECC (Ref 3) (mg/L)
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Anions									
Ammonia (NH_3) as N	-	-	-	-	1.47	1.65	1.91	1.58	0.91
Metal									
Arsenic (As)	6.67	3.51	0.0022	0.0020	0.0031	0.0025	0.0017	0.0015	NC
Cadmium (Cd)	0.640	0.80	0.0010	0.0000	0.0001	0.0000	0.0007	0.0019	0.0007
Cobalt (Co)	-	-	-	-	0.0006	0.0003	0.0108	0.0284	0.001
Chromium (Cr)	41.8	38.2	0.0014	0.0009	0.0006	0.0002	0.0009	0.0008	0.0044 (1)
Copper (Cu)	18.5	13.0	0.0058	0.0038	0.0007	0.0004	0.415	1.20	0.0013
Iron (Fe)	37600	26600	0.121	0.188	0.0910	0.189	5.10	5.64	NC
Manganese (Mn)	1320	2660	0.0052	0.0005	0.410	1.79	2.78	5.96	1.9
Nickel (Ni)	18.4	16.6	0.0010	0.0000	0.0022	0.0062	0.0081	0.0190	0.007
Lead (Pb)	86.3	128	0.0020	0.0017	0.0006	0.0006	0.0014	0.0022	0.0044
Zinc (Zn)	779	1370	0.0730	0.0440	0.0036	0.0019	0.0133	0.0184	0.015
Selenium (Se)	-	-	-	-	0.0015	0.0014	0.0015	0.0030	NC
Mercury (Hg)	0.196	0.331	0.00072	0.00049	0.00008	0.00006	0.00009	0.00007	0.0001 (2)
Cyanide									
Total Cyanide	-	-	-	-	0.0030	0.0029	0.0032	0.0042	0.004
TRH									
C_6 - C_9	17.8	9.61	-	-	0.137	0.587	0.0071	0.0063	NC
C_{10} - C_{14}	-	-	-	-	2.05	8.93	0.0419	0.0437	NC
C_{15} - C_{28}	-	-	-	-	2.11	5.51	0.0683	0.0444	NC
C_{29} - C_{36}	-	-	-	-	0.436	0.774	0.0500	0.0000	NC
C_{10} - C_{36}	76.1	68.8	-	-	-	-	-	-	NC
BTEX									
Benzene	2.35	3.55	-	-	0.0954	0.416	0.0005	0.0000	0.5
Toluene	1.40	2.50	-	-	0.0197	0.0895	0.0005	0.0001	0.18 (L)
Ethyl Benzene	0.958	1.04	-	-	0.0009	0.0022	0.0006	0.0003	0.08 (L)
Xylene	4.30	8.52	-	-	0.0095	0.0387	0.0015	0.0000	NC
PAHs									
Total PAHs	9590	22300	4.98	5.89	0.249	0.829	0.0017	0.0021	NC
Naphthalene	2720	3020	4.35	5.44	0.131	0.413	0.0006	0.0011	0.05
Acenaphthylene	811	1200	0.349	0.343	0.0109	0.0457	0.0002	0.0004	NC
Acenaphthene	54.5	58.3	0.0168	0.0182	0.0081	0.0177	0.0001	0.0002	NC
Fluorene	699	1040	0.0980	0.0930	0.0121	0.0362	0.0002	0.0004	NC
Phenanthrene	3060	4570	0.124	0.116	0.0466	0.148	0.0007	0.0016	0.0006 (L)
Anthracene	782	1210	0.0142	0.0129	0.00306	0.0106	0.000086	0.000153	0.00001 (L)
Fluoranthene	2140	3200	0.0177	0.0165	0.0233	0.0724	0.0002	0.0005	0.001 (L)
Pyrene	1660	2490	0.0123	0.0114	0.0183	0.0581	0.0002	0.0003	NC
Benzo[a]anthracene	568	876	0.0016	0.0023	0.0055	0.0160	0.0001	0.0000	NC
Chrysene	536	787	0.0010	0.0016	0.0039	0.0130	0.0001	0.0000	NC
Benzo[b,k]fluoranthene	792	1160	0.0012	0.0021	0.0037	0.0115	0.0001	0.0001	NC
Benzo[a]pyrene	379	890	0.00086	0.00153	0.00198	0.00718	0.00006	0.00004	0.0001 (L)

Notes to Table 22:

NC – No Criteria

(L) – Low reliability criteria

(1) – Chromium (VI) criteria

(2) – Mercury (inorganic)

Shaded result indicate exceedances of ANZECC (Ref 3) criteria

Table 22 indicates the following:

- Mean soil leachable concentrations are greater than ANZECC criteria (Ref 3) for the following: Cd, Cu, Mn, Zn, Hg, Naphthalene, Ammonia, Phenanthrene, Anthracene, Fluoranthene, Benzo(a)pyrene. Standard deviations for the above organics are high relative to the means due to a small number of high results;
- Mean groundwater concentrations in the Fill Aquifer are generally significantly less than the soil leachable means and only exceed ANZECC for Ammonia, Naphthalene, Phenanthrene, Anthracene, Fluoranthene, Benzo(a)pyrene. This suggests that the waste in Ponds 5/7 is the source of elevated concentrations in the Fill Aquifer, however that the leachable concentrations over-estimate the actual leaching occurring on site. This is probably largely because judgemental sampling was undertaken with soils with evidence of tar contamination being selected for sampling which skews the mean and standard deviation. The concentrations measured in groundwater are expected to provide a better overall estimate of the leachability of the soil mass for the purposes of the probabilistic analyses; and
- Mean groundwater concentrations in the Estuarine Aquifer are generally higher than the Fill Aquifer for metals with Cd, Co, Cu, Ni, Mn and Ammonia exceeding ANZECC, however lower for organics with only Phenanthrene and Anthracene exceeding ANZECC. Ammonia exceeds ANZECC criteria in the Estuarine Aquifer. The mean concentrations of Cu and Ni are also greater than the leachable concentrations suggesting that Pond 5/7 are unlikely to be the source of these elevated concentrations.

For comparison purposes the background statistics for Area A which exclude Pond 5 data are presented in Table 23 below.

Table 23: Area A Background Statistics (Excluding Pond 5)

Parameter	Fill Aquifer (mg/L)		Estuarine Aquifer (mg/L)		ANZECC (Ref 3) (mg/L)
	Mean	SD	Mean	SD	
EC (mS/cm)	3260	3060	21900	13700	NC
Anions					
Ammonia (NH_3) as N	1.85	2.75	1.89	2.53	0.91
Metals					
Arsenic (As)	0.0041	0.0030	0.0029	0.0037	NC
Cadmium (Cd)	0.0001	0.0000	0.0001	0.0000	0.0007
Cobalt (Co)	0.0005	0.0000	0.0009	0.0008	0.001
Chromium (Cr)	0.0008	0.0008	0.0010	0.0011	0.0044 (1)
Copper (Cu)	0.0018	0.0035	0.0014	0.0011	0.0013
Iron (Fe)	0.0243	0.0198	13.9	17.0	NC
Manganese (Mn)	0.0233	0.0520	1.48	1.28	1.9
Nickel (Ni)	0.0050	0.0086	0.0067	0.0075	0.007
Lead (Pb)	0.0010	0.0011	0.0005	0.0000	0.0044
Zinc (Zn)	0.0097	0.0207	0.0170	0.0142	0.015
Selenium (Se)	0.0028	0.0019	0.0009	0.0011	NC
Mercury (Hg)	0.00009	0.00007	0.00011	0.00008	0.0001 (2)
Cyanide					
Total Cyanide	0.0042	0.0069	0.0022	0.0003	0.004
TRH					
C_6 - C_9	0.0050	0.0000	0.0050	0.0000	NC
C_{10} - C_{14}	0.0382	0.0437	0.0250	0.0000	NC
C_{15} - C_{28}	0.0873	0.0837	0.0630	0.0411	NC
C_{29} - C_{36}	0.0727	0.0754	0.0580	0.0253	NC
BTEX					
Benzene	0.0011	0.0019	0.0005	0.0000	0.5
Toluene	0.0008	0.0009	0.0013	0.0020	0.18 (L)
Ethyl Benzene	0.0005	0.0000	0.0005	0.0000	0.08 (L)
Xylene	0.0017	0.0005	0.0015	0.0000	NC
PAHs					
Total PAHs	0.0039	0.0065	0.0010	0.0003	NC
Naphthalene	0.0047	0.0108	0.0002	0.0003	0.05
Acenaphthylene	0.0002	0.0004	0.0001	0.0000	NC
Acenaphthene	0.0005	0.0005	0.0001	0.0000	NC
Fluorene	0.0002	0.0002	0.0001	0.0000	NC
Phenanthrene	0.0006	0.0006	0.0001	0.0001	0.0006 (L)
Anthracene	0.000123	0.000175	0.000055	0.000016	0.00001 (L)
Fluoranthene	0.0003	0.0003	0.0001	0.0001	0.001 (L)
Pyrene	0.0002	0.0003	0.0001	0.0001	NC

Notes to Table 23:

NC – No Criteria

(L) – Low reliability criteria

(1) – Chromium (VI) criteria

(2) – Mercury (inorganic)

Shaded result indicate exceedances of ANZECC (Ref 3) criteria

Table 23 indicates the following:

- In the areas surrounding Ponds 5/7 concentrations of metals are generally greater in the Estuarine Aquifer than in the Fill Aquifer, however concentrations of PAHs are generally greater in the Fill Aquifer than the Estuarine Aquifer;
- Mean groundwater concentrations of metals in the fill aquifers are similar for the area near Ponds 5/7 and the remaining parts of Site A, with Cu exceeding ANZECC in the general site and not in the vicinity of Ponds 5/7;
- For the PAHs, however the concentrations in the Fill Aquifer are much higher near to Ponds 5/7 than in the surrounding Site A, as this area was used for disposal of tar; and
- For the Estuarine Aquifer, concentrations are generally of a similar order near Ponds 5/7 compared to surrounding areas, with the exception of Cu and Mn. Anthracene is the only PAH with a mean above ANZECC and this has a similar mean concentration both near Ponds 5/7 and in surrounding areas of Site A.

These results suggest the following:

- Pond 5/7 is a source of PAH contamination in the Fill Aquifer, however at concentrations less than the measured leachable concentrations. Ponds 5/7 may also be a source of PAH contamination in the Estuarine Aquifer, however this is limited because of the presence of the Clay Aquitard; and
- Pond 5/7 is not a significant source of metals contamination in either aquifer any more than surrounding parts of the site. The Fill Aquifer in general indicates lower concentrations of metals than the Estuarine Aquifer and concentrations in the Estuarine Aquifer may well be background concentrations. An exception to this is Manganese (Mn) which is likely to be emanating from Site C and slag filling in general.

During Stage 1 of construction the following would occur with respect to groundwater levels and flow rates (Refer to Figure 23 for predicted hydrographs over this period):

- Temporary increase in heads to about RL 8 NHTG to 9 NHTG for the Fill Aquifer and RL 3.0 NHTG for the Estuarine Aquifer during dredging for a period of about 10 months for much of the area;
- Placement of sand filling to the east and west of the cells and filling of up to about 2 m over the cells. This would effectively remove the direct flow path to the toe of the eastern batter;
- Filling of Ponds 9 to 12 and the drain to the north would extend the flow path to the north, with areas in the vicinity of the existing OEH Wetland 2 now becoming the primary receptor. Key to the south of the site would be the Blue Billed Duck Pond. Both receptors are a similar distance from Ponds 5/7;
- Preloading of Stage 1, which partly lies over Pond 7, would lead to increased heads in Pond 7 of up to about RL 8 NHTG for the Fill Aquifer and RL 2.5 NHTG to 2.8 NHTG for the Estuarine Aquifer for the period of about 20 weeks (estimated preload time);
- Capping of the Stage 1 site and adjacent areas including Ponds 5 and 7 would lead to reduced water levels of about RL 3 NHTG to 4 NHTG in the Fill Aquifer and near pre development levels in the Estuarine Aquifer; and

- Construction of water management ponds within Deep Pond would include impermeable bund walls around the perimeter and lining of the base of the ponds and increased typical water levels within the water management ponds compared to the existing Deep Pond. This would effectively result in removal of the flow path from the Ponds 5 and 7 towards Deep Pond.

For subsequent stages of construction the ongoing capping of the T4 Project area as part of the development would lead to an ongoing decrease in typical heads in both the Fill and Estuarine Aquifers, to below pre development levels. Preloading of subsequent stages would result in temporary (estimated to be 20 weeks) increases in the heads ranging from about RL 5 NHTG to RL 9 NHTG in the Fill Aquifer. In the Estuarine Aquifer, increases in the heads are expected to generally remain below the pre development groundwater heads.

Modelling

The computer program ConSim, Version 2.05.0004, has been used to model the chemical transport processes at the site. ConSim was developed on behalf of the Environment Agency of the United Kingdom (EA) for undertaking risk assessment of contaminant transport in groundwater. The basic conceptual model is illustrated in Figure 37.

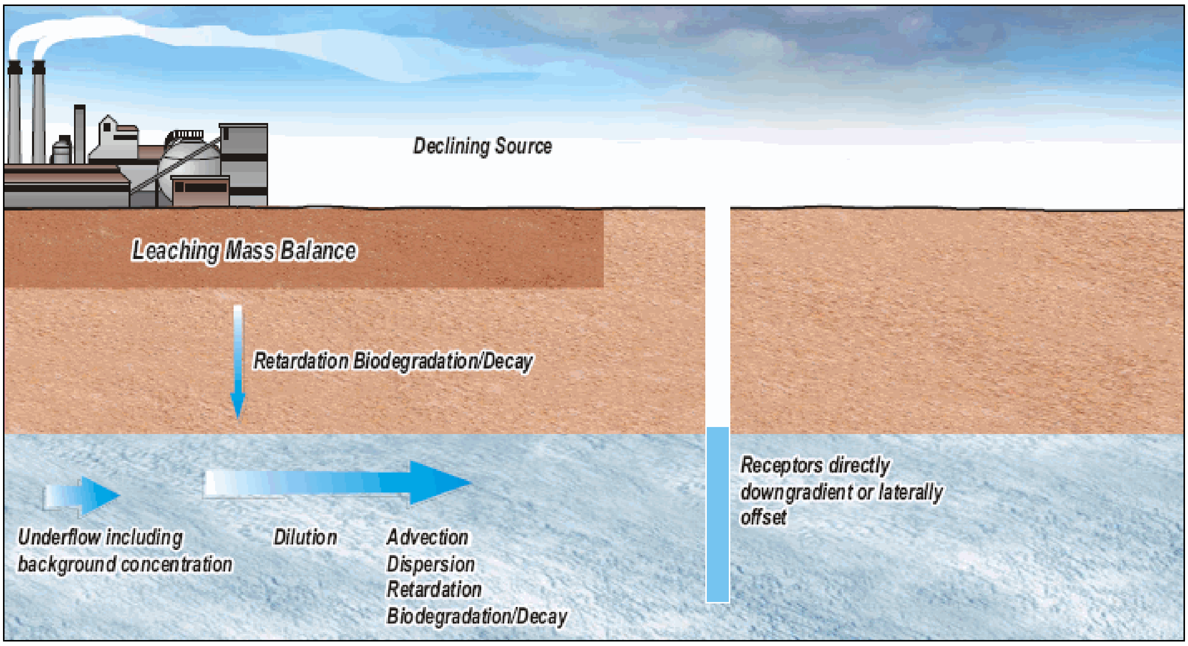

Figure 37: ConSim Conceptual Model

Using the basic conceptual model in Figure 37, ConSim comprises the following components:

- Leaching due to flow through contaminated soil (Source). Leachate concentrations can be added direct from the results of leachability testing or in the absence of such testing a mass balance calculation is undertaken to assess leachate concentrations based on an estimated partition coefficient (K_d), which in simple terms is the ratio of the concentration of a contaminant in a soil with the concentration in the leachate. For the majority of modelling the former approach of directly inputting measured leachate concentrations was adopted. A conservative approach is to assume the source is constant, however in reality the source will decrease as it is progressively leached;
- In situations where the source is separated from the primary flow path (Aquifer) by an intermediate layer/flow path, such as where vertical leakage occurs through the Clay Aquitard, retardation and decay of the contaminants is then accounted for as the leachate travels vertically through the clay towards the aquifer;
- Once the leachate arrives at the 'Aquifer', dilution of the leachate by existing flow in the aquifer is accounted for, followed by advection, dispersion, retardation and decay along the flow path within the aquifer; and
- Concentrations and travel times are then calculated at defined target points / Receptors.

The aquifer/flow path will depend on the scenario modelled and are summarised in Table 24.

Table 24: Summary of Contaminant Transport Scenarios

Scenario	Source	Intermediate Pathway	Aquifer Pathway	Receptor
FDF - Fill	Leachable concentrations in FDF soil	Nil	Flow in sand blanket due to infiltration from fill above (no background base flow)	Wetlands about 50 m to North
FDF - Estuarine	Leachable concentrations in FDF soil	Vertical Flow Through Clay	Flow in Estuarine Aquifer	Northern Site Boundary North Arm of Hunter River
Ponds 5/7 - Fill	Leachable concentrations set as existing groundwater concentrations in Aquifer	Nil	Flow in Pond 5/7, sand and slag bund material associated with Ponds 9 to 12 and rail embankment.	Wetlands about 300 m to North and Blue Billed Duck Pond about 350 m to the south.
Pond 5/7 - Estuarine	Concentrations in groundwater	Vertical Flow Through Clay	Flow in Estuarine Aquifer	Northern Site Boundary Southern Site Boundary with BHPB site North Arm of Hunter River

Due to the large number of input parameters and the high variability or uncertainty in many of the parameters a probabilistic approach is taken, using Monte Carlo simulation methods. Each input parameter is given a probability distribution. The model is then run many times, each time selecting parameters based on their likelihood (from the individual probability distributions). The results are then presented as a total probability distribution.

11.3.7.1 Application of the Model

Specific parameters and associated probability distributions used for each scenario and parameter are summarised below.

Sources

- The source areas were based on the plan area of the defined contaminant source areas as shown on 5.26 in Appendix C;
- Partition coefficients were generally not used for the sources, with the concentrations input directly from the results of leachability testing, as recommended by the ConSim Manual (Ref 34);
- It is noted however that the leachability testing undertaken used the TCLP method, which is an aggressive test method and is expected to over-estimate the actual leachability of contaminants in the field. Therefore this will tend to over-estimate predicted concentrations of contamination;
- Contaminant concentrations in the Unit 1.2 soil have been input (From Table 21 to Table 23) using either normal or log normal distributions, depending on which provide a better fit to the data;
- For the FDF, the air filled porosity was set in the range 0.0 to 0.2 to replicate partial saturation for the upper parts of the fill and the water filled porosity was set in the range 0.2 to 0.4. For Pond 5 the source was assumed to be saturated and was assigned a porosity in the range 0.3 to 0.45; and
- Rainfall recharge was based on the expected range of rates occurring across the stages of development estimated from the groundwater flow modelling.

Vertical Pathway

- The thickness of the Unit 2 clay was represented by a block distribution across the measured range of thicknesses shown on Drawing 5.11 (2 m to 5 m below FDF and 2 m to 3 m for Pond 5);
- Vertical flow rates through the Unit 2 Clay were estimated from the difference in head between the two aquifers, the thickness of the layer and the estimated vertical hydraulic conductivity of the layer from the MODFLOW-SURFACT modelling (5×10^{-9} m/s). A triangular distribution with a mean of 30, 70 and 550 mm/year was used for Pond 5/7 and 0, 56 and 113 mm/year for the FDF;
- A porosity of 0.63 and dry density of 10 kg/L were calculated from the results of mechanical laboratory testing and input as triangular distributions with upper and lower bounds of ±20% and ±10% respectively; and

- No specific leachability testing of the Unit 2 Clay was undertaken for this development, however such testing for selected heavy metals was undertaken for the Unit 1.2 fines on the adjacent site (Ref 15). The Unit 1.2 Clays are generally less plastic and have lesser organic content than the natural clay and therefore would be expected to provide conservative estimates for the retardation (over-estimate mobility of contamination) of the Unit 2 Clay. For the Unit 2 clay the upper limit partition coefficient were set from the mean Round 1 results presented in Table 25 below. The lower bound was based on published lower bound values and are presented in Table 26 in the following section.

Table 25: Summary of Calculated Partition Coefficients for Unit 1.2 Fines (From Leachability Test Results)

Parameter	Calculated Partition Coefficients in Unit 1.2 Fines (L/kg)						Typical published values (Refs 1, 34, 36 & 41)
	Round 1 using demineralised water as leachate		Round 2 using site water as leachate(1)		Both Rounds Combined		
	Mean	SD	Mean	SD	Mean	SD	
Cadmium (Cd)	373	164	566	277	518	269	0.1 to 17,000
Chromium (Cr)	1882	862	5799	3615	4701	3579	1 to 4,400
Copper (Cu)	522	246	2728	1502	2200	1623	40 to 27,500
Nickel (Ni)	1397	639	2418	1502	2133	1403	3 to 8100
Lead (Pb)	486	748	4728	3367	3530	3448	0.7 to 27,000
Zinc (Zn)	2263	6475	30814	34218	21712	31265	1.0 to 100,000
Mercury (Hg)	281	115	293	108	290	116	2.2 to 5280

Notes to Table 25:

(1) The majority of results of leachability testing for metals in the second round were less than the PQL. Where leachable concentration less than PQL, then PQL used in calculations, with exception of PAH as only a low percentage of PAH were less than PQL.

(2) All second round results below PQL which is well below criteria.

Estuarine Aquifer

- Initial (background) concentrations in the Estuarine Aquifer were based on measured concentrations using a normal distribution, as presented in Table 23;
- The hydraulic gradient in the aquifer was based on a range of predicted gradients estimated from the above groundwater flow modelling. Flow was assumed to be in a northerly direction;
- A uniform distribution was also adopted for the hydraulic conductivity, with upper and lower bounds of $2x10^{-4}$ m/s and $4x10^{-4}$ m/s;
- The aquifer thickness was based on contoured aquifer thicknesses and set as a uniform distribution ranging from 8 m to 12 m at Pond 5 and 18 to 20 m at the FDF;
- A porosity of 0.35 and dry density of 21 kg/L were calculated from the results of in-situ testing and input as triangular distributions with upper and lower bounds of ±20% and ±10% respectively;
- Dilution due to mixing with the upstream base flow was allowed for, using a mixing depth calculated from USEPA methods;

- The longitudinal dispersivity was based on the flow path length to the receptor using the methods from the US EPA *On-Line Tools for Site Assessment Calculation* (2011 – Ref 42). A triangular distribution was used based on the approximate lower limit, Xu and Eckstein (Ref 46) and approximate upper limit; and
- The lateral dispersivity was taken as 10% of the vertical dispersivity. This only applies at the outer edges of the flow path and has no influence on flow directly downstream of the site.

In order to adopt appropriate partition coefficients for the sand a literature search was undertaken. Significant work has been undertaken by US EPA and others and three key papers were identified as follows:

- US EPA (1996) "*Soil Screening Guidance: Technical Background Documents*" (Ref 41). This provides various tabulated partition coefficients for a large range of contaminants;
- Allison and Allison (2005), "*Partition Coefficients for Metals in Surface Water, Soil and Waste*". This provides an overview of measured partition coefficients as well as predicted coefficients for various types of landfills (Ref 1); and
- Hassan *et al* (1996), "*Estimation of Partition Coefficients for Five Trace Metals in Sandy Sediments and Application to Sediment Quality Criteria*" (Ref 36). This provides median and recommended lower bound partition coefficients for Cadmium, Copper, Nickel, Lead and Zinc in sand sediments.

The published values for the partition coefficients are summarised in Table 26.

Table 26: Summary of Published Partition Coefficients for Metals

Parameter	Allison & Allison Unspecified pH or soil type (Ref 1)		Hassan et al Chromatographic sand at pH=5.6 (Ref 36)	US EPA Soil Screening Document (Ref 41)		
	Median	Range		Collected Literature Values	Predicted at pH=6.8	Predicted at pH=8.0
Cadmium	2.9	0.1 - 5.0	4 ± 1	1.26 - 17,000	75	4300
Chromium	3.9	1.0 - 4.7	ND	1.7 - 2,517	$1.8x10^6$	$4.3x10^6$
Copper	2.7	0.1 - 3.6	17 ± 4	ND	ND	ND
Nickel			3 ± 1	12.2 - 4,700	65	1900
Lead	4.2	0.7 - 5.0	296 ± 21	ND	ND	ND
Zinc	3.1	1.0 - 5.0	3 ± 1	0.1 - 100,000	62	530
Mercury	3.8	2.2 - 5.8	ND	10 - 5280	52	200

Notes to Table 26:
All measurements in L/kg

It is noted that the partitioning is highly dependent on pH, with greater partitioning to soil (higher coefficient) for higher pH. The pH of the Estuarine Aquifer is typically in the order of pH 7 or greater and therefore coefficients at the lower end of the published ranges are likely to be conservative for the T4 Project area (i.e. over-predict concentrations in groundwater). For the purposes of the assessment uniform distributions were adopted using the shaded values in Table 26.

For PAH and benzo(a)pyrene the partitioning is directly related to the organic content of the sediments, which is expected to be less for the sand, using Equation 4 below:

$$K_d = K_{oc} \times TOC \qquad \text{(Equation 4)}$$

where:

K_d = soil water partition coefficient
K_{oc}= partition coefficient to organic carbon (specific to contaminant)
TOC = Total Organic Carbon

US EPA (1996, Ref 41) lists partition coefficients for benzo(a)pyrene as well as various other PAHs. Benzo(a)pyrene is listed with an average K_{oc} of 1×10^6 L/kg. Of the various PAHs, Naphthalene has a lower bound K_{oc} of about 1200 L/kg.

Measured fraction organic contents were based on measured values from Table 12 and ranged from 1% to 3 % for Unit 2 Clay, with one measured value of 18% excluded as a likely outlier.

The total organic carbon was not directly measured for the sand, however Di Toro and De Rosa (1996 - Ref 7) suggest that 90% of estuarine and coastal sediments have an organic carbon of greater than 0.2%. Therefore the partition coefficients were calculated based on a TOC ranging from 0.1% to 1% as a uniform distribution.

11.3.7.2 Results

The results of ConSim contaminant transport modelling are presented and discussed in the following sections. The potential impacts on sensitive receptors as a result of contaminant transport are discussed in Section 12.

Fines Disposal Facility

Modelling for the FDF was initially based on long term conditions with capping of the surface at the FDF limiting infiltration to generally about 5% of rainfall and less than 10% of rainfall. Saturation of the filling in the FDF was assumed to occur due to settlement effects and failure of the leachate collection system. A second run was undertaken assuming that the T4 Project area was not fully capped until the end of all stages of construction.

The results of modelling of leaching of existing soils through the sand base of the FDF towards the OEH Wetlands[1] receptor are presented in Table 27.

[1] Existing OEH Wetland 3 used as receptor for FDF

Table 27: Calculated FDF Fill Aquifer Concentrations at OEH Wetlands Receptor

Parameter	10 Years (No capping)		10 Years (Capped)		100 years (Capped)		1000 Years (Capped)		Background Fill Aquifer Concentrations (mg/L)		ANZECC (Ref 3) (mg/L)
	50th %'ile	95th %'ile	50th %'ile	95th %'ile	50th %'ile	95th %'ile	50th %'ile	95th %'ile	Mean	Max	
Metals											
Aluminium (Al)	0.67	3.14	0.12	2.18	1.5	4.0	2.2	5.0	0.0140	0.14	0.055
Cadmium (Cd)	0.0003	0.0016	0.0002	0.00095	0.00065	0.0018	0.00095	0.0022	0.0001	0.0025	0.0007
Chromium (Cr)	0.0046	0.017	0.003	0.011	0.0076	0.02	0.011	0.025	0.0012	0.03	0.0044 (1)
Copper (Cu)	0.0066	0.032	0.0016	0.02	0.014	0.045	0.018	0.022	0.0021	0.23	0.0013
Manganese (Mn)	1.62	4.08	1.66	3.88	1.66	1.78	1.66	3.88	1.2512	7	1.9
Nickel (Ni)	0.005	0.028	0.003	0.018	0.013	0.038	0.021	0.048	0.0017	0.046	0.007
Lead (Pb)	0.023	0.16	0.003	0.096	0.059	0.21	0.1	0.27	0.0009	0.06	0.0044
Zinc (Zn)	0.19	1.08	0.095	0.68	0.44	1.5	0.74	1.96	0.0320	0.48	0.015
Mercury (Hg)	0.0002	0.0005	0.0002	0.0005	0.0002	0.0006	0.0003	0.0006	0.00012	0.005	0.0001 (2)
PAHs											
Naphthalene	0.0024	0.047	0.0002	0.031	0.016	0.075	0.044	0.1	0.0001	0.3	0.05
Phenanthrene	0.00014	0.00065	0.0001	0.0003	0.0001	0.003	0.0011	0.0096	0.0001	0.0001	0.0006 (L)
Anthracene	0.00005	0.0001	0.00005	0.000055	0.00005	0.000055	0.0003	0.0015	0.00005	0.00005	0.00001 (L)
Fluoranthene	0.0001	0.0003	0.0001	0.0003	0.00015	0.0008	0.0006	0.002	0.0001	0.0004	0.001 (L)
Benzo[a]pyrene	0.0003	0.0006	0.0003	0.0006	0.0003	0.00065	0.0003	0.0007	0.0003	0.0009	0.0001 (L)

Notes to Table 27
NC – No Criteria
(L) – Low reliability criteria
(1) – Chromium (VI) criteria
(2) – Mercury (inorganic)
50th percentile has 50% chance of being exceeded (median); 95th percentile has 5% change of exceeded
Shaded result indicate exceedances of ANZECC (Ref 3) criteria

The results in Table 27 indicate the following:

- Concentrations reaching the OEH Wetland at 10 years due to early capping of the FDF would generally be similar or less than existing background groundwater concentrations, with the exception of Aluminium. For the predicted concentrations at 10 years 50th percentile concentrations of Al, Cu, Zn, Hg and Benzo (a) Pyrene exceed ANZECC criteria;
- If the FDF leachate collection system fails and the site is not fully capped until later stages, the concentrations at 10 years would be significantly higher than if the FDF was capped early, with 50th percentile concentrations of Pb and Cr also exceeding ANZECC criteria;

- The concentration of metals reaching the OEH Wetlands would increase with time if the FDF is capped early and metal concentrations would increase above background concentrations at the OEH Wetland for Al, Cr, Cu, Ni, Pb, and Zn. The 50th and 95th percentile concentrations would be above ANZECC criteria at the OEH Wetland 3 for all metals within 100 years;
- For PAHs, concentrations would build over time at the OEH Wetlands . Concentrations would be below background concentrations and generally below ANZECC criteria at 10 years, however by 1000 years would generally exceed ANZECC criteria for both 50th and 95th percentile concentrations;
- These results indicate that the combination of settlement leading to additional saturation of the clay and possible failure of the existing leachate collection system could lead to increased mobility of contaminants reaching the OEH Wetlands at concentrations in excess of ANZECC criteria;
- If the leachate collection system were to withstand the filling and preload process then these impacts would be expected to be mitigated to an extent by keeping much of the filling dry and by intercepting the leachate before it reaches OEH Wetland . If the effectiveness of the leachate collection system is impaired, resulting in increased leachate concentrations reaching the OEH Wetland mitigation measures may be required to protect the OEH Wetland.

The potential for contamination in the Fill Aquifer to leach through the Unit 2 Clay and then north towards the northern site boundary and North Arm of the Hunter River was assessed. The results are presented in Table 28.

Table 28: Calculated Concentrations at Source (FDF), Base of Clay and Northern Boundary at 1000 years

Parameter	Source		Base of Unit 2 at 1000 years		Prediction at 1000 years at Nth Boundary (Nth Arm Hunter River[3])		Background Estuarine Aquifer Concentration		ANZECC (Ref 3) (mg/L)
	50th %'ile	95th %'ile	50th %'ile	95th %'ile	50th %'ile	95th %'ile	Mean	Max	
Metals									
Aluminium (Al)	2.5	5	2.4	4.9	0.3* (0.27)	1.0 (0.83)	0.0375	0.84	0.055
Cadmium (Cd)	0.0009	0.0025	0.00009	0.0009	0.0003	0.00009	0.0002	0.0027	0.0007
Chromium (Cr)	0.005	0.007	0	0.0007	0.008* (0.008)*	0.02* (0.02)*	0.0049	0.05	0.0044 (1)
Copper (Cu)	0.021	0.053	0.00045	0.006	0.003* (0.003)	0.009 (0.008)	0.0025	0.017	0.0013
Manganese (Mn)	0.0096	0.011	0.009	0.011	1.4* (1.4)	3.4* (3.4)	1.3823	4.26	1.9
Nickel (Ni)	0.022	0.051	0	0.0003	0.0021	0.005	0.0020	0.006	0.007
Lead (Pb)	0.11	0.29	0.004	0.098	0.003	0.008	0.0025	0.012	0.0044
Zinc (Zn)	0.73	2.0	7.3	0.058	0.21* (0.21)	0.51* (0.51)	0.0665	2.29	0.015
Mercury (Hg)	0.00011	0.00027	0	0.0001	0.0001*	0.00038*	0.00011	0.0005	0.0001 (2)
PAHs									
Naphthalene	0.011	0.05	0.011	0.05	0.0005	0.009	0.0001	0.001	0.05
Phenanthrene	0.007	0.017	0	0.00006	0.00005*	0.00005*	0.00005	0.00005	0.0006 (L)
Anthracene	0.001	0.002	0	0.000007	0.00005*	0.00005*	0.00005	0.00005	0.00001 (L)
Fluoranthene	0.00006	0.00013	0	0.00003	0.00006*	0.0001*	0.00006	0.0002	0.001 (L)
Benzo(a)pyrene	0.0003	0.0007	0	$3x10^{-21}$	0.00003*	0.000055*	0.00003	0.00007	0.0001 (L)

Notes to Table 28:
* Concentration controlled by background concentration
NC – No Criteria
(L) – Low reliability criteria
(1) – Chromium (VI) criteria
(2) – Mercury (inorganic)
50th percentile has 50% chance of being exceeded (median); 95th percentile has 5% change of exceeded
Shaded result indicate exceedances of ANZECC (Ref 3) criteria

The results in Table 28 indicate the following:

- The 50th percentile concentrations of metals reaching the base of the clay would generally be less than ANZECC criteria with the exception of Aluminium. Of the 95th percentile concentrations reaching the base of the clay, ANZECC criteria would be exceeded for: Al, Cu, Mn, Pb and Zn, however these concentrations would all be less than background maximum concentrations in the Estuarine Aquifer, with the exception of Aluminium;
- For some of the metals, the calculated 50th percentile results are at the receptor are controlled by the calculated background concentrations. The distribution of background contamination is heavily skewed by occasional high readings, leading to a high standard deviation, which results in ConSim over-estimating the background 50th percentile concentrations, which then over-estimates the 50th percentile predicted groundwater concentrations.

- The 95th percentile concentrations for metals are not affected by the skew described above and are therefore more indicative of potential impacts at the receptor from metals leaching. The 95th percentile predicted concentrations of metals are generally below background maximum concentrations, with Aluminium at a similar concentration to background. Therefore, leaching of metals through the clay into the Estuarine Aquifer is not expected to have an adverse impact on existing concentrations, and would be expected to have minimal impact on the Hunter River; and
- For PAHs, the 50th and 95th percentile concentration reaching the base of the clay and the northern receptors would be less than ANZECC criteria and therefore no significant impact is expected. It should be noted that elevated concentrations of Anthracene are controlled by background concentrations which exceed ANZECC.

Ponds 5/7

Modelling for Ponds 5/7 was initially run based on the site being capped and no additional flows due to dredging and preloading. The source was based on existing groundwater concentrations rather than leachable concentrations which are likely to be statistically skewed due to judgemental sampling of PAH contamination. The results of modelling of transport of contamination towards the OEH Wetland 2 receptor to the north of the site are presented in Table 29. Table 29 also includes the results of a 10 year run based on an increased range of infiltration and flow rates which account for dredging and preloading which would occur prior to capping of the site, to provide an indication of the potential increase in migration of contamination which may occur from these processes.

[2] Existing OEH Wetland 2 used as receptor for pond 5/7

Table 29: Calculated Pond 5/7 Fill Aquifer Concentrations at OEH Wetland Receptor

Parameter	10 Years (dredging and preload)		10 Years (capped)		100 years (capped)		1000 Years (capped)		Background Fill Aquifer Concentrations (mg/L)		ANZECC (Ref 3) (mg/L)
	50th %'ile	95th %'ile	50th %'ile	95th %'ile	50th %'ile	95th %'ile	50th %'ile	95th %'ile	Mean	Max	
Metals											
Cadmium (Cd)	0.0015	0.00019	0.00013	0.00017	0.00015	0.00018	0.00015	0.00018	0.0001	0.0001	0.0007
Chromium (Cr)	0.0016	0.0028	0.0013	0.0026	0.0015	0.0027	0.0016	0.0028	0.0008	0.003	0.0044 (1)
Copper (Cu)	0.0036*	0.0087*	0.0036	0.0087	0.0038	0.0089	0.0038	0.0090	0.0018	0.012	0.0013
Manganese (Mn)	1.13	3.61	0.14	3.16	0.74	3.2	1.14	3.4	0.0233	0.17	1.9
Nickel (Ni)	0.014*	0.026*	0.01	0.024	0.012	0.025	0.013	0.026	0.0050	0.028	0.007
Lead (Pb)	0.0019	0.0037	0.0016	0.0034	0.0018	0.0035	0.0019	0.0036	0.0010	0.004	0.0044
Zinc (Zn)	0.022*	0.051*	0.020	0.048	0.020	0.048	0.021	0.049	0.0097	0.07	0.015
Mercury (Hg)	0.00018*	0.00032*	0.00014	0.00029	0.00015	0.00030	0.00017	0.0003	0.00009	0.0002	0.0001 (2)
PAHs											
Naphthalene	0.069	0.7890	0.027	0.06	0.1	0.76	0.24	0.8	0.0047	0.036	0.05
Phenanthrene	0.0018	0.2840	0.0017	0.26	0.0092	0.26	0.06	0.26	0.0006	0.0019	0.0006 (L)
Anthracene	0.00047	0.0190	0.00043	0.018	0.0008	0.0195	0.0035	0.0196	0.000123	0.0006	0.00001 (L)
Fluoranthene	0.00086	0.1339	0.00079	0.138	0.0053	0.128	0.028	0.131	0.0003	0.001	0.001 (L)
Benzo(a)pyrene	0.0002	0.0124	0.0002	0.0126	0.00038	0.0126	0.0023	0.013	0.00008	0.0003	0.0001 (L)

Notes to Table 29:
NC - No Criteria
(L) - Low reliability criteria
(1) – Chromium (VI) criteria
(2) – Mercury (inorganic)
* Controlled by background concentration
50th percentile has 50% chance of being exceeded (median)
95th percentile has 5% change of exceeded
Shaded result indicate exceedances of ANZECC (Ref 3) criteria

The results in Table 29 indicate the following:

- For metals, the calculated results are controlled by the calculated background concentrations. The 50th percentile leachable source concentrations and existing groundwater concentrations in the Pond 5 area are actually much lower than the predicted concentrations presented in Table 37 above. The distribution of background contamination is heavily skewed by occasional high readings, leading to a high standard deviation, which results in ConSim over-estimating the background 50th percentile concentrations, which then over-estimates the 50th percentile predicted groundwater concentrations;
- The 95th percentile concentrations for metals are not affected by the skew described above and are therefore more indicative of actual impacts from metals leaching. The 95th percentile concentrations of source concentrations of metals would generally be below background concentrations and therefore the impact of leaching would only be a slight incremental effect on background concentrations, with the exception of Manganese. Therefore leaching of metals from Ponds 5/7 into the surrounding Fill Aquifer is generally not expected to have an adverse impact on existing concentrations with the exception of Manganese;
- The PAH results indicate the potential for leaching of PAHs in excess of background and ANZECC criteria in the long term if the site was capped with no development. The results may over-estimate the 50th percentile concentrations for the capped situation as the model cannot fully account for the lower hydraulic gradients in the preferred flow paths such as slag bunds, compared to the coal fines; and
- For the case which models potential short term impacts due to dredging and preloading, the results indicate generally slightly higher concentrations of PAHs at the receptors, and in the case of Naphthalene double that compared to the no development case. The 50th percentile concentrations are not expected to be underestimated in the same manner as the capped case, as the hydraulic gradients in the preferred flow paths would be controlled by the dredge and preload surcharge heads.

