Transport
Roads & Maritime
Services

GROUNDWATER MONITORING PROGRAM

Nambucca Heads to Urunga upgrade

JANUARY 2013

Groundwater Monitoring Program

Nambucca Heads to Urunga Pacific Highway Upgrade

quality solutions **sustainable** future

Groundwater Monitoring Program

Nambucca Heads to Urunga Pacific Highway Upgrade

Prepared for: Roads and Maritime Services

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Introduction

This document presents the Groundwater Monitoring Program for the northern section of the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade. The northern section of the highway upgrade covers a distance of approximately 22 kilometres from Nambucca Heads to Urunga (termed 'NH2U' in this report), which runs from design chainage 19,500 m to 41,300 m.

The purpose of this document is to detail a monitoring program for groundwater levels and groundwater quality for pre-construction, construction and post-construction stages of the NH2U section of the Pacific Highway Upgrade. This document forms part of an overall Water Quality Monitoring Program for the Warrell Creek to Urunga Pacific Highway Upgrade which includes the following accompanying documents:

- Surface Water Quality Monitoring Program - Nambucca Heads to Urunga Pacific Highway Upgrade;
- Groundwater Monitoring Program – Warrell Creek to Nambucca Heads Pacific Highway Upgrade; and
- Surface Water Quality Monitoring Program – Warrell Creek to Nambucca Heads Pacific Highway Upgrade.

1.1 Project Overview

The Warrell Creek to Urunga Pacific Highway Upgrade involves an upgrade of the existing highway to a four lane divided highway from the existing Allgomera deviation, south of Warrell Creek, to Waterfall Way at Raleigh north of Urunga. The proposed upgrade extends over approximately 42 kilometres.

The Warrell Creek to Urunga (WC2U) project was identified as a critical infrastructure project by the NSW Government, designed to improve safety, traffic efficiency and increase capacity along the Pacific Highway. It forms part of the overall program for upgrading the Pacific Highway. Planning commenced on the WC2U project in 2003 and project approval was granted on 19 July 2011, under Part 3A of the *Environmental Planning and Assessment Act 1979*.

The 22 kilometre section of the highway upgrade from Nambucca Heads to Urunga has been agreed between the Australian and NSW Governments with major construction likely to commence in 2013. Therefore the Water Quality Monitoring Program for the Warrell Creek to Urunga Pacific Highway Upgrade has been divided into the two highway upgrade sections: Warrell Creek to Nambucca Heads (WC2NH) and Nambucca Heads to Urunga (NH2U).

As part of the proposals approval, preparation and implementation of a Water Quality Monitoring Program is required to address the Minister for Planning and Infrastructure's Condition of Approval (CoA) B17, and Sections 2.15.4, and Commitments W3, W6, W7 of the "Warrell Creek to Urunga Submissions and preferred project report" (hereafter referred to as the 'Submissions Report'). Requirements outlined in each of the Conditions and relevant section of the Submissions Report is provided below.

1.2 Regulatory Context

1.2.1 Environmental Assessment

The Minister for Planning declared on 5 December 2006 that the Warrell Creek to Urunga upgrade is a project to which Part 3A of the *Environmental Planning and Assessment Act 1979* applies. In accordance with the requirements of the *Environmental Planning and Assessment Act 1979*, an environmental assessment was prepared (SKM, 2010) to assess the potential impacts of the Proposal.

The environmental assessment for the WC2U project outlined a Draft Statement of Commitments that identified a range of environmental outcomes and management measures required to avoid, minimise, manage, mitigate or offset and/or monitor impacts identified in the environmental assessment. After consideration of the issues raised in the public submissions, the draft statement of commitments for the WC2U project were revised as detailed below.

1.2.2 Statements of Commitments

The revised Statement of Commitments relevant to this Groundwater Monitoring Program is reproduced in **Table 1.1** overleaf.

1.2.3 Conditions of Approval

The project approval documents for the WC2U project (RTA, 2011) include conditions of approval from the NSW Minister for Planning. The condition of approval relevant to this Groundwater Monitoring Program is detailed below.

Condition of Approval B17- Water Quality
The Proponent shall prepare and implement a **Water Quality Monitoring Program** to monitor the impacts of the project on SEPP 14 wetlands, surface water quality and groundwater resources during construction and operation. The Program shall be developed in consultation with OEH (now EPA) and DPI and shall include but not necessarily be limited to:

a) identification of surface water and groundwater quality monitoring locations which are representative of the potential extent of impacts from the project;
b) identification of works and activities during construction and operation of the project, including emergencies and spill events, that have the potential to impact on surface water quality and risks to oyster farming in the Nambucca, Bellinger, and Kalang rivers;
c) representative background monitoring of surface water and groundwater quality parameters for a minimum of six (6) months (considering seasonality) prior to the commencement of construction to establish baseline water conditions;
d) development and presentation of indicators or standards against which any changes to surface water quality will be assessed, having regard to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC, 2000);
e) contingency and ameliorative measures in the event that adverse impacts to surface water quality are identified;
f) a minimum monitoring period of three years following the completion of construction or until any disturbed waterways/ groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales); and
g) reporting of the monitoring results to the Department, OEH and DPI.

The Program shall be submitted to the Director General for approval six (6) months prior to the commencement of construction of the project, or as otherwise agreed by the Director General. A copy of the Program shall be submitted to OEH (now EPA) and DPI prior to its implementation.

Table 1.1 Statements of Commitments

Outcome	*Ref No.*	*Key Action*	*Timing*	*Reference document*
Water quality and hydrology	W3	Monitoring of groundwater impacts and surface water quality upstream and downstream of the site during construction will determine the effectiveness of mitigation strategies Implementation of additional feasible and reasonable management measures will occur if necessary.	Pre-construction and construction	Draft *DECC "Managing Urban Stormwater: Soils and Construction, Volume 2, Book 4, Main Road Construction (2006)".* Volume 2A Installation of Services (DECCW 2008). Volume 2C Unsealed Roads (DECCW 2008). Volume 2D Main Roads Construction (DECCW 2008). Managing Urban *Stormwater: soils and construction* (Landcom 2004). The RTA's *Code of Practice for Water Management – Road Development and Management.* RTA *QA Specification G38 Soil and Water Management.*
Minimise groundwater related impacts	W6	Investigation of the potential for changes in the groundwater table will take place before starting any major earthworks. Where a potential for change is identified, the significance of the change and any resultant impacts will be determined and measures to manage the changes will be designed and implemented as necessary.	Pre-construction and construction	Section 16.4 and table 16-4 of the EA. *RTA's Code of Practice for Water Management – Road Development and Management (1999).* RTA *QA Specification G38 Soil and Water Management.* *Water Act 1912*
	W7	Base line monitoring of groundwater levels and chemical levels at cutting sites near springs, creeks or endangered ecological communities prior to construction commenting.	Pre-construction and construction	Section 16.4.1.3 and Table 16-4 of the EA. *RTA's Code of Practice for Water Management – Road Development and Management (1999).* RTA *QA Specification G38 Soil and Water Management.* *Water Act 1912*

1.3 Groundwater Policy Framework

There are a set of NSW policies which aim to protect groundwater from unsustainable degradation. These policies are organised into three component policies which come under the overall NSW Groundwater Policy Framework Document. The NSW State Groundwater Policy Framework Document 199 sets the overall direction for groundwater management in NSW, with broad objectives and principles to guide decisions. The NSW State Groundwater Quality Protection Policy 1998 provides more detail and guidance on how to protect groundwater quality. The NSW State Groundwater Quantity Management Policy (unpublished) was aimed at managing extraction of groundwater within sustainable yields. This policy has been superseded by the ongoing implementation of water sharing plans. NSW State Groundwater Dependent Ecosystems Policy 2002 guides the management of groundwater to ensure the maintenance and protection of groundwater dependent ecosystems. These policies and their relationship are shown below in **Plate 1.1**.

Plate 1.1 Relationship of NSW State Groundwater Policies

The principles outlined in these policies require the protection of groundwater quantity and quality for the towns and ecosystems that depend on it.

1.3.1 The NSW State Groundwater Policy Framework Document

The Goal for the management of groundwater in New South Wales is:

To manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW.

1.3.1.1 Policy Objectives

It is the policy of the NSW Government to encourage the ecologically sustainable management of the State's groundwater resources, so as to:

- *slow and halt, or reverse any degradation of groundwater resources;*
- *ensure long term sustainability of the systems ecological support characteristics;*
- *maintain the full range of beneficial uses of these resources; and*
- *maximise economic benefit to the Region, State and Nation.*

1.3.1.2 Policy Principles

The State Groundwater Policy objectives will be achieved through application of the following resource management principles:

- *An ethos for the ecologically sustainable management of groundwater resources should be encouraged in all agencies, communities and individuals, who own, manage or use these resources, and its practical application facilitated.*
- *Non-sustainable resource uses should be phased out.*
- *Significant environmental and/or social values dependent on groundwater should be accorded special protection.*

- *Environmentally degrading processes and practices should be replaced with more efficient and ecologically sustainable alternatives.*
- *Where possible, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.*
- *Where appropriate, the management of surface and groundwater resources should be integrated.*
- *Groundwater management should be adaptive, to account for both increasing understanding of resource dynamics and changing community attitudes and needs.*
- *Groundwater management should be integrated with the wider environmental and resource management framework, and also with other policies dealing with human activities and land use, such as urban development, agriculture, industry, mining, energy, transport and tourism* (Department of Land and Water Conservation 1997).

As mentioned, the State Groundwater Policy encompasses three component policies. Clearly, and necessarily, these policies overlap and interrelate in many regards. They include the:

- Quality Protection Policy;
- Quantity Management Policy; and
- Dependent Ecosystems Policy.

In association with the Framework Document these policy documents make up the State Groundwater Policy. The Framework document sets out the overall direction of groundwater management in NSW and provides broad objectives and principles to guide management (as above). The component policies build on this approach and provide more detail and guidance on how to manage and protect groundwater quality, groundwater quantity and groundwater dependent ecosystems respectively (Department of Land and Water Conservation 1998).

1.3.2 The NSW Groundwater Quality Protection Policy

The Groundwater Quality Protection Policy is specifically designed to protect our valuable groundwater resources against pollution. Adoption of this Policy means that the sustainability of groundwater resources and their ecosystem support functions will be given explicit consideration in resource management decision making.

1.3.2.1 Policy Objectives

For groundwater quality protection, it is the policy of the NSW Government to encourage the ecologically sustainable management of the State's groundwater resources so as to:

- *slow and halt, or reverse any degradation in groundwater resources;*
- *direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater;*
- *establish a methodology for reviewing new developments (industrial/mining/urban and rural) with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource; and*
- *establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps, or groundwater protection zones* (Department of Land and Water Conservation 1998).

1.3.2.2 Policy Principles

The Groundwater Quality Protection Policy adopts the principles outlined in the NSW State Groundwater Policy Framework Document. In relation to Groundwater Quality Protection, the following principles specifically apply:

- *All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.*
- *Town water supplies should be afforded special protection against contamination.*
- *Groundwater pollution should be prevented so that future remediation is not required.*

- *For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.*
- *A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation or receiving waters.*
- *Groundwater dependent ecosystems will be afforded protection.*
- *Groundwater quality protection should be integrated with the management of groundwater quantity.*
- *The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.*
- *Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored* (Department of Land and Water Conservation 1998).

1.3.3 The NSW Groundwater Quantity Management Policy

The NSW State Groundwater Quantity Management Policy (unpublished) was aimed at managing extraction of groundwater within sustainable yields to ensure continuing availability of groundwater into the future and ensure the viability of groundwater dependant ecosystems. The quantity policy has been in draft form for approximately seven years and is not publicly available. The draft policy has essentially been superseded by the ongoing implementation of water sharing plans which detail quantity management for specific groundwater aquifers. The only current water sharing plan relevant to the highway upgrade is for the Bellinger River Area Unregulated and Alluvial Water Sources (2008). Review of the water sharing plan indicates no significant restrictions or implications for the highway upgrade.

1.3.4 The NSW Groundwater Dependent Ecosystems Policy

The State Groundwater Dependant Ecosystems Policy is specifically designed to protect our valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems area maintained or restored, for the benefit of the present and future generations.

This Policy provides guidance on how to protect and manage these valuable natural systems in a practical sense. The range of tools that can be used to manage these ecosystems should be adapted to suit local conditions.

The following principles apply to the management of groundwater-dependent ecosystems in NSW:

1. *The scientific, ecological, aesthetic and economic values of groundwater-dependent ecosystems, and how threats to them may be avoided, should be identified and action taken to ensure that the most vulnerable and the most valuable ecosystems are protected.*
2. *Groundwater extraction should be managed within sustainable yield of aquifer systems, so that the ecological processes and biodiversity of their dependent ecosystems area maintained and/or restored. Management may involve establishment of threshold levels that are critical for ecosystem health, and controls on extraction in the proximity of groundwater dependent ecosystems.*
3. *Priority should be given to ensuring that sufficient groundwater of suitable quality is available at the time when it is need:*
   - *For protecting ecosystems which are known to be, or are most likely to be, groundwater dependent; and*
   - *For the groundwater dependent ecosystems which are under an immediate or high degree of threat from groundwater-related activities.*
4. *Where scientific knowledge is lacking, the Precautionary Principle should be applied to protect groundwater dependent ecosystems. The development of adaptive management systems and research to improve understanding of these ecosystems is essential to their management.*
5. *Planning, approval and management of development and land use activities should aim to minimise adverse impacts on groundwater dependent ecosystems by:*

- *Maintaining, where possible, natural patterns of groundwater flow and not disruption groundwater levels that are critical for ecosystems;*
- *Not polluting or causing adverse changes in groundwater quality;*
- *Rehabilitating degraded groundwater systems where practical* (Department of Land and Water Conservation 2002).