The potential for vertical leaching of the contaminants, in particular PAHs, into the underlying Estuarine Aquifer was assessed, using measured groundwater concentrations in the Fill Aquifer and comparing calculated concentrations of PAHs at the base of the clay to existing Estuarine Aquifer concentrations. As many of the concentrations were limited to detection limits, the mean concentrations of PAHs in the Estuarine Aquifer was skewed by the detection limits and therefore the calibration was based on calculated 95th percentile concentrations versus maximum observed concentrations. An approximate timeframe of 30 years was used for the calibration, equivalent to the approximate time the waste has been in place. The calibration was limited to PAHs as these are not expected to occur naturally in the Estuarine Aquifer. The calibration was not possible as metal concentrations are likely to be naturally occurring. The results are presented in Table 30.

Table 30: Calculated Concentrations at Source, Base of Clay and Northern Boundary for Ponds 5/7 (groundwater source concentrations)

Parameter	Source*		Base of Unit 2 Calibration[1] at at 30 years		Background Below Pond 5		Prediction at 1000 years at Nth Boundary (Nth Arm Hunter River[3])		Background Surrounding Estuarine Aquifer		ANZECC (Ref 3) (mg/L)
	50th %'ile	95th %'ile	50th %'ile	95th %'ile	Mean[2]	Max	50th %'ile	95th %'ile	Mean*	Max	
Metals											
Cadmium (Cd)	0.00006	0.00009	0.00005	0.00007	0.0007	0.006	0.0001	0.0001	0.00007	0.0002	0.0007
Chromium (Cr)	0.0006	0.0010	0.0005	0.0008	0.0010	0.003	0.001	0.003	0.0010	0.004	0.0044 (4)
Copper (Cu)	0.0007	0.0013	0.0004	0.001	0.4154	3.7	0.0016	0.0033	0.0014	0.003	0.0013
Manganese (Mn)	1.4061	3.8440	0.7	2.8	2.7780	19	1.9	3.9	1.4759	3.9	1.9
Nickel (Ni)	0.0050	0.0140	0.0021	0.0096	0.0081	0.072	0.009	0.02	0.0067	0.019	0.007
Lead (Pb)	0.0007	0.0016	0.00035	0.001	0.0014	0.0030	0.0005	0.0009	0.0005	0.0005	0.0044
Zinc (Zn)	0.0036	0.0069	0.0019	0.0051	0.0133	0.066	0.019	0.043	0.017	0.046	0.015
Mercury (Hg)	0.00009	0.0002	0.00003	0.0001	0.0001	0.0002	0.0001	0.0002	0.00011	0.0002	0.0001 (5)
PAHs											
Naphthalene	0.3379	0.8681	0	0.0009	0.0006	0.0041	0.0004 (0.0035)	0.0009 (0.0008)	0.0002	0.001	0.05
Phenanthrene	0.1260	0.3154	0	0.004	0.0007	0.0063	0.0002 (0.0001)	0.02 (0.00026)	0.0001	0.0004	0.0006 (L)
Anthracene	0.0087	0.0233	0	0.0002	0.00009	0.0007	0.00007 (0.000055)	0.0014 (0.000085)	0.00006	0.0001	0.00001 (L)
Fluoranthene	0.0592	0.1568	0	0.0018	0.0002	0.0019	0.0002 (0.0001)	0.0085 (0.0002)	0.0001	0.0005	0.001 (L)
Benzo(a)pyrene	0.0060	0.0154	0	0.00011	0.00006	0.0002	0.00009 (0.00007)	0.0009 (0.0001)	0.00007	0.0002	0.0001 (L)

Notes to **Table 30**:

Calibrated for PAH 95th percentile to maximum background below pond

Mean concentrations for PAHs skewed by detection limits and likely overestimate mean

Concentration in brackets is for North Arm of Hunter River

* Controlled by background concentration — (4) – Chromium (VI) criteria

(5) – Mercury (inorganic) — (L) Low reliability criteria

50th percentile has 50% chance of being exceeded (median) — 95th percentile has 5% change of exceeded

Shaded result indicate exceedances of ANZECC (Ref 3) criteria

The results in Table 30 indicate the following:

- The leachable concentration of most metals in Ponds 5/7 would be less than the background concentrations for surrounding areas and therefore have no significant adverse impacts on the background concentrations;
- Manganese and Copper would have high concentrations in the Estuarine Aquifer below Ponds 5/7, much higher than leachable concentration in the Ponds 5/7 and higher than background concentrations in the surrounding Estuarine Aquifer and are probably coming from Site C to the west; and
- For the PAHs, modelling indicates a reasonable correlation between the calculated 95th percentile concentrations at the base of the clay and measured maximum values in the Estuarine Aquifer below Ponds 5/7 at 30 years, the approximate time that the waste has been in place. The calculated 50% percentile breakthrough times are greater than 30 years; however these cannot be directly compared to the measured mean concentration in the aquifer below as these mean concentrations are skewed by the detection limits. Therefore it is considered that the model provides a reasonable calibration for transport of the PAHs through the clay. The calibration required that the minimum thickness of the clay was reduced to 0.3 m and the maximum FOC was decreased to 3.0 to allow the observed migration of PAHs into the Estuarine Aquifer.

The calculated concentrations of PAH at the northern boundary after 1000 years generally indicates 50th percentile concentrations would be well below ANZECC criteria (Ref 3), with the exception of Anthracene, which would be seven times ANZECC criteria. The 95th percentile concentrations for all PAHs except Naphthalene would be above ANZECC criteria at the northern boundary and the North Arm of the Hunter River.

12. Assessment of Groundwater Impacts and Mitigations

12.1 General

The results of the numerical groundwater flow and contaminant transport modelling are discussed in the following sections with regard to potential impacts on sensitive receptors, together with a comparison of the potential future impacts without the proposed development. Potential mitigation measures and their effectiveness at reducing potential impacts are also discussed, and are developed further in the Assessment of Remediation Options Report (Ref 25).

12.2 Salinity from Dredging

The process of dredging would lead to the transport of sand containing saline water to much of the T4 Project area. Discharge of large volumes of saline water to Deep Pond would occur as a result. The placement of saturated sand over the site would lead to temporary mounding of groundwater and increases in groundwater flow rates for the period of the dredging, typically at about three times the current flows for the period of the dredging.

The saline water associated with dredging also has potential to impact on surface water quality, in particular sensitive Green and Golden Bell Frog habitats, including the following:

- OEH Wetland 1;
- Rail Road Pond;
- Blue Billed Duck Pond; and
- BHPB Wetland.

The results of modelling indicate that a number of suitable mitigation measures could reduce potential impacts of saline water on these ponds, including:

- Use of a low permeability liner around the southern, northern and western perimeter of the Deep Pond area;
- Use of a low permeability or lined bund along the southern extent of the proposed dredging;
- Capping of Site C using a low permeability liner, prior to dredging;
- Diversion of dredge water around Ponds 5 to 8 or selective capping of sections of bund walls around Ponds 5 to 8 to prevent infiltration of dredge water and subsequent preferential flow towards Blue Billed Duck Pond; and
- Monitoring of salinity levels during construction upstream of BHPB Wetland, Blue Billed Duck Pond, Rail Road Pond and OEH Wetland 1 to allow for additional mitigation measures, if required, to be implemented. Such measures could include diversion of the saline water source and/or diversion/interception of any identified saline seepages.

Table 31 provides a comparison of the potential impacts to salinity of groundwater from dredging compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 31: Comparison of Potential Impacts from Dredge Water Salinity

Potential Impact	Pre-Development	Base Development without Mitigation Measures	Potential Mitigation Measure	Predicted Impact following Mitigation
Elevated saline water reaching sensitive habitat	NA - No dredging would occur	Salinity >10,000 mg/L at Rail Road Pond Salinity between 1,000 mg/L and 5,000 mg/L in OEH Wetland 1, with potential adverse effects on GGBF	Lining of Deep Pond Batters	Salinity impact <1000 mg/L in OEH Wetland 1 and Rail Road Pond, at lower range of background fluctuations
		Possible saline water reaching Blue Billed Duck Pond and BHPB Wetland along preferential pathways from Ponds 5 to 8 with potential adverse effects on GGBF	Divert dredge water to north of Ponds 5 to 8, or across Ponds 5 to 8 in lined channels, and place only dry sand over Ponds 5 to 8	Salinity impact < 1000 mg/L, resulting in minimal impact on background fluctuations
			Low permeability liners over higher permeability bund areas	Salinity impact< 1000 mg/L, resulting in minimal impact on background fluctuations
		Salinity >10,000 mg/L in Easement Pond	Low permeability liner at base of Site C	Salinity impact< 1000 mg/L, resulting in minimal impact on background fluctuations
		All of above	Monitoring of groundwater upstream of sensitive receptors	Reduced risk of unexpected elevated seepage reaching receptors

12.3 Mobilisation of Contamination From Dredging

The dredging process will lead to substantially increased groundwater flow rates below the T4 Project for the period of the dredging. This has the potential to lead to increased mobilisation of contamination from the site towards sensitive receptors including:

- North and South Arm of Hunter River;
- OEH Wetlands 1 to 3;
- Rail Road Pond;
- Blue Billed Duck Pond; and
- BHPB Wetland.

For OEH Wetlands 1 and 2, Rail Road Pond, Blue Billed Duck Pond and BHPB Wetland the identified risk with respect to contamination (apart from salinity) is from Ponds 5 and 7, in particular PAHs. The provision of lining in the Dredge Receival Pond and diversion of dredge water away from Ponds 5 and 7 are expected to significantly reduce the potential impacts to these receiving waters. Detailed contaminant transport modelling has also been undertaken to assess the potential impacts on these receptors and additional mitigations are proposed, as described in Section 12.9.

For OEH Wetland 2 and the Ramsar wetlands to the north the identified risk with regard to contamination is the Lead Dust Disposal Area. Proposed mitigations for this risk are discussed in Section 12.10.

For OEH Wetland 3 and the Ramsar wetlands to the identified risk with regard to contamination is the FDF. Detailed contaminant transport modelling has been undertaken to assess the potential impacts on these receptors and additional mitigations are proposed as described in Section 12.8.

For the North Arm and South Arm of the Hunter River the temporary increased flow rates will lead to a temporary increase in the flux of any general background contamination in the Estuarine Aquifer. Flow rates in the Estuarine Aquifer are estimated to increase from a typical seepage rate of about 15 m/year to about 40 m/year during the two years of dredging. Following capping typical seepage rates are expected to drop to about 10 m/year. Therefore the dredging represents an additional 3 to 4 years flow distance compared to the no development case. When compared to the overall travel time to the Hunter River of about 50 years, this is considered insignificant. Over such a time frame, taking into account the reduced flow rates from the capping, the net travel distance will be reduced.

12.4 Impacts on Water Levels in OEH Wetland 1 and Rail Road Pond

OEH Wetlands 1 and Rail Road Pond are understood to be important habitats for Green and Golden Bell Frogs. The results of modelling indicated that OEH Wetland 1 and Rail Road Pond water levels are primarily controlled by rainfall and evaporation, with groundwater flows being a relatively minor control. This is clearly evidenced in OEH Wetland 1 which has been observed to dry following periods of low rainfall whilst the adjacent Deep Pond still maintained significantly higher water levels.

Modelling of potential impacts on water levels from the proposed development indicated that net changes in the water levels would be less than about 0.1 m. Mitigation measures included in the model to limit impacts include the following:

- Diverting the proposed additional rail line to the southern side of the existing rail line to prevent construction over the existing ponds;
- Construction of the new rail embankment with relatively permeable material to reduce and impacts on groundwater flows through the embankment; and
- Maintain the existing surface water run-off conditions into the OEH Wetland 1 and Rail Road Pond, as the water levels in the ponds are affected by surface water run-off;

Modelling was undertaken for the option of retaining of a narrow strip of Deep Pond in its existing unlined condition to the south of the new rail line, separating it from the proposed stormwater ponds, essentially retaining the existing surface water conditions upstream of the rail lines. The results indicated that this would further limit the potential impacts to water levels in OEH Wetland 1 and Rail Road Pond.

Monitoring of the water levels should be undertaken, and if any changes in water levels are observed post development, then this could be mitigated by adjusting the amount of run-off diverted to the Wetland and Pond.

Table 32 provides a comparison of the potential impacts to groundwater levels in the OEH Wetlands compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 32: Comparison of Potential Impacts on Pond Water Levels

Potential Impact	Pre-Development	Base Development Mitigation Measures	Possible Additional Mitigation Measures	Predicted Impact following Mitigation
Variations in Water Levels in OEH Wetlands and Rail Road Pond	Natural fluctuations occur in response to direct rainfall, rainfall runoff and evaporation and to a minor extent groundwater flows from the site.	Diverting new rail line to south of existing rail embankment through Deep Pond	Not applicable	Water levels would continue to fluctuate in response to climatic conditions, within about 0.1 m of previous levels
		Permeable material for construction of new rail embankment	Retain a strip of Deep Pond in its current unlined condition between rail embankment and water treatment ponds	
		Maintain run-off into OEH Wetland 1 and Rail Road Pond	Monitor water levels and adjust run-off to ponds if necessary	

12.5 Tidal Flats to North of Site and Swan Pond to the West

Water levels in the tidal flats to the north of the site, including adjacent OEH Wetlands and the more distant Ramsar wetlands, are not expected to be affected by the development as the water levels in the more elevated areas are controlled primarily by rainfall and evaporation, as well as occasional tidal inundation, whereas water level in the lower areas are controlled primarily by tidal fluctuations.

These areas may receive some saline inflows during dredging, however these areas are already saline and therefore significant net impacts due to saline water are not expected.

No mitigation measures are required to address this issue.

12.6 Water levels in BHPB Wetland and Blue Billed Duck Pond

The proposed HDC capping will lead to reduced groundwater levels in the Fill and Estuarine Aquifers, which is predicted to lead to a reduction in the typical water levels in BHPB Wetland and Blue Billed Duck Pond by up to about 0.15 m.

When the impacts of the dredging and preloading a superimposed (cumulative impact) there is a temporary increase in water levels of about 0.15 m, flowed by a decrease in water levels due to the effects of the capping. The net long term difference in water levels between HDC capping and the T4 Project is predicted to be less than 0.05 m, this is because the extent of capping in the vicinity of the BHPB Wetland and Blue Billed Duck Pond is similar for both cases.

The impacts during dredging can be reduced by diversion of the dredge water to the north of Ponds 5/7 and/or lining of permeable bund materials, as recommended in Section 12.4.

Table 33 provides a comparison of the potential impacts to groundwater levels in the BHPB Wetland and Blue Billed Duck Pond compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 33: Comparison of Potential Impacts on BHP Wetland and Blue Billed Duck Pond Water Levels

Potential Impact	Pre-Development	Base Development Mitigation Measures	Possible Additional Mitigation Measures	Predicted Impact following Mitigation
HDC Capping	Natural fluctuations occur in response to direct rainfall, rainfall runoff and evaporation, leakage to the Estuarine Aquifer and groundwater flows from the site.	Water levels reduced by up to 0.15 m.	Increase recharge to Fill Area to north of ponds and /or runoff to ponds from capped area.	Subject to detailed design, target pre-capping levels.
Dredging for T4 Project		Temporary increase in typical water levels by up to 0.15 m for less than 2 years, mostly due to temporary increases in Estuarine Aquifer heads.	Divert dredge water to north of Ponds 5 to 8, or across Ponds 5 to 8 in lined channels, and place only dry sand over Ponds 5 to 8. Low permeability liners over higher permeability bund areas	Partial reduction in levels
Long Term Net Impact from T4 Development.		Water levels within 0.05 m of levels HDC capping. Net impact less than 0.05 m.	As per HDC capping.	As per HDC capping.

12.7 Preloading and Capping

The process of preloading is expected to lead to temporary increased flow rates in both the Fill Aquifer and the Estuarine Aquifer, which have potential to temporarily increase the flux of contamination. The increases would be short term and have a lesser impact to the dredging discussed above, and would be undertaken in smaller stages and incrementally over a longer period.

Detailed assessment of the potential impacts of preloading and capping on groundwater levels are presented in Figure 24 to Figure 28.

The additional flow from preloading comes from water squeezed out of the pore spaces of compressible fine grained silt / clay soils. The Clay Aquitard is the major stratum subject to the squeezing effect and this is generally not a source of contamination. The water squeezed from the Clay Aquitard temporarily adds to the flow rates in the Fill and Estuarine Aquifers, however does not provide a source of contamination. The increased flow rates may, however, have an effect on the mobility of contamination already present in the Fill and Estuarine Aquifers, in a similar manner to the dredging.

The volumes of water expelled by the preloading process are typically in the range of about 0.55 m^3/m^2 to 0.70 m^3/m^2. Recharge rates on site, with the exception of existing capped areas such as Pond 5 and the FDF (the latter having a partial informal 'cap' due to cement-modified sediment being placed), are estimated to typically range from about 20% to 50% of annual rainfall (about 0.22 m to 0.33 m/yr). Consequently the preloading represents about two to three years' annual recharge rates, which is generally distributed about one-third to the Estuarine Aquifer and two-thirds to the Fill Aquifer. The preloading flows occur over three separate stages, each of which occur over less than one-third of the T4 Project area, and less again compared to the groundwater recharge catchment.

The above results in overall increases in flow distances in the Estuarine Aquifer equivalent to about 1 year's flow for the preloading as a whole. The Estuarine Aquifer groundwater travel time for groundwater to the Hunter River is estimated to be about 50 years, and therefore any increase mobility of existing contamination due to increased flow rates from preloading are considered to be insignificant.

For the Fill Aquifer, where flow paths to receptors are shorter, such temporary increases in flow rate can be more significant in places. In some areas, the fill contains substantial fines which also contain elevated concentrations of contaminants, specifically, Ponds 5 and 7, as well as the FDF. In these areas, preloading does result in squeezing of contaminated material, however, transport of contamination is limited by the leachability of the source contaminants into the expelled water. The potential for contaminant transport under construction conditions has been assessed in detail in Section 11.3.6, the results of which are summarised in Sections 12.8 and 12.9.

As can be seen from Figure 24 to Figure 28, the proposed capping of the site has significant impacts on groundwater levels and therefore flow rates and flux of existing contamination from the site. Overall the final capping of the T4 Project is more extensive that the proposed HDC capping. Therefore the long term water levels and flow rates, and the ongoing flux of existing contaminants, is predicted to be similar or less than without the T4 Project.

With appropriate mitigations in the areas of Ponds 5/7, lead dust disposal area, FDF and free phase product in Area B, the long term risks to ecological and human health are expected to be similar to the base case of no T4 development.

12.8 Site D – Former FDF

The FDF on Site D has been identified as an area of potential concern with regard to existing contamination (Ref 23). The FDF contains metals and PAHs with leachable concentrations above ANZECC criteria (Ref 3). Leachate is currently collected using a leachate collection system constructed at the base of the FDF prior to filling. Settlement of the FDF due to preloading is expected to lower the existing filling by about 0.5 m to 1.0 m and may also affect the performance of the existing leachate collection system. This has the potential to lead to increased leaching of contamination into the environment. Potential receptors include the OEH Wetlands and the North Arm of the Hunter River.

The results of contaminant transport modelling indicate that if the leachate collection system fails there is potential for leaching of groundwater with metal and PAH concentrations exceeding ANZECC criteria into the OEH Wetlands to the near north. The modelling also indicates that impacts on the Estuarine Aquifer and North Arm of the Hunter River would be limited by the presence of the Unit 2 Clay, which provides a barrier to transport of contamination, with only Aluminium expected to reach the North Arm of the Hunter River at concentrations exceeding ANZECC criteria (Ref 3).

Potential suitable mitigation measures could include the following:

- Place a low permeability cap over the site during the Stage 1 of the development to prevent high recharge occurring into the dredged sand filling;
- Design preload to minimise differential settlement with the aim of maintaining the integrity of the existing leachate collection system;
- Install a permeable reactive barrier (PRB) to ‘treat’ any leachate flowing from the FDF without altering the groundwater flow regime; or
- Install a leachate collection system in the Fill Aquifer, comprising a deep drain or line of wells, penetrating into the sand base layer below the FDF to allow collection of leachate in a similar manner to the existing system and preventing it from reaching the OEH Wetlands to the north.

Table 34 provides a comparison of the potential impacts associated with the transport of contamination from the FDF toward sensitive receptors, compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 34: Comparison of Potential Impacts from Leaching of Contamination from FDF

Potential Impact	No-Development	Base Development without Mitigation Measures	Mitigation Measure	Predicted Impact following Mitigation
Dredging: Increased flows in Fill Aquifer	Current leachate collection system maintains groundwater levels at about RL 1.6 NHTG	The existing leachate collection system is expected to remain operational for the dredging, which involves fill heights of only about 2 m in this location. Therefore the leachate collection system is expected to collect leachate from the dredging process in a similar manner to previous occurrences.	Not applicable	Similar to pre development
Preloading leads to lower waste becoming saturated below water table and leaching of contaminants	Existing groundwater concentrations in Fill Aquifer at FDF indicates some existing contamination with NH_4, Cu, Ni, Zn, Hg and Benzo(a)Pyrene above ANZECC criteria	Limited additional impact if leachate collection system continues to operate	Not applicable	Not applicable
Preloading leads to failure of leachate collection system – Impacts on OEH Wetland	As above	Groundwater levels could rise to RL 6 NHTG until all stages are subject to capping, with associated increased offsite migration of contamination. CONSIM modelling indicates mean concentrations in Fill Aquifer in excess of ANZECC criteria at OEH Wetland 3 within 10 years for Al, Cr, Cu, Pb, Zn, Hg, Anthracene and Benzo(a) pyrene	Capping of future stages following completion of dredging	Concentrations reaching OEH Wetland still exceed ANZECC criteria, however at substantially lower concentrations
			Design preload to minimise potential impact on leachate collection system	Limited additional impact if used in conjunction with early capping
			Installation of PRB or Leachate collection trench to north of FDF to replace leachate collection system	Detailed design to limit concentrations below ANZECC criteria or background levels. Would be more effective in conjunction with capping
Preloading leads to failure of leachate collection system Transport of contamination from FDF through clay aquitard and towards north arm of Hunter River though Estuarine Aquifer.	Head in Estuarine Aquifer is higher than in fill due to leachate collection system and therefore downwards flow and associated impact is unlikely. Background concentrations of many metals already exceed ANZECC criteria. These may be naturally occurring concentrations.	CONSIM modelling indicates only contaminant of concern is Aluminium, which could reach the river in excess of ANZECC criteria, however at similar concentrations to background.	Design preload to minimise potential impact on leachate collection system Install drain to replace leachate collection	Limited impact if in conjunction with early capping.

12.9 Pond 5/7 within Site A

Pond 5 and part of Pond 7, which contain tar waste with high concentrations of PAHs, have been identified as areas of potential concern with regard to existing contamination (Ref 23). The ponds contain tar waste with high concentrations of PAHs.

The results of contaminant transport modelling indicates that with no development occurring and capping of the site as proposed by HDC, there is a potential for leaching of PAHs, in excess of ANZECC criteria over time for both the 50th and upper 95th percentile predicted concentrations, with potential receptors being Deep Pond, Blue Billed Duck Pond and Easement Pond. Modelling indicates that dredging and preloading would lead to faster transport of these contaminants towards the receptors and concentrations typically slightly higher, but up to twice as high for Naphthalene, at the receptors at the completion of dredging and preloading.

Existing groundwater quality in the Estuarine Aquifer below Ponds 5/7 indicated PAH concentrations generally below detection limits with the exception of a small number of positive results. As PAHs are not expected to be present in natural background conditions this suggests that some transport of PAHs is occurring into the Estuarine Aquifer, probably through localised thinner areas of Unit 2 Clay. The results of contaminant transport modelling indicates that the 50th percentile concentrations that would reach the Hunter River are less than ANZECC, however the upper 95th percentile concentrations exceed ANZECC and the background concentrations in the Hunter River. This does not account for potential biodegradation of the PAHs, which is quite likely to lead to attenuation of the PAHs prior to reaching the river.

The impact from increased short term flow rates due to dredging and preloading would be insignificant over the long term taking into account the distance to the Hunter River.

- Potential suitable mitigation measures are discussed in the Remediation Options Report (Ref 26).

Table 35 provides a comparison of the potential impacts of transport of PAH contamination from Ponds 5/7 toward sensitive receptors, compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 35: Comparison of Potential Impacts from Pond 5/7 PAH Contamination

Potential Impact	No-Development	Base Development without Mitigation measures	Mitigation Measure	Predicted Impact following Mitigation
Dredging: Increased flows in Fill Aquifer below Ponds 5/7.	Heads of 3.5 to 4.5 NHTG in Pond 5 and 3.5 to 6.0 NHTG in Pond 7. Seepage rates in range 0.2 m/year to about 40 m/year.	Head in Ponds 5 and 7 increase to about 8 to 9 NHTG for a period of about 10 months. Seepage flow rates increase to about 0.3 m to 150 m/year, resulting in an additional travel distance of up to about 300 m, about 28 years additional flow distance. See below for contaminant transport impacts.	Divert dredge water to north of Ponds 5 to 8 and place dry sand in these areas	Similar to pre development
Preloading: Increased flows in Fill Aquifer below Ponds 5/7.	As above	Similar increase in flow rates to dredging, however over shorter period. See below for contaminant transport impacts.	See below	See below
Capping of Site – reduced flows in Fill Aquifer	Heads are reduced to less than about 3 m NHTG	Development capping is to be at least as effective as proposed HDC cap, leading to similar reduction in flows in the long term. Capping of site will occur incrementally.	Not applicable	Similar or lesser long term impacts to no development case
Transport of PAH contamination from Ponds 5/7 towards OEH Wetlands and/or BHPB Wetlands	50th percentile and 95th percentile concentrations above ANZECC at potential receptors	50th percentile and 95th percentile concentrations typically slightly above those predicted for no development case (with exception of Naphthalene which is about twice) due to short term flow impacts from dredging and preloading, however still well above ANZECC.	Refer to the Assessment of Remediation Options report	Refer to Assessment of Remediation Options report
Dredging: Increased flows in Estuarine Aquifer.	Head under Site C in Estuarine Aquifer of 2.1 NHTG Hydraulic gradient up to about 0.0004 and seepage flow rates of about 15 m/year.	Head under Site C in Estuarine Aquifer of RL 3.7 NHTG Hydraulic gradient up to about 0.0015 and seepage flow rates of about 40m/year for 2 years, equivalent to an additional 5 years flow distance, which is insignificant compared to the overall travel time to the North Arm of the Hunter River of about 50 years.	Low permeability liner at base of Site C	Head under Site C in Estuarine Aquifer of RL 3.0 NHTG Hydraulic gradient up to about 0.001 and seepage flow rates of about 40 m/year for 10 months, equivalent to an additional 1.25 years flow distance.

Table 35: Comparison of Potential Impacts from Pond 5/7 PAH Contamination (Continued)

Potential Impact	No-Development	Base Development without Mitigation Measures	Mitigation Measure	Predicted Impact following Mitigation
Preloading: Increased flows in Estuarine Aquifer.	As for dredging case.	Similar increase in flow rates to dredging, however over shorter period.	Barrier Wall around Ponds 5/7	Minimal Flow from Ponds 5/7, much less than pre-development.
Capping of Site – reduced flows in Estuarine Aquifer	Final capped hydraulic gradients of about 0.0003 with flows of about 10 m/year	Development capping is to be at least as effective as proposed HDC cap, leading to similar reduction in flows in the long term.	Not applicable	Similar or lesser long term impacts to no development case
Transport of PAH contamination from Ponds 5/7 through clay aquitard and towards north arm of Hunter River though Estuarine Aquifer.	50th Percentile Concentrations at Nth Arm Hunter River generally less than ANZECC after 1000 years. 95Th percentile concentrations Exceed ANZECC at 1000 years	Based on flow modelling above short term incremental increase in flow during construction will have insignificant impact on potential impacts over long term compared to no development case	Refer to Assessment of Remediation Options report	Detailed design to limit concentrations below ANZECC criteria or background levels

12.10 Lead Dust in Asbestos Disposal Area

As detailed in the Contamination Assessment report (Ref 22) lead dust is known to be buried in the asbestos disposal area. The base of the lead dust is estimated to range from about RL 1.7 to RL 5.8 NHTG. Settlement due to the placement of dredged fill and preloading is expected to lead to settlement in the range 0.85 m to 1.3 m and which would lead to the base of the lead dust being in the range RL 0.86 to RL 4.6 NHTG.

Typical water levels pre-development are in the range RL 2.5 to 3.0 NHTG. Therefore the lead dust material is mostly above the existing water table.

Water levels during dredging and preloading are expected to increase up to about RL 9 NHTG to 10 NHTG which would fully inundate the buried lead dust. Following construction and capping, water levels could be expected to typically drop to about RL 1.5 to 2.5 NHTG, however this may still result in some lead dust material being permanently inundated as due to settlement it would be at a lower level than pre development.

It is understood the lead dust was buried in polyethylene bags, however it cannot be assumed that the bags will continue to remain water-tight, or that the bags are or won't become ruptured during loading and/or settlement. There are no chemical data relating to the lead dust and therefore no quantitative modelling was undertaken on the potential for leaching. However as the lead is in the form of a fine grained 'dust' the propensity for the materials to leach is considered to be higher, therefore leachable lead concentrations may exceed the relevant ANZECC criteria during and post construction. The pathway for such leachate would be towards the OEH Wetlands to the north of the rail line.

The preferred mitigation measures include the following:

- Permeable reactive barrier (PRB);
- Upstream barrier wall and/or cap.

Table 36 provides a comparison of the potential impacts associated with the transport of contamination from the lead dust toward sensitive receptors, compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 36: Comparison of Potential Impacts from Lead Dust Contamination

Potential Impact	No-Development	Base Development without Mitigation measures	Mitigation Measure	Predicted Impact following Mitigation
Dredging: Saturation of contaminated material and leaching of lead contamination towards Wetlands to the north.	Heads of 2.5 to 3.0 NHTG, generally below the level of lead dust which is at RL 1.7 to 5.8 NHTG. (No HDC capping is proposed in this area)	Heads increase to about 9 to 10 NHTG for a period of about 2 years	Permeable Reactive Barrier	Detailed design to limit lead concentrations below ANZECC criteria or background levels
Preloading: Increased flows in Fill Aquifer below Ponds 5/7.	As above	Similar increase in flow rates to dredging, however over shorter period. See below for contaminant transport impacts.	As above	As above
Settlement: Reducing levels and leading to saturation of contaminated material	As above	Base level of material may be reduced from about RL 0.86 m to RL 4.6 m.	As above	As above
Long term capping of Site – reduced water levels	As above	Groundwater heads are reduced to less than about 1.5 to 2.0 m NHTG , however some saturation and leaching of lead could still occur. Probably similar to pre-development situation.	As above	As above

12.11 Free Phase Contamination at Site B North

Non-aqueous phase liquid (NAPL) hydrocarbon impact was encountered in groundwater collected from the upper aquifer monitoring well B-01-U. The source and extent of the contamination associated with B-01-U was subsequently further investigated to assess the extent of impact and possible implications to T4 Project development. More detail on the extent of contamination and implications is described in Section 10 of the Contamination Assessment Report (Ref 23). Drawing 5.02 shows the location of bore B-01-U.

The remediation strategy for this area is likely to comprise source removal and treatment. This approach is consistent with OEH policy which suggests that such contamination should be removed or treated as much as practicable. Following removal/treatment of the NAPL the risk to the environment would be substantially reduced.

Further details are presented in the Remediation Options report (Ref 26).

Table 37 provides a comparison of the potential impacts associated with the transport of contamination from the free phase contamination toward sensitive receptors, compared to the potential future impacts without the proposed development, as well as the likely reduction in impacts associated with various mitigation measures.

Table 37: Comparison of Potential Impacts from Free Phase Contamination

Potential Impact	No-Development	Base Development without Mitigation measures	Mitigation Measure	Predicted Impact following Mitigation
Dredging:	Not applicable	No impacts on this part of site from dredging	Not applicable	Not applicable
Preloading:	Not applicable	No impacts on this part of site from preloading	Not applicable	Not applicable
Transport of Free Phase contamination	Potential risk to receptors including Long Pond and South Arm Hunter River.	No specific development proposed in this area.	Removal and treatment of source	Detailed Design to limit concentrations below ANZECC criteria or background levels
Capping of Site – reduced groundwater levels	Heads are reduced from about RL 5 to RL 3 NHTG	Placement of HDC cap will lead to reduction in flows in the long term. .	Not applicable	Further reduction in risk

12.12 Penetration of Unit 2 Aquitard

Penetration of the Unit 2 aquitard has the potential to lead to vertical flows from the Fill Aquifer, which is generally more contaminated, to the Estuarine Aquifer. This could also lead to increased overall flow rates in the underlying Estuarine Aquifer leading to increased flux of existing contamination. Penetrations of the Unit 2 aquitard would be required for construction of the Dump Station as well as for areas where ground improvement by conventional preloading is not practical.

Dump stations which penetrate into the Estuarine Aquifer can be designed and constructed using diaphragm walls and jet grout floors to prevent and actual hydraulic connection between the aquifers. Similarly piles, founding in the Estuarine Aquifer would not be expected to lead to a significant permanent hydraulic connection between the aquifers.

The use of stone columns, wick drains or dynamic replacement would be expected to lead to a significant and permanent connection between the aquifers and are therefore not proposed to be used at this stage. Deep soil mixing may be used in specific areas and is expected to only slightly impact on soil permeability and therefore would be expected to have only minor impacts on the groundwater flow regime.

Mitigation measures would be required to prevent a permeable connection of the aquifers due to the penetrations. These could include:

- Use of diaphragm wall and jet grouted floor for Dump Station which would prevent hydraulic connection during construction and subsequent operation;
- Use of deep soil mixing for ground improvement where preload is not practical, as this leaves the clay in-situ as opposed to alternatives such as stone column, dynamic replacement or wick drains, which would leave a permanent permeable connection between the aquifers.

12.13 Excavations and Dewatering

Excavations associated with construction of the Dump Station as well as various proposed pipelines would potentially require dewatering. Dewatering has the potential to lead to drawdown of groundwater levels outside the excavations, which could have impacts on any nearby sensitive habitats. Such effects would generally be short term and localised.

It is proposed to construct the relocated gas main using horizontal directional drilling techniques, with localised open cuts at pipeline tie-ins. The relocated water main is proposed to be constructed using open trench techniques. Such excavations will be likely to extend below the water table and therefore some form of groundwater control will be required during the construction works to prevent the excavations filling with water.

For short term excavations in clay soils (Unit 2 Clay Aquitard), such as would be expected for the new gas and water lines, groundwater inflows will be limited and can generally be controlled using sheet pile walling, together with sump and pump dewatering. In this case impacts on groundwater levels over the short period required for installation of the pipes would be expected to be minimal.

For excavations in permeable filling, the use of spear point dewatering may be required due to the potentially higher flow rates. Based on conventional dewatering with spears installed at 2 m intervals, flow rates could range up to about 50 m^3/day per metre of open trench, and the open trench length would typically be limited to about 50 m or less (2500 m^3/day). Such flow rates, and impacts on surrounding groundwater levels can be reduced by the use of sheet pile walls driven to the depth of the underlying Clay Aquitard and/or re-injection of the abstracted water. In this instance the dewatering could be controlled by sump and pump methods and flow rates may be about 10% of those used for conventional dewatering Drawdowns would be localised, with the majority of drawdown occurring within the sheet pile walls and with minor drawdown immediately adjacent to the walls.

For the Dump Station, which will be excavated through the clay aquitard and into the Estuarine Aquifer, conventional methods of construction would involve the installation of dewatering wells and abstraction of significant volumes of groundwater to achieve the required depth of dewatering. Based on previous experience flow rates for conventional dewatering of a dump station could range up to about 20,000 m^3/day. Such conventional dewatering would lead to significant drawdown of surrounding groundwater levels with potential impacts on any adjacent sensitive habitats. Construction using diaphragm walls with either a jet grout floor or walls keyed into the deep clay, however, result in the excavation being sealed off and would require only removal of water contained inside the sealed structure, thereby significantly reducing the volume of water removed and minimising impacts on groundwater levels outside of the sealed Dump Station excavations. Based on previous experience flow rates for dewatering following jet grouting could range up to about 10 m^3/day). Drawdowns outside the dump station walls would be expected to be negligible.

Flow rates estimates are approximate and would require confirmation as part of detailed design.

Mitigations measures could include:

- Dump Station: use of diaphragm wall with either a jet grouted floor or walls keyed into the deep clay, which only requires internal dewatering of the sealed structure and reduces impacts on adjacent groundwater levels;
- Pipeline excavations: use of horizontal directional drilling which requires no or only localised excavations at entry and exit points; and
- General excavations: use of sheet pile walls founded in the Clay Aquitard material.

Subject to appropriate detailed design and implementation of the above mitigations, impacts on the adjacent wetlands would be expected to be minimal.

13. Conclusions

The groundwater assessment and numerical modelling has identified a number of groundwater related matters which can be suitably managed by implementing appropriate mitigation measures during staged construction of the T4 Project. The following groundwater issues were identified:

- Potential salinity impacts both on and off-site due to dredging;
- Potential mobilisation of contaminants and groundwater interactions at the former Delta EMD site during the dredging phase;
- Changes to water levels in the wetlands west and north of the T4 Project area;
- Changes to water levels and flow rates due to filling, preloading and subsequent capping the site;
- Potential groundwater impact associated with tar waste in Pond 5;
- Lead dust co-disposed with asbestos could come into contact with groundwater due to settlement under the T4 Project load;
- Free phase oil contamination at Bore B-01 in Site B;

- Potential mobilisation of contaminants (mainly hydrocarbons and metals) at the Fines Disposal Facility associated with settlement under the T4 load and a rise in the water table;
- Groundwater interactions and potential contaminant pathways where the clay aquitard is penetrated by development; and
- Groundwater drawdown due to dewatering of excavations.

These groundwater issues would require appropriate management to mitigate the impacts on the environment, which have been assessed in conjunction with the Contamination Assessment (Ref 23).

The groundwater modelling has assessed the risks of off-site migration of contaminants during and following construction, and compared them to the "no development" case. The Contamination and Groundwater Reports provided the basis for the assessment and selection of suitable mitigation measures and management strategies for the T4 Project, which are presented in the Remediation Options Report (Ref 26).