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2

Groundwater Environment and Risks

This section provides background information regarding the groundwater environment and the general risks to groundwater posed by the highway upgrade. The information in this section is largely based on the environmental assessment by SKM (2010) for the highway upgrade. The purpose of this section is to provide the context to the groundwater monitoring program which is detailed in **Section 4** of this report.

2.1 Topography and Geology

The study area comprises two major terrain units: the alluvial floodplains and the foothills of the coastal ranges. The floodplains comprise flat to gently sloping coastal plains and river terraces, with estuarine mud flats. The foothills are gently to moderately undulating hills, with wide river valleys and creeks. The characteristics of the geology and soils associated with the two units are:

- Floodplains: Quaternary alluvial and estuarine soils up to about 15 to 35 m thick. Alluvial estuarine soils: sands, silts, clays, organic clays, possible gravels, and potential acid sulfate soils.
- Foothills: Nambucca Beds (mainly phyllites with some slate and schists), with some granite intrusions and local granodiorite dykes. Soils: residual clay of high plasticity to less than 5m depth and alluvial/colluvial sandy clay sediments in the small creeks (SKM, 2010a:422-423).

2.1.1 Floodplains

The soils on the floodplains and surrounding the waterways are fine-grained alluvial soils such as silty clays and sandy clays. Archaeological investigations also uncovered quartz gravel in some areas which would have a greater permeability. Compaction by livestock which was evident on much of the agricultural land along the highway upgrade, would act to reduce groundwater permeability (SKM, 2010c:27).

2.1.2 Foothills

Phyllite is a fine-grained rock formed from low grade metamorphism of claystones. Boreholes, up to 26 m in depth, encountered moderately to highly weathered phyllite. There is a gradual transition from weathered rock to residual clay soil. Rock below alluvial flats exhibited less weathered rock than those located in the ridgelines.

Boreholes encountered extensive quartz veining in the phyllite. The phyllite predominantly displays signs of increased weathering in the vicinity of the quartz veining, which is likely due to groundwater flow through the veining (SKM, 2010a:424).

2.2 Existing Groundwater Conditions

The EA indicates there are two main types of groundwater regimes likely to be found along the area of the highway upgrade based on geological types and groundwater levels observed in standpipe piezometers. These include:

- Foothills; and
- Alluvial floodplains

2.2.1 Groundwater in Foothills

The phyllite in the hilly areas exhibits low permeability with the main groundwater transport route being defects in the rock, particularly along veins and foliation partings. Groundwater level measurements in these areas indicated that groundwater levels were generally greater than 10 m depth (SKM, 2010a:370).

2.2.2 Groundwater in Alluvial Floodplains

The groundwater tables found in the alluvial floodplains were high (less than five meters in depth) and typically reflected their proximity to the major water courses. Groundwater levels across the floodplains are likely to fluctuate due to tidal influences by up to 0.5 m (SKM, 2010a:370).

2.2.3 Groundwater Quality

There is limited data with respect to existing groundwater quality. Previous risk assessments of groundwater bores and monitoring programs indicate low risk of contamination of groundwater in the vicinity of the highway upgrade.

A desktop assessment including a site visit undertaken as part of the EA to identify potentially contaminating land uses indicated the risk to groundwater of contamination from heavy metals, pesticides and herbicides is considered to be low (SKM, 2010c:29).

2.3 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) in the area of the highway upgrade include terrestrial vegetation, base flows in streams, aquifers, or wetlands. Those vegetation communities and habitats with the greatest potential to be affected by changing groundwater levels consist of terrestrial vegetation and wetlands located in the low-lying floodplain areas intersected by the proposed highway upgrade, including:

- Swamp oak floodplain forest;
- Swamp sclerophyll forest;
- Subtropical coastal floodplain forest;
- Lowland rainforest; and
- Freshwater wetlands.

Other vegetation communities within riparian areas may have some level of ground-water dependence, including wet sclerophyll forests in proximity to creek flats (SKM, 2010a:190-191).

2.4 Groundwater Users

A search of the NSW groundwater database in 2004 indicated the majority of groundwater bores in the vicinity of the highway upgrade are used for domestic supply with or without stock (SKM, 2010c:28).

2.5 Risks to Groundwater

The three main risks to groundwater posed by the construction and operation of the highway upgrade include leaching of acid sulfate soils (ASS), contamination from accidental spills, and cuttings of the proposal intersecting or diverting groundwater from the existing groundwater regime and limiting base flow to waterways, wetlands and groundwater dependent ecosystems (GDEs).

2.5.1 Risks to Groundwater Quality - Leaching of Acid Sulfate Soils

Disturbance of ASS can occur during the construction process or through activities which lower the water table such as excavation and dewatering operations. These activities create the potential for oxidation of ASS and subsequent generation of acidic runoff to surface waters and acidic leachate to groundwater. This is generally a risk within the floodplain areas.

2.5.2 Risks to Groundwater Quality - Accidental Spills

Groundwater bores may be exposed to risk of impact from accidental spillages of fuels, oils and chemical agents associated with construction and operation of the highway upgrade. Such pollutants may infiltrate to the groundwater and adversely affect groundwater quality. The EA concluded that the likelihood of significant impacts to groundwater quality from accidental spills is low (SKM, 2010c:52).

2.5.3 Risks to Groundwater Quantity – In-Stream Structures and Embankments

Groundwater barriers can form from construction and operation of in-stream structures such as bridges, or embankments on soft soil which compresses and forms a less permeable layer of soil. The bridges that would be built would only impact groundwater movement in very localised areas and are therefore not considered to be a risk to groundwater flow. Mitigation measures would be put in place to minimise the degree to which soft soils would compress, and therefore construction of embankments should pose little risk to the formation of groundwater barriers (SKM, 2010c:53).

The Flora and Fauna Working Paper (SKM, 2010b) addressed the impact of in-stream structures or embankments on groundwater flow. There would be a greater impact on areas with naturally high water tables and saturated soils such as freshwater wetlands and swamps. One higher quality area of this community is present adjacent to the eastern side of the existing highway near Deep Creek which comprises open areas of water, dense sedges and interspersed paperbacks. However, in general, the Working Paper concluded that provision of minimum design standard drainage structures adjacent to wetlands and saturated soils is expected to mitigate the potential impacts from altered ground-water recharge rates and that a detectable change in groundwater levels is not expected (SKM, 2010b:169).

2.5.4 Risks to Groundwater Quantity - Cuttings

Geotechnical investigations have found that base flows to local creeks are provided largely by relatively shallow local and intermediate groundwater flow systems. This infers that any cutting that significantly diverts potential rainfall recharge away from the local shallow groundwater system, or intersects the water table significantly, is likely to diminish water discharges to the creeks and water bodies, therefore having secondary impacts on groundwater dependent ecosystems (GDEs) reliant on this recharge (SKM, 2010a:377-378).

There are three cuttings considered to have a high risk and 19 cuttings considered to have a moderate risk of impacting surrounding ecosystems and groundwater sensitive areas – refer to **Table 2.1** and **Illustrations 2.1** to **2.4**. Groundwater depths measured in the vicinity of Cutting No. 4.10 were in the range of 15.75m depth to 21.40 m depth below ground level (SKM, 2010c:29). The proposed depth of cut at this location is estimated to be approximately 15 m based on cutting depths reported in Table 6.2 in the EA (SKM, 2010a:111). A comparison of typical cutting depths and groundwater depths is shown in **Table 2.2** of this report.

Table 2.1 Cuttings with a Moderate to High Risk of Groundwater Impact

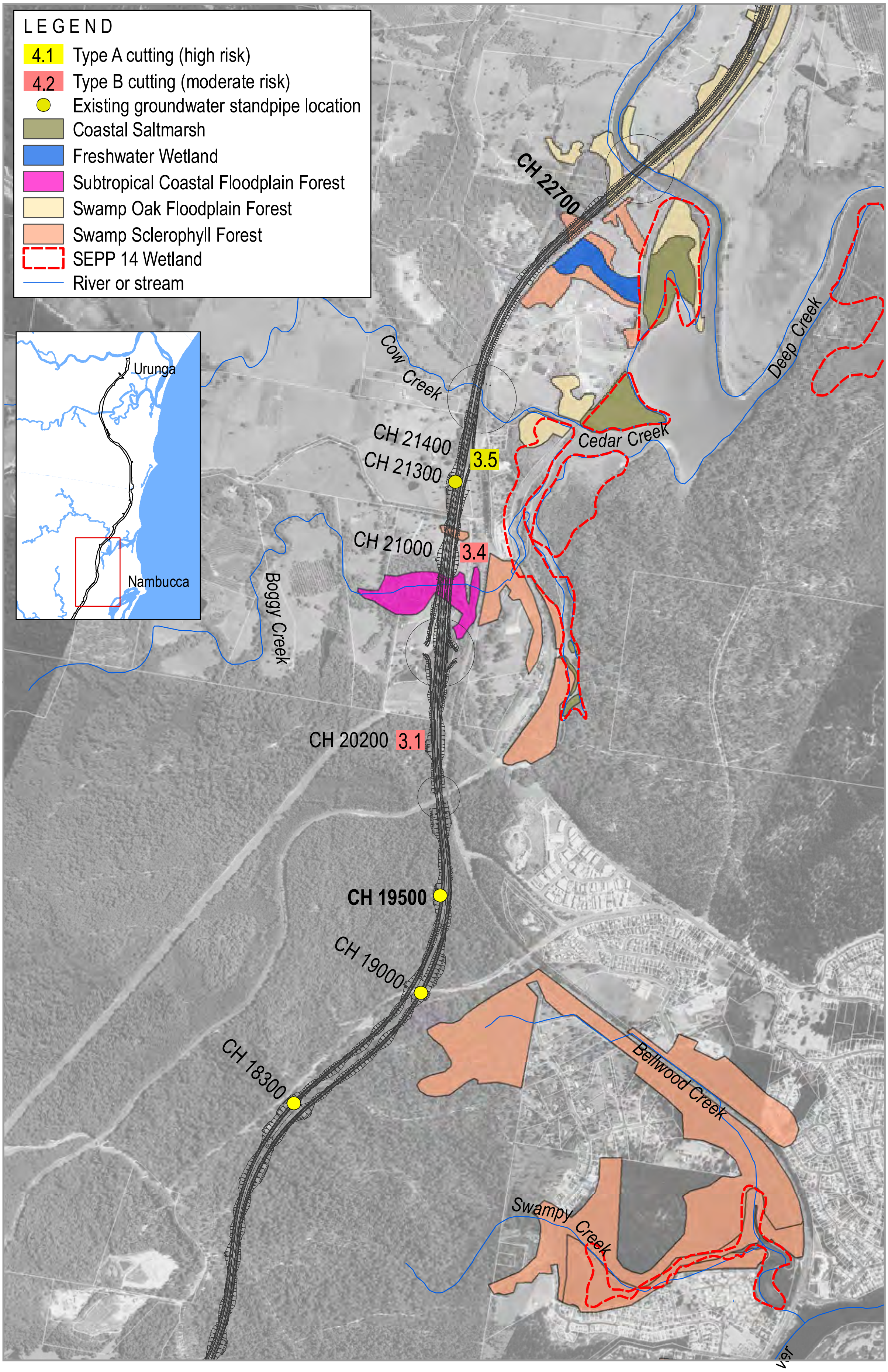
Classification	*Numbers of Cuttings within Category*[1]	*Cutting Identifiers*[1]
High Risk – cuttings with a significant depth of excavation into the topography (> 10 m depth), a large length and area of extent, and/or with known EECs, creeks, bores or structures in the immediate vicinity of the cutting (within approx. 250 m).	Section 3: one Section 4: two **Total: three**	Section 3: 3.5 Section 4: 4.2 and 4.10
Moderate Risk – cuttings with a moderate depth of excavation into the topography (5 - 10 m depth), a small to moderate length and area of extent, and/or with known EECs, creeks, bores or structures in the vicinity of the cut (within approx. 500 m).	Section 3: nine Section 4: ten **Total: 19**	Section 3: 3.1, 3.4, 3.8, 3.9, 3.10, 3.12, 3.14, 3.15 and 3.16 Section 4: 4.1, 4.3, 4.5, 4.7, 4.9, 4.11, 4.14, 4.15, 4.16 and 4.17

Source: Table 16-4 in SKM, 2010a:379

Notes: 1. Section 3 and 4 refer to sections of the WC2U highway upgrade as described in the EA documents (SKM, 2010a). Section 3 is from approximate design chainage 19,500 to 30,000 (Nambucca Heads to Ballards Road) and Section 4 from 30,000 to 41,300 (Ballards Road to Raleigh).