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15. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for the T4 Project at Kooragang Island in accordance with DP's proposal NCL100317 Rev 1 dated 26 July 2010 and Consultancy Agreement with PWCS dated 4 August 2010. The report is provided for the exclusive use of Port Waratah Coal Services Limited for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in soil conditions between sampling locations. The advice may also be limited by constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

Douglas Partners Pty Ltd

Appendix A

About this Report
Geotechnical Data Summary

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

T4 GEOTECHNICAL DATA SUMMARY

Project 49533.02

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
49533.02	A-01	Bore	368482.81	1362121.27	4.14	S-U	5.10	NHTG	47.60	Sandstone: Extremely Low Str	2.90	2.90	10.00	10.00	16.30	47.45	2.84				1.24	1.24	-5.86	7.10	-5.86	-12.16	-43.31	2.25	
49533.02	A-02-L	Bore	368482.71	1361888.44	8.80	E-L	9.31	NHTG	14.95	Sand: dense	8.30	8.30	11.60	11.60	>14.95	>14.95		7.28			0.50	0.50	-2.80	3.30	-2.80	-	-		2.03
49533.02	A-02-U	Bore	368483.72	1361888.92	8.90	E-U	9.62	NHTG	8.20	Fill: Black Sandy Clay	8.30	8.30	11.60	11.60	>14.95	>14.95	4.23				0.60	0.60	-2.70	3.30	-2.70	-	-	5.39	
49533.02	A-03	Bore	369115.91	1361870.48	7.94	S-L	8.73	NHTG	79.05	Shale: Extremely Low Strength	6.50	6.50	10.30	10.30	35.10	77.60		6.64			1.44	1.44	-2.36	3.80	-2.36	-27.16	-69.66		2.09
49533.02	A-04-L	Bore	368915.46	1361816.43	8.83	E-L	10.02	NHTG	14.95	Sand: Dense to very dense	7.70	7.70	11.50	11.50	>14.95	>14.95		7.95			1.13	1.13	-2.67	3.80	-2.67	-	-		2.06
49533.02	A-04A-U	Bore	368914.84	1361817.62	8.78	E-U	9.69	NHTG	7.50	Fill: Light grey clayey silt	>7.70	>7.70	>7.70	>7.70	>7.70	>7.70	5.38				-	-	-	-	-	-	-	4.31	
49533.02	A-05-L	Bore	368232.49	1361801.02	6.71	E-L	7.24	NHTG	51.70	Shale: Extremely Low Strength	6.50	6.50	9.50	9.50	16.20	50.00		5.32			0.21	0.21	-2.79	3.00	-2.79	-9.49	-43.29		1.92
49533.02	A-05-U	Bore	368232.12	1361802.44	6.71	E-U	7.35	NHTG	7.00	Clay: Firm	6.50	6.50	>7.00	>7.00	>7.00	>7.00	4.09				0.21	0.21	-	-		-	-	3.26	
49533.02	A-06-U	Bore	368460.82	1361732.69	8.86	E-U	9.85	NHTG	9.00	Clay/Filling: Dark grey	8.00	8.00	>9.00	>9.00	>9.00	>9.00	6.29				0.86	0.86	-	-		-	-	3.56	
49533.02	A-06-L	Bore	368441.75	1361740.25	8.01	E-L	9.38	NHTG	14.95	Sand: medium dense	8.20	8.20	9.60	9.60	>14.95	>14.95		7.30			-0.19	-0.19	-1.59	1.40	-1.59	-	-		2.07
49533.02	A-06-D	Bore	368463.98	1361743.42	9.02	E-D	9.85	NHTG	38.95	Silty Clay: Stiff	8.00	8.00	9.70	9.70	36.70	>38.95				7.51	1.02	1.02	-0.68	1.70	-0.68		-		
49533.02	A-07	Bore	368606.57	1361681.82	9.33	E-L	10.17	NHTG	14.95	Sand: Very Dense	8.10	8.10	11.00	11.00	>14.95	>14.95					1.23	1.23	-1.67	2.90	-1.67	-	-		
49533.02	A-07A	Bore	368606.46	1361680.61	9.31	E-U	10.49	NHTG	7.80	Fill:Dk grey/black silty clay	>7.80	>7.80	>7.80	>7.80	>7.80	>7.80					-	-	-	-	-	-	-		
49533.02	A-08	Bore	368115.90	1361746.04	8.57	S-U	9.63	NHTG	14.95	Sand: Dense	9.40	9.40	11.30	11.30	>14.95	>14.95	4.64				-0.83	-0.83	-2.73	1.90	-2.73	-	-	4.99	
49533.02	A-09-L	Bore	368380.88	1361516.62	8.56	E-L	9.45	NHTG	14.95	Sand: medium dense	6.40	6.40	8.50	8.50	>14.95	>14.95		7.40			2.16	2.16	0.06	2.10	0.06	-	-		2.05
49533.02	A-09-U	Bore	368381.69	1361517.06	8.53	E-U	9.51	NHTG	7.50	Sandy Clay: Soft	6.40	6.40	>7.50	>7.50	>7.50	>7.50	5.22				2.13	2.13	-	-		-	-	4.29	
49533.02	A-09-D	Bore	368382.60	1361520.08	8.68	E-D	9.64	NHTG	41.50	Silty Clay: Stiff	7.65	7.65	9.00	9.00	39.50	>39.5				7.98	1.03	1.03					-		
49533.02	A-10	Test Pit	367620.78	1361791.41	4.50			NHTG	2.40	Fill: Dark Brown sandy gravel	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-10	CPT	367622.40	1361796.33	4.63			NHTG	38.50	Silty Clay/Clayey Sand: Hard	6.10	2.03	6.10	13.30	28.42	>38.50					-1.47	2.60	-1.47	4.07	-8.67	-23.79	-		
49533.02	A-11	Bore	368312.61	1361394.14	9.08	S-U	9.72	NHTG	51.63	Shale: Extremely Low Strength	6.50	6.50	9.10	9.10	17.00	51.25	7.23				2.58	2.58	-0.02	2.60	-0.02	-7.92	-42.17	2.49	
49533.02	A-12	CPT	368453.99	1361350.77	8.78			NHTG	20.00	Clay:Very stiff to hard	6.20	6.20	7.64	7.64	>20.00	>20.00					2.58	2.58	1.14	1.44	1.14	-	-		
49533.02	A-13	Test Pit	367673.15	1361860.53	4.74	NA		NHTG	3.00	Fill: Light grey gravelly sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-14	Bore	368229.70	1361275.90	9.27	S-U	10.26	NHTG	14.95	Sand:loose to medium dense	7.35	7.35	8.40	8.40	>14.95	>14.95	5.23				1.92	1.92	0.87	1.05	0.87	-	-	5.03	
49533.02	A-15	CPT	368094.18	1361424.04	8.70			NHTG	15.00	Sand: Medium dense to dense	6.90	6.90	8.70	8.70	>15.00	>15.00					1.80	1.80	0.00	1.80	0.00	-	-		
49533.02	A-16	Bore	367981.34	1361495.31	8.37		8.97	NHTG	14.95	Sand: Dense	6.50	6.50	9.20	9.20	>14.95	>14.95					1.87	1.87	-0.83	2.70	-0.83	-	-		
49533.02	A-17	Bore	367795.40	1361486.15	6.16	S-U	7.12	NHTG	14.95	Sand: Medium dense to dense	4.50	4.50	5.30	5.30	>14.95	>14.95	4.85				1.66	1.66	0.86	0.80	0.86	-	-	2.27	
49533.02	A-18-L	Bore	367627.62	1361699.21	5.52	E-L	6.51	NHTG	17.95	Sand: Dense	3.80	3.80	11.70	11.70	>17.95	>17.95		4.70			1.72	1.72	-6.18	7.90	-6.18	-	-		1.81
49533.02	A-18-U	CPT	367628.16	1361700.17	5.50	E-U	6.44	NHTG	11.00	Clay: Firm	3.40	3.40	5.95	5.95	6.20	>11.00	3.85				2.10	2.10	-0.45	2.55	-0.45	-0.70	-	2.59	
49533.02	A-19	Bore	367725.63	1361778.69	5.15	S-L	5.78	NHTG	48.07	Shale: Medium Strength	6.40	6.40	12.80	14.80	18.80	45.90		3.96			-1.25	-1.25	-7.65	6.40	-9.65	-13.65	-40.75		1.81
49533.02	A-20	CPTu	367838.70	1362117.20	0.80			AHD	30.00	Clay: Very stiff to Hard	1.00	1.00	14.50	21.60	14.50	>30.00					0.81	0.81	-12.69	13.50	-19.79	-12.69	-		
49533.02	A-21	Test Pit	368771.40	1361997.56	8.14			NHTG	2.80	Fill: Grey, Sandy silt (Ash)	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-21	CPTu	368768.99	1362001.45	7.87			NHTG	20.00	Sand: Medium dense to dense	7.50	7.50	10.50	10.50	>20.00	>20.00					0.37	0.37	-2.63	3.00	-2.63	-	-		
49533.02	A-22	Test Pit	369086.89	1361923.60	8.19	NA		NHTG	3.10	Fill: Grey sandy silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-23	Test Pit	368649.83	1362008.19	7.77	NA		NHTG	2.60	Fill: dark brown coal reject	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-24	Test Pit	368847.49	1361869.48	9.38	NA		NHTG	2.60	Fill: grey/black sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-25	Test Pit	368646.59	1361922.63	3.73	NA		NHTG	1.60	Fill: silty clay	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-25	CPTu	368646.59	1361922.63	3.73	NA		NHTG	30.00	Clay: Very stiff to Hard	2.70	2.70	7.80	9.90	17.00	>30.00					1.03	1.03	-4.07	5.10	-6.17	-13.27	-		
49533.02	A-26	Test Pit	368294.38	1361907.64	7.84	NA		NHTG	2.65	Fill: dark grey/black clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-27	Test Pit	368371.22	1361838.50	7.29	NA		NHTG	1.60	Fill: Grey brown slag and coal fines	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-27	CPT	368371.22	1361838.50	7.29	NA		NHTG	22.00	Sand: Medium Dense	6.30	6.30	9.13	9.13	18.78	>22.00					0.99	0.99	-1.84	2.83	-1.84	-11.49	-		
49533.02	A-28	Test Pit	368537.65	1361879.38	8.93	NA		NHTG	3.10	Fill: dark grey/black clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-29	Test Pit	368694.33	1361820.93	4.73	NA		NHTG	2.50	Fill: dark grey gravelly	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-29	CPTu	368694.33	1361820.93	4.73	NA		NHTG	15.00	Sand: Medium Dense	3.10	3.10	11.34	11.34	>15.00	>15.00					1.63	1.63	-6.61	8.24	-6.61	-	-		
49533.02	A-30	Test Pit	368526.19	1361742.27	9.22			NHTG	3.10	Fill: dark grey/black, clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-30	CPT	368526.19	1361742.27	9.22			NHTG	30.00	Sand: Medium Dense	8.00	8.00	10.13	10.13	21.00	>30.00					1.22	1.22	-0.91	2.13	-0.91	-11.78	-		
49533.02	A-31	Test Pit	368117.44	1361704.92	8.76			NHTG	3.00	Fill: dark red-brown, clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-31	CPTu	368117.44	1361704.92	8.76			NHTG	44.45	Clay: Very stiff to Hard	7.20	7.20	11.10	11.10	20.45	>44.54					1.56	1.56	-2.34	3.90	-2.34	-11.69	-		
49533.02	A-32	Test Pit	368312.62	1361676.24	7.19			NHTG	2.00	Fill: grey/brown slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-32	CPT	368312.62	1361676.24	7.19			NHTG	30.00	Sand: Loose to Medium Dense	5.80	5.80	8.90	8.90	>30.00	>30.00					1.39	1.39	-1.71	3.10	-1.71	-	-		
49533.02	A-33	Test Pit	368621.52	1361567.59	5.11			NHTG	1.80	Fill: grey slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-33	CPTu	368621.52	1361567.59	5.11			NHTG	15.00	Sand: Medium dense to dense	3.40	3.40	5.90	5.90	>15.00	>15.00					1.71	1.71	-0.79	2.50	-0.79	-	-		
49533.02	A-34	Test Pit	368016.56	1361644.04	8.39			NHTG	3.20	Fill grey sand and general rubbish	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-34	CPT	368016.56	1361644.04	8.39			NHTG	20.00	Sand: Medium dense to dense	6.05	6.05	9.90	9.90	>20.00	>20.00					2.34	2.34	-1.51	3.85	-1.51	-	-		
49533.02	A-35	Test Pit	367738.87	1361870.78	4.57			NHTG	3.00	Fill: brown clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-35	CPT	367738.87	1361870.78	4.57			NHTG	20.00	Clay:Stiff to Very Stiff	2.90	8.80	15.50	7.60	15.50	>20.00					1.67	-4.23	-10.93	6.70	-3.03	-10.93	-		
49533.02	A-36	Test Pit	368083.26	1361510.58	8.69			NHTG	2.90	Fill: light grey ash	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-36	CPTu	368083.26	1361510.58	8.69			NHTG	30.00	Clay: Stiff to Very Stiff	5.60	5.60	11.00	11.00	22.10	>30.00					3.09	3.09	-2.31	5.40	-2.31	-13.41	-		
49533.02	A-37	Test Pit	368211.31	1361527.67	8.96			NHTG	0.75	Fill: light brown and grey slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-37	CPT	368211.31	1361527.67	8.96			NHTG	18.00	Sand: Medium Dense	6.00	6.00	10.30	10.30	>18.00	>18.00					2.96	2.96	-1.34	4.30	-1.34	-	-		
49533.02	A-38	Test Pit	368447.01	1361487.02	8.77			NHTG	3.00	Fill: dark grey/black clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-39	Test Pit	368160.67	1361378.41	8.88			NHTG	1.55	Fill: grey/black, gravelly slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-40	Test Pit	367959.59	1361411.99	7.76			NHTG	3.10	Fill: coal reject and ash	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-40	CPT	367959.59	1361411.99	7.76			NHTG	52.70	Clay: Hard	6.10	6.10	8.50	10.60	19.40	52.00					1.66	1.66	-0.74	2.40	-2.84	-11.64	-44.24		
49533.02	A-41	Test Pit	368447.99	1361251.58	8.98			NHTG	1.20	Fill: grey-brown slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-41	CPTu	368446.58	1361244.59	9.04			NHTG	30.00	Sand: Medium Dense	4.90	4.90	7.90	7.90	>30.00	>30.00					4.14	4.14	1.14	3.00	1.14	-	-		
49533.02	A-42	Test Pit	367548.00	1361697.00	4.21			NHTG	2.50	Fill: sandy slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	A-42	CPT	367548.00	1361697.00	4.21			NHTG	22.00	Clay: Firm to Very Stiff	7.00	7.00	10.00	10.00	15.10	>22.00					-2.79	-2.79	-5.79	3.00	-5.79	-10.89	-		
49533.02	A-43	CPTu	367805.00	1361714.00	1.79			NHTG	9.63	Sand: Loose to Medium Dense	NE	0.00	5.60	5.60	>9.63	>9.63					-	1.79	-3.81	5.60	-3.81	-	-		
49533.02	A-43	Push Core	367805.00	1361714.00	1.79			NHTG	1.44	Silt: (Soft)	NE	0.00	>1.44	>1.44	>1.44	>1.44					-	1.79	-	-	-	-	-		
49533.02	A-44	CPTu	367891.00	1361681.00	1.78			NHTG	5.30	Sand: Loose to Dense	NE	0.00	4.15	4.15	>5.30	>5.30					-	1.78	-2.37	4.15	-2.37	-	-		
49533.02	A-44	Push Core	367891.00	1361681.00	1.78			NHTG	0.30	Silty Clay: (Firm to Stiff)	NE	0.00	>0.30	>0.30	>0.30	>0.30					-	1.78	-	-	-	-	-		
49533.02	A-45	CPTu	367967.00	1362098.00	1.57			NHTG	21.13	Silty Sand: loose	NE	0.00	13.14	20.52	>21.13	>21.13					-	1.57	-11.57	13.14	-18.95	-	-		
49533.02	A-45	Push Core	367967.00	1362098.00	1.57			NHTG	1.30	Sand	NE	0.00	0.30	0.30	>1.30	>1.30					-	1.57	1.27	0.30	1.27	-	-		
49533.02	A-46	CPTu	368197.00	1362098.00	1.67			NHTG	18.27	Clay: Stiff to Very Stiff	NE	0.00	15.21	NE	15.21	>18.27					-	1.67	-13.54	15.21	-	-13.54	-		
49533.02	A-46	Push Core	368197.00	1362098.00	1.67			NHTG	0.42	Silty Clay: (Soft)	NE	0.00	>0.42	>0.42	>0.42	>0.42					-	1.67	-	-	-	-	-		
49533.02	A-47	CPTu	367815.00	1361960.00	1.60			NHTG	22.00	Silty Clay: Stiff to Very Stiff	NE	0.00	15.20	NE	15.20	>22.00					-	1.60	-13.60	15.20	-	-13.60	-		
49533.02	A-47	Push Core	367815.00	1361960.00	1.60			NHTG	0.40	Sity Clay: (Soft to Firm)	NE	0.00	>0.40	>0.40	>0.40	>0.40					-	1.60	-	-	-	-	-		
49533.02	A-48	CPTu	368195.00	1361953.00	1.71			NHTG	19.15	Silty Clay: Stiff to Very Stiff	NE	0.00	9.30	9.30	12.43	>19.15					-	1.71	-7.59	9.30	-7.59	-10.72	-		
49533.02	A-48	Push Core	368195.00	1361953.00	1.71			NHTG	0.70	Silty Clay: (Soft)	NE	0.00	>0.70	>0.70	>0.70	>0.70					-	1.71	-	-	-	-	-		
49533.02	A-49	CPTu	368040.00	1361905.00	1.60			NHTG	10.33	Sand: Loose to Medium Dense	NE	2.00	9.85	9.85	>10.33	>10.33					-	-0.40	-8.25	7.85	-8.25	-	-		

Dark Red = entry aprroximate or unconfirmed

S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY

Project 49533.02

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
49533.02	A-49	Push Core	368040.00	1361905.00	1.60			NHTG	0.75	Clayey Sand	NE	0.00	0.30	>0.75	>0.75	>0.75					-	1.60	1.30	0.30	-	-	-		
49533.02	A-50	CPTu	367906.00	1361821.00	1.60			NHTG	11.54	Sand: Loose to Medium Dense	NE	0.00	9.80	9.80	>11.54	>11.54					-	1.60	-8.20	9.80	-8.20	-	-		
49533.02	A-50	Push Core	367906.00	1361821.00	1.60			NHTG	0.35	Silty Clay: (Firm)	NE	0.00	>0.35	>0.35	>0.35	>0.35					-	1.60	-	-	-	-	-		
49533.02	A-101	Bore	368627.08	1361662.32	4.85			NHTG	4.60	Silty Sand: Very Loose	2.50	3.40	3.70	3.70	NE	NE					2.35	1.45	1.15	0.30	1.15	-	-		
49533.02	A-102	Bore	368630.60	1361700.20	4.78			NHTG	4.00	Fill: Slag	4.00	NE	NE	NE	NE	NE					0.78	-	-	-	-				
49533.02	A-102A	Bore	368630.59	1361699.17	4.78			NHTG	4.45	Silty Clay: Very soft	2.50	2.50	NE	NE	NE	NE					2.28	2.28	-	-	-				
49533.02	A-103	Bore	368597.72	1361709.26	9.53			NHTG	5.70	Filling: Slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-				
49533.02	A-103A	Bore	368592.59	1361709.45	9.60			NHTG	9.30	Silty Clay: Very Soft	8.80	8.80	NE	NE	NE	NE					0.80	0.80	-	-	-				
49533.02	A-104	Bore	368541.55	1361739.12	9.14			NHTG	9.95	Clay: Soft	8.80	8.80	NE	NE	NE	NE					0.34	0.34	-	-	-				
49533.02	A-105	Bore	368474.68	1361763.78	9.05			NHTG	8.95	Clay: Very Soft	8.00	8.00	NE	NE	NE	NE					1.05	1.05	-	-	-				
49533.02	A-106	Bore	368437.82	1361767.30	8.43			NHTG	8.55	Silty Clay: Very Soft	7.25	7.25	NE	NE	NE	NE					1.18	1.18	-	-	-				
49533.02	A-107	Bore	368423.09	1361723.54	8.51			NHTG	8.00	Silty Clay: Soft	6.80	6.80	NE	NE	NE	NE					1.71	1.71	-	-	-				
49533.02	A-108	Bore	368474.24	1361812.73	9.01			NHTG	2.60	Fill: Slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-				
49533.02	A-108A	Bore	368465.00	1361821.00	9.07			NHTG	8.95	Silty Clay: Very Soft	8.50	8.50	NE	NE	NE	NE					0.57	0.57	-	-	-				
49533.02	A-109	Bore	368513.72	1361782.03	9.03			NHTG	4.00	Filling: Firm silty clay, PAH odour	NE	NE	NE	NE	NE	NE					-	-	-	-	-				
49533.02	A-110-U	Bore	368411.54	1361797.84	8.81	E-U	9.25	NHTG	8.50	Filling: Slag, coal fines	NE	NE	NE	NE	NE	NE			3.88		-	-	-	-	-			5.37	
49533.02	A-110-L	Bore	368411.15	1361798.77	8.82	E-L	9.29	NHTG	11.80	Silty Sand: Very loose	8.50	8.50	8.80	8.80	NA	NA				7.40	0.32	0.32	0.02	0.30	0.02				1.89
49533.02	A-111-U	Bore	368357.05	1361640.29	7.34	E-U	8.29	NHTG	7.20	Sandy Clay: Very soft	5.80	5.80	NE	NE	NE	NE			2.08		1.54	1.54	-	-	-			6.21	
49533.02	A-111-L	Bore	368358.59	1361643.51	7.26	E-L	7.88	NHTG	11.00	Sand: Very Loose	5.80	5.80	8.10	8.10	NE	NE				5.83	1.46	1.46	-0.84	2.30	-0.84				2.05
49533.02	A-112-U	Bore	368482.96	1361466.87	8.84	E-U	9.59	NHTG	7.20	Silty Clay: Soft	7.70	7.70	NE	NE	NE	NE			3.78		1.14	1.14	-	-	-			5.81	
49533.02	A-112-L	Bore	368483.61	1361465.48	8.82	E-L	9.42	NHTG	11.95	Sand: Loose	7.70	7.70	7.90	7.90	NE	NE				7.37	1.12	1.12	0.92	0.20	0.92				2.05
49533.02	A-113	Bore	368495.75	1361726.01	9.40			NHTG	9.40	Clayey Silty Sand	8.00	8.00	8.90	8.90	NE	NE					1.40	1.40	0.50	0.90	0.50				
49533.02	A-114	Bore	368598.17	1361736.15	9.48			NHTG	8.50	Silty Clay: Soft to firm	8.50	8.50	NE	NE	NE	NE					0.98	0.98	-	-	-				
49533.03	A-115-U	Bore	368517.00	1361814.67	8.67	E-U	9.68	NHTG	7.05	Sandy Clay: Soft	6.65	6.65	NE	NE	NE	NE			4.40		2.02	2.02	-	-	-			5.28	
49533.04	A-115-L	Bore	368516.83	1361813.54	8.70	E-L	9.63	NHTG	12.35	Snad/Shells: Very Loose	6.65	6.65	9.20	9.20	NE	NE				7.78	2.05	2.05	-0.50	2.55	-0.50				1.85
49533.02	B-01-L	Bore	368861.45	1361105.93	11.31	E-L	11.85	NHTG	14.95	Sand: Medium dense to dense	9.50	9.50	11.30	11.30	>14.95	>14.95		9.81			1.81	1.81	0.01	1.80	0.01	-	-		2.04
49533.02	B-01-U	Bore	368861.90	1361106.91	11.35	E-U	11.90	NHTG	9.20	Fill: Black Sand	>9.20	>9.20	>9.20	>9.20	>9.20	>9.20	6.68				-	-	-	-	-	-	-	5.21	
49533.02	B-02-L	Bore	369509.61	1360881.07	10.45	E-L	11.47	NHTG	15.00	Sand: Dense	9.00	9.00	9.80	9.80	>15.00	>15.00		9.77			1.45	1.45	0.65	0.80	0.65	-	-		1.70
49533.02	B-02-U	Bore	369507.00	1360881.09	10.56	E-U	11.44	NHTG	9.95	Sandy Clay: Firm to Stiff	9.00	9.00	>9.95	>9.95	>9.95	>9.95	9.19				1.56	1.56	-	-	-	-	-	2.25	
49533.02	B-03	CPTu	369860.98	1360834.86	4.90			NHTG	55.40	Clay: Stiff to Hard	2.75	2.75	5.30	5.30	28.15	54.70					2.15	2.15	-0.40	2.55	-0.40	-23.25	-49.80		
49533.02	B-04-L	Bore	368839.29	1360890.46	11.02	E-L	11.97	NHTG	19.45	Sand: Very Dense	9.00	NE	NE	10.70	>19.45	>19.45		10.13			2.02	-	-	-	0.32	-	-		1.84
49533.02	B-04-U	Bore	368836.03	1360888.70	10.93	E-U	11.78	NHTG	8.00	Fill: Slag	>8.00	>8.00	>8.00	>8.00	>8.00	>8.00	7.34				-	-	-	-	-	-	-	4.44	
49533.02	B-05	Test Pit	369495.43	1360775.90	3.65			NHTG	2.10	Fill: dark brown silty sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-06	CPT	369356.06	1360793.08	3.11			NHTG	51.26	Clay: Very stiff to Hard	1.90	1.90	2.60	2.60	19.20	51.00					1.21	1.21	0.51	0.70	0.51	-16.09	-47.89		
49533.02	B-07	Bore	369672.23	1360770.60	4.38	S-L	5.33	NHTG	14.95	Sand: Very Dense	2.80	NE	NE	4.30	>14.95	>14.95		3.74			1.58	-	-	-	0.08	-	-		1.59
49533.02	B-08	Test Pit	368717.74	1361096.21	11.51			NHTG	3.00	Fill: black silty sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-09	Test Pit	368980.07	1361089.97	11.02			NHTG	3.00	Fill: dark grey black sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-09	CPTu	368980.07	1361089.97	11.02			NHTG	57.24	Clay: Hard	6.60	6.60	10.70	10.70	37.70	>57.24					4.42	4.42	0.32	4.10	0.32	-26.68	-		
49533.02	B-10	Test Pit	369114.29	1361031.34	10.64			NHTG	3.00	Fill: black sand coal fines	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-11	Test Pit	368696.34	1360891.04	11.18			NHTG	3.20	Fill: black sand coal fines	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-12	Test Pit	368957.80	1360903.01	10.46			NHTG	3.10	Fill: dark grey/black clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-12	CPTu	368957.80	1360903.01	10.46			NHTG	15.00	Sand: Medium Dense	9.80	NE	NE	9.80	>15.00	>15.00					0.66	-	-	-	0.66	-	-		
49533.02	B-13	Test Pit	369105.31	1360922.58	10.77			NHTG	3.20	Fill: black clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-14	Test Pit	369404.05	1360888.52	10.59			NHTG	3.30	Fill: dark grey gravely slag sand	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-14	CPTu	369400.52	1360886.81	10.63			NHTG	40.00	Clay: Very stiff	7.70	7.70	12.00	12.00	27.90	>40.00					2.93	2.93	-1.37	4.30	-1.37	-17.27	-		
49533.02	B-15	Test Pit	368800.59	1360756.54	2.00			NHTG	3.10	Fill: grey silty clay	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-16	Test Pit	368755.51	1360720.80	2.45			NHTG	3.20	Fill: grey clayey silt	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
49533.02	B-16	CPT	368755.51	1360720.80	2.45			NHTG	25.00	Silty Sand: Loose to Medium Dense	1.00	1.00	8.30	8.30	14.90	>25.00					1.45	1.45	-5.85	7.30	-5.85	-12.45	-		
49533.03	B-101	Bore	368845.76	1361120.63	11.26			NHTG	9.20	Fill: Slag, gravel	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-			
49533.04	B-101A-U	Bore	368835.63	1361131.37	11.19	E-U	11.64	NHTG	13.45	Silty Clay: Stiff	10.10	10.10	NE	NE	NE	NE			7.21		1.09	1.09	-	-	-	-		4.43	
49533.05	B-101A-L	Bore	368836.79	1361131.46	11.01	E-L	11.64	NHTG	13.45	Sand: Loose to Medium Dense	9.90	9.90	10.50	10.50	NE	NE				10.82	1.11	1.11	0.51	0.60	0.51	-			0.82
49533.06	B-102-U	Bore	368881.02	1361115.48	11.50	E-U	12.32	NHTG	9.50	Silty Clay: Very Soft	7.20	7.20	NE	NE	NE	NE			6.97		4.30	4.30	-	-	-	-		5.35	
49533.07	B-102-L	Bore	368880.03	1361115.40	11.51	E-U	12.40	NHTG	15.00	Sand: Loose	7.20	7.20	11.30	11.30	NE	NE				10.40	4.31	4.31	0.21	4.10	0.21	-			2.00
49533.08	B-103	Bore	368877.23	1361086.50	11.21			NHTG	7.10	Filling: Silty Clay, Slag	NE	NE	NE	NE	NE	NE					-	-	-	-	-	-			
49533.09	B-104-U	Bore	368851.37	1361089.88	11.25	E-U	11.67	NHTG	8.50	Filling: Sand/Silty Sand	NE	NE	NE	NE	NE	NE			6.72		-	-	-	-	-	-		4.95	
49533.10	B-104-L	Bore	368850.00	1361090.03	11.25	E-U	11.74	NHTG	15.50	Sand: Loose	9.50	9.50	11.20	11.60	NE	NE				9.98	1.75	1.75	0.05	1.70	-0.35	-			1.76
49533.11	B-105-U	Bore	368873.37	1361062.09	11.39	E-U	11.99	NHTG	6.50	Silty Clay:Soft to Firm	6.10	6.10	NE	NE	NE	NE			4.37		5.29	5.29	-	-	-	-		7.62	
49533.12	B-105-L	Bore	368873.45	1361063.81	11.45	E-U	12.46	NHTG	15.20	Sand: Medium Dense	6.10	6.10	11.65	11.65	NE	NE				10.54	5.35	5.35	-0.20	5.55	-0.20	-			1.92
49533.02	C-01	Bore	368865.74	1361733.28	6.17	S-U	6.76	NHTG	16.45	Sand: Dense to very dense	5.00	5.00	8.00	8.00	>16.45	>16.45	3.40				1.17	1.17	-1.83	3.00	-1.83	-	-	3.36	
49533.02	C-02	Bore	369184.46	1361652.85	4.97	S-U	5.90	NHTG	61.30	Clayey Sand: Dense	2.70	2.70	7.10	7.10	31.40	>61.30	3.26				2.27	2.27	-2.13	4.40	-2.13	-26.43	-	2.64	
49533.02	C-03B-U	Bore	368735.92	1361578.91	6.51	E-U	6.82	NHTG	5.55	Sandy Clay: Very soft to soft	5.50	5.50	>5.55	>5.55	>5.55	>5.55	3.24				1.01	1.01	-	-	-	-	-	3.58	
49533.02	C-03A-L	Bore	368736.63	1361577.63	6.54	E-L	6.93	NHTG	14.95	Sand: medium Dense	5.50	5.50	8.20	8.20	>14.95	>14.95		4.78			1.04	1.04	-1.66	2.70	-1.66	-	-		2.15
49533.02	C-04	Bore	368857.02	1361576.33	5.47	S-L	6.11	NHTG	39.06	Shale: Low Strength	4.30	4.30	6.00	6.00	32.50	36.90		4.06			1.17	1.17	-0.53	1.70	-0.53	-27.03	-31.43		2.05
49533.02	C-05-L	Bore	369050.91	1361530.59	6.39	E-L	6.28	NHTG	14.95	Sand: Dense	5.80	5.80	7.00	7.00	>14.95	>14.95		4.16			0.59	0.59	-0.61	1.20	-0.61	-	-		2.12
49533.02	C-05-U	Bore	369048.61	1361533.05	6.37	E-U	7.28	NHTG	5.90	Silty Sandy Clay: Very Soft	5.80	5.80	>5.90	>5.90	>5.90	>5.90	4.55				0.57	0.57	-	-	-	-	-	2.73	
49533.02	C-06	Bore	369274.84	1361468.67	4.67	S-U	5.49	NHTG	14.95	Sand: Very Dense	4.00	4.00	5.70	5.70	>14.95	>14.95	3.03				0.67	0.67	-1.03	1.70	-1.03	-	-	2.46	
49533.02	C-07	Test Pit	368724.16	1361719.22	6.42			NHTG	3.10	Fill: Dark Grey, Slightly Clayey Silt	>3.10	>3.10	>3.10	>3.10	>3.10	>3.10					-	-	-	-	-	-	-		
49533.02	C-07	CPTu	368724.16	1361719.22	6.42			NHTG	15.00	Sand: Medium Dense	3.50	3.50	8.05	8.05	>15.00	>15.00					2.92	2.92	-1.63	4.55	-1.63	-	-		
49533.02	C-08	Test Pit	368898.04	1361666.66	7.72			NHTG	3.10	Fill:Dark brown Sandy Silt	>3.10	>3.10	>3.10	>3.10	>3.10	>3.10					-	-	-	-	-	-	-		
49533.02	C-08	CPT	368898.04	1361666.66	7.72			NHTG	49.06	Clay: Very stiff to Hard	5.80	7.40	10.90	12.17	34.80	>49.06					1.92	0.32	-3.18	3.50	-4.45	-27.08	-		
49533.02	C-09	Test Pit	369028.24	1361611.77	5.94			NHTG	3.20	Fill: Dark Brown, Silty Clay	>3.20	>3.20	>3.20	>3.20	>3.20	>3.20					-	-	-	-	-	-	-		
49533.02	C-09	CPTu	369028.21	1361607.05	5.79			NHTG	30.00	Sand: Very Dense	3.05	3.05	8.00	8.00	21.10	>30.00					2.74	2.74	-2.21	4.95	-2.21	-15.31	-		
49533.02	C-10	Test Pit	369180.02	1361609.64	4.51			NHTG	3.20	Fill: Dark Brown, Silty Clay	>3.20	>3.20	>3.20	>3.20	>3.20	>3.20					-	-	-	-	-	-	-		
49533.02	C-10	CPT	369180.02	1361609.64	4.51			NHTG	15.02	Sand: Dense	3.20	3.20	5.86	5.86	>15.02	>15.02					1.31	1.31	-1.35	2.66	-1.35	-	-		
49533.02	C-11	Test Pit	368894.29	1361476.69	4.97			NHTG	2.40	Fill: Dark Grey, Silty Clay	>2.40	>2.40	>2.40	>2.40	>2.40	>2.40					-	-	-	-	-	-	-		
49533.02	C-11	CPTu	368894.29	1361476.69	4.97			NHTG	30.00	Sand: Medium dense to dense	2.60	2.60	6.00	6.00	18.50	>30.00					2.37	2.37	-1.03	3.40	-1.03	-13.53	-		
49533.02	C-12	Test Pit	368675.27	1361416.06	5.51			NHTG	3.00	Fill: Grey, Silty Clay	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0					-	-	-	-	-	-	-		
49533.02	C-12	CPT	368675.27	1361416.06	5.51			NHTG	15.00	Sand: Medium Dense	3.10	3.10	5.90	5.90	>15.00	>15.00					2.41	2.41	-0.39	2.80	-0.39	-	-		
49533.02	C-13	Bore	368663.14	1361306.12	5.74	S-L	6.75	NHTG	47.85	Silty Clay: Very Stiff	2.70	NE	NE	5.20	18.70	>47.85		4.55			3.04	-	-	-	0.54	-12.96	-		2.20