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: June 2012
Source of base data: Roads and Maritime Services



North

0 500

Cuttings with a Moderate to High Groundwater Risk - Ch 19500 to 22700

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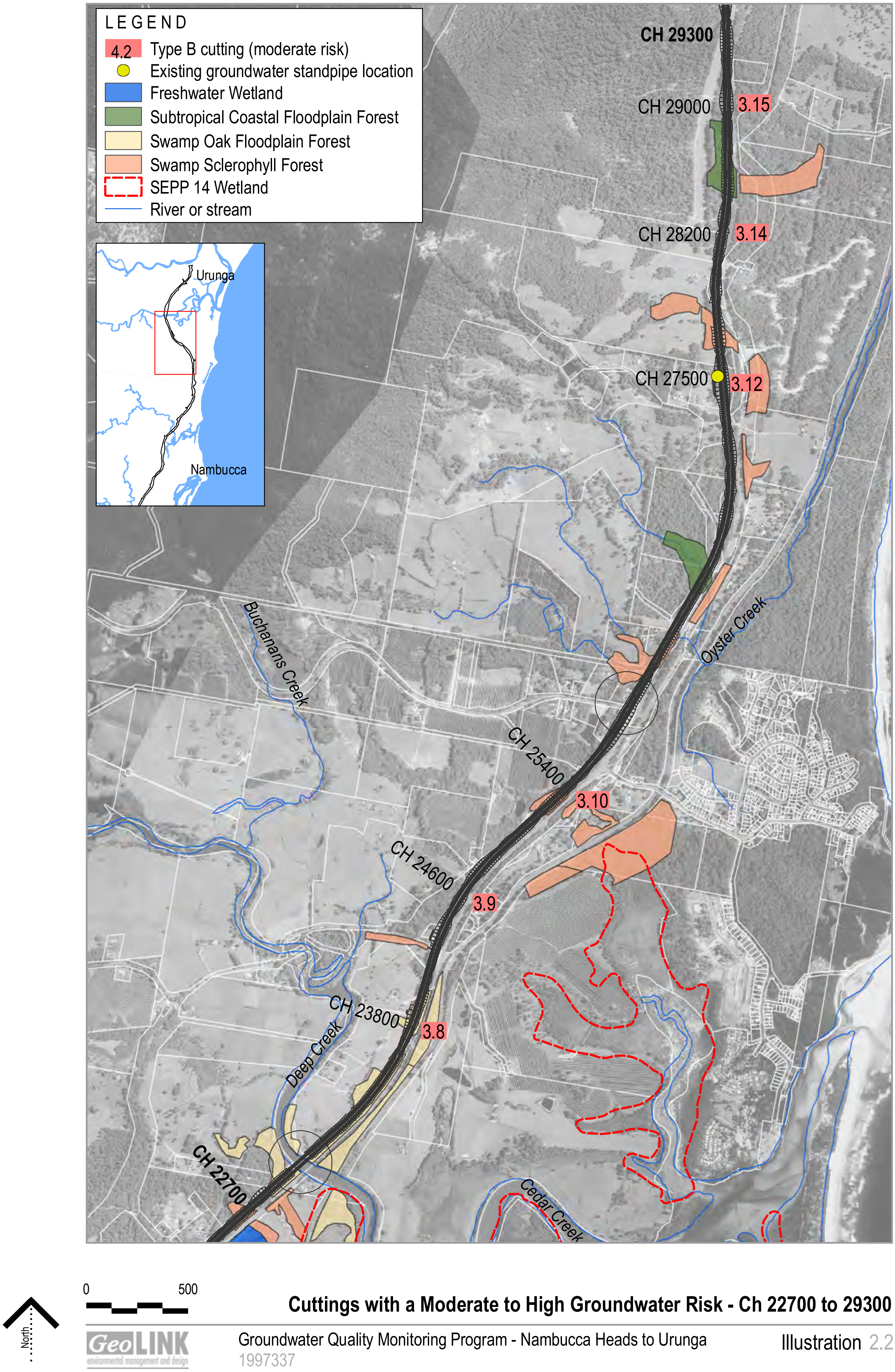
Groundwater Quality Monitoring Program - Nambucca Heads to Urunga
1997336

Illustration 2.1

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: June 2012
Source of base data: Roads and Maritime Services
Information shown is for illustrative purposes only

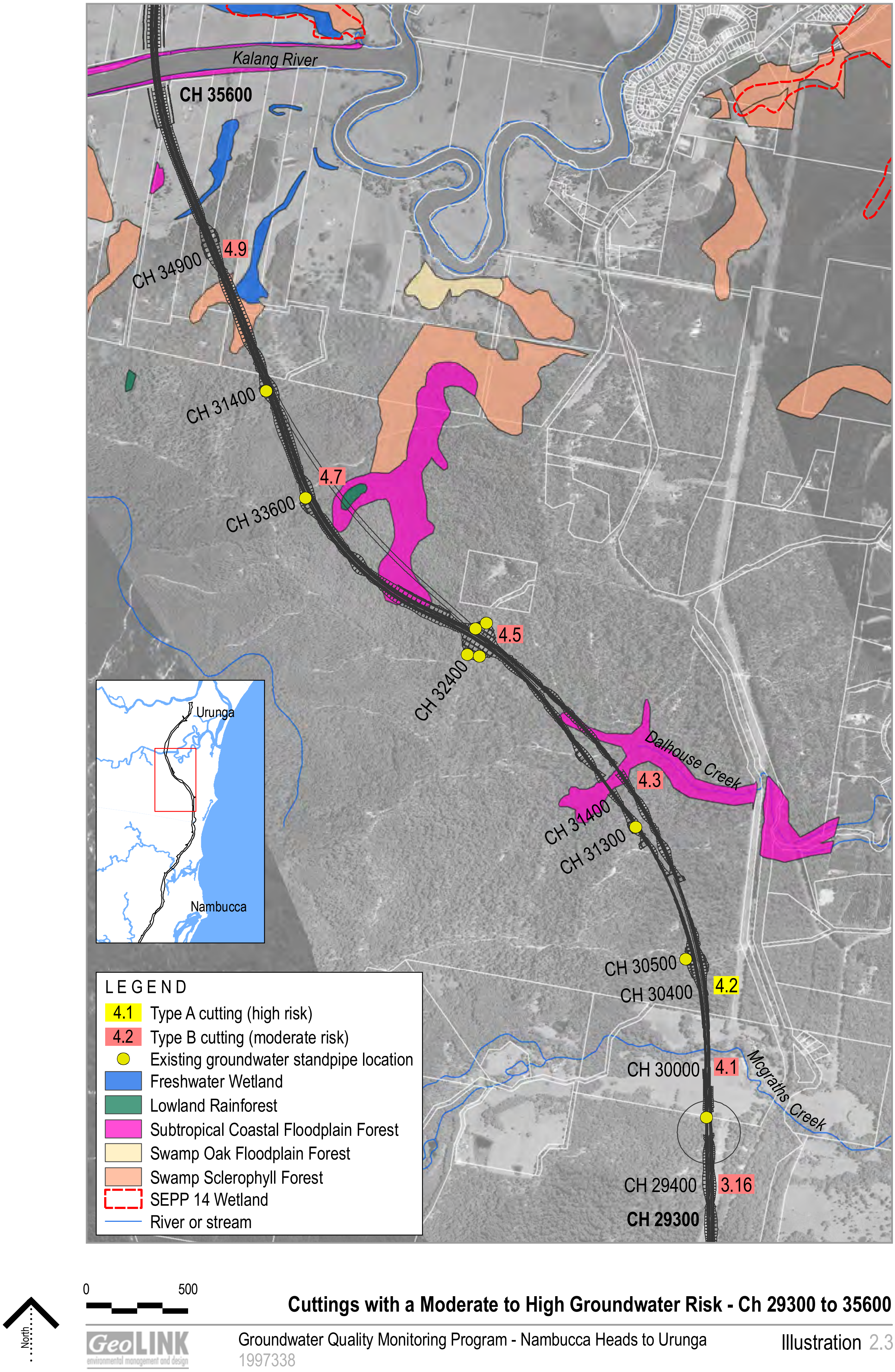


Cuttings with a Moderate to High Groundwater Risk - Ch 22700 to 29300

Groundwater Quality Monitoring Program - Nambucca Heads to Urunga
1997337

Illustration 2.2

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: June 2012
Source of base data: Roads and Maritime Services
Information shown is for illustrative purposes only



Cuttings with a Moderate to High Groundwater Risk - Ch 29300 to 35600

Groundwater Quality Monitoring Program - Nambucca Heads to Urunga
1997338

Illustration 2.3

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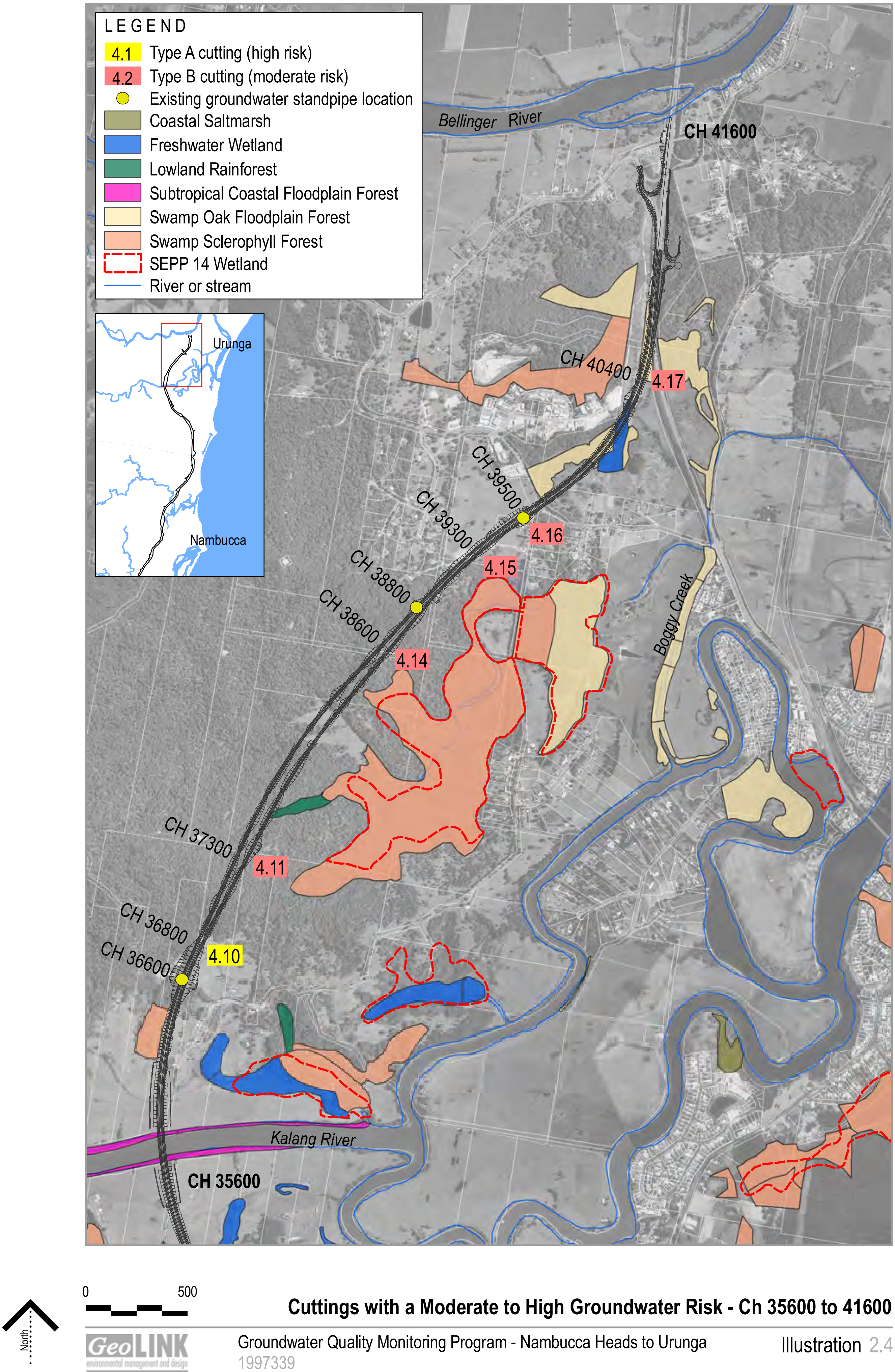
Source of base data: Roads and Maritime Services



Cuttings with a Moderate to High Groundwater Risk - Ch 35600 to 41600

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Groundwater Quality Monitoring Program - Nambucca Heads to Urunga
1997339

Illustration 2.4

Table 2.2 Typical Cutting Depths and Groundwater Depths

Section of Proposed Highway[1]	*Approximate Cutting Depth*[2]		*Groundwater Depth (m below ground level)* [3]	
	Max. Cut	*Typical Cut*	*Depth*	*Dates of Sampling*
Section 3 - design chainage 19,500 to 30,000	12 m	8 m	Dry (no groundwater encountered)	15/03/08
Section 4 - design chainage 30,000 to 41,300	24 m	10 m	17.00 – 19.75 21.37 – 21.40 15.75	22/09/07, 10/02/08, 15/03/08 & 25/07/08 15/03/08 & 25/07/08 10/02/08

Source: Table 16-4 in SKM, 2010a:379

Notes:
1. Section 3 and 4 refer to sections of the WC2U highway upgrade as described in the EA documents (SKM, 2010a). Section 3 is from approximate design chainage 19,500 to 30,000 (Nambucca Heads to Ballards Road) and Section 4 from 30,000 to 41,300 (Ballards Road to Raleigh).
2. Source: Table 6-2 in SKM, 2010a:111
3. Source: Table 4-1 in SKM, 2010c:29

The Flora and Fauna Working Paper (SKM, 2010b) also highlights the potential for altered hydrology (operation) regimes to impact on SEPP 14 wetlands including Deep Creek complex near Boggy and Cow Creeks, and wetlands west of Urunga and Newry Island (SKM, 2010b:170).