Dark Red = entry aprroximate or unconfirmed

S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY

Project 49533.02

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
49533.02	D-01	Bore	369236.49	1361969.01	8.50			NHTG	19.95	Sand: Very Dense	4.90	4.90	5.90	5.90	>19.95	>19.95					3.60	3.60	2.60	1.00	2.60	-	-		
49533.02	D-02	Bore	369794.23	1361826.77	7.24			NHTG	40.45	Clay: Firm To Stiff	6.20	6.20	9.80	9.80	25.15	>40.45					1.04	1.04	-2.56	3.60	-2.56	-17.91	-		
49533.02	D-03	Bore	369464.94	1361693.36	7.30			NHTG	14.95	Sand: Dense	6.60	6.60	7.00	11.50	>14.95	>14.95					0.70	0.70	0.30	0.40	-4.20	-	-		
49533.02	D-04	Bore	369970.44	1361636.10	5.65	S-L	6.35	NHTG	14.95	Sand: Very Dense	4.70	4.70	8.00	8.00	>14.95	>14.95		4.15			0.95	0.95	-2.35	3.30	-2.35	-	-		2.20
49533.02	D-05	Bore	369698.36	1361564.40	7.24			NHTG	17.95	Sand: Dense	7.25	7.25	9.10	9.10	>17.95	>17.95					-0.01	-0.01	-1.86	1.85	-1.86	-	-		
49533.02	D-06	Bore	369916.79	1361305.10	7.70	S-L	8.15	NHTG	80.58	Shale: Medium Strength	6.50	6.50	8.00	8.00	33.00	78.80		6.07			1.20	1.20	-0.30	1.50	-0.30	-25.30	-71.10		2.08
49533.02	D-07	Bore	369413.36	1361425.50	8.36			NHTG	28.45	Silty Clay: Stiff	8.50	8.50	11.00	11.00	27.40	>28.45					-0.14	-0.14	-2.64	2.50	-2.64	-19.04	-		
49533.02	D-08	Test Pit	369706.59	1361841.52	6.40			NHTG	2.80	Fill: Brown Sand	>2.80	>2.80	>2.80	>2.80	>2.80	>2.80					-	-	-	-	-	-	-		
49533.02	D-08	CPTu	369706.59	1361841.52	6.40			NHTG	35.00	Clay: Stiff to Very Stiff	4.50	5.30	9.60	9.60	25.30	>35.00					1.90	1.10	-3.20	4.30	-3.20	-18.90	-		
49533.02	D-09	Test Pit	369255.12	1361813.97	5.31			NHTG	3.00	Fill: brown Silty Clay	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
49533.02	D-09	CPT	369255.12	1361813.97	5.31			NHTG	15.00	Sand: Medium Dense	3.25	4.10	6.30	6.30	>15.00	>15.00					2.06	1.21	-0.99	2.20	-0.99	-	-		
49533.02	D-10	Test Pit	369539.79	1361754.79	6.75			NHTG	3.00	Fill: brown Silty Clay	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
49533.02	D-10	CPTu	369539.79	1361754.79	6.75			NHTG	15.00	Sand: Medium dense to dense	6.00	6.00	10.60	10.60	>15.00	>15.00					0.75	0.75	-3.85	4.60	-3.85	-	-		
49533.02	D-11	Test Pit	369838.00	1361716.01	6.44			NHTG	3.00	Fill: brown Silty Clay	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
49533.02	D-11	CPT	369838.00	1361716.01	6.44			NHTG	15.02	Sand: Medium dense to dense	5.60	5.60	8.20	8.20	>15.02	>15.02					0.84	0.84	-1.76	2.60	-1.76	-	-		
49533.02	D-12	Test Pit	369410.92	1361578.60	6.50			NHTG	3.00	Fill: brown Silty Clay	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
49533.02	D-12	CPTu	369410.92	1361578.60	6.50			NHTG	15.00	Sand: Medium dense to dense	4.13	4.13	8.53	8.53	>15.00	>15.00					2.37	2.37	-2.03	4.40	-2.03	-	-		
49533.02	D-13	Test Pit	369611.97	1361553.51	6.92			NHTG	3.10	Fill: brown Silty Clay	>3.10	>3.10	>3.10	>3.10	>3.10	>3.10					-	-	-	-	-	-	-		
49533.02	D-13	CPT	369611.97	1361553.51	6.92			NHTG	33.00	Sand: Medium Dense	6.50	6.50	8.80	9.87	27.40	>33.00					0.42	0.42	-1.88	2.30	-2.95	-20.48	-		
49533.02	D-14	CPT	370033.31	1361756.24	3.77			NHTG	51.16	Silty Sand: Very Dense	2.15	2.15	5.40	5.40	27.60	>51.16					1.62	1.62	-1.63	3.25	-1.63	-23.83	-		
49533.02	R-01	Bore	368812.82	1360590.63	-0.11			NHTG	18.45	Sand - loose	0.00	0.00	8.00	8.00	15.70	>18.45					-0.11	-0.11	-8.11	8.00	-8.11	-15.81	-		
49533.02	R-02	Bore	369022.65	1360532.69	-1.27			NHTG	17.15	Sandy Clay - firm	0.00	0.00	2.50	2.50	8.60	>17.15					-1.27	-1.27	-3.77	2.50	-3.77	-9.87	-		
49533.02	R-03	Bore	369266.47	1360635.97	-0.46			NHTG	19.05	Clayey Sand - very loose	0.00	0.00	6.20	6.20	>19.05	>19.05					-0.46	-0.46	-6.66	6.20	-6.66	-	-		
49533.02	R-04	Bore	369493.98	1360659.45	0.42			NHTG	18.85	Sand - medium dense	0.00	0.00	5.35	5.35	>18.50	>18.50					0.42	0.42	-4.93	5.35	-4.93	-	-		
49533.02	R-05	Bore	368750.64	1360411.27	-2.05			NHTG	16.90	Sand - medium dense	0.00	0.00	3.75	3.75	16.50	>16.9					-2.05	-2.05	-5.80	3.75	-5.80	-18.55	-		
49533.02	R-06	Bore	368925.45	1360433.80	-1.85			NHTG	31.85	Silty Clay - hard (siltstone)	0.00	0.00	2.00	2.00	15.00	31.25					-1.85	-1.85	-3.85	2.00	-3.85	-16.85	-33.10		
49533.02	R-07	Bore	369128.57	1360420.28	-2.51			NHTG	16.10	Silty Clay - soft to firm	0.00	0.00	0.30	0.30	9.95	>16.1					-2.51	-2.51	-2.81	0.30	-2.81	-12.46	-		
49533.02	R-08	Bore	369151.86	1360506.08	-1.17			NHTG	17.85	Clay - soft, some sand	0.00	0.00	2.00	2.00	17.35	>17.85					-1.17	-1.17	-3.17	2.00	-3.17	-18.52	-		
49533.02	R-09	Bore	369241.21	1360414.91	-1.88			NHTG	40.50	Sand - trace clay	0.00	0.00	0.45	0.45	15.20	>40.5					-1.88	-1.88	-2.33	0.45	-2.33	-17.08	-		
49533.02	R-10	Bore	369323.04	1360389.63	-2.57			NHTG	39.25	Clay - Stiff; refusal on rock	0.00	0.00	2.60	2.60	16.20	39.25					-2.57	-2.57	-5.17	2.60	-5.17	-18.77	-41.82		
49533.02	R-11	Bore	369494.89	1360363.89	-0.55			NHTG	17.15	Sand - very dense	0.00	0.00	0.30	0.30	13.25	>17.15					-0.55	-0.55	-0.85	0.30	-0.85	-13.80	-		
49533.02	V-01	Vibrocore	368628.30	1360576.33	-0.90			NHTG	6.00	Sand	NE	NE	NE	2.40	>6.00	>6.00					-	-	-	-	-3.30	-	-		
49533.02	V-02	Vibrocore	368738.75	1360560.90	-0.90			NHTG	4.20	Sand	NE	NE	NE	0.00	>4.20	>4.20					-	-	-	-	-0.90	-	-		
49533.02	V-03	Vibrocore	369155.52	1360584.08	-0.87			NHTG	5.40	Sand	NE	NE	NE	0.50	>5.40	>5.40					-	-	-	-	-1.37	-	-		
49533.02	V-04	Vibrocore	369359.42	1360654.91	0.15			NHTG	5.85	Sand	NE	NE	NE	3.80	>5.85	>5.85					-	-	-	-	-3.65	-	-		
49533.02	V-05	Vibrocore	368614.88	1360485.99	-1.38			NHTG	6.00	Sand	NE	NE	NE	0.00	>6.00	>6.00					-	-	-	-	-1.38	-	-		
49533.02	V-06	Vibrocore	369244.14	1360606.87	-2.12			NHTG	4.20	Sand	NE	NE	NE	1.20	>4.20	>4.20					-	-	-	-	-3.32	-	-		
49533.02	V-07	Vibrocore	368919.66	1360480.09	-1.37			NHTG	4.80	Sand	NE	NE	NE	0.90	>4.80	>4.80					-	-	-	-	-2.27	-	-		
49533.02	V-08	Vibrocore	369031.15	1360498.95	-1.17			NHTG	5.30	Sand	NE	NE	NE	0.00	>5.30	>5.30					-	-	-	-	-1.17	-	-		
49533.02	V-09	Vibrocore	369133.28	1360488.04	-1.09			NHTG	5.00	Sand	NE	0.00	1.20	2.80	>5.00	>5.00					-	-1.09	-2.29	1.20	-3.89	-	-		
49533.02	V-10	Vibrocore	369223.85	1360465.65	-1.44			NHTG	5.00	Sand	NE	NE	NE	1.20	>5.00	>5.00					-	-	-	-	-2.64	-	-		
49533.02	V-11	Vibrocore	368854.89	1360458.94	-1.40			NHTG	5.35	Sand	NE	NE	NE	0.00	>5.35	>5.35					-	-	-	-	-1.40	-	-		
49533.02	V-12	Vibrocore	369001.86	1360411.32	-2.64			NHTG	4.00	Sand	NE	NE	NE	0.15	>4.00	>4.00					-	-	-	-	-2.79	-	-		
49533.02	V-13	Vibrocore	369416.82	1360380.58	-0.90			NHTG	4.90	Sand	NE	NE	NE	0.35	>4.90	>4.90					-	-	-	-	-1.25	-	-		
49533.02	V-14	Vibrocore	368876.27	1360404.82	-1.74			NHTG	4.15	Sand	NE	NE	NE	0.00	>4.15	>4.15					-	-	-	-	-1.74	-	-		
49533.02	PC-01	Push Core	368637.28	1360435.00	-1.95			NHTG	1.35	Sand	NE	NE	NE	0.00	>1.35	>1.35					-	-	-	-	-1.95	-	-		
49533.02	PC-02	Push Core	368734.47	1360472.76	-1.41			NHTG	0.52	Sand?	NE	NE	NE	0.00	>0.52	>0.52					-	-	-	-	-1.41	-	-		
49533.02	PC-03	Push Core	368821.09	1360519.46	-0.74			NHTG	0.65	Sand	NE	NE	NE	0.00	>0.65	>0.65					-	-	-	-	-0.74	-	-		
49533.02	PC-04	Push Core	368906.42	1360558.38	-0.39			NHTG	1.25	Silty Sand	NE	NE	NE	0.00	>1.25	>1.25					-	-	-	-	-0.39	-	-		
49533.02	PC-05	Push Core	368999.35	1360597.86	0.02			NHTG	2.15	Silty Sand	NE	NE	NE	0.00	>2.15	>2.15					-	-	-	-	0.02	-	-		
49533.02	PC-06	Push Core	369098.77	1360641.23	0.22			NHTG	1.23	Sandy Silt	0.20	0.20	>1.23	>1.23	>1.23	>1.23					0.02	0.02	-	-	-	-	-		
49533.02	PC-07	Push Core	368694.05	1360408.28	-1.52			NHTG	0.65	Sand?	NE	0.00	0.26	0.26	>0.65	>0.65					-	-1.52	-1.78	0.26	-1.78	-	-		
49533.02	PC-08	Push Core	368785.20	1360446.99	-1.44			NHTG	0.40	Sand	NE	NE	NE	0.00	>0.40	>0.40					-	-	-	-	-1.44	-	-		
49533.02	PC-09	Push Core	368876.10	1360490.89	-0.97			NHTG	0.79	Sand	NE	NE	NE	0.00	>0.79	>0.79					-	-	-	-	-0.97	-	-		
49533.02	PC-10	Push Core	368970.18	1360527.80	-1.17			NHTG	0.75	Sand	0.20	0.20	0.50	0.50	>0.75	>0.75					-1.37	-1.37	-1.67	0.30	-1.67	-	-		
49533.02	PC-11	Push Core	369061.71	1360564.40	-0.89			NHTG	2.10	Sand	0.05	0.05	0.74	0.74	>2.10	>2.10					-0.94	-0.94	-1.63	0.69	-1.63	-	-		
49533.02	PC-12	Push Core	369137.75	1360611.84	-0.31			NHTG	1.76	Sand	0.20	0.20	0.85	0.85	>1.85	>1.85					-0.51	-0.51	-1.16	0.65	-1.16	-	-		
49533.02	PC-13	Push Core	369236.23	1360655.22	0.20			NHTG	0.81	Sand	0.05	0.05	0.65	0.65	>0.81	>0.81					0.15	0.15	-0.45	0.60	-0.45	-	-		
49533.02	PC-14	Push Core	369305.74	1360652.57	0.19			NHTG	1.11	Sand	0.12	0.12	0.81	0.81	>1.11	>1.11					0.07	0.07	-0.62	0.69	-0.62	-	-		
49533.02	PC-15	Push Core	368653.72	1360556.74	-0.84			NHTG	0.70	Silt	0.18	0.18	>0.7	>0.70	>0.70	>0.70					-1.02	-1.02	-	-	-	-	-		
49533.02	PC-16	Push Core	368736.89	1360551.10	-0.76			NHTG	1.02	Sandy Silt	0.75	0.75	>1.02	>1.02	>1.02	>1.02					-1.51	-1.51	-	-	-	-	-		
49533.02	PC-17	Push Core	368653.74	1360512.93	-1.25			NHTG	0.51	Silty Sand	0.20	0.20	>0.51	>0.51	>0.51	>0.51					-1.45	-1.45	-	-	-	-	-		
49533.02	PC-18	Push Core	368827.44	1360586.43	-0.26			NHTG	1.90	Sand?	0.50	0.50	5.65	5.65	>5.65	>5.65					-0.76	-0.76	-5.91	5.15	-5.91	-	-		
49533.02	PC-19	Push Core	368918.97	1360622.75	-0.18			NHTG	1.38	Sand	0.15	0.15	2.25	2.25	>2.25	>2.25					-0.33	-0.33	-2.43	2.10	-2.43	-	-		
49533.02	PC-20	Push Core	368853.91	1360415.66	-2.46			NHTG	0.35	Sand	0.35	NE	NE	0.35	>0.35	>0.35					-2.81	-	-	-	-2.81	-	-		
49533.02	PC-21	Push Core	368939.43	1360462.11	-1.36			NHTG	0.55	Sand	NE	NE	NE	0.00	>0.55	>0.55					-	-	-	-	-1.36	-	-		
49533.02	PC-22	Push Core	369053.47	1360501.51	-1.14			NHTG	0.05	Sand	NE	NE	NE	0.00	>1.15	>1.15					-	-	-	-	-1.14	-	-		
49533.02	PC-23	Push Core	369132.91	1360533.50	-1.18			NHTG	1.00	Silt	0.50	0.50	2.85	2.85	>2.85	>2.85					-1.68	-1.68	-4.03	2.35	-4.03	-	-		
49533.02	PC-24	Push Core	369129.11	1360472.28	-1.05			NHTG	0.46	Sandy Silt	0.30	0.30	1.45	1.45	>1.45	>1.45					-1.35	-1.35	-2.50	1.15	-2.50	-	-		
49533.02	PC-25	Push Core	369215.64	1360435.99	-2.09			NHTG	0.30	Silty Sand	0.13	0.13	0.75	0.75	>0.75	>0.75					-2.22	-2.22	-2.84	0.62	-2.84	-	-		
31310	SA01	Bore	370305.00	1359993.00	-1.08			NHTG	17.15	Sandstone: very low strength	NE	0.00	7.50	7.50	8.50	14.10					-	-1.08	-8.58	7.50	-8.58	-9.58	-15.18		
31310	SA02	Bore	370123.00	1360036.00	-0.66			NHTG	17.70	Siltstone:extremely low strength	NE	0.00	4.25	4.25	5.50	6.00					-	-0.66	-4.91	4.25	-4.91	-6.16	-6.66		
31310	SA03	Bore	369669.00	1360581.00	-1.80			NHTG	16.70	Sand: medium dense	NE	0.00	4.35	4.35	7.80	>16.7					-	-1.80	-6.15	4.35	-6.15	-9.60	-		
31310	SA04	Bore	369045.00	1360590.00	-0.61			NHTG	17.80	Silty Clay: firm to stiff	NE	0.00	5.10	5.10	12.95	>17.8					-	-0.61	-5.71	5.10	-5.71	-13.56	-		
31310	SA05	Bore	369014.00	1360427.00	-2.14			NHTG	16.30	Sand: medium dense to dense	NE	0.00	2.50	2.50	>16.3	>16.3					-	-2.14	-4.64	2.50	-4.64	-	-		
31310	SA06	Bore	370253.00	1360208.00	-2.89			NHTG	15.80	Sandstone: medium strength	NE	0.00	4.00	4.00	5.10	8.75					-	-2.89	-6.89	4.00	-6.89	-7.99	-11.64		
31310	SA07	Bore	369591.00	1360350.00	-0.33			NHTG	18.20	Sand - very dense	NE	0.00	3.10	3.10	13.80	>18.2					-	-0.33	-3.43	3.10	-3.43	-14.13	-		
CW HK5301	BH 126	Bore	368216.30	1361446.20	7.60		NA	AHD	5.95	Fill	>5.95	>5.95	>5.95	>5.95	>5.95	NE					-	-	-	-	-	-	-		
CW HK5301	BH 129	Bore	368515.90	1361226.80	8.10		NA	AHD	2.95	Fill	>2.95	>2.95	>2.95	>2.95	>2.95	NE					-	-	-	-	-	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
CW HK5301	BH 135	Bore	368581.30	1361096.90	4.50		NA	AHD	29.25	Silty sand	4.10	4.10	6.00	6.00	18.00	>29.25					1.41	1.41	-0.49	1.90	-0.49	-12.49	-		
CW HK5301	BH 139	Bore	368541.70	1361130.30	5.70		NA	AHD	8.45	Sand	6.50	6.50	7.20	7.20	>8.45	>8.45					0.21	0.21	-0.49	0.70	-0.49	-	-		
CW HK5301	BH101	Bore	369040.00	1360890.00	9.90			AHD	59.00	Silty Clay	10.00	10.00	14.00	14.00	26.00	NE					0.91	0.91	-3.09	4.00	-3.09	-15.09	-		
CW HK5301	BH102	CPT	368580.20	1361478.45	7.80			AHD	45.10	Shale: Med strength	8.50	NE	NE	8.50	35.50	40.00					0.31	-	-	-	0.31	-26.69	-31.19		
CW HK5301	BH103	CPT	367451.15	1361580.36	3.40			AHD	5.50	Silty Clay	5.00	5.00	>5.50	>5.50	>5.50	>5.50					-0.59	-0.59	-	-		-	-		
CW HK5301	CPT103	CPT	367451.15	1361580.36	3.40		NA	AHD	5.50	Silty clay	5.00	5.00	>5.5	>5.5	>5.5	>5.5					-0.59	-0.59	-	-		-	-		
CW HK5301	CPT104	CPT	368330.00	1362140.00	3.00			AHD	5.5/25.0	Sand	4.00	4.00	13.00	13.00	15.00	>25					0.01	0.01	-8.99	9.00	-8.99	-10.99	-		
CW HK5301	BH105	Bore	367480.00	1361650.00	3.90			AHD	18.20	Siltstone: L-M strength	4.00	4.00	8.00	8.00	13.50	15.20					0.91	0.91	-3.09	4.00	-3.09	-8.59	-10.29		
CW HK5301	CPT106	CPT	368535.10	1361285.80	7.60		NA	AHD	8.5/28.8	Sand	7.00	NE	NE	7.00	20.50	>28.5					1.61	-	-	-	1.61	-11.89	-		
CW HK5301	CPT107	CPT	368925.00	1361305.00	9.50			AHD	2.5/29.64	Sand	9.28	9.28	10.50	10.50	>29.64	>29.64					1.23	1.23	0.01	1.22	0.01	-	-		
CW HK5301	CPT109	CPT	369785.00	1360875.00	9.20			AHD	10.45/29	Sand	10.00	10.00	12.40	12.40	19.80	>29.5					0.21	0.21	-2.19	2.40	-2.19	-9.59	-		
CW HK5301	CPT112	CPT	368511.40	1360936.90	3.10		NA	AHD	5.5/28.14	Sand	2.50	NE	NE	2.50	17.00	>28					1.61	-	-	-	1.61	-12.89	-		
CW HK5301	CPT113	CPT	368140.00	1360919.96	7.40		NA	AHD	8.5/31.56	Silty Clay	7.50	7.50	11.00	11.00	22.50	>31.56					0.91	0.91	-2.59	3.50	-2.59	-14.09	-		
CW HK5301	CPT115	CPT	368218.18	1361417.88	7.80			AHD	8.5/36.5	Sand	8.50	8.50	12.00	12.00	33.00	>36.50					0.31	0.31	-3.19	3.50	-3.19	-24.19	-		
CW HK5301	CPT116	CPT	368107.90	1361284.11	7.90		NA	AHD	7.0/32.0	Sand	5.00	5.00	7.00	7.00	22.00	>32.00					3.91	3.91	1.91	2.00	1.91	-13.09	-		
CW HK5301	CPT117	CPT	368430.00	1361695.00	7.70			AHD	8.5/25.2	Sand	6.80	6.80	10.00	10.00	19.00	>25.2					1.91	1.91	-1.29	3.20	-1.29	-10.29	-		
CW HK5301	CPT118	CPT	367894.77	1361091.47	7.30		NA	AHD	34.20	Sand	6.00	6.00	10.00	10.00	23.50	>34.00					2.31	2.31	-1.69	4.00	-1.69	-15.19	-		
CW HK5301	CPT119	CPT	368630.00	1361820.00	8.10			AHD	8.5/33.7	Sand/Gravelly sand	7.50	7.50	11.20	11.20	22.00	>33.7					1.61	1.61	-2.09	3.70	-2.09	-12.89	-		
CW HK5301	CPT120	CPT	368350.00	1361170.00	8.00			AHD	5.95/17.4	Sand	7.30	7.30	10.00	10.00	>17.4	NE					1.71	1.71	-0.99	2.70	-0.99	-	-		
CW HK5301	BH121	Bore	368095.00	1361540.00	NA				5.95	Fill	>5.95	>5.95	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH122	Bore			NA				30.00	Sand	9.50	9.50	12.50	12.50	>30	NE					-	-	-	3.00	-	-	-		
CW HK5301	BH123	Bore	369416.00	1361262.00	9.32			AHD	11.45	Clayey Silt	9.50	9.50	>11.45	>11.45	>11.45	NE					0.83	0.83	-	-	-	-	-		
CW HK5301	BH124	Bore	367710.00	1361767.00	4.32			AHD	41.00	Shale: Med strength	7.70	7.70	12.50	12.50	21.50	40.00					-2.37	-2.37	-7.17	4.80	-7.17	-16.17	-34.67		
CW HK5301	BH125	Bore	368008.30	1361617.00	7.65			AHD	53.00	Gravel	7.50	7.50	10.00	10.00	22.50	>53.0					1.16	1.16	-1.34	2.50	-1.34	-13.84	-		
CW HK5301	BH127	Bore	368259.30	1361344.10	7.50		NA	AHD	5.95	Fill	>5.95	>5.95	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH128	Bore	368409.60	1361264.80	8.20		NA	AHD	5.40	Fill	>5.4	>5.4	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH130	Bore	368830.00	1361221.00	NA		NA		2.95	Fill	>2.95	>2.95	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH131	Bore	368947.00	1361271.00	NA		NA		2.95	Fill	>2.95	>2.95	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH132	Bore	369124.00	1361335.00	NA		NA		2.95	Fill	>2.95	>2.95	NE	NE	NE	NE					-	-	-	-	-	-	-		
CW HK5301	BH209	Bore	370280.00	1360650.00	3.70			AHD	48.05	Siltstone: Med strength	3.00	3.00	5.50	5.50	32.00	45.20					1.71	1.71	-0.79	2.50	-0.79	-27.29	-40.49		
CW HK5301	BH210	Bore	371050.00	1360510.00	3.50			AHD	16.00	Sandstone: Med-High strength	2.90	2.90	6.20	6.20	NE	12.30					1.61	1.61	-1.69	3.30	-1.69	-	-7.79		
CW HK5301	BH211	Bore	370750.00	1360520.00	3.80			AHD	13.13	Sandstone	3.10	3.10	4.20	4.20	11.75	13.00					1.71	1.71	0.61	1.10	0.61	-6.94	-8.19		
CW HK5301	BH212	Bore	370650.00	1360900.00	3.20			AHD	58.00	Gravelly Sand	4.70	NE	NE	4.70	22.00	NE					-0.49	-	-	-	-0.49	-17.79	-		
CW HK5301	BH213	Bore			NA				10.57	Sand	3.30	NE	NE	3.30	>10.57	NE					-	-	-	-	-	-	-		
CW HK5301	CPT108a	CPT	369490.00	1361245.00	NA				28.22	Sand	3.50	3.50	11.00	11.00	26.60	>28.2					-	-	-	7.50	-	-	-		
CW HK5301	CPT110	CPT	369190.00	1360915.00	NA				32.00	Silty Sand	7.00	7.00	11.50	11.50	25.60	>32.0					-	-	-	4.50	-	-	-		
CW HK5301	CPT111	CPT	369055.00	1361140.00	NA				34.10	Silty Sand	6.00	6.00	12.20	12.20	27.00	>34.1					-	-	-	6.20	-	-	-		
CW HK5301	CPT114	CPT	367850.00	1361400.00	NA				28.42	Silty clay/clayey silt	2.50	2.50	6.50	6.50	16.00	>28.42					-	-	-	4.00	-	-	-		
00299	1	Bore	368530.00	1360720.00	1.30		NA	AHD	25.30	Shale	1.00	NE	NE	1.00	11.43	18.52					1.31	-	-	-	1.31	-9.12	-16.21		
00299	2	Bore	368590.00	1360715.00	1.41		NA	AHD	26.52	Shale: "hard"	2.05	NE	NE	2.05	19.05	23.47					0.37	-	-	-	0.37	-16.63	-21.05		
04800	1	Bore	368615.00	1362110.00	1.00			AHD	25.80	Gravel & Sand	0.20	0.20	5.70	5.70	21.00	>25.8					1.81	1.81	-3.69	5.50	-3.69	-18.99	-		
04800	2	Bore	369440.00	1361850.00	1.52			AHD	58.50	Sandy Gravel	1.20	1.20	5.50	5.50	25.00	>58.5					1.33	1.33	-2.97	4.30	-2.97	-22.47	-		
04800	3	Bore	370060.00	1361890.00	3.05			AHD	67.30	Gravel & Boulders	1.80	1.80	13.00	13.00	29.50	>67.3					2.26	2.26	-8.94	11.20	-8.94	-25.44	-		
04800	4	Bore	368625.00	1361490.00	1.22			AHD	25.30	Gravel & Sand	0.50	0.50	4.50	4.50	15.00	>25.30					1.73	1.73	-2.27	4.00	-2.27	-12.77	-		
04800	5	Bore	369375.00	1361475.00	1.22			AHD	54.30	Shale: "medium hard"	1.30	1.30	5.00	5.00	19.10	50.80					0.93	0.93	-2.77	3.70	-2.77	-16.87	-48.57		
04800	6	Bore	369755.00	1361665.00	1.27			AHD	40.45	Silty Clay: stiff	0.70	0.70	7.50	7.50	25.60	>40.45					1.58	1.58	-5.22	6.80	-5.22	-23.32	-		
04800	7	Bore	369965.00	1361380.00	4.26			AHD	34.95	Silty Clay: soft to firm	2.80	2.80	5.00	5.00	28.50	>34.95					2.47	2.47	0.27	2.20	0.27	-23.23	-		
04800	8	Bore	368630.00	1361095.00	1.08			AHD	28.50	Gravel & sand	0.30	0.30	1.80	1.80	14.50	>28.50					1.79	1.79	0.29	1.50	0.29	-12.41	-		
04800	9	Bore	369081.00	1360930.00	1.86			AHD	25.45	Sand: med dense	1.50	1.50	6.50	6.50	16.50	>25.45					1.37	1.37	-3.63	5.00	-3.63	-13.63	-		
04800	10	Bore	369702.00	1360869.00	2.29			AHD	30.45	Silty Clay: firm	3.00	3.00	4.50	4.50	29.00	>30.45					0.30	0.30	-1.20	1.50	-1.20	-25.70	-		
04800	11	Bore	368681.00	1360717.00	1.37			AHD	25.38	Sand: dense	2.80	2.80	7.50	7.50	16.00	>25.38					-0.42	-0.42	-5.12	4.70	-5.12	-13.62	-		
04800	12	Bore	369289.00	1360344.00	5.59			AHD	30.60	Silty Clay: firm (?)	4.30	4.30	9.00	9.00	23.00	>30.6					2.30	2.30	-2.40	4.70	-2.40	-16.40	-		
04800	19	Bore	369381.00	1360630.00	-2.25			AHD	20.45	Sand: dense	NE	0.00	5.75	5.75	>20.45	NE					-	-1.24	-6.99	5.75	-6.99	-	-		
04800	20	Bore	369728.00	1360487.00	-1.84			AHD	20.45	Sand: dense	NE	0.00	2.00	2.00	10.70	>20.45					-	-0.83	-2.83	2.00	-2.83	-11.53	-		
16686	CPT25	CPT	368455.00	1361670.00	8.29		NA	AHD	15.00	Sand: Medium dense to dense	7.60	7.60	10.20	10.20	>15.00	>15.00					1.70	1.70	-0.90	2.60	-0.90	-	-		
16686	CPT26	CPT	368450.00	1361660.00	8.29		NA	AHD	15.00	Sand: Medium dense to dense	7.30	3.00	10.10	10.10	>15.00	>15.00					2.00	6.30	-0.80	7.10	-0.80	-	-		
16686	CPT28	CPT	368460.00	1361690.00	8.29		NA	AHD	15.00	Sand: Medium dense to dense	7.80	7.60	12.00	12.00	>15.00	>15.00					1.50	1.70	-2.70	4.40	-2.70	-	-		
16686	CPT29	CPT	368445.00	1361570.00	8.29		NA	AHD	15.00	Sand: Medium dense to dense	7.80	10.90	12.66	12.66	>15.00	>15.00					1.50	-1.60	-3.36	1.76	-3.36	-	-		
17074	1	Bore	369380.00	1361330.00	9.44			AHD	10.45	Fill: slag gravel	>10.45	>10.45	NE	NE	NE	NE					-	-	-	-	-	-	-		
17074	2	Bore	369260.00	1361360.00	10.54			AHD	12.80	Silty Clay: Soft to firm	11.50	11.50	>12.8	>12.8	NE	NE					0.05	0.05	-	-	-	-	-		
17074	3	Bore	369085.00	1361380.00	10.04			AHD	11.75	Clayey Sand: Loose to firm	10.60	10.60	>11.75	>11.75	NE	NE					0.45	0.45	-	-	-	-	-		
17074	4	Bore	368890.00	1361330.00	10.59			AHD	12.45	Sand with some silt: Loose	11.00	11.00	>12.45	>12.45	NE	NE					0.60	0.60	-	-	-	-	-		
17074	5	Bore	368730.00	1361210.00	10.14			AHD	10.00	Fill: sandy gravel	>10.00	>10	NE	NE	NE	NE					-	-	-	-	-	-	-		
31552	BB1	Bore	369039.00	1360804.00	0.77			AHD	47.50	Siltstone - vlow strength	1.80	1.80	7.15	7.15	16.80	43.00					-0.02	-0.02	-5.37	5.35	-5.37	-15.02	-41.22		
31552	BB2	Bore	369557.00	1360763.00	1.73			AHD	67.60	Siltstone - vlow strength	2.20	2.20	4.10	4.10	23.30	64.00					0.54	0.54	-1.36	1.90	-1.36	-20.56	-61.26		
31552	BC01	CPTu	368549.06	1360615.70	1.44			AHD	34.18	Clay - stiff to very stiff	1.27	1.27	6.70	7.63	16.43	>34.18					1.18	1.18	-4.25	5.43	-5.18	-13.98			
31552	BC02	CPTu	368839.95	1360783.88	2.25			AHD	46.22	Silty Sand - dense	1.20	1.20	5.48	9.45	16.04	>46.22					2.06	2.06	-2.22	4.28	-6.19	-12.78			
31552	BC03	CPTu	369037.95	1360804.58	1.76			AHD	45.28	Clay - very stiff to hard	0.67	1.46	4.32	7.02	16.31	>45.28					2.10	1.31	-1.55	2.86	-4.25	-13.54			
31552	BC04	CPTu	369188.69	1360807.91	1.80			AHD	55.92	Clay & Sandy clay - stiff to hard	0.67	0.67	4.53	6.73	17.04	>55.92					2.14	2.14	-1.72	3.86	-3.92	-14.23			
31552	BC05	CPTu	369358.76	1360779.34	0.88			AHD	48.70	Sandy Clay - very stiff to hard	0.75	0.75	2.87	2.87	18.08	>48.70					1.14	1.14	-0.98	2.12	-0.98	-16.19			
31552	BC06a	CPTu	369556.64	1360763.29	2.67			AHD	60.00	Sandy Clay - very stiff to hard	1.00	2.39	3.74	3.74	23.14	>60.00					2.68	1.29	-0.06	1.35	-0.06	-19.46			
31552	BC07	CPTu	369829.23	1360632.70	2.37			AHD	48.52	Sand - medium dense to dense	1.90	1.90	3.66	3.66	28.23	>48.52					1.48	1.48	-0.28	1.76	-0.28	-24.85			
31552	PB1	Bore	368726.00	1360982.00	9.39			AHD	55.20	Siltstone- low-medium strength	11.70	NE	NE	11.70	25.00	51.60					-1.30	-	-	-	-1.30	-14.60	-41.20		
31552	PB2	Bore	369276.00	1360981.00	8.59			AHD	62.20	Siltstone - extr low str	9.00	9.00	11.40	11.40	26.90	61.50					0.60	0.60	-1.80	2.40	-1.80	-17.30	-51.90		
31552	PB3	Bore	369002.00	1360926.00	8.59			AHD	62.42	Siltstone - vlow to low strength	10.00	10.00	11.50	11.50	25.20	58.40					-0.40	-0.40	-1.90	1.50	-1.90	-15.60	-48.80		
31552	PC01	CPTu	368697.00	1361038.00	10.21			AHD	43.80	Clay -stiff to very stiff	10.90	NE	10.90	10.90	24.90	>43.8					0.32	-	0.32	-	0.32	-13.68	-		
31552	PC10	CPTu	369151.00	1361037.00	9.61			AHD	38.00	Sand - medium dense	9.10	9.10	10.80	10.80	26.55	>38.0					1.52	1.52	-0.18	1.70	-0.18	-15.93	-		
31552	PC13a	CPTu	369299.00	1361036.00	9.76			AHD	15.00	Silty Sand / Sandy Silt - medium der	9.56	9.56	11.50	11.50	>15.0	NE					1.21	1.21	-0.73	1.94	-0.73	-	-		
31552	PC17	CPTu	368851.00	1360982.00	10.25			AHD	20.00	Sand - medium dense to dense	10.90	NE	10.90	10.90	>20.0	NE					0.36	-	0.36	-	0.36	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

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T4 GEOTECHNICAL DATA SUMMARY