2.6 Management of Risks to Groundwater

The Water Quality Working Paper (SKM, 2010c) states that the main safeguards to protect groundwater quantity and quality involve mitigation of impacts from accidents and spills, mitigation of impacts from cuttings, groundwater monitoring, and minimising excavation and lowering the water table in acid sulfate soil areas. In respect to the management of groundwater impacts to GDEs and SEPP 14 wetlands, the Flora and Fauna Working Paper (SKM, 2010b:196) states that the highway will be designed to minimise impacts to hydrological regimes.

2.6.1 Groundwater Monitoring

2.6.1.1 Pre-construction and Construction Stage

To quantitatively assess possible groundwater impacts, management requirements, or mitigation measures, the EA recommended that baseline monitoring of both groundwater levels and chemical quality be completed at selected cutting sites at the detail design stage. Establishing these monitoring systems will help to resolve the uncertainty of groundwater behaviour, which will be especially important at cutting sites which may potentially impact upon features such as springs, creeks, and endangered ecological communities. The EA (SKM, 2010a) recommends monitoring of selected cutting sites should commence in advance of construction and comprise the following:

- installation and monitoring of groundwater wells (potentially nested or multi-level) prior to road construction;
- hydraulic tests (falling head) to estimate hydraulic conductivities of the shallow and possible deep aquifer systems that the cuts may intersect (prior to road construction);
- groundwater sampling and analysis for at least total dissolved solids, pH, and heavy metals and hydrocarbon compounds prior to, during, and following road construction to identify whether base flow to creeks is provided by the groundwater systems;
- monitoring of cuttings to determine whether these are having an adverse impact on water quality;
- visual observations and quantitative measurements of surface water flows at creeks;
- an assessment of the condition of endangered ecological communities; and

- where there is the potential for adverse impacts on groundwater, measures including the use of groundwater diversion systems would be included in the detailed design.

2.6.1.2 Operational Stage

Groundwater monitoring will continue for a minimum of three years following completion of construction or until any disturbed waterways/ groundwater resources are certified as being rehabilitated to an acceptable condition (refer to Section 4.3). The objective of monitoring would be to verify the validity of groundwater levels, and to flag adverse trends.

At cuttings where mitigation measures are implemented, monitoring may permit an early assessment of groundwater behaviour in response to the mitigation measures and verify the effective functioning of those measures.

The transfer of seepage or extracted water downstream to maintain local groundwater levels may be required. Transfer could include the collection of seepage from the cut face in the drainage system which would be diverted to absorption trenches or to water quality ponds to be tested and possibly treated before being released back to the creek or natural drainage system at some point downstream.

During construction, storage of potentially harmful materials would be undertaken away from watercourses and within impermeable, bunded facilities to protect water quality from accidents and spills. Spill contingency equipment would also be stored in close proximity (SKM, 2010c:69).

During operation the concept design includes scope for inclusion of spill contingency measures, which capture accidental spillages to ensure that they are not released directly to the environment (SKM, 2010c:69).

2.6.2 Management of Impacts from Cuttings

The Water Quality Working Paper (SKM, 2010c) outlines the following measures. If seepages in the batter face of road cuttings develop due to interception of a permeable layer of soil/rock, sub-horizon drains should be installed to relieve the water pressure in the batter. If seepages develop from interception of a perched water table, engineering mitigation measures need to be installed to transfer the seepage water into the groundwater ecosystem immediately downslope of the cut. These measures should involve collecting the seepage water from the cut face just above the level of the road and piping it under the cut/fill platform to the downslope side of the highway. The water could either be returned to the ground through absorption trenches, or held in water quality ponds to be tested and possibly treated before being discharged back into the surface water system (SKM, 2010c:69).

2.6.3 Management of Acid Sulfate Soils

Management of acid sulfate soils (ASS) will be adequately addressed with the implementation of an Acid Sulfate Soil Management Plan (ASSMP). This will include:

- avoidance or minimising the disturbance of ASS by minimising excavation or lowering the water table in ASS areas; and
- treatment of acid generation where ASS is disturbed (SKM, 2010c:68).

2.6.4 Management of Accidental Spills

In terms of protecting water quality from accidents and spills during construction, storage of potentially harmful materials would be undertaken away from watercourses and within impermeable, bunded facilities. Spill contingency equipment would also be stored in close proximity. During operation the concept design includes scope for inclusion of spill contingency measures, which capture accidental spillages to ensure that they are not released directly to the environment (SKM, 2010c:68).

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3

Monitoring Objectives

3.1 RMS and NSW Government Policy and Objectives

3.1.1 RMS Water Policy

The NSW Roads and Maritime Services' commitment to water management as outlined in the RTA Water Policy states:

> *"The RTA will use the most appropriate water management practices in the planning, design, construction, operation and maintenance of the roads and traffic system in order to:*
>
> - *conserve water*
> - *protect the quality of water resources; and,*
> - *preserve ecosystems."*

The general water quality objectives described in the RMS Code of Practice for Water Management (RTA, 1999) essentially aim at minimising potential impacts on the environment as indicated in the following general principles:

- Pre-Construction – the project design is to target the minimisation of impacts on the groundwater regimes in and around road corridors and designs will incorporate appropriate techniques to contain and treat road run-off to avoid or minimise potential impacts to aquatic and riparian environments (RTA,1999:8);
- Construction – Effective water management practices and procedures will be implemented, in accordance with the CEMP/SWMP, as an integral part of on-site construction management to ensure that water quality and quantity impacts to the environment are minimised (RTA, 1999:10); and
- Operational – The RTA will investigate and incorporate appropriate pollution control technologies on existing major roads and bridges to contain and treat road run-off, wherever practical and cost-effective, in order to minimise potential impacts on the environment (RTA, 1999:13).

3.1.2 NSW Government Policy

As described in **Section 1**, the NSW State Groundwater Policy Framework Document has a range of broad objectives and principles including:

- managing groundwater systems such that their most sensitive identified beneficial use (or environmental value) is maintained; and
- ensuring the viability of groundwater dependant ecosystems by:
  - maintaining, where possible, natural patterns of groundwater flow and not disruption groundwater levels that are critical for ecosystems; and
  - not polluting or causing adverse changes in groundwater quality.

3.1.3 Link with this Groundwater Monitoring Program

This Groundwater Monitoring Program links with the above objectives by providing groundwater levels and quality information to assess the impacts of the highway upgrade on the groundwater in the study area. This is the general objective of the Statement of Commitment No. W3:- *Monitoring of groundwater impacts and surface water quality upstream and downstream of the site during construction will determine the effectiveness of mitigation strategies. Implementation of additional feasible and reasonable management measures will occur if necessary*.