Project 49533.02

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
31552	PC22	CPTu	369102.00	1360981.00	9.87			AHD	20.00	Sand - medium dense to dense	10.35	NE	10.35	10.35	>20.0	NE					0.53	-	0.53	-	0.53	-	-		
31552	PC26	CPTu	369301.00	1360982.00	9.89			AHD	25.02	Sand - medium dense to dense	9.87	9.87	10.84	10.84	>25.0	NE					1.03	1.03	0.06	0.97	0.06	-	-		
31552	PC27c	CPTu	368702.00	1360926.00	10.15			AHD	42.00	Clay - stiff to very stiff	10.35	10.35	11.42	11.42	24.55	>42.0					0.81	0.81	-0.26	1.07	-0.26	-13.39	-		
31552	PC30	CPTu	368852.00	1360926.00	10.33			AHD	41.98	Clay - stiff to very stiff	11.04	NE	11.04	11.04	25.00	>42.0					0.30	-	0.30	-	0.30	-13.66	-		
31552	PC33	CPTu	369002.00	1360926.00	9.64			AHD	42.00	Clay - stiff to very stiff	10.13	10.13	11.20	11.20	25.07	>42.0					0.52	0.52	-0.55	1.07	-0.55	-14.42	-		
31552	PC36	CPTu	369152.00	1360925.00	9.66			AHD	41.02	Clay - stiff to very stiff	10.70	NE	10.70	10.70	25.33	>41.0					-0.03	-	-0.03	-	-0.03	-14.66	-		
31552	PC39	CPTu	369301.00	1360927.00	9.87			AHD	40.00	Silty Sand - medium dense	9.10	9.10	11.22	11.22	26.53	>40.0					1.78	1.78	-0.34	2.12	-0.34	-15.65	-		
31552	PC04B	CPTu	368851.00	1361037.00	9.87			AHD	35.00	Silty Sand/clay - loose-medium dens	10.30	NE	10.30	10.30	25.10	>35.0					0.58	-	0.58	-	0.58	-14.22	-		
31552	PC07	CPTu	369001.00	1361036.00	9.86			AHD	57.78	Clay / Sandy Clay - hard	9.18	9.18	11.20	11.20	25.33	>57.8					1.69	1.69	-0.33	2.02	-0.33	-14.46	-		
31552	SA101	Bore	368707.00	1360591.00	-1.17			AHD	47.85	Siltstone - extr low str	NE	0.00	6.20	6.20	12.50	38.90					-	-0.16	-6.36	6.20	-6.36	-12.66	-39.06		
31552	SA102	Bore	369025.00	1360635.00	-0.71			AHD	45.60	Siltstone - extr low str	NE	0.00	11.00	11.00	31.50	45.40					-	0.30	-10.70	11.00	-10.70	-31.20	-45.10		
31552	SA103	Bore	369384.00	1360653.00	-0.71			AHD	52.00	Siltstone - medium strength	NE	0.00	5.50	5.50	19.80	45.50					-	0.30	-5.20	5.50	-5.20	-19.50	-45.20		
31552	SA104	Bore	369568.00	1360653.00	-0.67			AHD	65.50	Siltstone - extr low str	NE	0.00	3.50	3.50	21.60	59.00					-	0.34	-3.16	3.50	-3.16	-21.26	-58.66		
31552	SA105	Bore	369777.00	1360558.00	-2.91			AHD	56.00	Siltstone: low - medium strength	NE	0.00	2.50	2.50	20.20	49.60					-	-1.90	-4.40	2.50	-4.40	-22.10	-51.50		
31552	SA106	Bore	369445.00	1360533.00	-2.15			AHD	29.90	Gravel - medium dense to dense	NE	0.00	5.10	5.10	20.90	>29.9					-	-1.14	-6.24	5.10	-6.24	-22.04	-		
31552	TC01C	CPTu	368581.79	1361011.22	3.49		NA	AHD	46.62	Sand: Very dense	2.86	2.86	4.84	4.84	16.98	>46.62					1.64	1.64	-0.34	1.98	-0.34	-12.48	-		
31552	TC02	CPTu	368504.60	1360794.23	5.16		NA	AHD	17.00	Sand: Dense to very dense	3.77	5.29	9.75	9.75	>17.00	>17.00					2.40	0.88	-3.58	4.46	-3.58	-	-		
31552	TC03	CPTu	368333.43	1360858.48	5.50		NA	AHD	34.80	Gravelly Sand	5.90	5.90	8.72	8.72	14.24	>34.80					0.61	0.61	-2.21	2.82	-2.21	-7.73	-		
31552	TC05	CPTu	367633.00	1360957.40	1.65		NA	AHD	15.22	Sandy Clay: Hard	1.05	1.05	2.15	2.15	6.70	>15.22					1.61	1.61	0.51	1.10	0.51	-4.04	-		
31552	TC06	CPTu	367385.00	1361125.00	1.27		NA	AHD	9.84	Clay: Very stiff to Hard	1.42	1.42	5.59	5.59	7.83	>9.84					0.86	0.86	-3.31	4.17	-3.31	-5.55	-		
31552	TC07	CPTu	367151.00	1361277.00	1.44		NA	AHD	7.36	Clay: Hard	1.22	1.22	6.57	NE	6.57	>7.36					1.23	1.23	-4.12	5.35	-	-4.12	-		
31552	TC08	CPTu	367196.00	1361310.00	1.46		NA	AHD	6.48	Clay	1.02	1.02	6.22	NE	6.22	>6.48					1.45	1.45	-3.75	5.20	-	-3.75	-		
31552	TC09	CPTu	367274.00	1361379.00	2.63		NA	AHD	9.38	Sandy Clay	2.13	2.13	6.46	6.46	8.43	>9.38					1.51	1.51	-2.82	4.33	-2.82	-4.79	-		
31552	TC04	CPTu	368090.00	1360787.34	2.05		NA	AHD	17.80	Silty Clay	1.83	1.83	4.99	4.99	13.25	>17.80					1.23	1.23	-1.93	3.16	-1.93	-10.19	-		
31552	TP11	Pit	367235.00	1361473.00	0.89		NA	AHD	2.20	Clayey sand	0.25	0.25	1.20	1.20	>2.2	>2.2					1.65	1.65	0.70	0.95	0.70	-	-		
31552	TC25	CPTu	367407.00	1361213.00	1.31		NA	AHD	8.64	Clay/Sandy Clay	0.50	0.50	7.83	NE	7.83	>8.64					1.82	1.82	-5.51	7.33	-	-5.51	-		
31552	TC26	CPTu	367427.00	1361324.00	6.24		NA	AHD	14.72	Hard clay	6.69	6.69	12.20	12.20	13.50	>14.72					0.56	0.56	-4.95	5.51	-4.95	-6.25	-		
31552	TC27	CPTu	367610.00	1361242.00	10.88		NA	AHD	24.54	Hard clay	10.16	10.16	11.77	11.77	22.90	>24.54					1.73	1.73	0.12	1.61	0.12	-11.01	-		
31552	TC28	CPTu	367783.00	1361140.00	7.61		NA	AHD	25.00	Clay/Sandy Clay	7.72	7.72	9.79	12.34	21.17	>25.00					0.90	0.90	-1.17	2.07	-3.72	-12.55	-		
31552	TC29	CPTu	368488.00	1360918.00	3.29		NA	AHD	2.2/44.76	Silty Sand & Sand	3.23	3.23	6.26	6.26	19.55	>44.76					1.07	1.07	-1.96	3.03	-1.96	-15.25	-		
31552	TC30	CPTu	368141.00	1360946.00	7.15		NA	AHD	1.8/25	Stiff Clay	7.44	7.44	10.79	12.68	22.02	>25.00					0.72	0.72	-2.63	3.35	-4.52	-13.86	-		
31733-2	E01	CPT	367575.03	1361381.99	11.47			AHD	22.98	Hard Silty Clay (weathered rock)	11.02	11.02	12.49	12.49	20.93	>23.00					1.46	1.46	-0.01	1.47	-0.01	-8.45	-		
31733-2	E02	CPT	367942.33	1361310.87	3.31			AHD	49.00	Hard clay	3.00	3.00	6.88	6.88	16.01	>49.00					1.32	1.32	-2.56	3.88	-2.56	-11.69	-		
31733-2	E03	CPT	368478.05	1361143.84	7.90			AHD	55.54	Hard clay	8.20	NE	NE	8.20	21.39	>55.54					0.71	-	-	-	0.71	-12.48	-		
31733-2	E04	CPT	367689.83	1361831.46	3.05			AHD	41.10	Dense sand & Hard clay (weathered	8.38	8.38	15.00	15.00	31.59	41.10					-4.32	-4.32	-10.94	6.62	-10.94	-27.53	-37.04		
31733-2	E05B	CPT	368085.41	1361615.02	7.13		NA	AHD	50.00	Very stiff to hard Clay	6.22	6.22	9.51	9.51	21.44	>50.00					1.92	1.92	-1.38	3.29	-1.38	-13.31	-		
31733-2	E06	CPT	368538.98	1361448.93	7.78			AHD	42.44	Hard clay	6.65	6.65	9.70	9.70	40.60	>42.44					2.14	2.14	-0.91	3.05	-0.91	-31.81	-		
31733-2	E07B	CPT	369000.95	1361220.93	10.21			AHD	47.68	Probably gravel (abrupt refusal)	10.36	10.36	11.83	11.83	25.32	>47.6					0.86	0.86	-0.61	1.47	-0.61	-14.10	-		
31733-2	E08A	CPT	369522.12	1361195.24	9.01			AHD	60.00	Very stiff to hard clay	11.17	NE	NE	11.17	30.95	>60.0					-1.15	-	-	-	-1.15	-20.93	-		
31733-2	E09	CPT	368302.00	1361975.01	2.58			AHD	46.02	Hard clay (weathered rock)	2.94	2.94	10.00	10.00	14.67	45.50					0.65	0.65	-6.41	7.06	-6.41	-11.08	-41.91		
31733-2	E10	CPT	369110.47	1361951.96	6.41			AHD	56.90	Very stiff to hard Clay	5.93	5.93	9.80	9.80	22.93	>56.9					1.49	1.49	-2.38	3.87	-2.38	-15.51	-		
31733-2	E11	Bore	367494.37	1361607.59	2.55			AHD	16.10	Siltstone - low strength	2.00	2.00	6.70	6.70	12.65	14.05					1.56	1.56	-3.15	4.70	-3.15	-9.10	-10.50		
31733-2	E12	Bore	368223.43	1361650.27	5.58			AHD	48.70	Gravel	4.50	4.50	8.50	8.50	18.50	>48.7					2.09	2.09	-1.92	4.00	-1.92	-11.92	-		
31733-2	E13	Bore	368676.89	1361789.20	3.39			AHD	37.50	Siltstone - low strength	2.80	2.80	5.00	8.00	19.00	35.65					1.60	1.60	-0.61	2.20	-3.61	-14.61	-31.26		
31733-2	E14	Bore	368041.15	1362205.39	1.64			AHD	47.80	Siltstone - med strength	1.50	1.50	16.50	16.50	22.00	46.30					1.15	1.15	-13.85	15.00	-13.85	-19.35	-43.65		
31733-2	E15	Bore	368916.98	1361144.73	10.49			AHD	11.05	Sand	9.00	NE	NE	9.00	>11.05	>11.05					2.50	-	-	-	2.50	-	-		
31733-2	E16	Bore	369408.71	1361221.13	9.67			AHD	11.05	Silty clay	10.20	10.20	>11.05	>11.05	>11.05	>11.05					0.48	0.48	-	-	-	-	-		
31733-2	E17	Pit	368362.30	1360788.40	5.18		NA	AHD	4.60	Fill	>4.60	>4.60	>4.60	>4.60	>4.60	>4.60					-	-	-	-	-	-	-		
31733-2	E18	Pit	368058.31	1360992.92	7.27		NA	AHD	3.00	Fill	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
31733-2	E19	Pit	367648.31	1361084.73	7.00		NA	AHD	3.40	Fill	>3.40	>3.40	>3.40	>3.40	>3.40	>3.40					-	-	-	-	-	-	-		
31733-2	E20	Pit	367364.55	1361386.40	6.74		NA	AHD	3.10	Fill	>3.10	>3.10	>3.10	>3.10	>3.10	>3.10					-	-	-	-	-	-	-		
31733-2	E21	Pit	367902.09	1361257.66	2.47		NA	AHD	2.10	Silty Clay	1.40	1.40	>2.10	>2.10	>2.10	>2.10					2.08	2.08	-	-	-	-	-		
31733-2	E22	Pit	368408.56	1361157.93	7.69		NA	AHD	4.00	FIll	>4.00	>4.00	>4.00	>4.00	>4.00	>4.00					-	-	-	-	-	-	-		
31733-2	E23	Pit	368168.03	1361415.09	7.88		NA	AHD	4.20	Fill	>4.20	>4.20	>4.20	>4.20	>4.20	>4.20					-	-	-	-	-	-	-		
31733-2	E24	Pit	367683.61	1361705.52	1.66		NA	AHD	1.00	Clayey sand	NE	0.00	>1.00	>1.00	>1.00	>1.00					-	2.67	-	-	-	-	-		
31733-2	E25	Pit	368570.80	1361539.45	8.27		NA	AHD	3.70	Fill	>3.70	>3.70	>3.70	>3.70	>3.70	>3.70					-	-	-	-	-	-	-		
39342.05	301	CPT	367999.70	1361115.10	7.15		NA	AHD	34.62	Sand	6.80	6.80	8.20	8.20	22.75	>34.62					1.36	1.36	-0.04	1.40	-0.04	-14.59	-		
39342.05	302	CPT	367929.30	1361014.60	8.31		NA	AHD	34.26	Sand	8.30	8.30	11.30	11.30	25.81	>34.26					1.02	1.02	-1.98	3.00	-1.98	-16.49	-		
39342.05	302	Pit	367931.30	1361017.20	8.37		NA	AHD	3.60	Fill	>3.60	>3.60	>3.60	>3.60	>3.60	>3.60					-	-	-	-	-	-	-		
39342.05	303	Pit	367856.10	1361057.50	8.48		NA	AHD	3.00	Fill	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
39342.05	303A	Bore	367856.12	1361065.66	8.16	E-U	8.95	AHD	8.20	Silty Clay	7.80	7.80	>8.20	>8.20	>8.20	>8.20					1.37	1.37	-	-	-	-	-		
39342.05	303B	Bore	367852.13	1361064.58	8.18	E-L		AHD	15.10	Sand	8.00	NE	NE	10.25	>15.10	>15.10					1.19	-	-	-	-1.06	-	-		
39342.05	303B	CPT	367856.40	1361058.40	8.43		NA	AHD	26.16	Clay	7.95	NE	NE	12.93	22.03	>26.16					1.49	-	-	-	-3.49	-12.59	-		
39342.05	304	CPT	367905.20	1361155.60	6.25		NA	AHD	34.46	Clay	6.10	6.10	8.66	8.66	20.82	>34.46					1.16	1.16	-1.40	2.56	-1.40	-13.56	-		
39342.05	305	CPTu	367705.70	1361070.00	8.36		NA	AHD	27.00	Silty Clay	8.05	8.05	9.89	9.89	20.54	>27.00					1.32	1.32	-0.52	1.84	-0.52	-11.17	-		
39342.05	305	Pit	367702.60	1361072.10	8.32		NA	AHD	4.30	Fill	>4.30	>4.30	>4.30	>4.30	>4.30	>4.30					-	-	-	-	-	-	-		
39342.05	306	CPT	367762.00	1361164.10	7.88		NA	AHD	29.24	Sand	7.60	7.60	9.98	9.98	21.40	>29.24					1.29	1.29	-1.09	2.38	-1.09	-12.51	-		
39342.05	306	Pit	367759.70	1361102.00	7.78		NA	AHD	4.50	Fill	>4.50	>4.50	>4.50	>4.50	>4.50	>4.50					-	-	-	-	-	-	-		
39342.05	307	CPT	367823.20	1361235.30	6.50		NA	AHD	43.64	Clay	5.95	5.95	8.80	8.80	21.26	>43.64					1.56	1.56	-1.29	2.85	-1.29	-13.75	-		
39342.05	308	CPTu	367873.20	1361312.40	3.33		NA	AHD	48.20	Clay	2.55	2.55	6.77	6.77	16.25	>48.20					1.79	1.79	-2.43	4.22	-2.43	-11.91	-		
39342.05	308	Pit	367879.90	1361313.80	3.45		NA	AHD	2.90	Clayey Silt	2.70	2.70	>2.90	>2.90	>2.90	>2.90					1.76	1.76	-	-	-	-	-		
39342.05	309	CPTu	368019.30	1360900.40	8.71		NA	AHD	30.26	Clay	8.72	8.72	11.50	11.50	23.88	>30.26					1.00	1.00	-1.78	2.78	-1.78	-14.16	-		
39342.05	309	Pit	368016.80	1360900.20	8.73		NA	AHD	2.70	Fill	>2.70	>2.70	>2.70	>2.70	>2.70	>2.70					-	-	-	-	-	-	-		
39342.05	310	Pit	367807.70	1361090.50	8.31		NA	AHD	2.70	Fill	>2.70	>2.70	>2.70	>2.70	>2.70	>2.70					-	-	-	-	-	-	-		
39342.05	311	Pit	367896.40	1361108.10	7.15		NA	AHD	4.50	Fill	>4.5	>4.5	>4.5	>4.5	>4.5	>4.5					-	-	-	-	-	-	-		
39342.05	312	Pit	367950.70	1361088.50	7.69		NA	AHD	4.60	Fill	>4.6	>4.6	>4.6	>4.6	>4.6	>4.6					-	-	-	-	-	-	-		
39342.05	313	Pit	367986.00	1361000.60	7.89		NA	AHD	3.60	Fill	>3.6	>3.6	>3.6	>3.6	>3.6	>3.6					-	-	-	-	-	-	-		
39342.05	314	Pit	368029.50	1361047.70	7.71		NA	AHD	3.40	Fill	>3.4	>3.4	>3.4	>3.4	>3.4	>3.4					-	-	-	-	-	-	-		
39342.05	315	Pit	367868.80	1361173.20	6.40		NA	AHD	3.00	Fill	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0					-	-	-	-	-	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
39342.05	317	Pit	368581.70	1361017.60	3.52		NA	AHD	3.10	Silty Clay	2.90	2.90	>3.1	>3.1	>3.1	>3.1					1.63	1.63	-	-	-	-	-		
39342.05	318	Pit	368236.60	1361065.40	3.09		NA	AHD	2.80	Silty Clay	2.50	2.50	>2.8	>2.8	>2.8	>2.8					1.60	1.60	-	-	-	-	-		
39342.05	319	Pit	368137.80	1361194.90	7.90		NA	AHD	3.10	Fill	>3.1	>3.1	>3.1	>3.1	>3.1	>3.1					-	-	-	-	-	-	-		
39342.05	320	Pit	367972.10	1361129.20	7.22		NA	AHD	3.40	Fill	>3.4	>3.4	>3.4	>3.4	>3.4	>3.4					-	-	-	-	-	-	-		
39342.05	321	Pit	367895.40	1361253.00	2.36		NA	AHD	1.20	Clayey Silt	1.00	1.00	>1.2	>1.2	>1.2	>1.2					2.37	2.37	-	-	-	-	-		
39342.05	322	Pit	367779.80	1361254.50	7.16		NA	AHD	4.20	Fill	>4.2	>4.2	>4.2	>4.2	>4.2	>4.2					-	-	-	-	-	-	-		
39342.05	325	Bore	367721.00	1361258.00	7.24		NA	AHD	23.10	Siltstone	6.80	6.80	9.50	13.00	21.00	22.00					1.45	1.45	-1.25	2.70	-4.75	-12.75	-13.75		
39342.05	326	Pit	367685.80	1361317.80	6.97		NA	AHD	5.00	Fill	>5.00	>5.00	>5.00	>5.00	>5.00	>5.00					-	-	-	-	-	-	-		
39342.05	326	Bore	367691.36	1361306.84	6.79		NA	AHD	22.35	Sitstone	6.20	6.20	6.70	10.50	NE	18.75					1.60	1.60	1.10	0.50	-2.70	-	-10.95		
39342.05	326	CPT	367685.76	1361317.85	6.97		NA	AHD	20.46	Clay/Sandy Clay	6.30	6.30	8.46	8.46	18.07	>20.46					1.68	1.68	-0.48	2.16	-0.48	-10.09	-		
39342.05	327	Bore	368375.67	1361163.00	7.80		NA	AHD	50.40	Silty Clay	7.00	7.60	9.80	9.80	22.50	>50.4					1.81	1.21	-1.00	2.20	-1.00	-13.70	-		
39342.05	328	Bore	368245.76	1361071.97	3.33		NA	AHD	24.95	Sandy Clay	2.60	2.60	4.00	4.00	17.60	>24.95					1.74	1.74	0.34	1.40	0.34	-13.26	-		
39342.05	329	Bore	368242.62	1361000.93	3.27		NA	AHD	50.40	Siltstone	3.00	3.00	3.80	4.50	18.00	46.75					1.28	1.28	0.48	0.80	-0.22	-13.72	-42.47		
39342.05	330	Pit	367697.06	1361214.33	7.22		NA	AHD	4.10	Fill	>4.1	>4.1	>4.1	>4.1	>4.1	>4.1					-	-	-	-	-	-	-		
39342.05	331	Bore	367939.70	1361136.91	6.92		NA	AHD	36.90	Siltstone	7.35	7.35	8.60	9.40	18.75	33.60					0.58	0.58	-0.67	1.25	-1.47	-10.82	-25.67		
39342.05	332	Bore	367925.26	1361266.97	3.25		NA	AHD	25.05	Silty Clay	3.10	3.10	3.80	4.70	16.80	>25.05					1.16	1.16	0.46	0.70	-0.44	-12.54	-		
39342.05	333	Bore	367767.43	1361165.08	8.11		NA	AHD	25.05	Clayey Sand/Sandy Clay	7.90	7.90	8.30	10.00	21.70	>25.05					1.22	1.22	0.82	0.40	-0.88	-12.58	-		
39342.05	334	Bore	367772.11	1361350.14	5.05		NA	AHD	38.40	Siltstone	4.85	4.85	6.85	9.70	18.20	36.00					1.21	1.21	-0.79	2.00	-3.64	-12.14	-29.94		
39342.05	335	Bore	367593.35	1361205.41	8.09		NA	AHD	29.18	Siltstone	7.50	7.50	8.70	8.70	19.40	25.50					1.60	1.60	0.40	1.20	0.40	-10.30	-16.40		
39342.05	336B	Bore	367549.04	1361159.45	5.93	E-L		AHD	12.05	Sand	5.80	NE	NE	8.90	>12.05	>12.05					1.14	-	-	-	-1.96	-	-		
39342.05	337B	Bore	367707.35	1361030.32	7.62	E-L		AHD	13.45	Sand	6.90	6.90	9.30	9.30	>13.45	>13.45					1.73	1.73	-0.67	2.40	-0.67	-	-		
39342.05	338B	Bore	367827.06	1360971.37	9.21	E-L		AHD	14.95	Sand	9.20	9.20	10.50	10.50	>14.95	>14.95					1.02	1.02	-0.28	1.30	-0.28	-	-		
39342.05	339B	Bore	368149.49	1360867.25	7.23	E-L		AHD	13.40	Sand	7.60	7.60	9.50	9.50	>13.40	>13.40					0.64	0.64	-1.26	1.90	-1.26	-	-		
39342.05	340B	Bore	367975.67	1360910.28	8.99	E-L		AHD	16.45	Sand	8.80	8.80	11.00	11.00	>16.45	>16.45					1.20	1.20	-1.00	2.20	-1.00	-	-		
39342.05	341B	Bore	367908.02	1361311.62	3.16	E-L		AHD	9.95	Sand	3.30	3.30	3.90	3.90	>9.95	>9.95					0.87	0.87	0.27	0.60	0.27	-	-		
39342.05	345	CPT	367749.75	1361414.06	5.08		NA	AHD	35.12	Sandy/Silty Clay (weathered rock?)	4.90	4.90	7.20	7.20	17.24	34.56					1.19	1.19	-1.11	2.30	-1.11	-11.15	-28.47		
39342.05	345	Pit	367749.80	1361414.10	5.08		NA	AHD	4.50	Fill	>4.50	>4.50	>4.50	>4.50	>4.50	>4.50					-	-	-	-	-	-	-		
39342.05	346	CPT	367774.79	1361298.20	5.78		NA	AHD	32.54	Clay (weathered rock ?)	5.40	5.40	7.65	7.65	18.70	32.40					1.39	1.39	-0.86	2.25	-0.86	-11.91	-25.61		
39342.05	346	Pit	367774.80	1361298.20	5.78		NA	AHD	4.50	Fill	>4.50	>4.50	>4.50	>4.50	>4.50	>4.50					-	-	-	-	-	-	-		
39342.05	347	CPT	367654.02	1361212.95	7.37		NA	AHD	25.92	Silty Clay/Sandy Clay (weathered ro	6.60	6.60	8.06	8.06	21.02	24.01					1.78	1.78	0.32	1.46	0.32	-12.64	-15.63		
39342.05	347	Pit	367658.00	1361211.70	7.23		NA	AHD	3.00	Fill	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00					-	-	-	-	-	-	-		
39342.05	348	CPT	367660.11	1361116.47	7.40		NA	AHD	40.88	Clay/Silty Clay (weathered rock?)	6.80	6.80	8.75	8.75	20.97	40.53					1.61	1.61	-0.34	1.95	-0.34	-12.56	-32.12		
39342.05	348	Pit	367660.10	1361116.50	7.40		NA	AHD	4.50	Fill	>4.50	>4.50	>4.50	>4.50	>4.50	>4.50					-	-	-	-	-	-	-		
39342.05	349	CPT	367623.67	1361100.86	6.45		NA	AHD	33.96	Clay/Clayey Silt (weathered rock?)	7.08	NE	NE	7.08	20.88	32.50					0.38	-	-	-	0.38	-13.42	-25.04		
39342.05	349	Pit	367623.70	1361100.90	6.45		NA	AHD	4.60	Fill	>4.60	>4.60	>4.60	>4.60	>4.60	>4.60					-	-	-	-	-	-	-		
39342.05	303A	Bore	367856.17	1361065.66	8.16		8.95	AHD	8.20	Silty Clay	7.80	7.80	>7.80	>7.80	>7.80	>7.80					1.37	1.37	-	-	-	-	-		
39342.05	303B	Bore	367852.13	1361064.58	8.18		NA	AHD	15.10	Sand	8.00	NE	NE	11.40	>15.1	>15.1					1.19	-	-	-	-2.21	-	-		
39342.05	325	Bore	367721.00	1361258.00	7.24			AHD	23.10	Siltstone	6.80	6.80	9.50	9.50	21.00	22.00					1.45	1.45	-1.25	2.70	-1.25	-12.75	-13.75		
39342.05	325A	Bore	367720.71	1361257.76	7.18		7.99	AHD	7.50	Silty clay/clayey silt	6.80	6.80	>7.50	>7.50	>7.50	>7.50					1.39	1.39	-	-	-	-	-		
39342.05	325B	Bore	367718.18	1361259.03	7.18		8.12	AHD	12.40	Silty Sand	6.80	6.80	9.50	9.50	>12.40	>12.40					1.39	1.39	-1.31	2.70	-1.31	-	-		
39342.05	336A	Bore	367549.87	1361158.40	5.91	E-U	6.72	AHD	6.00	Silty Clay	5.80	5.80	>6.00	>6.00	>6.00	>6.00					1.12	1.12	-	-	-	-	-		
39342.05	336B	Bore	367549.04	1361159.45	5.93	E-L	6.71	AHD	12.05	Sand	5.80	5.80	8.90	8.90	>8.9	>8.9					1.14	1.14	-1.96	3.10	-1.96	-	-		
39342.05	337A	Bore	367708.34	1361029.70	7.63	E-U	8.40	AHD	7.00	Silty Clay	6.90	6.90	>7.00	>7.00	>7.00	>7.00					1.74	1.74	-	-	-	-	-		
39342.05	337B	Bore	367707.35	1361030.32	7.62	E-L	8.26	AHD	13.45	Sand	6.90	6.90	9.30	9.30	>13.45	>13.45					1.73	1.73	-0.67	2.40	-0.67	-	-		
39342.05	338A	Bore	367825.82	1360971.75	9.14	E-U	9.92	AHD	9.20	Fill: Grey sandy gravel slag	>9.20	>9.20	>9.20	>9.20	>9.20	>9.20					-	-	-	-	-	-	-		
39342.05	338B	Bore	367827.06	1360971.37	9.21	E-L	9.98	AHD	14.95	Sand	9.20	9.20	10.50	10.50	>14.95	>14.95					1.02	1.02	-0.28	1.30	-0.28	-	-		
39342.05	339A	Bore	368147.96	1360867.48	7.18	E-U	7.93	AHD	7.80	Silty Clay	7.60	7.60	>7.80	>7.80	>7.80	>7.80					0.59	0.59	-	-	-	-	-		
39342.05	339B	Bore	368149.49	1360867.25	7.23	E-L	7.92	AHD	13.40	Sand	7.60	7.60	9.50	9.50	>13.40	>13.40					0.64	0.64	-1.26	1.90	-1.26	-	-		
39342.05	340A	Bore	367974.34	1360910.82	9.00	E-U	9.74	AHD	9.20	Silty Clay	8.80	8.80	>9.20	>9.20	>9.20	>9.20					1.21	1.21	-	-	-	-	-		
39342.05	340B	Bore	367975.67	1360910.28	8.99	E-L	9.69	AHD	16.45	Sand	8.80	8.80	11.00	11.00	>16.45	>16.45					1.20	1.20	-1.00	2.20	-1.00	-	-		
39342.05	341A	Bore	367909.34	1361311.05	3.15	E-U	3.90	AHD	3.30	Fill	>3.30	>3.30	>3.30	>3.30	>3.30	>3.30					-	-	-	-	-	-	-		
39342.05	341B	Bore	367908.02	1361311.62	3.16	E-L	3.85	AHD	9.95	Sand	3.30	3.30	6.00	6.00	>9.95	>9.95					0.87	0.87	-1.83	2.70	-1.83	-	-		
39342.05	342A	Bore	367935.07	1361297.68	3.30	E-U	4.06	AHD	3.40	Silty Clay	3.20	3.20	>3.40	>3.40	>3.40	>3.40					1.11	1.11	-	-	-	-	-		
39342.05	342B	Bore	367934.07	1361298.18	3.32	E-L	4.02	AHD	9.95	Sand	3.20	3.20	5.10	5.10	>9.95	>9.95					1.13	1.13	-0.77	1.90	-0.77	-	-		
39342.05	343A	Bore	367837.37	1361353.47	2.86	E-U	3.66	AHD	2.70	Silty Clay	2.60	2.60	>2.70	>2.70	>2.70	>2.70					1.27	1.27	-	-	-	-	-		
39342.05	343B	Bore	367836.29	1361354.15	2.87	E-L	3.54	AHD	8.95	Sand	2.60	2.60	3.10	3.10	>8.95	>8.95					1.28	1.28	0.78	0.50	0.78	-	-		
39342.05	344A	Bore	368270.25	1361379.39	7.81	E-U	8.60	AHD	7.70	Silty Clay	7.50	7.50	>7.70	>7.70	>7.70	>7.70	3.87				1.32	1.32	-	-	-	-	-	5.74	
39342.05	344B	Bore	368269.25	1361379.79	7.84	E-L	8.63	AHD	11.95	Sand	7.50	7.50	7.90	7.90	>11.95	>11.95		7.71			1.35	1.35	0.95	0.40	0.95	-	-		1.92
39342.05	350A	Bore	367791.15	1361386.08	3.50	E-U	4.16	AHD	3.40	Fill: Silty Sand	>3.40	>3.40	>3.40	>3.40	>3.40	>3.40					-	-	-	-	-	-	-		
39342.05	350B	Bore	367790.45	1361386.81	3.54	E-L	4.25	AHD	10.45	Sand	3.40	3.40	4.20	4.20	>10.45	>10.45					1.15	1.15	0.35	0.80	0.35	-	-		
39342.05	351A	Bore	367737.84	1361417.24	6.75	E-U	7.53	AHD	6.80	Fill	>6.80	>6.80	>6.80	>6.80	>6.80	>6.80					-	-	-	-	-	-	-		
39342.05	351B	Bore	367738.05	1361418.45	6.82	E-L	7.50	AHD	13.29	Sand	6.80	6.80	8.00	8.00	>13.29	>13.29					1.03	1.03	-0.17	1.20	-0.17	-	-		
39342.05	352A	Bore	368344.56	1360729.46	1.87	E-U	2.60	AHD	1.70	Silty Clay	1.30	1.30	>1.70	>1.70	>1.70	>1.70	1.88				1.58	1.58	-	-	-	-	-	1.73	
39342.05	352B	Bore	368346.03	1360728.98	1.89	E-L	2.49	AHD	7.70	Sand	1.30	1.30	1.80	1.80	>7.70	>7.70		1.81			1.60	1.60	1.10	0.50	1.10	-	-		1.69
39342.05	353A	Bore	367943.24	1361154.60	5.93	E-U	6.69	AHD	7.00	Silty Clay	6.70	6.70	>7.00	>7.00	>7.00	>7.00					0.24	0.24	-	-	-	-	-		
39342.05	353B	Bore	367942.04	1361154.21	6.02	E-L	6.78	AHD	11.95	Sand	6.70	6.70	7.40	7.40	>11.95	>11.95					0.33	0.33	-0.37	0.70	-0.37	-	-		
39342.05	354A	Bore	367664.51	1361338.29	11.04	E-U	11.84	AHD	11.10	Silty Clay	10.65	10.65	>11.10	>11.10	>11.10	>11.10					1.40	1.40	-	-	-	-	-		
39342.05	354B	Bore	367663.90	1361336.98	11.13	E-L	11.76	AHD	16.55	Sand	10.65	10.65	11.90	11.90	>16.55	>16.55					1.49	1.49	0.24	1.25	0.24	-	-		
39342.05	355A	Bore	367631.22	1361265.36	11.87	E-U	12.64	AHD	11.75	Silty Clay	11.60	11.60	>11.75	>11.75	>11.75	>11.75					1.28	1.28	-	-	-	-	-		
39342.05	355B	Bore	367631.94	1361266.42	11.90	E-L	12.65	AHD	17.95	Sand	11.60	11.60	12.50	12.50	>17.95	>17.95					1.31	1.31	0.41	0.90	0.41	-	-		
39342	BH13	Bore	368552.00	1360901.00	NA		NA		0.60	Fill	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6					-	-	-	-	-	-	-		
39342	BH14	Bore	368525.00	1360818.00	NA		NA		4.45	Silty sand	3.00	3.00	4.00	>4.45	>4.45	>4.45					-	-	-	1.00	-	-	-		
39342	BH15	Bore	368526.00	1360775.00	NA		NA		6.00	Silty sand	5.50	>6.0	>6.0	>6.0	>6.0	>6.0					-	-	-	-	-	-	-		
39342	BH16	Bore	368510.00	1360805.00	NA		NA		1.20	Fill	>1.2	>1.2	>1.2	>1.2	>1.2	>1.2					-	-	-	-	-	-	-		
39342.05	C01	Bore	368242.12	1361074.60	3.31		NA	AHD	48.65	Gravel	2.80	2.80	3.90	3.90	16.80	>48.65					1.52	1.52	0.42	1.10	0.42	-12.48	-		
39342.05	C02	Bore	368336.76	1360916.63	5.79		NA	AHD	44.26	Sand	5.30	5.30	8.60	11.30	27.10	>44.26					1.50	1.50	-1.80	3.30	-4.50	-20.30	-		
39342.05	C03/D	Bore	368518.39	1360824.18	4.07		4.29	AHD	11.95	Sand	4.30	4.30	8.00	8.00	>11.95	>11.95					0.78	0.78	-2.92	3.70	-2.92	-	-		
39342.05	C03/S	Bore	368519.06	1360821.93	4.07		4.32	AHD	3.10	Fill	>3.10	>3.10	>3.10	>3.10	>3.10	>3.10					-	-	-	-	-	-	-		
39342.05	C04/D	Bore	368335.76	1360868.38	5.48		5.52	AHD	12.50	Sand	6.40	6.40	9.20	9.20	>12.5	>12.5					0.09	0.09	-2.71	2.80	-2.71	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

Douglas Partners

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
39342.05	C04/S	Bore	368334.12	1360868.60	5.48		6.18	AHD	7.00	Sandy silty Clay	6.40	6.40	>7.00	>7.00	>7.00	>7.00					0.09	0.09	-	-	-	-	-		
39342.05	C05/D	Bore	368185.36	1361022.84	3.39		3.89	AHD	8.50	Sand	3.10	3.10	5.00	5.00	>8.5	>8.5					1.30	1.30	-0.60	1.90	-0.60	-	-		
39342.05	C05/S	Bore	368182.89	1361023.94	3.39		3.94	AHD	3.50	Silty Clay	3.10	3.10	>3.50	>3.50	>3.50	>3.50					1.30	1.30	-	-	-	-	-		
39342.05	C06/S	Bore	368086.32	1360898.58	6.61		7.30	AHD	7.30	Silty Clay	7.10	7.10	>7.30	>7.30	>7.30	>7.30					0.52	0.52	-	-	-	-	-		
39342.05	C07/D	Bore	368426.52	1361153.57	7.78	E-L	8.13	AHD	11.50	Sand	6.80	NE	NE	8.30	>11.5	>11.5		7.19			1.99	-	-	-	0.49	-	-		1.95
39342.05	C07/S	Bore	368424.67	1361153.73	7.78	E-U	8.06	AHD	7.10	Clayey Sand	6.80	NE	NE	6.80	>7.10	>7.10	5.51				1.99	-	-	-	1.99	-	-	3.56	
39342.05	C08/D	Bore	368275.16	1361182.64	8.28	E-L	8.66	AHD	11.50	Sand	7.80	7.80	10.15	10.15	>11.5	>11.5		7.79			1.49	1.49	-0.86	2.35	-0.86	-	-		1.88
39342.05	C08/S	Bore	368272.85	1361183.00	8.28	E-U	8.65	AHD	6.00	Fill	>6.00	>6.00	>6.00	>6.00	>6.00	>6.00	4.95				-	-	-	-	-	-	-	4.71	
39342.05	C08A/S	Bore	368273.44	1361183.19	8.28	E-U	8.76	AHD	8.30	Sandy Clay	8.00	8.00	>8.30	>8.30	>8.30	>8.30	7.85				1.29	1.29	-	-	-	-	-	1.92	
39342.05	C09/D	Bore	368453.81	1360938.84	2.95		3.55	AHD	10.30	Sand	3.00	3.00	5.10	6.00	>10.3	>10.3					0.96	0.96	-1.14	2.10	-2.04	-	-		
39342.05	C09/S	Bore	368451.75	1360940.23	2.95		3.45	AHD	3.10	Sandy silty Clay	3.00	3.00	>3.10	>3.10	>3.10	>3.10					0.96	0.96	-	-	-	-	-		
39342.05	C10	Bore	368084.46	1360909.22	6.65		7.13	AHD	37.15	Siltstone	7.60	7.60	8.20	10.20	20.20	34.20					0.06	0.06	-0.54	0.60	-2.54	-12.54	-26.54		
39342.05	C101	CPT	368003.88	1361033.37	7.50		NA	AHD	24.00	Clay	8.47	8.47	10.79	10.79	21.92	>24.00					0.04	0.04	-2.28	2.32	-2.28	-13.41	-		
39342.05	C102	CPT	368064.30	1360974.71	7.89		NA	AHD	25.00	Clay	8.40	8.40	11.21	11.21	22.98	>25.00					0.50	0.50	-2.31	2.81	-2.31	-14.08	-		
39342.05	C103	CPT	368198.84	1360927.51	7.20		NA	AHD	24.02	Clay	8.25	8.25	10.87	10.87	21.99	>24.02					-0.04	-0.04	-2.66	2.62	-2.66	-13.78	-		
39342.05	C104	CPT	368327.06	1360886.22	6.11		NA	AHD	33.98	Sand	7.87	7.87	9.50	9.50	16.55	>33.98					-0.75	-0.75	-2.38	1.63	-2.38	-9.43	-		
39342.05	C105	CPT	368337.66	1360918.20	5.81		NA	AHD	29.80	Clay	5.38	5.38	8.95	8.95	26.45	>29.80					1.44	1.44	-2.13	3.57	-2.13	-19.63	-		
39342.05	C106	CPT	368433.42	1360889.73	3.62		NA	AHD	26.00	Clay some Silty Clay	3.39	3.39	6.63	9.40	21.77	>26.00					1.24	1.24	-2.00	3.24	-4.77	-17.14	-		
39342.05	C107	CPT	368534.76	1361128.71	6.08		NA	AHD	23.06	Clay	5.70	5.70	7.55	7.55	19.59	>23.06					1.39	1.39	-0.46	1.85	-0.46	-12.50	-		
39342.05	C108C	CPT	368424.15	1361151.20	7.76		NA	AHD	25.00	Clay	6.87	NE	NE	7.85	19.65	>25.00					1.90	-	-	-	0.92	-10.88	-		
39342.05	C109	CPT	368338.52	1361170.23	7.78		NA	AHD	24.00	Clay	7.29	7.29	9.77	9.77	21.45	>24.00					1.50	1.50	-0.98	2.48	-0.98	-12.66	-		
39342.05	C11	CPT	368446.13	1360940.12	2.79		NA	AHD	41.50	Sand	2.59	2.59	4.93	4.93	21.62	>41.50					1.21	1.21	-1.14	2.34	-1.14	-17.83	-		
39342.05	C110B	CPT	368199.57	1361204.27	8.18		NA	AHD	34.22	Sand	7.59	7.59	8.69	8.69	21.95	>34.22					1.60	1.60	0.50	1.10	0.50	-12.76	-		
39342.05	C111	CPT	368105.22	1361201.13	7.79		NA	AHD	24.00	Clay	5.96	5.96	8.29	8.29	21.14	>24.00					2.84	2.84	0.51	2.33	0.51	-12.34	-		
39342.05	C112	CPT	368053.16	1361121.88	4.78		NA	AHD	21.00	Clay	3.68	3.68	5.16	5.16	17.90	>21.00					2.11	2.11	0.63	1.48	0.63	-12.11	-		
39342.05	C113	CPT	368283.05	1361011.99	2.72		NA	AHD	20.98	Clay	2.56	2.56	3.49	3.49	16.06	>20.98					1.17	1.17	0.24	0.93	0.24	-12.33	-		
39342.05	C12	CPT	368518.11	1360822.94	4.09		NA	AHD	41.00	Sand	4.00	4.00	8.49	8.49	21.91	>41.00					1.10	1.10	-3.39	4.49	-3.39	-16.81	-		
39342.05	C13	Bore	368200.42	1361198.58	8.24		NA	AHD	7.30	Fill	>7.30	>7.30	>7.30	>7.30	>7.30	>7.30					-	-	-	-	-	-	-		
39342.05	C14	CPT	368103.12	1361147.03	4.87		NA	AHD	40.26	Weathered rock?	4.24	4.24	4.86	4.86	17.90	40.26					1.64	1.64	1.02	0.62	1.02	-12.02	-34.38		
39342.05	C15	CPT	368082.10	1361047.85	6.35		NA	AHD	35.02	Sand	6.00	6.00	8.49	8.49	20.61	>35.02					1.36	1.36	-1.13	2.49	-1.13	-13.25	-		
39342.05	C16	CPT	368178.46	1361022.67	3.26		NA	AHD	43.58	Weathered rock?	2.98	2.98	4.70	4.70	18.13	42.00					1.29	1.29	-0.43	1.72	-0.43	-13.86	-37.73		
39342.05	C17	CPT	368245.90	1360909.12	7.19		NA	AHD	41.12	Weathered rock?	8.61	8.61	10.98	10.98	20.34	41.12					-0.41	-0.41	-2.78	2.37	-2.78	-12.14	-32.92		
39342.05	C18a	CPTu	368155.36	1361092.27	2.55		NA	AHD	15.00	Sand	2.05	2.05	3.00	3.00	>15.00	>15.00					1.51	1.51	0.56	0.95	0.56	-	-		
39342.05	C19	CPTu	368273.21	1360993.23	3.00		NA	AHD	15.00	Sand	2.67	2.67	3.54	4.13	>15.00	>15.00					1.34	1.34	0.47	0.87	-0.12	-	-		
39342.05	C20	CPTu	368435.15	1360873.25	3.93		NA	AHD	15.00	Sand	3.65	4.47	7.50	7.50	>15.02	>15.02					1.29	0.47	-2.56	3.03	-2.56	-	-		
39342.05	C201A	Bore	368200.01	1361199.21	8.23	E-U	8.73	AHD	8.00	Sandy Clay	7.30	NE	NE	NE	>8.00	>8.00	4.60				1.94	-	-	-	-	-	-	5.14	
39342.05	C201B	Bore	368198.41	1361198.85	8.23	E-L	8.64	AHD	11.70	Sand	7.30	NE	NE	8.70	>11.7	>11.7		7.78			1.94	-	-	-	0.54	-	-		1.87
39342.05	C202C	Bore	368268.70	1361183.81	8.28		8.57	AHD	23.00	Clay	8.00	8.00	10.20	10.20	22.30	>23.00					1.29	1.29	-0.91	2.20	-0.91	-13.01	-		
39342.05	C203A	Bore	368338.86	1361170.96	7.82	E-U	8.19	AHD	7.80	Clay	7.30	7.30	>7.80	>7.80	>7.80	>7.80	4.49				1.53	1.53	-	-	-	-	-	4.71	
39342.05	C203B	Bore	368336.24	1361171.36	7.82	E-L	8.24	AHD	12.80	Sand	7.30	7.30	9.80	9.80	>12.80	>12.80		7.31			1.53	1.53	-0.97	2.50	-0.97	-	-		1.94
39342.05	C204A	Bore	368502.54	1361140.87	7.75	E-U	8.17	AHD	7.50	Clay	7.20	7.20	>7.50	>7.50	>7.50	>7.50	4.50				1.56	1.56	-	-	-	-	-	4.69	
39342.05	C204B	Bore	368500.11	1361141.73	7.75	E-L	8.19	AHD	12.00	Sand	7.20	7.20	9.00	9.00	>12.00	>12.00		7.24			1.56	1.56	-0.25	1.80	-0.25	-	-		1.96
39342.05	C205C	Bore	368526.14	1361135.75	7.24	E-L	7.70	AHD	21.00	Clay	6.80	6.80	8.60	8.60	20.50	>21.00		6.89			1.45	1.45	-0.35	1.80	-0.35	-12.25	-		1.82
39342.05	C206A	Bore	368583.64	1361036.57	3.64	E-U	4.01	AHD	3.30	Fill	>3.30	>3.30	>3.30	>3.30	>3.30	>3.30	2.04				-	-	-	-	-	-	-	2.97	
39342.05	C206B	Bore	368583.93	1361038.45	3.64	E-L	4.03	AHD	7.80	Sand	3.30	3.30	4.80	4.80	>7.80	>7.80		3.07			1.35	1.35	-0.15	1.50	-0.15	-	-		1.97
39342.05	C207A	Bore	368480.94	1360910.62	3.38	E-U	3.65	AHD	3.50	Fill	>3.50	>3.50	>3.50	>3.50	>3.50	>3.50					-	-	-	-	-	-	-		
39342.05	C207B	Bore	368479.28	1360909.12	3.38	E-L	3.75	AHD	9.60	Sand	3.50	3.50	6.60	6.60	>9.60	>9.60					0.89	0.89	-2.21	3.10	-2.21	-	-		
39342.05	C208C	Bore	368448.89	1360894.99	3.59	E-L	3.97	AHD	23.00	Clay	3.50	3.50	6.60	9.40	22.10	>23.00					1.10	1.10	-2.00	3.10	-4.80	-17.50	-		
39342.05	C209C	Bore	368336.19	1360916.84	5.77	E-L	6.12	AHD	27.70	Clay	6.00	6.00	9.00	11.20	27.20	>27.70					0.78	0.78	-2.22	3.00	-4.42	-20.42	-		
39342.05	C21	CPTu	368577.37	1361101.62	4.32		NA	AHD	15.00	Sand	3.50	3.50	4.84	4.84	>15.00	>15.00					1.83	1.83	0.49	1.34	0.49	-	-		
39342.05	C210A	Bore	368324.72	1360886.41	6.12	E-U	6.50	AHD	8.30	Clay	8.00	8.00	>8.30	>8.30	>8.30	>8.30					-0.88	-0.88	-	-	-	-	-		
39342.05	C210B	Bore	368327.10	1360887.77	6.12	E-L	6.40	AHD	12.50	Sand	8.00	8.00	9.80	9.80	>12.50	>12.50					-0.88	-0.88	-2.68	1.80	-2.68	-	-		
39342.05	C211A	Bore	368246.15	1360912.25	7.13	E-U	7.43	AHD	9.00	Sandy Clayey Silt	8.60	8.60	>9.00	>9.00	>9.00	>9.00					-0.46	-0.46	-	-	-	-	-		
39342.05	C211B	Bore	368245.36	1360909.28	7.13	E-L	7.39	AHD	14.00	Sand	8.60	8.60	11.00	11.00	>14.00	>14.00					-0.46	-0.46	-2.86	2.40	-2.86	-	-		
39342.05	C212C	Bore	368140.72	1360947.45	7.16	E-L	7.62	AHD	22.55	Clay	7.10	7.10	10.00	10.00	22.10	>22.55					1.07	1.07	-1.83	2.90	-1.83	-13.93	-		
39342.05	C213C	Bore	368063.77	1360974.95	7.19	E-L	8.23	AHD	23.50	Clay	8.40	8.40	11.20	11.20	23.00	>23.50					-0.20	-0.20	-3.00	2.80	-3.00	-14.80	-		
39342.05	C214A	Bore	368004.26	1361021.74	7.21	E-U	7.52	AHD	8.50	Clay	8.00	8.00	>8.50	>8.50	>8.50	>8.50					0.22	0.22	-	-	-	-	-		
39342.05	C214B	Bore	368002.47	1361022.43	7.21	E-L	7.50	AHD	13.50	Sand	8.00	8.00	10.50	10.50	>13.50	>13.50					0.22	0.22	-2.28	2.50	-2.28	-	-		
39342.05	C215A	Bore	368067.86	1361156.89	4.88	E-U	5.25	AHD	4.00	Clay	3.90	3.90	>4.00	>4.00	>4.00	>4.00					1.99	1.99	-	-	-	-	-		
39342.05	C215B	Bore	368066.60	1361155.97	4.88	E-L	5.17	AHD	8.30	Sand	3.90	3.90	5.30	5.30	>8.30	>8.30					1.99	1.99	0.59	1.40	0.59	-	-		
39342.05	C22	CPT	368268.58	1361183.98	8.31		NA	AHD	51.80	Sand	8.00	8.00	10.17	10.17	22.45	>51.8					1.32	1.32	-0.85	2.17	-0.85	-13.13	-		
39342.05	C23	Pit	368520.85	1360836.67	4.44		NA	AHD	1.15	Fill	>1.15	>1.15	>1.15	>1.15	>1.15	>1.15					-	-	-	-	-	-	-		
39342.05	C24	Pit	368443.65	1360911.86	3.40		NA	AHD	3.80	Silty Clay	2.80	2.80	>3.8	>3.8	>3.8	>3.8					1.61	1.61	-	-	-	-	-		
39342.05	C25	Pit	368121.04	1361125.82	5.16		NA	AHD	3.90	Fill	>3.9	>3.9	>3.9	>3.9	>3.9	>3.9					-	-	-	-	-	-	-		
39342.05	C26	Pit	368098.05	1361087.38	5.21		NA	AHD	3.90	Fill	>3.8	>3.8	>3.8	>3.8	>3.8	>3.8					-	-	-	-	-	-	-		
39342.05	C27	Pit	368098.33	1361004.18	7.78		NA	AHD	3.50	Fill	>3.5	>3.5	>3.5	>3.5	>3.5	>3.5					-	-	-	-	-	-	-		
39342.05	C28	Pit	368144.27	1361000.79	6.93		NA	AHD	3.60	Fill	>3.6	>3.6	>3.6	>3.6	>3.6	>3.6					-	-	-	-	-	-	-		
39342.05	C29	Pit	368126.39	1360920.26	7.28		NA	AHD	3.50	Fill	>3.5	>3.5	>3.5	>3.5	>3.5	>3.5					-	-	-	-	-	-	-		
39342.05	C30	Pit	368178.19	1360891.49	7.25		NA	AHD	2.10	Fill	>2.1	>2.1	>2.1	>2.1	>2.1	>2.1					-	-	-	-	-	-	-		
39342.05	C301	Pit	368435.35	1360718.72	2.39		NA	AHD	1.80	Fill	>1.80	>1.80	>1.80	>1.80	>1.80	>1.80					-	-	-	-	-	-	-		
39342.05	C302	Pit	368243.19	1360756.09	1.78		NA	AHD	2.80	Clayey Sand/Sandy Clay	1.50	1.50	2.00	2.00	>2.80	>2.80					1.29	1.29	0.79	0.50	0.79	-	-		
39342.05	C303	Pit	368252.71	1360670.25	1.06		NA	AHD	3.00	Silty Sandy Clay	NE	0.00	1.00	1.00	>3.00	>3.00					-	2.07	1.07	1.00	1.07	-	-		
39342.05	C304	Pit	368047.05	1360806.36	1.95		NA	AHD	3.00	Clayey Sand/Sandy Clay	1.20	1.20	2.00	2.00	>3.00	>3.00					1.76	1.76	0.96	0.80	0.96	-	-		
39342.05	C31	Pit	368213.38	1360929.02	7.35		NA	AHD	0.15	Fill	>0.15	>0.15	>0.15	>0.15	>0.15	>0.15					-	-	-	-	-	-	-		
39342.05	C32	Pit	368277.59	1360937.13	7.11		NA	AHD	0.40	Fill	>0.40	>0.40	>0.40	>0.40	>0.40	>0.40					-	-	-	-	-	-	-		
39342.05	C33	Pit	368285.69	1361013.55	2.72		NA	AHD	3.00	Clayey Sand	2.50	2.50	2.80	>3.00	>3.00	>3.00					1.23	1.23	0.93	0.30	-	-	-		
39342.05	C34	Pit	368193.56	1361106.23	4.61		NA	AHD	3.50	Fill	>3.50	>3.50	>3.50	>3.50	>3.50	>3.50					-	-	-	-	-	-	-		
39342.05	C35	Pit	368266.10	1361099.34	3.91		NA	AHD	3.50	Silty Clay	3.20	3.20	>3.50	>3.50	>3.50	>3.50					1.72	1.72	-	-	-	-	-		
39342.05	C36	Pit	368241.33	1361004.41	3.40		NA	AHD	2.70	Fill	>2.7	>2.7	>2.7	>2.7	>2.7	>2.7					-	-	-	-	-	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY Project 49533.02

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
39342.05	C37	Pit	368163.15	1361059.36	2.94		NA	AHD	2.60	Clayey Sand	2.30	2.30	>2.6	>2.6	>2.6	>2.6					1.65	1.65	-	-	-	-	-		
39342.05	C38	Pit	368216.33	1361052.79	3.11		NA	AHD	0.20	Fill	>0.2	>0.2	>0.2	>0.2	>0.2	>0.2					-	-	-	-	-	-	-		
39342.05	C39	Pit	368315.73	1360936.44	5.97		NA	AHD	3.40	Fill	>3.4	>3.4	>3.4	>3.4	>3.4	>3.4					-	-	-	-	-	-	-		
39342.05	C40	Pit	368362.76	1360876.72	5.50		NA	AHD	3.20	Fill	>3.2	>3.2	>3.2	>3.2	>3.2	>3.2					-	-	-	-	-	-	-		
39342.05	C41	Pit	368401.11	1360908.66	2.62		NA	AHD	2.40	Silty Clay	2.20	2.20	>2.4	>2.4	>2.4	>2.4					1.43	1.43	-	-	-	-	-		
39342.05	C42	Pit	368472.36	1360867.27	4.47		NA	AHD	0.60	Fill	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6					-	-	-	-	-	-	-		
39342.05	C43	Pit	368559.19	1360951.51	2.97		NA	AHD	0.60	Fill	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6					-	-	-	-	-	-	-		
39342.05	C44	Pit	368511.41	1360893.73	4.68		NA	AHD	1.65	Fill	>1.65	>1.65	>1.65	>1.65	>1.65	>1.65					-	-	-	-	-	-	-		
39342.05	C45	Pit	368509.30	1360954.08	2.85		NA	AHD	2.60	Silty Clay	2.20	2.20	>2.60	>2.60	>2.60	>2.60					1.66	1.66	-	-	-	-	-		
39342.05	C46	Pit	368580.69	1361088.05	4.22		NA	AHD	3.20	Fill	>3.2	>3.2	>3.2	>3.2	>3.2	>3.2					-	-	-	-	-	-	-		
39342.05	C47	CPT	368108.14	1360961.16	7.37		NA	AHD	15.00	Sand	8.00	8.00	10.59	10.59	>15.00	>15.00					0.38	0.38	-2.22	2.59	-2.22	-	-		
39342.05	C48	CPT	368147.24	1361201.63	7.96		NA	AHD	15.00	Sand	6.90	6.90	8.60	8.60	>15.00	>15.00					2.07	2.07	0.37	1.70	0.37	-	-		
39342.05	C49	Bore	368339.19	1360792.43	1.00		NA	AHD	0.30	Fill	>0.30	>0.30	>0.30	>0.30	>0.30	>0.30					-	-	-	-	-	-	-		
39342.05	C50	Bore	368296.94	1360780.23	1.00		NA	AHD	0.35	Fill	>0.35	>0.35	>0.35	>0.35	>0.35	>0.35					-	-	-	-	-	-	-		
39342.05	C51	Bore	368205.70	1360875.00	0.90		NA	AHD	0.60	Silty Clay	0.30	0.30	>0.60	>0.60	>0.60	>0.60					1.61	1.61	-	-	-	-	-		
39342.05	C52	Bore	368187.83	1360935.36	0.70		NA	AHD	0.50	Fill (?)	>0.50	>0.50	>0.50	>0.50	>0.50	>0.50					-	-	-	-	-	-	-		
39342.05	C54	CPT	368472.63	1360997.37	1.63		NA	AHD	7.50	Sand	0.66	0.66	2.77	2.77	>7.5	>7.5					1.98	1.98	-0.13	2.11	-0.13	-	-		
39342.05	C55	Bore	368402.39	1361009.85	1.76		NA	AHD	0.70	Fill	>0.70	>0.70	>0.70	>0.70	>0.70	>0.70					-	-	-	-	-	-	-		
39342.05	C56	CPT	368484.25	1361050.75	2.16		NA	AHD	0.56	Fill	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6					-	-	-	-	-	-	-		
39342.05	C57	CPT	368525.32	1361038.67	1.59		NA	AHD	4.38	Sand	1.27	1.27	3.40	3.40	>4.38	>4.38					1.33	1.33	-0.80	2.13	-0.80	-	-		
39342.05	C58	CPT	368343.27	1361064.18	2.06		NA	AHD	7.00	Sand	1.27	1.27	3.32	3.32	>7.0	>7.0					1.80	1.80	-0.25	2.05	-0.25	-	-		
39342.05	C59	CPT	368522.63	1360985.92	1.47		NA	AHD	3.56	Sand	1.02	1.02	2.62	2.62	>3.56	>3.56					1.46	1.46	-0.14	1.60	-0.14	-	-		
EES 106121	BHe42	Bore	369817.80	1361130.00	2.23	E-U	NA	AHD	2.20	Clay	1.90	1.90	>2.2	>2.2	NE	NE					1.34	1.34	-	-	-	-	-		
EES 106121	BHe43S	Bore	369757.50	1361184.00	2.46	E-U	NA	AHD	4.20	Sand	2.80	2.80	3.10	3.10	NE	NE					0.67	0.67	0.37	0.30	0.37	-	-		
EES 106121	BHe43D	Bore	369758.20	1361184.00	2.45	E-U	NA	AHD	4.00	Sand	2.80	2.80	3.10	3.10	NE	NE					0.66	0.66	0.36	0.30	0.36	-	-		
EES 106121	BHe44	Pit	369568.33	1361244.24	NA		NA		3.90	Fill	>3.9	>3.9	NE	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe45	Bore	369494.35	1361262.13	NA		NA		3.60	Fill	>3.6	>3.6	NE	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe46	Pit	369366.96	1361276.46	NA		NA		4.60	Fill	>4.6	>4.6	NE	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe47	Bore	369249.10	1361323.00	5.37	E-U	NA	AHD	6.60	Sandy Clay	5.60	5.60	>6.6	NE	NE	NE					0.78	0.78	-	-	-	-	-		
EES 106121	BHe48	Pit	368728.36	1361169.65	NA		NA		3.80	Fill	>3.80	>3.8	NE	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe49	Bore	368637.00	1361108.00	1.19		NA	AHD	4.50	Sand	0.40	0.40	1.30	1.30	>4.5	NE					1.80	1.80	0.90	0.90	0.90	-	-		
EES 106121	BHe50D	Bore	368523.20	1361278.00	7.53	E-L	8.26	AHD	8.80	Sand	6.80	6.80	6.80	6.80	>8.4	>8.80		7.01			1.74	1.74	1.74	0.00	1.74	-	-		2.26
EES 106121	BHe50S	Bore	368524.30	1361278.00	7.58	E-U	8.36	AHD	3.00	Fill	>3.00	>3.00	>3.00	NE	NE	NE	3.08				-	-	-	-	-	-	-	6.29	
EES 106121	BHe51	Pit	368318.60	1361211.13	NA		NA		3.50	Fill	>3.5	>3.5	>3.5	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe52S	Bore	368234.60	1361201.00	6.10		6.50	AHD	7.30	Sand	5.80	5.80	6.60	6.60	>7.3	>7.3					1.31	1.31	0.51	0.80	0.51	-	-		
EES 106122	BHe52D	Bore	368235.30	1361201.00	6.08		7.52	AHD	7.70	Sand	5.80	5.80	6.60	6.60	>7.7	>7.7					1.29	1.29	0.49	0.80	0.49	-	-		
EES 106121	BHe53	Bore	368040.40	1361284.00	7.01		7.61	AHD	8.50	Sand	6.20	6.20	7.50	7.50	>8.5	>8.5					1.82	1.82	0.52	1.30	0.52	-	-		
EES 106121	BHe54	Pit	367910.90	1361391.82	NA		NA	AHD	4.50	Clay	4.00	4.00	>4.5	>4.5	>4.5	>4.5					-	-	-	-	-	-	-		
EES 106121	BHe55	Bore	367836.71	1361397.47	NA		NA	AHD	7.30	Sand	3.10	3.10	6.70	7.00	>7.3	>7.3					-	-	-	3.60	-	-	-		
EES 106121	BHe56	Bore	367810.05	1361459.20	NA		NA	AHD	7.30	Clayey Sand	4.40	4.40	>7.3	>7.3	>7.3	>7.3					-	-	-	-	-	-	-		
EES 106121	BHe57	Bore	367678.38	1361522.40	NA		NA	AHD	7.00	Fill	>7.0	>7.0	>7.0	>7.0	>7.0	>7.0					-	-	-	-	-	-	-		
EES 106121	BHe58	Bore	367365.30	1361525.68	NA		NA	AHD	7.30	Fill	>7.3	>7.3	>7.3	>7.3	>7.3	>7.3					-	-	-	-	-	-	-		
EES 106121	BHe59	Pit?	367280.75	1361443.08	NA		NA	AHD	5.00	Silty Clay	2.60	2.60	>5.0	>5.0	>5.0	>5.0					-	-	-	-	-	-	-		
EES 106121	BHe60D	Bore	367272.40	1361378.00	2.51	E-L	4.25	AHD	8.20	Clayey Sand	2.20	2.20	6.10	6.10	>8.20	>8.20					1.32	1.32	-2.58	3.90	-2.58	-	-		
EES 106121	BHe60S	Bore	367273.40	1361377.00	2.52	E-U	3.90	AHD	2.50	Clay	2.20	2.20	>2.20	>2.2	>2.20	>2.20					1.33	1.33	-	-	-	-	-		
EES 106122	BHe61S	Bore	368673.30	1362061.00	5.87			AHD	4.00	Fill	>4.0	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
EES 106121	BHe61D	Bore	368673.50	1362060.00	5.68			AHD	31.00	Sand	5.50	5.50	11.20	11.20	17.00	NE					1.19	1.19	-4.51	5.70	-4.51	-10.31	-		
EES 106122	BHe62D	Bore	369136.80	1361740.00	1.25	E-L		AHD	4.20	Sand	1.20	1.20	3.80	3.80	>4.2	NE					1.06	1.06	-1.54	2.60	-1.54	-	-		
EES 106121	BHe62S	Bore	369136.70	1361740.00	1.21	E-U		AHD	1.30	Silty Clay	1.20	1.20	>1.2	>1.2	NE	NE					1.02	1.02	-	-	-	-	-		
EES 106122	BHe62L	Bore	369134.80	1361729.00	3.59	E-L		AHD	29.50	Sand	5.50	5.50	8.00	8.00	20.50	>29.5					-0.90	-0.90	-3.40	2.50	-3.40	-15.90	-		
EES 106121	BHe63D	Bore	368649.00	1361694.00	4.31	E-L	4.92	AHD	9.00	Sand	5.20	5.20	6.30	6.30	>9.00	>9.00		3.82			0.12	0.12	-0.98	1.10	-0.98	-	-		2.11
EES 106121	BHe63S	Bore	368653.20	1361696.00	4.27	E-U	4.93	AHD	3.10	Fill	>3.10	>3.10	NE	NE	NE	NE	2.31				-	-	-	-	-	-	-	3.64	
EES 106121	BHe64D	Bore	368650.30	1361619.00	4.40	E-L	5.19	AHD	7.50	Sand	3.40	3.40	6.20	6.20	>7.5	>7.5		4.07			2.01	2.01	-0.79	2.80	-0.79	-	-		2.12
EES 106121	BHe64S	Bore	368649.80	1361618.00	4.41	E-U	4.96	AHD	3.00	Fill	>3.0	>3.0	NE	NE	NE	NE	2.36				-	-	-	-	-	-	-	3.61	
EES 106121	BHe65	Bore	368652.00	1361556.00	3.91			AHD	7.00	Sand	3.30	3.30	6.00	6.00	>7.0	>7.0					1.62	1.62	-1.09	2.70	-1.09	-	-		
EES 106121	BHe65D	Bore	368651.90	1361556.00	3.91	E-L	4.72	AHD	8.00	Sand	3.30	3.30	6.00	6.00	>8.0	>8.0		3.44			1.62	1.62	-1.09	2.70	-1.09	-	-		2.29
EES 106121	BHe65S	Bore	368652.00	1361555.00	3.90	E-U	4.52	AHD	3.80	Clay	3.30	3.30	>3.8	>3.8	NE	NE	2.35				1.61	1.61	-	-	-	-	-	3.19	
EES 106121	BHe66	Bore	368801.30	1360780.00	2.20	E-L		AHD	32.50	Gravels	1.30	1.90	6.50	11.50	16.00	>32.5					1.91	1.31	-3.29	4.60	-8.29	-12.79	-		
EES 106121	BHe67	Bore	369401.60	1360796.00	2.34	E-L		AHD	33.50	Sand	2.20	2.20	2.70	2.70	19.50	>33.5					1.15	1.15	0.65	0.50	0.65	-16.15	-		
EES 106121	BHe68D	Bore	369450.20	1361376.00	2.17	E-L		AHD	7.40	Sand	2.60	2.60	5.80	5.80	>7.4	NE					0.58	0.58	-2.62	3.20	-2.62	-	-		
EES 106121	BHe68S	Bore	369449.70	1361374.00	2.16	E-U	2.51	AHD	2.80	Silty Clay	2.60	2.60	>2.8	NE	NE	NE	2.00				0.57	0.57	-	-	-	-	-	1.52	
EES 106121	BHe69D	Bore	369619.60	1361339.00	2.31	E-L	3.00	AHD	7.20	Sand	2.20	2.20	5.00	5.00	>7.2	NE					1.12	1.12	-1.68	2.80	-1.68	-	-		
EES 106121	BHe69S	Bore	369618.80	1361339.00	2.28	E-U	2.99	AHD	2.60	Sandy Clay	2.20	2.20	>2.6	NE	NE	NE	2.20				1.09	1.09	-	-	-	-	-	1.80	
EES 106121	BHe70D	Bore	369890.70	1361280.00	2.22	E-L	2.50	AHD	7.20	Sand	2.20	2.20	4.80	4.80	>7.2	NE		2.03			1.03	1.03	-1.58	2.60	-1.58	-	-		1.48
EES 106121	BHe70S	Bore	369891.20	1361279.00	2.20	E-U	2.40	AHD	2.20	Fill	2.20	2.20	>2.2	NE	NE	NE	1.89				1.01	1.01	-	-	-	-	-	1.52	
EES 106121	BHe71	Bore	369736.10	1361198.00	2.33			AHD	2.10	Clay	1.90	1.90	>2.1	NE	NE	NE					1.44	1.44	-	-	-	-	-		
EES 106121	BHe72	Bore	369680.60	1361207.00	2.62			AHD	5.60	Sand	3.60	3.60	4.20	4.20	>5.6	>5.6					0.03	0.03	-0.57	0.60	-0.57	-	-		
EES 106121	BHe73	Bore	369688.10	1361150.00	2.55			AHD	3.40	Clay	3.20	3.20	>3.4	>3.4	NE	NE					0.36	0.36	-	-	-	-	-		
EES 106121	BHe74	Bore	369686.30	1361090.00	3.86			AHD	5.50	Sand	3.60	3.60	5.00	5.00	>5.5	NE					1.27	1.27	-0.13	1.40	-0.13	-	-		
EES 106121	BHe75	Bore	369783.00	1361136.00	2.46			AHD	4.50	Sand	1.80	1.80	3.80	3.80	>4.5	NE					1.67	1.67	-0.33	2.00	-0.33	-	-		
EES 106121	BHe76	Bore	369777.50	1361162.00	2.33			AHD	2.20	Clay	2.00	2.00	>2.2	NE	NE	NE					1.34	1.34	-	-	-	-	-		
EES 106121	BHe77	Bore	369791.90	1361162.00	2.27			AHD	2.20	Clay	2.00	2.00	>2.2	NE	NE	NE					1.28	1.28	-	-	-	-	-		
EES 106121	BHe78	Bore	369800.90	1361185.00	2.20			AHD	2.10	Clay	1.85	1.85	>2.1	NE	NE	NE					1.36	1.36	-	-	-	-	-		
EES 106121	BHe79	Bore	369849.90	1361164.00	2.36			AHD	4.50	Sand	1.90	1.90	3.40	3.40	>4.5	NE					1.47	1.47	-0.03	1.50	-0.03	-	-		
EES 9359	K1/1S	Bore	368043.20	1360810.14	1.87	E-L	2.36	AHD	4.94	Bore logs not provided	NE	NE	NE	NE	NE	NE	1.72				-	-	-	-	-	-	-	1.65	
EES 9359	K1/1W	Bore	368041.95	1360810.46	1.84	E-L	2.22	AHD	12.25	Sand	0.00	0.00	4.70	4.70	>12.25	NE		1.65			2.85	2.85	-1.85	4.70	-1.85	-	-		1.58
EES 9359	K1/2N	Bore	367709.91	1360938.27	1.24	E-L	1.62	AHD	10.75	Sandy clay	0.00	0.00	5.80	5.80	8.80	NE		1.14			2.25	2.25	-3.55	5.80	-3.55	-6.55	-		1.49
EES 9359	K1/2S	Bore	367709.66	1360937.25	1.12	E-L	1.69	AHD	5.00	Sand	0.00	0.00	4.30	4.30	>5.0	NE	1.27				2.13	2.13	-2.17	4.30	-2.17	-	-	1.43	
EES 9359	K2/1	Bore	367912.77	1361150.38	6.31		6.86	AHD	7.48	Fill	>7.0	>7.0	NE	NE	NE	NE					-	-	-	-	-	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

Douglas Partners

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
EES 9359	K2/2	Bore	367754.98	1361135.57	7.25		7.84	AHD	7.50	Clay	6.80	6.80	>7.5	>7.5	NE	NE					1.46	1.46	-	-	-	-	-		
EES 9359	K2/3	Bore	367799.00	1361261.40	7.29		8.20	AHD	7.38	Sandy clay	6.50	6.50	>7.38	>7.38	NE	NE					1.80	1.80	-	-	-	-	-		
EES 9359	K2/4N	Bore	367749.58	1361473.13	7.37	E-L		AHD	13.00	Silty sand	8.00	8.00	10.00	10.00	>13.0	>13.0					0.38	0.38	-1.62	2.00	-1.62	-	-		
EES 9359	K2/4S	Bore	367749.58	1361473.13	7.33	E-U		AHD	9.45	Sandy silt	8.00	8.00	10.00	10.00	>13.0	>13.0					0.34	0.34	-1.66	2.00	-1.66	-	-		
EES 9359	K3/1W	Bore	368017.56	1361578.65	7.60	E-L	8.46	AHD	14.05	Sand	7.50	7.50	12.70	12.70	>14.05	NE		7.40			1.11	1.11	-4.09	5.20	-4.09	-	-		2.07
EES 9359	K3/1E	Bore	368017.56	1361578.65	7.60	E-U	8.46	AHD	8.40	Silty clay	7.50	7.50	>8.4	>8.4	>8.4	>8.4	5.23				1.11	1.11	-	-	-	-	-	4.24	
EES 9359	K5/1	Bore	368344.05	1361363.12	8.13	E-U	8.66	AHD	5.45	Silty clay: very soft? (possible filling)	4.90	4.90	>5.45	>5.45	NE	NE	4.08				4.24	4.24	-	-	-	-	-	5.59	
EES 9359	K5/2	Bore	368643.30	1361822.30	3.06	E-U		AHD	4.00	Clay	2.80	2.80	>4.0	NE	NE	NE	1.39				1.27	1.27	-	-	-	-	-	-0.38	
EES 9359	K5/3	Bore	368450.28	1361684.81	8.13	E-U	8.13	AHD	10.30	Silty Sand: very loose	8.20	8.20	>10.3	>10.3	NE	NE	3.79				0.94	0.94	-	-	-	-	-	5.36	
EES 9359	K5/7E	Bore	368508.94	1361507.30	8.34	E-U	8.63	AHD	7.10	Fill: slag	>7.1	>7.1	NE	NE	NE	NE	4.15				-	-	-	-	-	-	-	5.49	
EES 9359	K5/7W	Bore	368507.43	1361507.55	8.31	E-L	8.80	AHD	14.50	Silty clay / sand	8.00	8.00	>14.5	NE	NE	NE		7.78			1.32	1.32	-	-	-	-	-		2.03
EES 9359	K5/8N	Bore	368419.41	1361582.97	8.64	E-U	9.15	AHD	7.60	Fill	>7.6	>7.6	NE	NE	NE	NE	4.49				-	-	-	-	-	-	-	5.67	
EES 9359	K5/8S	Bore	368419.01	1361581.51	8.62	E-L	9.22	AHD	14.60	Sand	8.00	8.00	10.00	10.00	>14.6	NE		8.26			1.63	1.63	-0.37	2.00	-0.37	-	-		1.97
GA 02622087	BH1	Bore	370070.00	1361231.00	3.85			AHD	9.45	Sand	0.05	0.05	4.40	4.40	>9.45	>9.45					4.81	4.81	0.46	4.35	0.46	-	-		
GA 02622087	BH4	Bore			7.00			AHD	16.00	Sand	6.40	6.40	7.20	7.20	8.25	>16.0					1.61	1.61	0.81	0.80	0.81	-0.24	-		
GA 02622087	BH5	Bore	368622.00	1361814.00	5.40			AHD	15.45	Sand	4.00	4.00	8.50	8.50	>15.45	>15.45					2.41	2.41	-2.09	4.50	-2.09	-	-		
GA 02622087	BH6	Bore			2.30			AHD	20.60	Silty Sand	0.80	0.80	15.00	15.00	15.80	>20.6					2.51	2.51	-11.69	14.20	-11.69	-12.49	-		
GA 02622087	BH7	Bore			2.80			AHD	10.95	Sand	1.20	1.20	6.20	6.20	>10.95	>10.95					2.61	2.61	-2.39	5.00	-2.39	-	-		
GHD 2710182	JDE1/CPT1	CPT	371066.00	1360578.00	4.05			NHTG	12.52	Sand	1.50	1.50	5.10	5.10	>12.52	>12.52					2.55	2.55	-1.05	3.60	-1.05	-	-		
GHD 2710182	JDE2/CPT2	CPT	371011.00	1360528.00	4.35			NHTG	11.50	Sand	1.70	1.70	5.70	5.70	>11.5	>11.5					2.65	2.65	-1.35	4.00	-1.35	-	-		
GHD 2710182	JDE3/CPT3	CPT	371101.00	1360512.00	4.15			NHTG	12.94	Sand	1.80	1.80	4.90	4.90	>12.94	>12.94					2.35	2.35	-0.75	3.10	-0.75	-	-		
GHD 2710182	JDE4/CPT4	CPT	370866.00	1360419.00	4.85			NHTG	10.98	Sand	2.50	2.50	4.50	4.50	>10.98	>10.98					2.35	2.35	0.35	2.00	0.35	-	-		
GHD 2710182	JDE5/CPT5	CPT	370943.00	1360414.00	4.70			NHTG	9.74	Sand	2.20	2.20	6.40	6.40	>9.74	>9.74					2.50	2.50	-1.70	4.20	-1.70	-	-		
GHD 2710182	JDE6/CPT6	CPT	370762.00	1360364.00	4.95			NHTG	11.02	Sand	3.00	3.00	4.20	4.20	>11.02	>11.02					1.95	1.95	0.75	1.20	0.75	-	-		
GHD 2710182	JH1	Bore	370665.28	1360273.64	5.07			NHTG	9.78	Shale	3.00	3.00	3.85	3.85	NE	9.70					2.07	2.07	1.22	0.85	1.22	-	-4.63		
GHD 2710182	JH2	Bore	371028.53	1360140.09	4.73			NHTG	10.30	Sand	2.90	2.90	4.30	4.30	>10.3	>10.3					1.83	1.83	0.43	1.40	0.43	-	-		
GHD 2710182	JH3	Bore	370786.19	1360459.71	4.89			NHTG	14.80	Siltstone/Sandstone	NE	NE	NE	10.00	NE	11.65					-	-	-	-	-5.11	-	-6.76		
GHD 2710182	JH4	Bore	370838.10	1360563.49	4.57			NHTG	15.50	Sandstone	1.90	1.90	3.70	3.70	NE	12.10					2.67	2.67	0.87	1.80	0.87	-	-7.53		
GHD 2710182	JH5	Bore	371058.46	1360482.38	4.46			NHTG	22.00	Sandstone/Siltstone	2.70	3.70	6.20	6.20	NE	11.70					1.76	0.76	-1.74	2.50	-1.74	-	-7.24		
GHD 2710182	JH6	Bore	371198.26	1360399.22	4.44			NHTG	14.40	Sandstone/Siltstone	3.10	3.10	4.50	4.50	NE	11.15					1.34	1.34	-0.06	1.40	-0.06	-	-6.71		
GHD 2710182	JH7	Bore	371015.37	1360905.76	3.05			NHTG	51.00	Clay	2.80	2.80	3.80	3.80	38.65	>51.0					0.25	0.25	-0.75	1.00	-0.75	-35.60	-		
GHD 2710182	JH8	Bore	371285.73	1360537.31	4.39			NHTG	14.40	Siltstone/Shale	3.70	3.70	5.90	5.90	NE	14.00					0.69	0.69	-1.51	2.20	-1.51	-	-9.61		
GHD 2710182	JLE1	CPTU	371182.00	1360360.00	4.00			NHTG	3.88	Sand	1.10	1.10	2.80	2.80	>3.88	>3.88					2.90	2.90	1.20	1.70	1.20	-	-		
GHD 2710182	JLE10	CPTU	371125.00	1360631.00	4.30			NHTG	6.48	Sand	1.90	1.90	5.30	5.30	>6.48	>6.48					2.40	2.40	-1.00	3.40	-1.00	-	-		
GHD 2710182	JLE11	CPTU	370663.00	1360276.00	5.01			NHTG	5.56	Sand	3.50	3.50	3.90	3.90	>5.56	>5.56					1.51	1.51	1.11	0.40	1.11	-	-		
GHD 2710182	JLE12	CPTU	370838.00	1360563.00	4.57			NHTG	4.96	Sand	1.80	1.80	4.00	4.00	>4.96	>4.96					2.77	2.77	0.57	2.20	0.57	-	-		
GHD 2710182	JLE13	CPTU	371324.00	1360744.00	2.89			NHTG	5.84	Sand	NE	0.00	5.40	5.40	>5.84	NE					-	2.89	-2.51	5.40	-2.51	-	-		
GHD 2710182	JLE2	CPTU	370963.00	1360216.00	4.86			NHTG	5.80	Sand	2.20	2.20	4.70	4.70	>5.8	NE					2.66	2.66	0.16	2.50	0.16	-	-		
GHD 2710182	JLE3	CPTU	371014.00	1360317.00	4.67			NHTG	5.24	Sand	2.00	2.00	4.60	4.60	>5.24	NE					2.67	2.67	0.07	2.60	0.07	-	-		
GHD 2710182	JLE4	CPTU	371067.00	1360408.00	4.52			NHTG	4.38	Sand	1.70	1.70	3.60	3.60	>4.38	NE					2.82	2.82	0.92	1.90	0.92	-	-		
GHD 2710182	JLE5	CPTU	371136.00	1360540.00	4.00			NHTG	5.36	Sand	1.30	1.30	4.00	4.00	>5.36	NE					2.70	2.70	0.00	2.70	0.00	-	-		
GHD 2710182	JLE6	CPTU	370833.00	1360324.00	4.92			NHTG	6.18	Sand	2.50	2.50	4.80	4.80	>6.18	NE					2.42	2.42	0.12	2.30	0.12	-	-		
GHD 2710182	JLE7	CPTU	370895.00	1360374.00	4.78			NHTG	5.62	Sand	2.50	2.50	4.70	4.70	>5.62	NE					2.28	2.28	0.08	2.20	0.08	-	-		
GHD 2710182	JLE8	CPTU	370982.00	1360446.00	4.58			NHTG	7.18	Sand	2.00	2.00	6.10	6.10	>7.18	NE					2.58	2.58	-1.52	4.10	-1.52	-	-		
GHD 2710182	JLE9	CPTU	371072.00	1360548.00	4.13			NHTG	7.50	Sand	1.40	1.40	5.50	5.50	>7.5	NE					2.73	2.73	-1.37	4.10	-1.37	-	-		
LM 951041	EH11W_L	Bore	369743.00	1361312.00	3.57	E-L	3.57	AHD	7.20	Sand	2.20	2.20	4.20	4.20	>7.2	>7.2		1.61			2.38	2.38	0.38	2.00	0.38	-	-		2.97
LM 951041	EH12	Bore	369216.00	1361968.00	7.12	E-L		AHD	10.80	Sand	5.90	5.90	8.00	8.00	>10.8	>10.8					2.23	2.23	0.13	2.10	0.13	-	-		
LM 951041	EH14W_L	Bore	369672.00	1361611.00	8.44	E-L	9.12	NHTG	14.00	Sand	7.40	7.40	9.70	9.70	>14.0	>14.0		7.21			1.04	1.04	-1.26	2.30	-1.26	-	-		1.91
LM 951041	EP1	Bore	369249.00	1361719.00	3.50	E-U	4.44	AHD	2.30	Fill (clay)	>2.3	>2.3	>2.3	>2.3	>2.3	>2.3	2.44				-	-	-	-	-	-	-	3.01	
LM 951041	EP2	Bore	369343.00	1361699.00	3.50	E-U	4.00	AHD	2.40	Fill (slag)	>2.4	>2.4	>2.4	>2.4	>2.4	>2.4					-	-	-	-	-	-	-		
LM 951041	EP3	Bore	369395.00	1361634.00	7.50	E-U		AHD	7.80	Fill (clay)	>7.8	>7.8	>7.8	>7.8	>7.8	>7.8					-	-	-	-	-	-	-		
LM 951041	EP4W_U	Bore	369499.00	1361655.00	7.50	E-L	8.69	AHD	6.30	Clay	6.30	6.30	>6.3	>6.3	>6.3	>6.3					2.21	2.21	-	-	-	-	-		
LM 951041	EP5AW_U	Bore	369390.00	1361561.00	7.30	E-U		AHD	5.70	Fill (clay)	>5.7	>5.7	>5.7	>5.7	>5.7	>5.7					-	-	-	-	-	-	-		
LM 951041	EP7W_U	Bore	369387.00	1361486.00	3.50	E-L	4.05	AHD	2.20	Fill (clay)	>2.2	>2.2	>2.2	>2.2	>2.2	>2.2		2.40			-	-	-	-	-	-	-		2.66
LM 951041	ESH1W_U	Bore	369610.00	1361352.00	3.55	E-U	4.01	AHD	2.00	Fill (sand)	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	2.11				-	-	-	-	-	-	-	2.91	
LM 951041	ESH2W_U	Bore	369902.00	1361277.00	3.66	E-U	4.70	AHD	2.30	Fill (sand)	>2.3	>2.3	>2.3	>2.3	>2.3	>2.3	2.35				-	-	-	-	-	-	-	3.36	
LM 951041	ESH3W_U	Bore	369977.00	1361488.00	4.07	E-U	4.49	AHD	2.90	Fill (sand)	>2.9	>2.9	>2.9	>2.9	>2.9	>2.9	1.61				-	-	-	-	-	-	-	3.89	
LM 951041	ESH4W_U	Bore	369986.00	1361525.00	4.08	E-U	5.40	AHD	3.00	Fill (sand)	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0					-	-	-	-	-	-	-		
LM 951041	ESH5W_U	Bore	370029.00	1361760.00	3.62	E-U	4.36	AHD	2.30	Fill (sand)	>2.3	>2.3	>2.3	>2.3	>2.3	>2.3					-	-	-	-	-	-	-		
LM 951041	ESH6W_U	Bore	369770.00	1361907.00	3.49	E-U	4.66	AHD	1.85	Fill (sand)	>1.85	>1.85	>1.85	>1.85	>1.85	>1.85	2.71				-	-	-	-	-	-	-	2.96	
LM 951041	ESH7W_U	Bore	369515.00	1361953.00	3.36	E-U	4.60	AHD	1.80	Fill (sand)	>1.8	>1.8	>1.8	>1.8	>1.8	>1.8	2.68				-	-	-	-	-	-	-	2.93	
LM 951041	ESH8W_U	Bore	369197.00	1361975.00	3.42	E-U	4.40	AHD	2.05	Fill (sand)	>2.05	>2.05	>2.05	>2.05	>2.05	>2.05	1.54				-	-	-	-	-	-	-	3.87	
LM 951041	ESH10B	Bore	369967.00	1361526.00	4.10	E-L	5.40	AHD	9.50	Sand	3.00	3.00	5.50	5.50	>9.5	>9.5					2.11	2.11	-0.39	2.50	-0.39	-	-		
LM 951041	ESH13	Bore	369454.00	1361693.00	7.31	E-L	8.16	AHD	10.50	Sand	7.20	7.20	9.10	9.10	>10.5	>10.5					1.12	1.12	-0.78	1.90	-0.78	-	-		
Railways 1960	1	Bore	366965.00	1361090.00	2.42			AHD	14.33	Shale: Hard	4.88	4.88	NE	NE	8.99	9.91					-1.45	-1.45	-	-	-	-5.56	-6.48		
Railways 1960	2	Bore	366975.00	1361108.00	-2.60			AHD	9.30	Shale: Very Hard	0.00	0.00	1.52	1.52	NE	3.25					-1.59	-1.59	-3.12	1.52	-3.12	-	-4.84		
Railways 1960	3	Bore	366990.00	1361127.00	-2.82			AHD	13.41	Shale: Very Hard	0.00	0.00	1.83	1.83	4.06	7.11					-1.81	-1.81	-3.63	1.83	-3.63	-5.87	-8.92		
Railways 1960	4	Bore	367005.00	1361145.00	-2.70			AHD	13.11	Shale: Very Hard	0.00	0.00	0.91	0.91	4.27	6.10					-1.69	-1.69	-2.61	0.91	-2.61	-5.96	-7.79		
Railways 1960	5	Bore	367025.00	1361164.00	-2.70			AHD	12.80	Shale: Very Hard	0.00	0.00	1.07	1.07	4.88	7.47					-1.69	-1.69	-2.76	1.07	-2.76	-6.57	-9.16		
Railways 1960	6	Bore	367038.00	1361182.00	-1.92			AHD	14.33	Shale: Hard	0.00	0.00	0.71	0.71	6.91	9.60					-0.91	-0.91	-1.62	0.71	-1.62	-7.82	-10.51		
Railways 1960	7	Bore	367052.00	1361200.00	-1.76			AHD	14.94	Shale: Hard	0.00	0.00	0.91	0.91	7.32	10.36					-0.75	-0.75	-1.67	0.91	-1.67	-8.07	-11.12		
Railways 1960	8	Bore	367067.00	1361220.00	-0.70			AHD	14.02	Shale: Hard	0.00	0.00	0.81	0.81	6.25	9.45					0.31	0.31	-0.50	0.81	-0.50	-5.94	-9.14		
Railways 1960	9	Bore	367084.00	1361239.00	0.87			AHD	16.77	Clay: hard	0.00	0.00	1.37	1.37	6.83	NE					1.88	1.88	0.51	1.37	0.51	-4.95	-		
Railways 1960	10	Bore	367100.00	1361257.00	1.01			AHD	17.38	Sand: med dense	0.00	0.00	1.52	1.52	6.58	NE					2.02	2.02	0.50	1.52	0.50	-4.56	-		
RCA 1287	BH1	Bore	369380.00	1360990.00	8.64			AHD	15.25	Sand: dense	8.50	8.50	11.20	11.20	>15.25	>15.25					1.15	1.15	-1.55	2.70	-1.55	-	-		
RCA 1287	BH2	Bore	369880.00	1361020.00	9.44			AHD	8.10	Fill: coal reject & slag	>8.10	>8.1	>8.1	>8.1	>8.1	>8.1					-	-	-	-	-	-	-		
EES	K10/1W	Bore	368970.00	1361055.00	10.01	E-L	10.59	AHD	15.10	Sand: loose	9.50	9.50	11.00	11.00	>15.1	>15.1		9.70			1.52	1.52	0.02	1.50	0.02	-	-		1.90
EES	K10/1E	Bore	368970.00	1361055.00	10.01	E-U	10.59	AHD	10.18	Clay: stiff?	9.50	9.50	>10.18	>10.18	>10.18	>10.18	6.92				1.52	1.52	-	-	-	-	-	4.68	
RCA 1476	K10/2	Bore	369405.00	1361065.00	9.38	E-U	9.68	AHD	10.28	Silty Sandy Clay: firm	9.50	9.50	>10.28	>10.28	>10.28	>10.28	3.24				0.89	0.89	-	-	-	-	-	7.45	

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
RCA 1476	K10/2N	Bore	369405.00	1361065.00	9.43	E-U	10.16	AHD	9.00	Fill: silty clay	>9.0	>9.0	>9.0	>9.0	>9.0	>9.0	5.00				-	-	-	-	-	-	-	6.17	
RCA 1476	K10/2NN	Bore	369405.00	1361065.00	9.43	E-L	10.12	AHD	13.00	Sand	9.30	9.30	12.00	12.00	>13.0	>13.0		9.49			1.14	1.14	-1.56	2.70	-1.56	-	-		1.64
RCA	K10/5E	Bore	368774.00	1361269.00	10.54			AHD	9.20	Silty Clay	8.00	8.00	>9.2	>9.2	>9.2	>9.2					3.55	3.55	-	-	-	-	-		
RCA	K10/5W	Bore	368774.00	1361269.00	10.69			AHD	16.10	Sand	8.00	9.00	11.00	11.00	>16.1	>16.1					3.70	2.70	0.70	2.00	0.70	-	-		
RCA 1632	K11/1	Bore	369621.90	1360765.98	2.98	E-U	2.94	AHD			NE	NE	NE	NE	NE	NE	2.36				-	-	-	-	-	-	-	1.59	
RCA 1632	K11/1S	Bore	369622.82	1360763.66	2.91	E-L	3.71	AHD	10.00	Sand with some clay	1.00	NE	NE	1.00	>10	NE		3.36			2.92	-	-	-	2.92	-	-		1.36
RCA 1632	K11/2E	Bore	369054.88	1360815.09	1.63	E-L	2.27	AHD	11.20	Sand	0.20	0.20	2.00	2.00	>11.2	NE		1.39			2.44	2.44	0.64	1.80	0.64	-	-		1.89
RCA 1632	K11/2W	Bore	369054.02	1360814.91	1.63	E-L	2.38	AHD	5.00	Sandy clay / clayey sand	1.00	>5	>5	>5	>5	>5	1.78	1.78			1.64	-	-	-	-	-	-	1.61	1.61
RCA 1632	K11/3W	Bore	368812.00	1360781.22	1.96	E-L	2.59	AHD	12.00	Sand	1.30	1.30	10.00	10.00	>12.0	>12.0		1.98			1.67	1.67	-7.03	8.70	-7.03	-	-		1.62
RCA 1632	K11/3E	Bore	368812.77	1360781.63	2.31	E-L	2.44	AHD	5.00	silty clay: very soft	1.30	1.30	>5.0	>5.0	>5.0	>5.0	1.60	1.60			2.02	2.02	-	-	-	-	-	1.85	1.85
RCA 1632	K12/10E	Bore	369930.59	1361939.04	2.04	E-L	2.27	AHD	6.25	Sandy clay	NE	0.00	>6.25	>6.25	>6.25	>6.25		1.20			-	3.05	-	-	-	-	-		2.09
RCA 1632	K12/1E	Bore	367114.12	1361359.98	1.44		1.81	AHD	9.25	Silty clay: hard	NE	0.00	5.60	5.60	8.70	>9.25					-	2.45	-3.15	5.60	-3.15	-6.25	-		
RCA 1632	K12/1W	Bore	367114.89	1361359.24	1.44		1.80	AHD	3.50	Sandy clay	NE	0.00	>3.5	>3.5	>3.5	>3.5					-	2.45	-	-	-	-	-		
RCA 1632	K12/3N	Bore	367496.45	1361777.83	1.09	E-L	1.29	AHD	12.25	Sand	3.25	3.25	11.80	11.80	>12.25	>12.25		0.62			-1.15	-1.15	-9.70	8.55	-9.70	-	-		1.68
RCA 1632	K12/5W	Bore	367775.00	1362255.00	1.19			AHD	13.00	Clay: firm	0.00	0.00	>13	>13	NE	NE					2.20	2.20	-	-	-	-	-		
RCA 1632	K12/7	Bore	368367.63	1362218.57	1.83		1.82	AHD	4.30	Silty Sand: loose	1.10	1.10	>4.3	>4.3	NE	NE					1.74	1.74	-	-	-	-	-		
RCA 1632	K12/7E	Bore	368375.67	1362217.95	1.34		1.76	AHD	11.60	Clayey sand	1.50	5.80	10.50	10.50	>11.6	>11.6		0.86			0.85	-3.45	-8.15	4.70	-8.15	-	-		1.91
RCA 1632	K12/9	Bore	369393.40	1362069.41	1.96		1.94	AHD	4.00	Silty Sand: loose	1.20	1.20	>4.0	>4	NE	NE					1.77	1.77	-	-	-	-	-		
RCA 1632	K12/9E	Bore	369398.16	1362069.48	1.54		2.45	AHD	11.30	Sand	1.30	1.30	3.70	3.70	>11.3	>11.3					1.25	1.25	-1.15	2.40	-1.15	-	-		
RCA 1632	K5/5N	Bore	368599.96	1361252.04	4.44	E-U	5.08	AHD	3.00	Fill: Slag	>3.0	>3.0	>3.0	>3.0	>3.0	NE	3.23				-	-	-	-	-	-	-	2.86	
RCA 1632	K5/5NN	Bore	368600.37	1361253.92	4.39	E-L	4.84	AHD	5.00	Silty Clay	3.50	3.50	>5.0	>5.0	>5.0	>5.0		3.08			1.90	1.90	-	-	-	-	-		2.78
RCA 1632	K5/5S	Bore	368598.81	1361249.70	4.39	E-L	5.09	AHD	9.10	Sand	3.50	3.50	5.70	5.70	>9.1	>9.1		3.97			1.90	1.90	-0.30	2.20	-0.30	-	-		2.13
RCA 1632	K5/6N	Bore	368615.34	1361481.89	3.84	E-U	4.54	AHD	2.80	Fill: slag	>2.8	>2.8	>2.8	>2.8	NE	NE	2.09				-	-	-	-	-	-	-	3.46	
RCA 1632	K5/6NN	Bore	368615.53	1361483.24	3.84	E-L	4.39	AHD	5.00	Clay: stiff	3.20	3.20	>5.0	>5.0	>5.0	>5.0		3.22			1.65	1.65	-	-	-	-	-		2.18
RCA 1632	K5/6S	Bore	368615.21	1361480.21	3.84	E-L	4.73	AHD	9.00	Sand	3.30	3.30	6.10	6.10	>9.0	>9.0		3.35			1.55	1.55	-1.25	2.80	-1.25	-	-		2.39
RCA 1632	K5/9E	Bore	368510.76	1361690.66	9.25	E-L	9.69	NHTG			NE	NE	NE	NE	NE	NE		7.62			-	-	-	-	-	-	-		2.07
RCA 1632	K7/2S	Bore	369139.09	1361902.25	7.48	E-L	7.57	AHD	12.00	Sand, grey	6.20	6.20	8.70	8.70	>12.0	>12.0		6.57			2.29	2.29	-0.21	2.50	-0.21	-	-		2.01
RCA 1632	K7/2N	Bore	369139.11	1361902.26	7.48	E-U	7.57	AHD	9.43	Sand	6.20	6.20	8.70	8.70	>9.43	>9.43	6.24				2.29	2.29	-0.21	2.50	-0.21	-	-	2.34	
RCA 1632	K7/4N	Bore	369036.56	1361816.07	6.59	E-U	6.99	AHD	8.50	Fill: fly ash	>8.5	>8.5	>8.5	>8.5	NE	NE					-	-	-	-	-	-	-		
RCA 1632	K7/4S	Bore	369036.29	1361815.22	6.59		7.19	AHD	14.10	Sand, grey	7.10	7.10	9.20	9.20	>14.1	>14.1					0.50	0.50	-1.60	2.10	-1.60	-	-		
RCA 1632	K8/5E (10B)	Bore	368858.44	1361448.47	5.71	E-U	7.39	NHTG	5.30	Sandy clay	3.60	3.60	>5.3	>5.3	>5.3	>5.3	4.63				2.11	2.11	-	-	-	-	-	2.76	
RCA 1632	K8/5W (10A)	Bore	368857.85	1361448.19	5.71	E-L	7.49	NHTG	8.00	Clayey sand: loose	3.60	3.60	>8.0	>8.0	>8.0	>8.0		5.08			2.11	2.11	-	-	-	-	-		2.41
RCA 1632	K9/2E	Bore	369704.43	1361321.35	2.44	E-L	2.85	AHD	12.00	Sand	NE	0.00	4.30	4.30	>12.0	>12.0		1.92			-	3.45	-0.85	4.30	-0.85	-	-		1.95
RCA 1632	K9/2W	Bore	369702.93	1361321.50	2.44	E-U	2.86	AHD	6.00	Sand	NE	0.00	4.30	4.30	>6.0	>6.0	1.95				-	3.45	-0.85	4.30	-0.85	-	-	1.93	
RCA 1632	K9/3N	Bore	369876.98	1360989.39	3.49	E-L	3.83	AHD	12.00	Sand	NE	NE	NE	0.00	>12.0	>12.0		3.13			-	-	-	-	4.50	-	-		1.72
RCA 1632	K9/3S	Bore	369876.60	1360988.46	3.49	E-U	4.09	AHD	4.50	Sand	NE	NE	NE	0.00	>4.5	>4.5	2.66				-	-	-	-	4.50	-	-	2.44	
RCA 1632	K9/4E	Bore	369342.25	1361405.04	2.74	E-U	3.13	AHD	6.00	Clayey sand	NE	0.00	>6.0	>6.0	>6.0	>6.0	1.96				-	3.75	-	-	-	-	-	2.18	
RCA 1632	K9/4W	Bore	369341.62	1361405.47	2.74	E-L	3.09	AHD	13.00	Sand	NE	0.00	6.25	6.25	>13.0	>13.0		2.20			-	3.75	-2.50	6.25	-2.50	-	-		1.90
RCA 2373	BH1	Bore	368819.00	1361172.00	NA			AHD	12.45	Silty sand	10.00	10.00	11.50	11.50	>12.45	>12.45					-	-	-	1.50	-	-	-		
RCA 2373	BH10	Bore	369101.00	1360969.00	NA			AHD	10.95	Silty sand	9.30	9.30	10.00	10.00	>10.95	>10.95					-	-	-	0.70	-	-	-		
RCA 2373	BH11	Bore	368958.00	1360965.00	NA			AHD	10.95	Silty sand	9.70	9.70	10.00	10.00	>10.95	>10.95					-	-	-	0.30	-	-	-		
RCA 2373	BH12	Bore	368768.00	1360983.00	NA			AHD	12.45	Silty sand	10.00	10.00	11.50	11.50	>12.45	>12.45					-	-	-	1.50	-	-	-		
RCA 2373	BH13	Bore	368552.00	1360901.00	NA			AHD	0.60	Fill: Sandy Gravel	>0.6	>0.6	>0.6	>0.6	>0.6	>0.6					-	-	-	-	-	-	-		
RCA 2373	BH14	Bore	368545.00	1360775.00	NA			AHD	4.45	Silty sand	3.00	3.00	4.00	4.00	>4.45	>4.45					-	-	-	1.00	-	-	-		
RCA 2373	BH15	Bore	368526.00	1360775.00	NA			AHD	6.00	Silty sand	5.50	NE	NE	5.50	>6.0	>6.0					-	-	-	-	-	-	-		
RCA 2373	BH16	Bore	368510.00	1360805.00	NA			AHD	1.20	Fill: Sandy Gravel	>1.2	>1.2	>1.2	>1.2	>1.2	>1.2					-	-	-	-	-	-	-		
RCA 2373	BH2	Bore	368983.00	1361161.00	NA			AHD	12.45	Silty sand	10.00	10.00	12.30	12.30	>12.45	>12.45					-	-	-	2.30	-	-	-		
RCA 2373	BH3	Bore	369124.00	1361141.00	NA			AHD	10.95	Silty sand	10.00	10.00	10.50	10.50	>10.95	>10.95					-	-	-	0.50	-	-	-		
RCA 2373	BH4	Bore	369313.00	1361138.00	NA			AHD	10.95	Sandy clay/ Clayey sand	9.30	9.30	10.70	10.70	>10.95	>10.95					-	-	-	1.40	-	-	-		
RCA 2373	BH5	Bore	369499.00	1361112.00	NA			AHD	12.45	Silty sand / Sand	9.70	NE	NE	9.70	>12.45	>12.45					-	-	-	-	-	-	-		
RCA 2373	BH6	Bore	369748.00	1360951.00	NA			AHD	10.95	Silty clayey sand	9.20	9.20	10.00	10.00	>10.95	>10.95					-	-	-	0.80	-	-	-		
RCA 2373	BH7	Bore	369637.00	1360953.00	NA			AHD	12.45	Silty sand	10.00	10.00	10.95	10.95	>12.45	>12.45					-	-	-	0.95	-	-	-		
RCA 2373	BH8	Bore	369490.00	1360957.00	NA			AHD	10.95	Silty sand	9.10	9.10	10.00	10.00	>10.95	>10.95					-	-	-	0.90	-	-	-		
RCA 2373	BH9	Bore	369290.00	1360968.00	NA			AHD	10.95	Sand	9.00	9.00	10.00	10.00	>10.95	>10.95					-	-	-	1.00	-	-	-		
RCA 3392	BH12E	Bore	369281.00	1361496.00	NA			AHD	7.20	Sand	3.50	NE	NE	NE	NE	NE					-	-	-	-	-	-	-		
RCA 3392	BH26E	Bore	368628.00	1361714.00	NA			AHD	7.00	Sand	3.00	4.00	6.50	6.50	>7.0	>7.0					-	-	-	2.50	-	-	-		
RCA 3392	BH36E	Bore	368820.00	1361541.00	NA			AHD	9.20	Sandy clay	6.00	6.00	NE	NE	NE	>9.2					-	-	-	-	-	-	-		
RCA 3392	BH48/48E	Bore	368988.00	1361666.00	NA			AHD	7.20	Silty sandy clay	4.00	4.00	NE	NE	NE	>7.2					-	-	-	-	-	-	-		
RCA 3392	BH49E	Bore	368899.00	1361420.00	NA			AHD	8.00	Silty sand	4.20	4.20	6.50	6.50	>8.0	>8.0					-	-	-	2.30	-	-	-		
RCA 3392	BH50/50E	Bore	368826.00	1361363.00	NA			AHD	7.40	Silty sand	4.00	4.00	6.50	6.50	>7.4	>7.4					-	-	-	2.50	-	-	-		
RCA 3392	BH52/52E	Bore	368691.00	1361464.00	NA			AHD	6.80	Sand	3.40	3.40	6.00	6.00	>6.8	>6.8					-	-	-	2.60	-	-	-		
RSA 823	1	Bore	367122.00	1361285.00	1.20			AHD	13.35	Shale: med strength	1.50	1.50	3.00	3.00	NE	7.30					0.71	0.71	-0.79	1.50	-0.79	-	-5.09		
RSA 823	2	Bore	367127.00	1361279.00	1.20			AHD	14.73	Shale: med strength	1.50	1.50	NE	NE	NE	7.25					0.71	0.71	-	-	-	-	-5.04		
RSA 823	EFCP 1	CPT	367121.00	1361286.00	1.20			AHD	8.06	Clay: hard (shale)	1.20	1.00	7.00	NE	NE	7.30					1.01	1.21	-4.79	6.00	-	-	-5.09		
RSA 823	EFCP 2	CPT	367128.00	1361278.00	1.20			AHD	7.82	Clay: hard (shale)	1.50	1.50	6.50	NE	NE	7.25					0.71	0.71	-4.29	5.00	-	-	-5.04		
RTA	TS1	Bore	368506.00	1360370.00	-0.21			AHD	21.45	Siltstone: low strength	2.50	2.50	7.00	7.00	13.00	17.35					-1.70	-1.70	-6.20	4.50	-6.20	-12.20	-16.55		
RTA	TS2	Bore	368518.00	1360412.00	-1.91			AHD	26.00	Siltstone: med strength	NE	2.80	4.00	4.00	6.78	16.10					-	-3.70	-4.90	1.20	-4.90	-7.68	-17.00		
RTA	TS3	Bore	368522.00	1360455.00	-2.71			AHD	35.00	Siltstone: med strength	NE	0.00	4.10	4.10	15.50	20.00					-	-1.70	-5.80	4.10	-5.80	-17.20	-21.70		
RTA	TS4	Bore	368533.00	1360497.00	-2.21			AHD	40.00	Siltstone: med strength	NE	0.00	4.00	4.00	23.50	30.82					-	-1.20	-5.20	4.00	-5.20	-24.70	-32.02		
RTA	TS5	Bore	368536.00	1360535.00	-2.21			AHD	41.00	Siltstone: med strength	NE	0.00	4.30	4.30	18.40	31.82					-	-1.20	-5.50	4.30	-5.50	-19.60	-33.02		
RTA	TS6	Bore	368547.00	1360577.00	-1.31			AHD	36.99	Siltstone: med strength	NE	0.00	4.38	4.38	10.00	31.53					-	-0.30	-4.68	4.38	-4.68	-10.30	-31.83		
RTA	TS7	Bore	368550.00	1360621.00	-0.01			AHD	36.53	Siltstone: med strength	0.60	0.60	7.60	7.60	16.40	33.65					0.40	0.40	-6.60	7.00	-6.60	-15.40	-32.65		
RTA	TS8	Bore	368558.00	1360665.00	0.99			AHD	44.31	Mudstone: med strength	NE	1.50	9.70	9.70	17.00	37.15					-	0.50	-7.70	8.20	-7.70	-15.00	-35.15		
	12	Bore	369232.66	1361545.67	4.41	E-U	4.98	NHTG			NE	NE	NE	NE	NE	NE	3.00				-	-	-	-	-	-	-	1.98	
	12E	Bore	369237.50	1361545.46	4.66	E-L	5.35	NHTG			NE	NE	NE	NE	NE	NE		3.03			-	-	-	-	-	-	-		2.32
	14	Bore	368615.10	1361292.05	5.48	E-U	6.06	NHTG			NE	NE	NE	NE	NE	NE	3.60				-	-	-	-	-	-	-	2.46	
	14E	Bore				E-L		NHTG			NE	NE	NE	NE	NE	NE		3.17			-	-	-	-	-	-	-		-3.17
EES	16A	Bore	368845.71	1361568.17	5.17	E-L	6.92	NHTG	7.00	Silty sand: soft/loose	3.00	3.00	>7.0	>7.0	>7.0	>7.0		4.77			2.17	2.17	-	-	-	-	-		2.15
EES	16B	Bore	368846.16	1361568.44	5.18	E-U	6.70	NHTG	3.00	Fill: silty sand	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>5.27				-	-	-	-	-	-	-		

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

T4 GEOTECHNICAL DATA SUMMARY **Project 49533.02**

Project No.	Test Number	Test Type	ISG Easting	ISG Northing	Ground Level	Well Type	Well Collar Level	Datum (AHD or NHTG)	End Depth (m)	Material at Termination Depth	Base of Fill (m)	Top of Soft Clay (m)	Base of Soft Clay (m)	Top of Sand (m)	Top of Deep Clay (m)	Top of Rock (m)	Water Depth TOC Upper (m) 25/11/2010	Water Depth TOC Lower (m) 25/11/2010	Water Depth TOC Upper (m) May/ June2011	Water Depth TOC Lower (m) May/ June2011	Base of Fill (NHTG)	Top of Soft Clay (NHTG)	Base of Soft Clay (NHTG)	Thickness of Soft Clay (m)	Top of Sand (NHTG)	Top of Deep Clay (NHTG)	Top of Rock (NHTG)	Water Level Upper (NHTG)	Water Level Lower (NHTG)
EES	18	Bore	369321.96	1361428.92	4.63	E-U	5.41	NHTG		no bore log	NE	NE	NE	NE	NE	NE	2.91				-	-	-	-	-	-	-	2.50	
EES	21A	Bore	369099.84	1361558.12	5.16	E-L	6.36	NHTG	7.00	Silty sand: loose	3.30	3.30	>7.0	>7.0	>7.0	>7.0		4.37			1.86	1.86	-	-	-	-	-		2.00
EES	21B	Bore	369097.19	1361550.05	5.24	E-U	5.46	NHTG	3.50	Silty clay: soft	3.50	3.50	>3.5	>3.5	>3.5	>3.5	2.92				1.74	1.74	-	-	-	-	-	2.54	
EES	24	Bore	368863.05	1361763.87	5.14	E-U	6.41	NHTG	3.50	Silty clay: soft	3.30	3.30	>3.5	>3.5	>3.5	>3.5	3.16				1.84	1.84	-	-	-	-	-	3.25	
EES	25	Bore	368704.25	1361781.02	4.20	E-U	5.22	NHTG	3.00	Clayey sand: loose	2.30	2.30	>3.0	>3.0	>3.0	>3.0	1.65				1.90	1.90	-	-	-	-	-	3.57	
EES	26	Bore	368641.76	1361708.77	4.77	E-U	5.62	NHTG	2.50	Fill: slag	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	2.06				-	-	-	-	-	-	-	3.56	
RCA 3392	26E	Bore	368641.41	1361711.94	4.77	E-L	5.58	NHTG	7.00	Sand: soft/loose	4.00	4.00	>7.0	>7.0	>7.0	>7.0		3.46			0.77	0.77	-	-	-	-	-		2.12
EES	27A	Bore	368636.08	1361635.15	5.20	E-L	6.18	NHTG	8.50	Sand, grey	3.80	3.80	5.20	5.20	>8.5	>8.5		3.74			1.40	1.40	0.00	1.40	0.00	-	-		2.44
EES	27B	Bore	368636.08	1361636.07	5.17	E-U	6.41	NHTG	3.50	Fill: clayey gravel	>3.5	>3.5	>3.5	>3.5	>3.5	>3.5	2.75				-	-	-	-	-	-	-	3.66	
EES	29	Bore	368622.48	1361406.95	5.43	E-U	7.16	NHTG	3.50	Clay: soft	2.80	2.80	>3.5	>3.5	>3.5	>3.5	3.67				2.63	2.63	-	-	-	-	-	3.49	
	29E	Bore	368622.30	1361410.69	5.15	E-L	5.89	NHTG		no bore log	NE	NE	NE	NE	NE	NE		3.74			-	-	-	-	-	-	-		2.15
EES	32	Bore	369128.22	1361662.96	5.05	E-L	6.45	NHTG	3.50	Silty clay: soft	3.50	3.50	>3.5	>3.5	>3.5	>3.5		4.14			1.55	1.55	-	-	-	-	-		2.31
EES	33	Bore	369085.72	1361735.81	4.60	E-U	6.25	NHTG	2.90	Silty clay: soft	2.90	2.90	>2.9	>2.9	>2.9	>2.9	4.01				1.70	1.70	-	-	-	-	-	2.24	
EES	36	Bore	368832.87	1361575.86	5.87	E-U	6.66	NHTG	3.00	Clay: soft	2.80	2.80	>3.0	>3.0	>3.0	>3.0	3.25				3.07	3.07	-	-	-	-	-	3.41	
RCA 3392	36E	Bore	368826.38	1361566.70	6.35	E-L	7.13	NHTG	9.20	Sandy clay: soft	6.00	6.00	>9.2	>9.2	>9.2	>9.2		4.91			0.35	0.35	-	-	-	-	-		2.22
	38	Bore	368719.70	1361411.61	5.89		6.08	NHTG																					
GA 9462317	46	Bore	368766.83	1361772.04	4.58	E-U	4.62	NHTG	3.00	Clay: soft	2.90	2.90	>3.0	>3.0	>3.0	>3.0	1.07				1.68	1.68	-	-	-	-	-	3.55	
	46A	Bore	368790.37	1361775.61	4.97	E-L	5.44	NHTG		no bore log	NE	NE	NE	NE	NE	NE		2.18			-	-	-	-	-	-	-		3.26
RCA 3392	49	Bore	368872.34	1361457.98	5.31	E-U	5.80	NHTG	4.20	Fill: slag	>4.2	>4.2	>4.2	>4.2	>4.2	>4.2	3.21				-	-	-	-	-	-	-	2.59	
RCA 3392	49E	Bore	368870.30	1361456.31	5.43	E-L	5.92	NHTG	8.00	Silty sand: loose	4.20	4.20	6.50	6.50	>8.0	>8.0		3.65			1.23	1.23	-1.07	2.30	-1.07	-	-		2.27
RCA 3392	50	Bore	368848.38	1361441.29	5.50	E-L	6.18	NHTG	4.00	Fill: slag	>4.0	>4.0	>4.0	>4.0	>4.0	>4.0		3.53			-	-	-	-	-	-	-		2.65
RCA 3392	52	Bore	368680.12	1361514.39	5.75	E-U	6.51	NHTG	4.00	Fill	>4.0	>4.0	>4.0	>4.0	>4.0	>4.0	3.25				-	-	-	-	-	-	-	3.26	
RCA 3392	52E	Bore	368679.92	1361512.18	5.82	E-L	6.61	NHTG	6.70	Sand: loose	3.40	3.40	6.00	6.00	>6.7	>6.7		4.39			2.42	2.42	-0.19	2.60	-0.19	-	-		2.23
Number:					765		246		791		559	569	447	490	226	81	77	73	8	10	526	541	423	440	464	220	81	85	81
Minimum:					-2.91		1.29		0.05		0.00	0.00	0.26	0.00	4.06	3.25	1.07	0.62	2.08	5.83	-4.32	-4.32	-13.85	0.00	-19.79	-35.60	-71.10	-0.38	-3.17
Maximum					11.90		12.65		80.58		11.70	11.60	16.50	21.60	40.60	78.80	9.19	10.13	7.21	10.82	5.35	6.30	2.60	15.21	4.50	-0.24	-4.63	7.62	3.26
Average:					5.05		6.74		14.75		4.88	4.38	7.31	7.13	19.61	30.99	3.59	4.76	4.93	8.56	1.20	1.13	-1.90	2.96	-1.86	-14.29	-27.42	3.58	1.95
St Dev:					3.44		2.72		14.92		3.08	3.18	3.36	3.71	7.09	18.30	1.70	2.52	1.84	1.72	1.15	1.29	2.63	2.31	2.70	5.65	17.22	1.51	0.67

Test Summary:

Number of Bores:		462
Number of CPTs:		101
Number of CPTus:		75
Number of Test Pits:		46
Number of Vibrocores:		14
Number of Push Cores:		33

Well Summary:

Number of Enviro Wells - Upper		99
Number of Enviro Wells - Lower		109
Number of Standpipes - Upper		8
Number of Standpipes - Lower		7

Dark Red = entry aprroximate or unconfirmed
S-U Standpipe Upper Aquifer; S-L Standpile Lower Aquifer; E-U Enviro well Upper Aquifer; E-L Enviro well Lower Aquifer.

Appendix B

Details of Numerical Model Calibration

APPENDIX B
Details of Numerical Calibration
Groundwater Assessment
Proposed Terminal 4 Project, Kooragang Island

1. Calibration

1.1 General

Model calibration was undertaken concurrently in both the steady state conditions using the target heads measured during the dip round on 25 November 2010 as well as transiently using target heads from data loggers installed over the period 26 November 2010 to 27 April 2011. The results were iterated until both models had matching hydraulic parameters and recharge and evapotranspiration multipliers.

For the steady state modelling the recharge and evapotranspiration were set at multiples of the annual average BoM data for Williamtown. Review of rainfall and evapotranspiration records indicated that for the preceding month of November, rainfall and evapotranspiration were 10% above annual average levels and therefore both were multiplied by 1.1 for assessment of the initial conditions on 26 November 2010.

For transient cases the recharge was set at multiples of the daily measured rainfall at PWCS and the evapotranspiration was set at multiples of the daily measured values at Williamtown.

In general evapotranspiration was set to 100% of measured values for the open water areas (ponds and wetlands) and 20% of measured values with an extinction depth of 2 m over the land areas.

Recharge rates were set at multiples of the Williamtown data based on calibrated infiltration rates for different materials on land in the range of 6% to 50% of rainfall. For the water bodies the rainfall was factored up to account for surface runoff into the ponds with the rates ranged from 100% to 400% of rainfall. Consideration was also given to the depth to groundwater below the ground surface based on the 25 November 2010 calibration data. The depth to groundwater below the surface is shown in Figure B1, with the resultant recharge and evapotranspiration zones shown in Figure B2 and Figure B3.

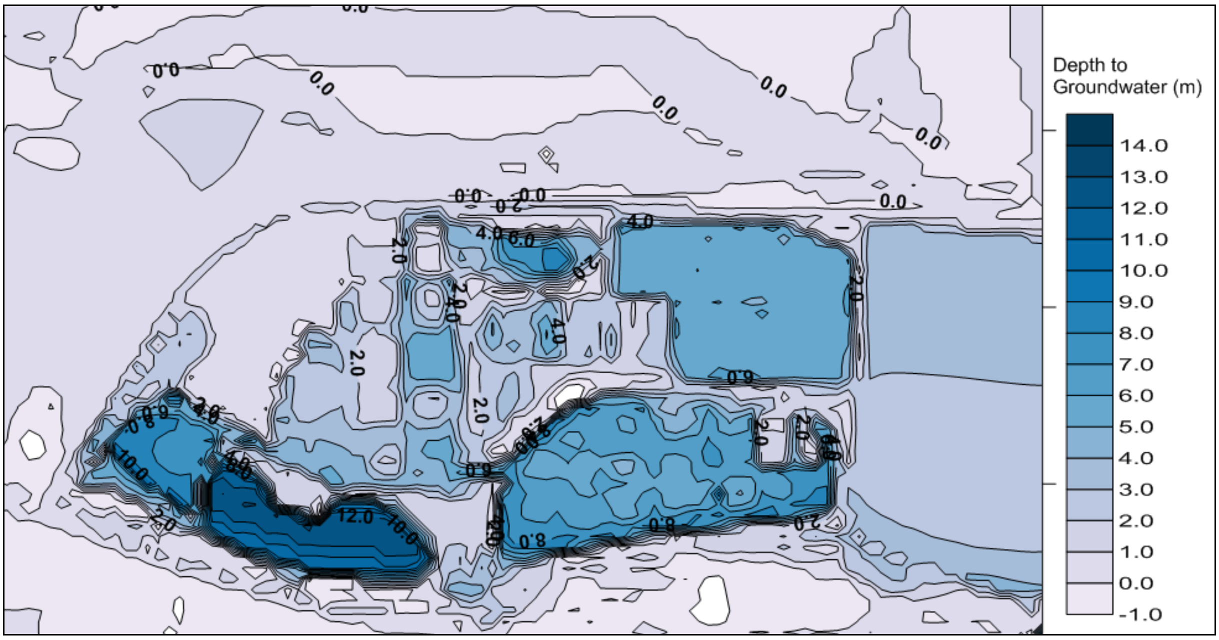

Figure B1: Depth to Groundwater below Top of Layer 1

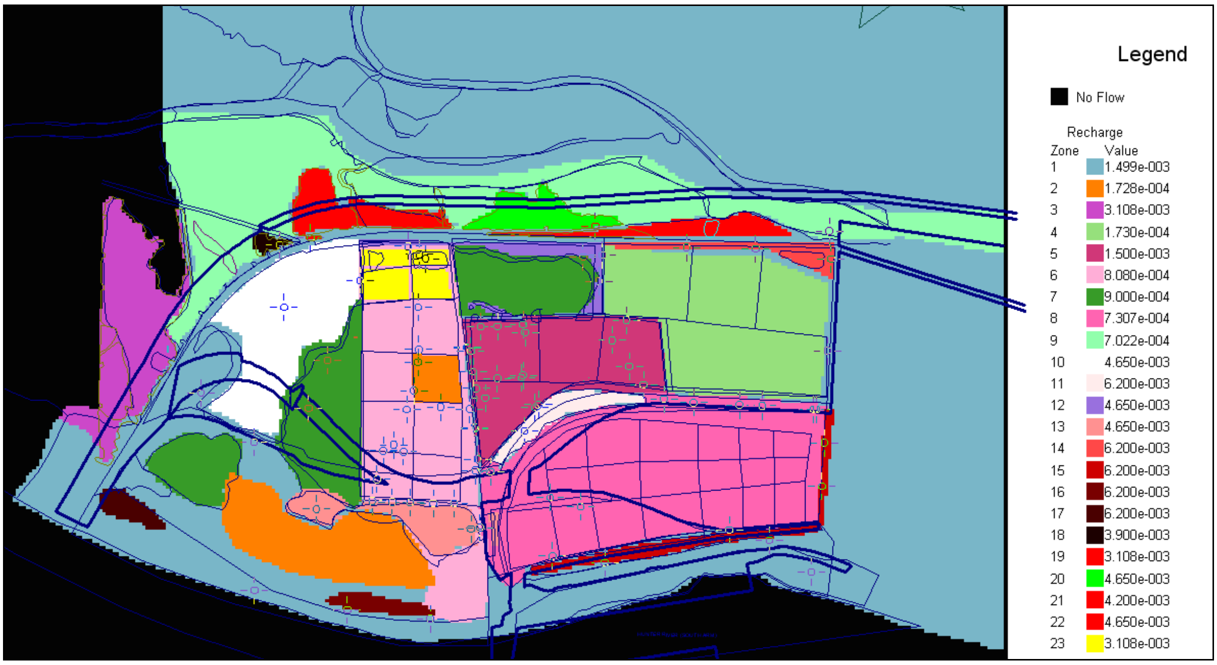

Figure B2: Recharge Zones for Layer 1 (Recharge in m/d)

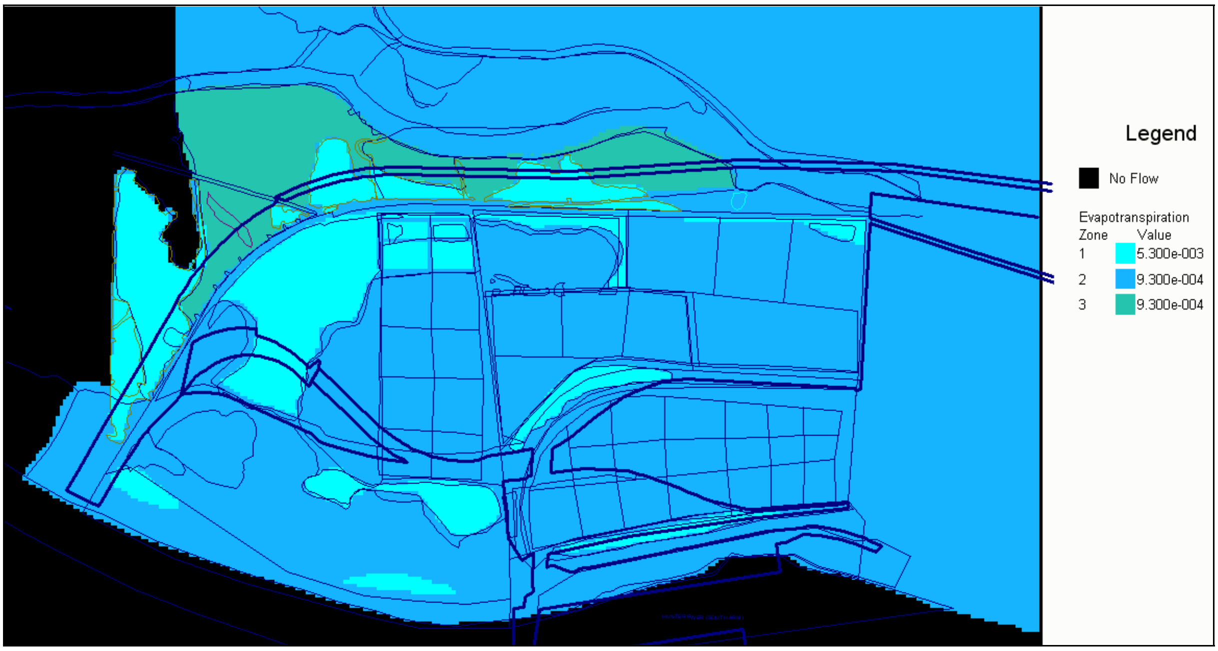

Figure B3: Evapotranspiration Zones for Layer 1 (ET in m/d)

The convergence parameters were set to a residual head of 0.01 m and the number of iterations required within the convergence limit was adjusted up until the mass balance indicated an error of less than 1%. This generally required 20 iterations within a residual head of 0.01 m.

The steady state model calibration was initially refined using the parameter estimation package PEST. Parameters which had been measured with reasonable certainty, or for which the model was unlikely to be sensitive, were excluded from the analyses. Reference was made to the results of the review of hydraulic conductivity data to establish the range of likely values and the manual calibration was used to set starting values.

A transient calibration process was then undertaken, however due to the complexity of the various input parameters and dependence on varying recharge multipliers for numerous individual zones (which is undertaken using a spread sheet external to the modelling software), PEST was not used for the transient calibration. The calibration process was continued until a reasonable fit of the calculated data to the measured data was obtained for both the initial steady state conditions as well as the transient conditions.

The various adopted calibration parameters, together with typical measured ranges for the various parameters are presented in Table B1 and Table B2. These parameters were developed from iteration of both the steady state and transient models. Calibrated parameters specific to the transient model (storage) are presented in the following section.

Table B1: Adopted Steady State Calibration Parameters

K Zone No.	Description	Typical Range of Measures Values (m/day) (K_h unless stated)			K_h	K_v
		Lower	Upper	Comment		
1	Estuarine Aquifer	1.5	39.7		30	8
2	Clay Aquitard	0.00008	0.002	K_v	0.0017	0.00044
3	-	-	-	-	17	2.6
4	Granular Fill / Slag	1.6	38		7.8	1.7
5	Surface Water			Arbitrarily high	864	86
6	Refuse			Calibrated	0.043	0.0043
7	Coarse Coal Reject	0.7	130		17	17
8	BOS Dust	0.07	2.6		3	1.33
9	Coal Fines / Unit 1.2	0.0006	0.65		0.017	0.003
10	Cemented Slag	0.04	17.3		0.086	0.086
11	FDF Cells				0.86	0.86
12	FDF Cell Walls			Gypsum	0.86	0.86
13	Sand Fill West of Site	10	25		17	7
14	KCT Wick Drains				0.0017	0.864
15	Northern Tidal Flats			Accounts for macro structure	0.0086	0.0086
16	Site C Fill	0.13	0.3		0.5	0.17
17	Site C – Unit 2 Clay			Calibrated	0.017	0.008

Notes to Table B1:

K – Hydraulic Conductivity

K_h – Horizontal Hydraulic Conductivity

K_v – Vertical Hydraulic Conductivity

Table B2: Adopted Steady State Recharge Parameters

Recharge Zone	Description	Recharge Multiplier
1	Granular Fill Areas (K Zones 3,4,7)	0.50
2	Pond 5, KIEC (capped)	0.06
3	Swan Pond	1.00
4	FDF / Site D	0.06
5	Delta / Site C	0.32-0.48
6	Site A Ponds (Ponds 1 to 8)	0.26
7	Refuse / Area K7	0.28
8	Site B	0.23
9	Tidal Flats (north and south)	0.18
10	Deep Pond	1.50
11	Easement Pond	2.00
12	Railway Pond	1.50
13	BHP Wetland, Blue Billed Duck Pond, Easement Pond South	1.50
14	FDF Pond	2.00
15	Long Pond	2.00
16	Adjacent to Hunter River (east)	2.00
17	Adjacent to Hunter River (west)	2.00
18	OEH Wetland 1 Pond	4.00
19	OEH Wetland 2	1.00
20	OEH Wetland 3	2.00
21	Rail Road Pond	2.50
22	Pond North of FDF and Railway	1.50
23	Ponds 9 to 12	1.00

The following points are noted:

- The calibration resulted in a hydraulic conductivity for the sand in the Estuarine Aquifer in the mid to upper range of those measured on site, however many of the tests by others included the zone immediately below the clay which is silt/clayey and is not representative of the layer as a whole. For the rising head testing undertaken for this assessment, the tests immediately below the clay were separated from the slightly deeper tests with the latter indicating a geometric mean of 30 m/day, which was adopted for the calibration;

- The vertical hydraulic conductivity of the Clay Aquitard was between the 5th percentile and 50th percentile of field measurements, as anticipated. The exception to this was below Site C where the clay was calibrated to about one order of magnitude more permeable, to account for the higher head recorded in the Estuarine Aquifer. This is consistent with expectations from the review of data logger records indicating that the Easement Pond drains much faster than other ponds;
- Recharge rates are in the range of about 5% to 50% of annual recharge, higher in areas of high permeability and vice versa. This is consistent with experience of such materials; and
- It is noted that when the model included a direct connection between the OEH Wetland 1 / Railway Road Pond and the granular filling associated with the railway line, this resulted in much higher heads in the ponds resulted than were actually observed. This is because this situation was over-estimating the flow from Deep Pond into these surface water bodies. In reality OEH Wetland 1 is not directly adjacent to the filling and therefore the model included a separation of one cell width, replicating actual conditions. Railway Road Pond was modelled in a similar manner to replicate siltation of the base of the pond, limiting connectivity, resulting in an accurate calibration of observed heads.

The overall mass balance for the steady state model was -0.4 % and the overall distribution of daily inflows and outflows for the model are presented in Table B3.

Table B3: Steady State Model Mass Balance

Model Feature	Inflow (ML/d)	Outflows (ML/d)
Storage	0	0
Constant Head Boundary	0.168	1.64
General Head Boundary	0	2.03
River	0.088	0.149
Drain	0	3.84
Stream	0	0
Recharge	15.7	0
ET	0	8.33
Total	15.9	16.0
Percent Error		**-0.4%**

The resulting head distributions for the Fill Aquifer and Estuarine Aquifers are presented on Figure B4 and Figure B5. The figures also include the magnitude of residuals at target points, which are the difference between the observed head at monitoring wells and the computed heads from the model. Where residuals are negative/red the observed head was lower than the computed head and where residuals are positive/blue the observed head was higher than the computed head.

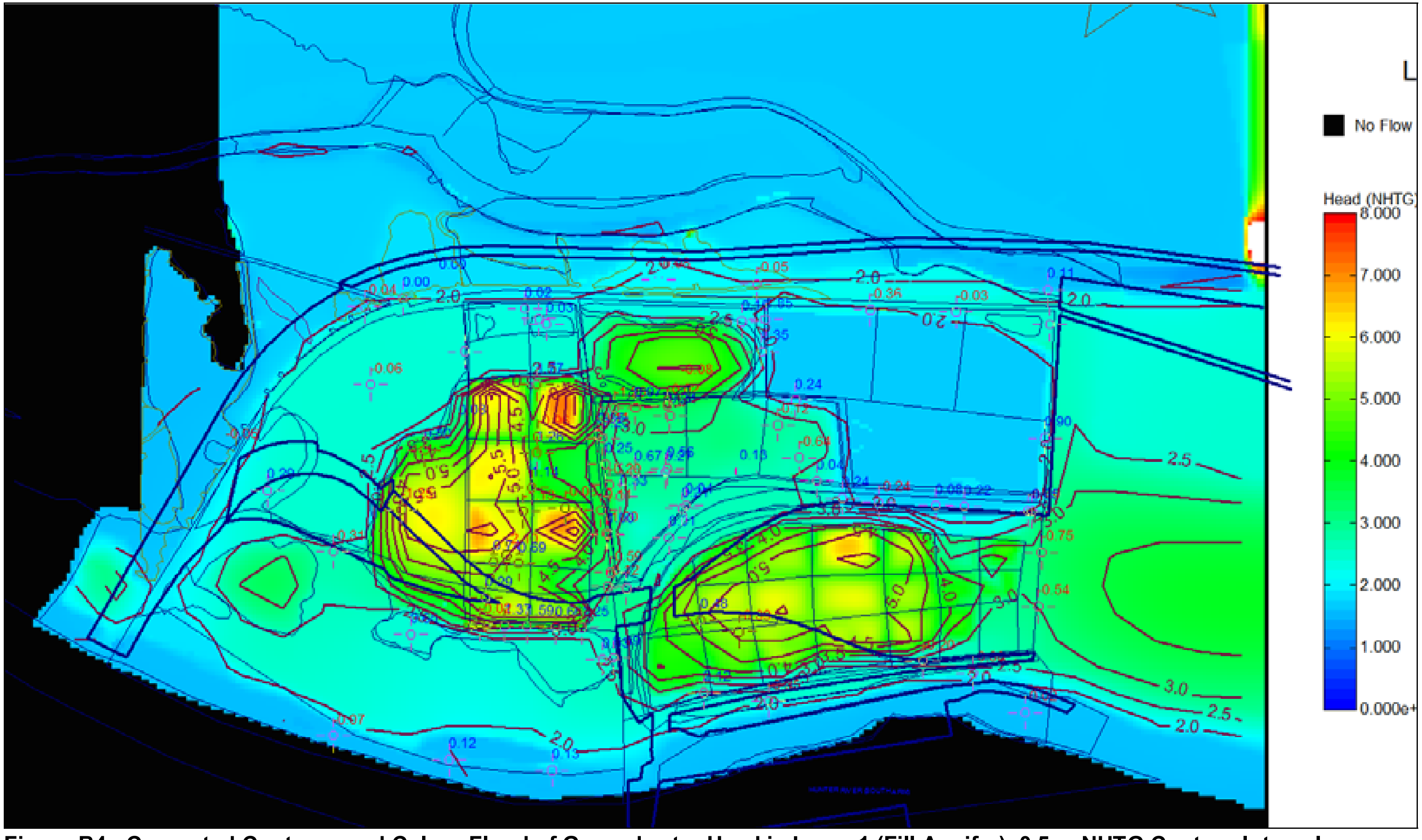

Figure B4: Computed Contours and Colour Flood of Groundwater Head in Layer 1 (Fill Aquifer), 0.5 m NHTG Contour Intervals

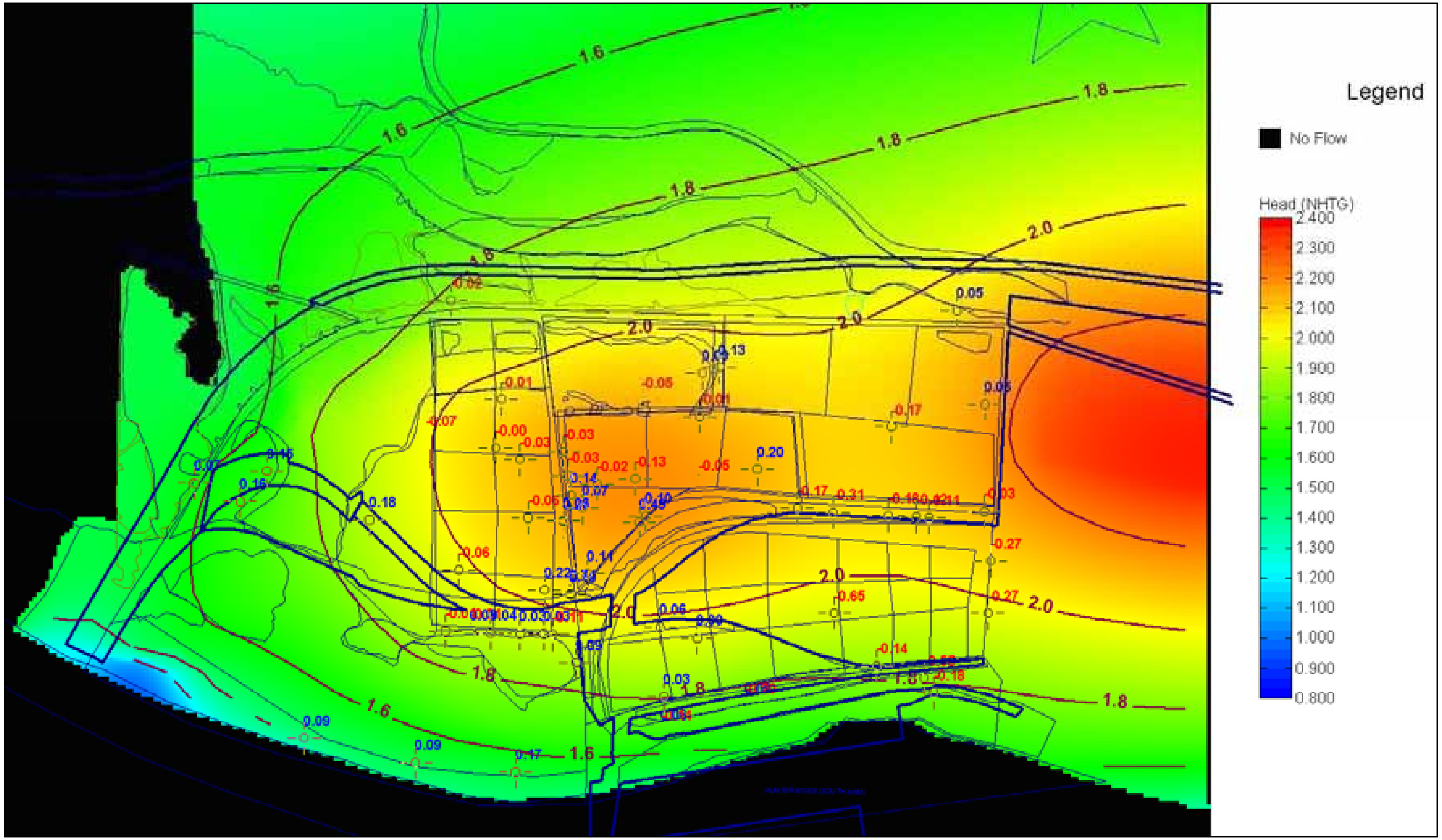

Figure B5: Computed Contours and Colour Flood of Groundwater Head in Layer 3 (Estuarine Aquifer), 0.2 m NHTG Contour Intervals

A scattergram of observed versus computed heads is shown in Figure B6 with the calibration statistics shown in Table B4.

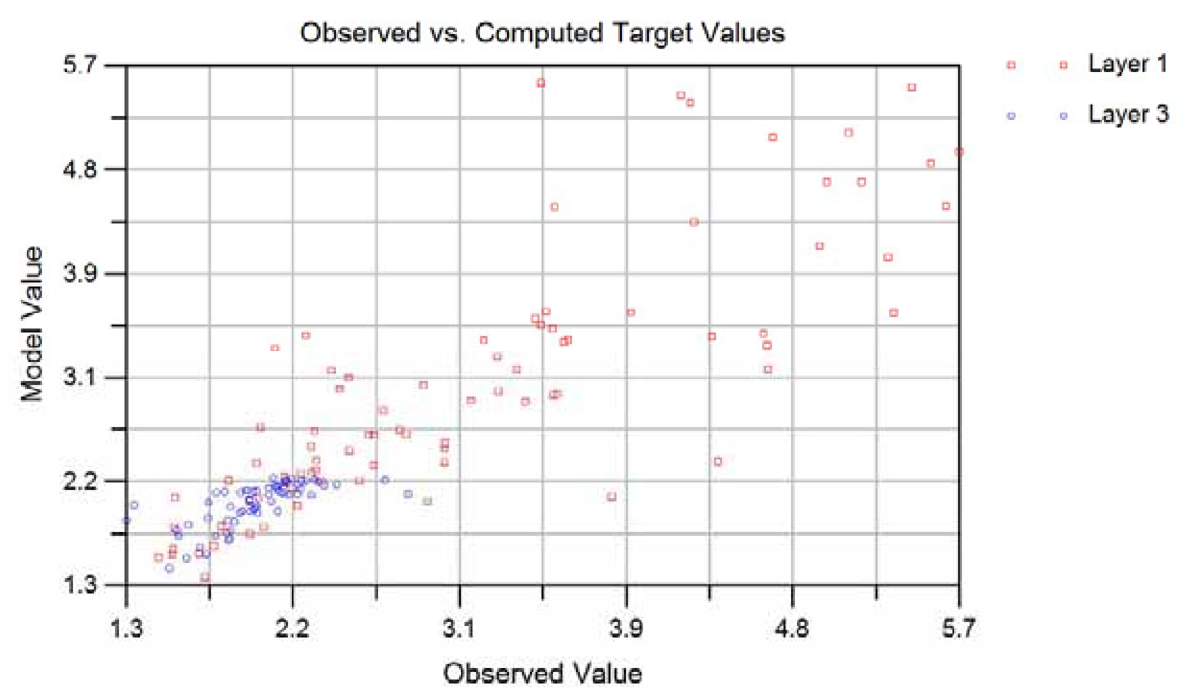

Figure B6: Model Calculated Value versus Target Values

Table B4: Model Calibration Statistics – Steady State

Statistic	Value
Residual Mean (m)	0.07
Residual Standard Deviation (m)	0.54
Absolute Residual Mean (m)	0.33
Residual Sum of Squares (m^2)	0.431
RMS Error (m)	0.54
Minimum Residual (m)	-2.10
Maximum Residual (m)	2.12
Range of Observations (m)	4.48
Scaled Standard Deviation	0.12
Scaled Absolute Mean	0.073
Scaled RMS	0.121

The residuals and calibration statistics indicates the following:

- The residuals for the Estuarine Aquifer (Layer 3) are relatively low (typically less than 0.2 m) and are scattered evenly above and below observed values;
- For the Fill Aquifer (Layer 2) there is a much larger scatter, however the scatter is reasonably evenly spread above and below observed values. Figure B4 indicates that residuals vary between negative and positive over a short distance. This is because observed heads are locally variable in the filling due to the locally variable nature of the filling. It is considered that given this high local variability of the fill materials, that it would be virtually impossible to accurately represent this local variability in the model and replication of such local variability is not necessary for assessing potential impacts of the development, which occur over a wide scale.

Therefore, based on the overall qualitative assessment of the contours of head indicating the various flow directions are well represented and the even scatter of heads, the replication of heads from the model is considered to provide a good fit.

2. Transient Calibration

2.1 General

The transient calibration was undertaken to simulate the aquifer responses to climatic variations in tide, evapotranspiration and rainfall. The calibration was undertaken in two stages as follows:

1. Response of piezometric heads in the Estuarine Aquifer to sub daily tidal variations. This allowed calibration of the tidal boundary conditions as well as the storativity of the estuarine aquifer.
2. Response of surface water and groundwater heads to daily variations in tide, evapotranspiration and rainfall. The water level data collected during the period 26 November 2010 to 27 April 2011 were used as targets for this calibration.

These calibrations are discussed in more detail in the following sections.

2.2 Tidal Calibration

The tidal calibration was undertaken in two stages, the first using analytical methods and the second using the numerical model.

Tidal responses were observed in the estuarine aquifer (Bores A05-L, C05-L and C04-L, Drawing 5.02 in Appendix B) during the period 26 November 2010 to 27 April 2011; however these were located below the central parts of the Kooragang Island and about 1 km from the river. Data were however available from Well 303B, screened in the Estuarine Aquifer, and located about 216 m from the south arm of the river as shown in Drawing 5.02 in Appendix B. The data were available from Well 303B for the period 8 December 2008 to 9 January 2009 and corresponding measured tide data were obtained from Newcastle Port Corporation for this same period. These data are plotted on Figure B7.

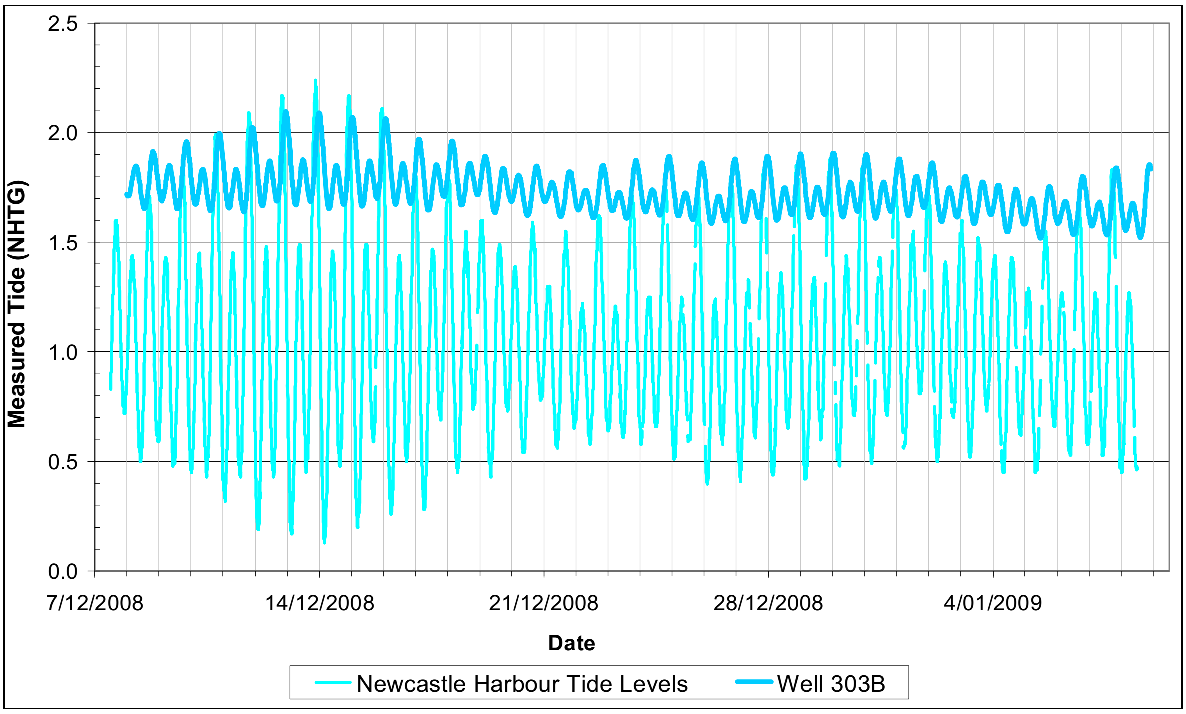

Figure B7: Measured Newcastle Harbour Tide Levels versus Recorded Water Levels for 303B (8 Dec 2008 to 9 Jan 2009)

As the two sets of data were obtained at different times (Figure 4 and Figure B7), the response to tide at each estuarine bore was converted to a tidal efficiency, being the ratio of the measured amplitude at the monitoring well to the actual amplitude of the tidal variation in the river. The tidal efficiency reduces with distance from the river as well as with increasing storage and decreasing hydraulic conductivity. The estimated tidal efficiencies from the available data are presented in Table B5.

Table B5: Estimated Tidal Efficiencies

Location	Distance from River (m)	Tidal Efficiency	Tidal Lag (hr)
303B	216	15-22%	1.5
A-05-L	1,040	1.8-2.3%	-
A-04-L	1,160	1.2-2.3%	-
C-05-L	880	2.8-3.8%	-

2.3 Analytical Methods

The aquifer efficiency and time lag can be calculated analytically by Equations B1 and B2 (Ref 36):

$$\text{Aquifer Efficiency} = \exp\left(-x\sqrt{\frac{\pi S}{t_p T}}\right) \qquad \text{(Equation B1)}$$

$$\text{Time Lag} = x\sqrt{\frac{t_p S}{4\pi T}} \qquad \text{(Equation B2)}$$

where: S = Storativity
T = Transmissivity
t_p= tidal period (6.2 hrs)
x = distance from river

Using the above formulae, the key aquifer parameters S and T were varied to fit the observed tidal efficiency and tidal lags. The results indicated that no unique combination of S and T fitted the data for Bore 303B and the more distant wells A-04-L, A-05-L and C-05-L. A lower hydraulic conductivity was required for the closer well locations. This is likely to be due to low permeability sediments on the bed of the river limiting transmissivity between the river and the aquifer.

Based on a bulk horizontal hydraulic conductivity of 30 m/day for the estuarine aquifer and typical thickness of 12 m, the following set of parameters satisfied the data:

- Estuarine Aquifer K_h= 30 m/day;
- Southern 216 m, effective K_h = 8 m/day;
- Storativity = $4x10^{-4}$.

As discussed above, the lower hydraulic conductivity for the southern 216 m is likely to be largely due to lower permeability of the river bed boundary rather than being representative of the estuarine aquifer across the area, which is likely to be similar in hydraulic conductivity to the rest of the estuarine aquifer.

2.4 Numerical Calibration

The steady state model described in Section 11.2.2 was converted to a transient model using the steady state parameters, with the exception of the following:

- The estuarine boundary conditions at the north and south arms of the Hunter River were changed to transient general head boundaries with the tidal fluctuation replicated by stress periods of 6.2 hours (equivalent to tidal period) and alternating between measured maximum and minimum tide levels for each subsequent stress period;

- The hydraulic conductivity of the boundary elements was adjusted to replicate the lower permeability of the river bed; and
- The storativity was adjusted to match the variation in observed tidal efficiency with distance from the river.

The following parameters provided a reasonable fit to the data:

- Storativity = 2.5×10^{-4};
- Hydraulic conductivity of the boundary elements = 0.5 m/day.

The above parameters were adopted for the Rainfall/ET calibration discussed in Section 11.2.4.

2.5 Rainfall / ET Calibration

The data collected during the period 26 November 2010 to 27 April 2011 were used as the basis for the transient calibration for ET and rainfall. A total of 153 daily stress periods were used for the period of the calibration, corresponding to about 5 months of logged water levels.

The starting heads for the transient runs were adopted from the steady state model. The initial recharge multipliers and hydraulic conductivities from the steady state model were used as a starting point, then refined during the transient calibration process and fed back into the steady state model so that the two were congruent.

The calibrated storage parameters from the transient calibration are presented in Table B6.

Table B6: Calibrated Storage Parameters

Zone	Description	Storativity	Specific Yield	Effective Porosity η_e
1	General Granular Filling	0.1	0.1	0.3
2	Unit 2 Clay	0.001	NA	0.5
3	Unit 3 Estuarine Aquifer	0.00025	NA	0.3
4	Surface Water	0.99	0.99	1.0
5	Coal Fines	0.01	0.01	0.5
6	Waste	0.1	0.1	0.3
7	BOS Dust	0.05	0.05	0.3

The calibrated responses at the various target points are presented in Figure B8 for surface water and Figure B9 for groundwater.

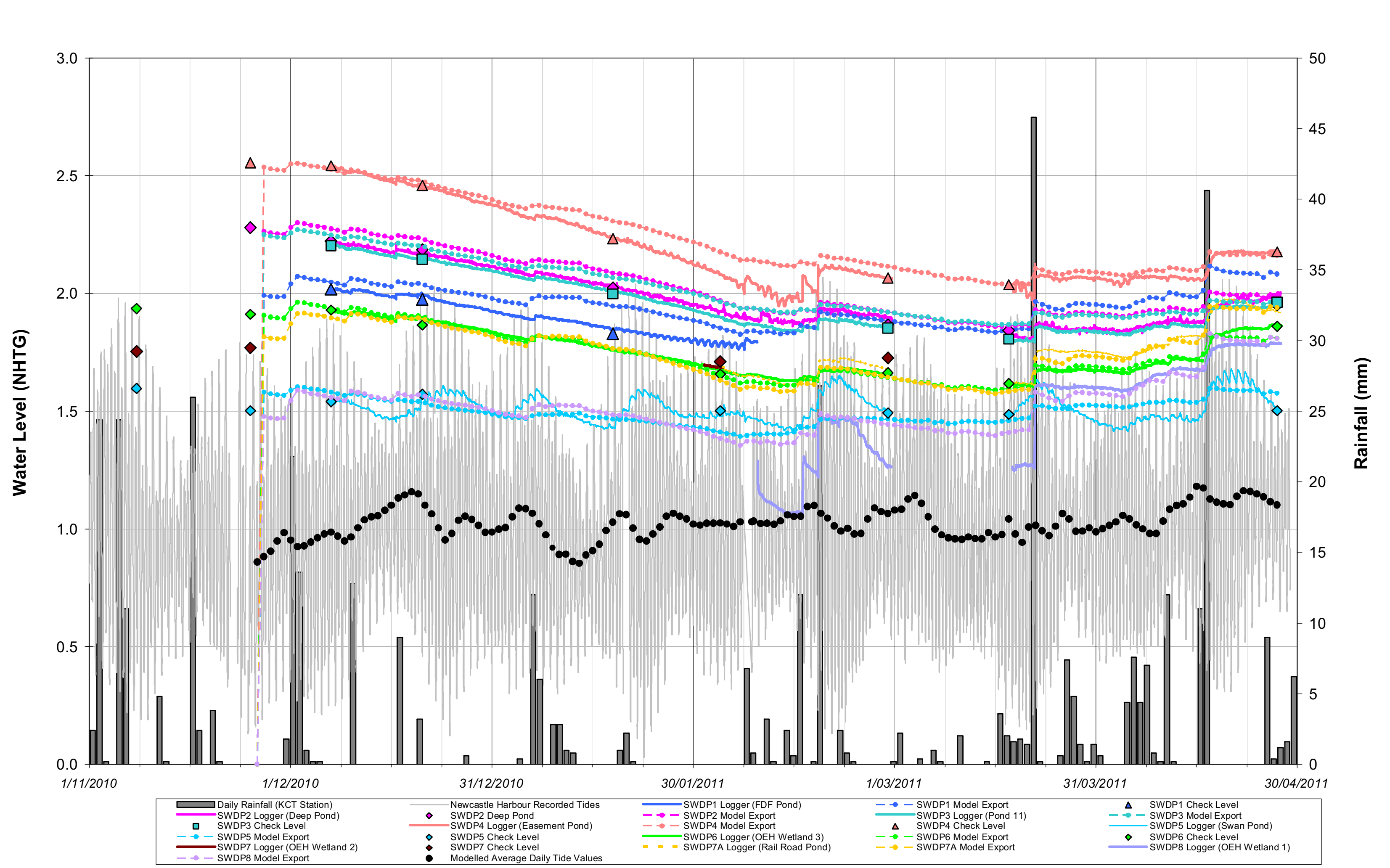

Figure B8: Calculated versus Measured Heads for Surface Water

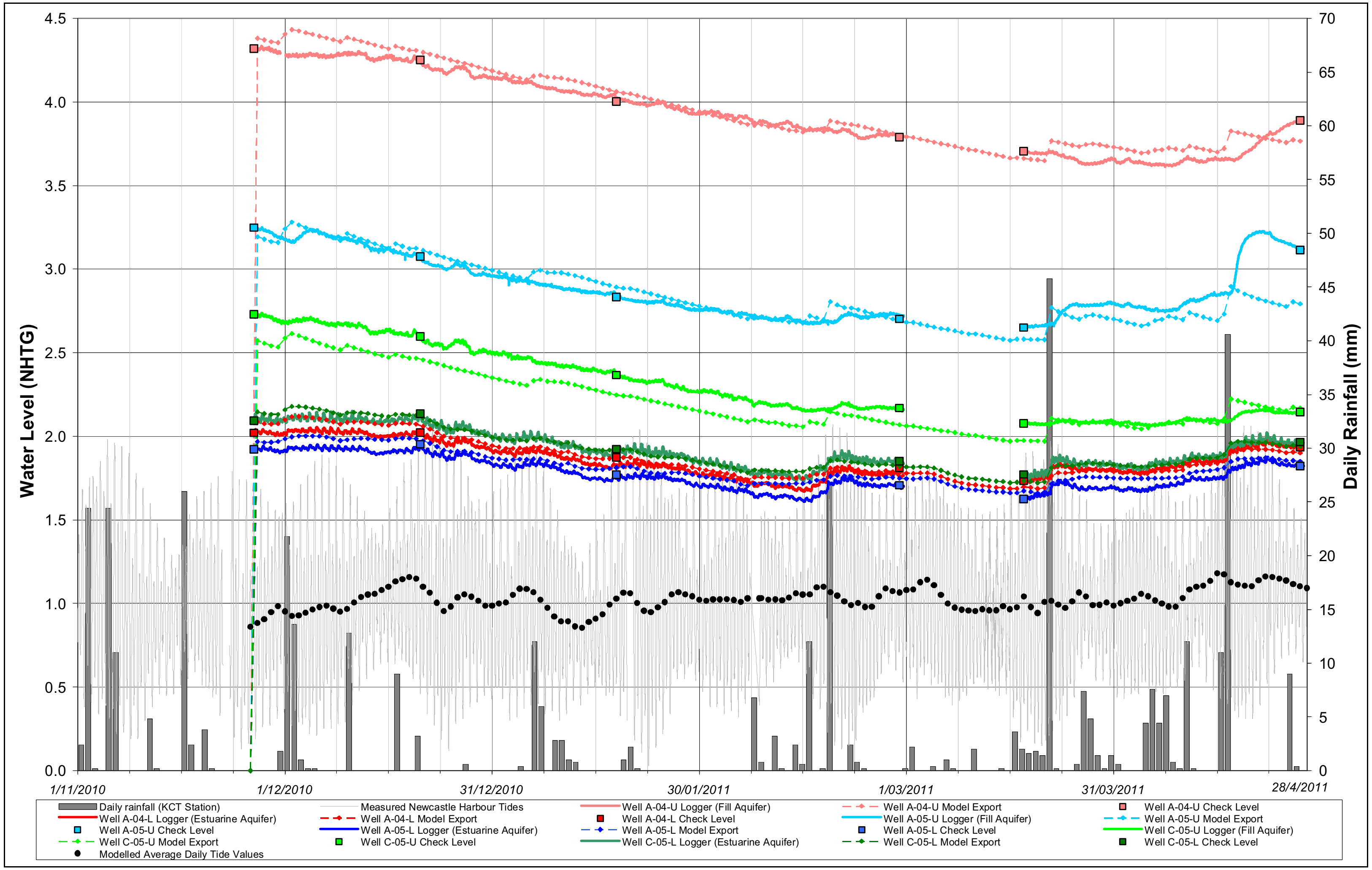

Figure B9: Calculated versus Measured Heads for Groundwater

Figure B8 and Figure B9 indicate the following with respect to the transient calibration:

- Although the PWCS rain gauge is located close to the T4 Project site, the plots still indicate that the rainfall records were not fully representative of rainfall on the T4 Project site. This was most obvious for the rainfall events on 23 March 2011 and 17 April 2011, where the rainfall was greater for the former date and observed response in the surface waters and fill aquifer were greater for the latter date. Other than this the rainfall reported by the PWCS rain gauge seems to be reasonably representative of the responses observed on site, more representative than information from more distance Bureau of Meteorology Sites, and is considered acceptable for purposes of the modelling;
- Constant recharge multipliers have been used, independent of the magnitude of rainfall and it is possible that small events are having slightly more influence on the calculated responses than has been observed. However, this effect is considered minor and has been ignored;
- For the surface waters, the results of which are presented on Figure B8, the calculated response generally gave a good correlation to the measured responses, typically within about 0.1 m or less, with starting and ending heads generally within less than 0.05m. A number of points to note regarding the surface water results include:
    - For Easement Pond the calculated recession for the middle period was slightly less than measured. This may be attributed in part to the water level where the logger is situated getting very low and affecting the accuracy of the plot (particularly for the very jagged section of measured head). The tapered shape of the base of the pond may also have an influence on the measured rate of fall of the water level;
    - OEH Wetland 1 was observed to periodically dry out (with levels below about RL 1.5) and therefore the sections of the observed head below this depth represent water levels in the sump of the installation well rather than actual levels in the wetland. The calculated response for when the pond becomes wet showed a good correlation with the measured response at these times;
    - For Swan Pond no attempt was made to replicate the attenuated tidal conditions at the boundary and therefore the calculated response does not replicate this fortnightly variation. The calculated response does however provide a response to rainfall and generally follows the overall rolling average level of the measured data.
- Overall the calculated responses for the Fill Aquifer (Figure B9) are considered to provide a reasonable replication of measured responses particularly taking into account the variability of the fill material and the scatter of heads observed across the fill site as evident from the steady state calibration. A number of points to note regarding the Fill Aquifer include:
    - The calculated responses to rainfall in the Fill Aquifer are more abrupt than the measured responses, which tend to build over several days. This is because in the model the recharge is assigned to the highest active layer (Layer 1) instantly, whereas in reality recharge will infiltrate slowly over time. The overall effect is similar if the abrupt changes are ignored;

- o For the rainfall event on 17 April 2011, the measured response in Well A-05-U was quite marked and could not be replicated in the calculated response. This is considered to be in part because of the disparity in the actual versus measured rainfall, but cannot be completely explained by this. This unusual response may be attributed to complex localised conditions which cannot be replicated in this model.
- For the Estuarine Aquifer the calculated responses follow the measured responses well, generally within about 0.05 m. The response in the Estuarine Aquifer is affected by both the leakage rate through the clay (which is affected by variation in head in the Fill Aquifer) as well as by variation in tide levels at the boundaries.

The transient model calibration statistics are presented in Table B7.

Table B7: Transient Model Calibration Statistics

Statistic	Value
Residual Mean (m)	-0.02
Residual Standard Deviation (m)	0.07
Absolute Residual Mean (m)	0.05
Residual Sum of Squares (m^2)	7.81
RMS Error (m)	0.07
Minimum Residual (m)	-0.24
Maximum Residual (m)	0.40
Range of Observations (m)	3.15
Scaled Standard Deviation	0.021
Scaled Absolute Mean	0.017
Scaled RMS	0.022

The above calibration statistics indicate the model provides a good fit to the transient data, with low residuals, Standard Deviation and RMS. The overall model mass balance with time (days) indicates the total error is low throughout the model simulation as shown in Figure B10.

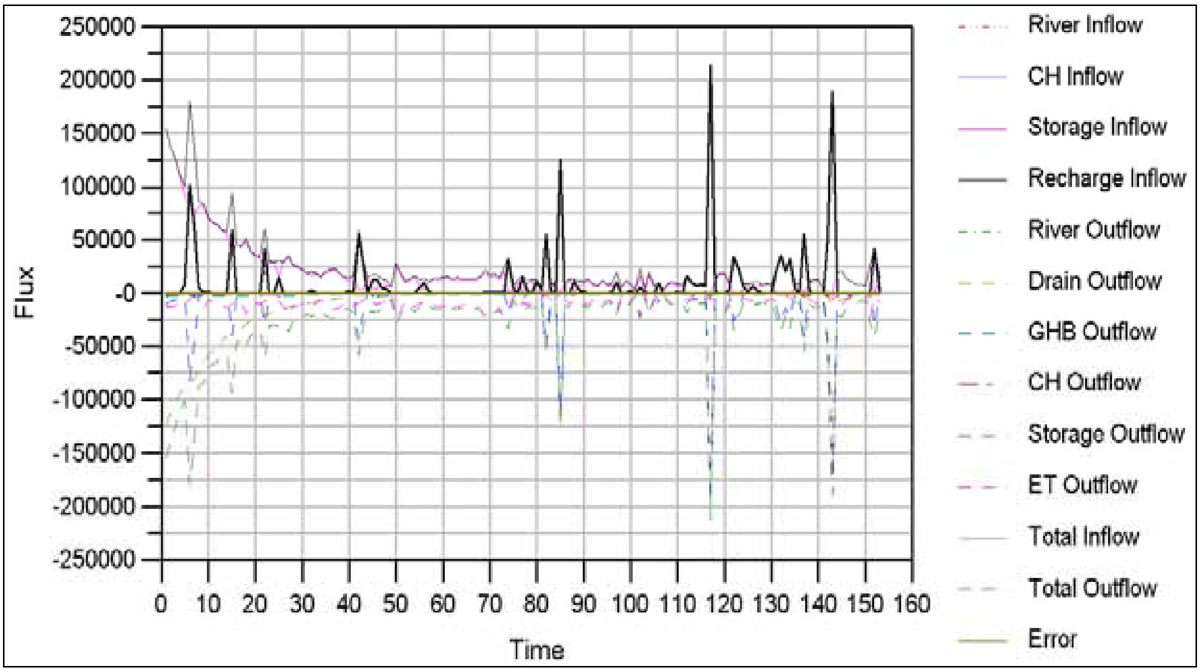

Figure B10: Mass Balance for Entire Transient Model (Flux in kL/day)

2.6 Sensitivity and Non Uniqueness

Although the observed heads are considered to be well represented by the model, there is still the issue of non-uniqueness to address. In a simple system there can be an infinite combination of hydraulic conductivity and recharge which will provide the same distribution of heads. Each of these parameters however should only be able to vary within a range of credible values (such as presented in Table B1) which limits the extent of the non-uniqueness of the calibration.

The model calibration data indicates that the model is most sensitive to the vertical hydraulic conductivity of the Clay Aquitard. This is because the heads in both the overlying Fill Aquifer and the underlying Estuarine Aquifer are both highly dependent on the amount of vertical leakage between the two through the Clay Aquitard. Also the flow in the Clay Aquitard is oriented vertically over a large area, compared to the sub-horizontal flow over a lesser cross sectional area in the aquifers, accentuating the systems sensitivity to it.

The hydraulic conductivity of the Clay Aquitard is difficult to measure accurately and has been estimated based on approximate degree of anisotropy. Therefore the measured results have a relatively high degree of uncertainty. Measurements of the horizontal hydraulic conductivity of the Estuarine Aquifer sand are within a much smaller range and have been measured directly. In this system the vertical hydraulic conductivity of the Clay Aquitard is directly related to the horizontal conductivity of the Estuarine Aquifer, as the flow in the Estuarine Aquifer is largely driven by vertical leakage through the Clay Aquitard. Therefore this limits the non-uniqueness of the solution. The rate of change in surface water levels is also highly influenced by the vertical leakage rates through the clay and therefore the transient calibration process, matching recession curves for the surface waters has further reduced the uncertainty in the vertical hydraulic conductivity of Layer 1 and horizontal conductivity Layer 3, providing additional uniqueness to the solution.

2.7 Calibration Summary

Overall the calibrations, both steady state and transient are considered to provide good representations of the groundwater system on the T4 Project site and are considered suitable for the purposes of assessing the sensitivity of the groundwater system to changes induced from the proposed T4 Project development.