3.2 Monitoring Objectives

The primary objective of this Groundwater Monitoring Program is to evaluate the impact of the highway upgrade on groundwater levels and quality in the study area from Nambucca Heads to Urunga.

To achieve the above monitoring objective, this report provides the following information:

- parameters for monitoring during pre-construction, construction and operational stages;
- monitoring locations for groundwater levels and groundwater quality;
- a monitoring program to establish baseline groundwater levels and quality data in areas where the highway upgrade is most likely to impact on groundwater;
- a monitoring program to identify impacts of the highway upgrade on groundwater levels and quality; and
- a monitoring program to help assess and refine groundwater management measures.

3.3 Monitoring Approach

The type of monitoring study to be employed is one that measures change (i.e. any change in groundwater levels and quality as a result of the highway upgrade). The general category of design for this monitoring program is the before–after, control–impact (BACI) type design as described in ANZECC ARMCANZ (2000b:3-3). This essentially involves monitoring two sites before and after the disturbance occurs (pre-construction and construction/ operation). The two sites comprise one that will be subjected to the disturbance (an 'impact' site) and one that will not (a 'control' site). The same parameters are monitored at both 'control' and 'impact' sites before and after the highway upgrade to determine whether or not the pattern of behaviour over time at the impact site(s) change relative to the control sites.

3.3.1 Defining the Control and Impact Site

The Groundwater Monitoring Program nominates sites on opposite sides at selected cuttings which are most likely to impact environmental features such as springs, creeks and endangered ecological communities (typically Type A cuttings in Table 16-4 of the EA (SKM, 2010a:394)):

- the monitoring site that is hydraulically downslope of the cutting will represent the 'impact' site; and
- the monitoring site that is hydraulically upslope of the cutting will represent the 'control' site.

It should be noted there is likely to be some 'natural' variation or difference in groundwater levels and quality between the upslope and downslope sampling sites at the pre-construction stage (pre-disturbance). A measure or sense of this 'natural' variation or difference can be established from the pre-construction monitoring. This 'natural' variation will then need to be incorporated into the analysis of the construction / operational stage monitoring to ensure it is not misinterpreted as an impact of the highway upgrade.

3.4 Statistical Analysis

The proposed technique for comparing sampling results and water quality guidelines or trigger values is with either the use of tabulated results or control charts as described in ANZECC ARMCANZ (2000b:6-17). This is discussed further in **Section 5** of this document.

4

Monitoring Program

4.1 Monitoring Site Locations

Selection of the groundwater monitoring sites is largely based on the cutting sites that were classified as high-risk in the EA (SKM, 2010a) – refer to **Table 2.1**. Cuttings classified as high-risk in the EA have a significant depth of excavation (> 10 m depth); a large length and area; and/or there are known EECs, creeks, bores or structures in the immediate vicinity of the cutting (within approx. 250 m). In addition to the high-risk cuttings, three moderate-risk cuttings that have existing boreholes with standpipes have also been selected for monitoring to confirm they are moderate-risk as opposed to high-risk. These moderate-risk cuttings were selected on the basis of either being in close vicinity to a SEPP 14 wetland, having a significant depth of cut or being in close vicinity to an EEC.

In addition to the cutting sites, a monitoring site is proposed in an area of embankment fill upslope of freshwater wetland EEC and SEPP 14 wetland No. 357. This site was selected to assess if the embankment is creating a groundwater barrier due to soil compression resulting in a less permeable layer of soil (refer to risks in **Section 2.5.3**). It is noted that the EA indicated that construction techniques would minimise the degree to which soft soils would compress, and therefore construction of embankments should pose little risk to the formation of groundwater barriers (SKM, 2010c:53). Nevertheless, monitoring is proposed in one of these locations to test this assessment. The selected site is based on the Flora and Fauna Working Paper (SKM, 2010b) which indicated there would be a greater impact on areas with naturally high water tables and saturated soils such as freshwater wetlands and swamps. One higher quality area of this community is present adjacent to the eastern side of the existing highway near Deep Creek which comprises open areas of water, dense sedges and interspersed paperbarks (Chainage 22,600) (SKM, 2010b:169).

The selected groundwater monitoring sites are shown in **Illustrations 4.1** to **4.4** and comprise:

- Chainage 21,300: Cutting No. 3.5 (Type A high-risk cutting);
- Chainage 22,600: embankment fill upslope of freshwater wetland EEC and SEPP 14 wetland No. 357;
- Chainage 30,500: Cutting No. 4.2 (Type A high-risk cutting);
- Chainage 32,500: Cutting No. 4.5 (Type B moderate-risk cutting);
- Chainage 33,600: Cutting No. 4.7 (Type B moderate-risk cutting);
- Chainage 36,600: Cutting No. 4.10 (Type A high-risk cutting); and
- Chainage 38,800: Cutting No. 4.14 (Type B moderate-risk cutting).

A monitoring bore is proposed on each side of the highway cutting (the western side and eastern side) at the high risk cuttings and the embankment fill site listed below. The monitoring bores will be located near the project boundary to avoid impacting on construction works and to safeguard against an induced gradient from the cut impacting on groundwater levels at the monitoring location. Based on preliminary information it is estimated that there will not be an impact from induced gradients, however the suitability of the locations will need to be reassessed following review of the pre-construction phase monitoring results (refer to **Section 5.1.1**). The monitoring bores will also be located approximately at the mid-point of the length of the cut for the cutting sites.

- Chainage 21,300: Cutting No. 3.5 (Type A high-risk cutting);
- Chainage 22,600: embankment fill upslope of freshwater wetland EEC and SEPP 14 wetland No. 357;
- Chainage 30,500: Cutting No. 4.2 (Type A high-risk cutting); and
- Chainage 36,600: Cutting No. 4.10 (Type A high-risk cutting).

At the moderate-risk cutting sites (Chainages 32,500, 33,600 and 38,800) it is proposed that the existing boreholes with standpipes established during the EA phase will be utilised for monitoring. If the pre-construction stage reporting indicates that these locations need to be retained for construction / operational phase monitoring (refer to **Section 4.3** and **Section 5.1.2**), these boreholes may need to be relocated prior to construction.

It is noted that areas of ASS are not specifically nominated for monitoring as this is not considered a significant risk to groundwater for the NH2U highway upgrade. The main ASS risks to groundwater are associated with lowering the water table during excavation and dewatering operations in the construction stage. The Acid Sulfate Soil Management Plan (ASSMP) for the construction stage will adequately address these risks and avoid any significant lowering of the water table in ASS areas. The ASSMP will also monitor water quality downstream of ASS risk areas to allow early identification of ASS leachate. Therefore, it is not considered necessary to monitor ASS areas as part of the groundwater monitoring program.

4.2 Monitoring Parameters

4.2.1 Groundwater Levels

Groundwater level monitoring will be undertaken at each of the monitoring sites using automatic water level recorders and will involve potentially nested or multi-level monitoring.

4.2.2 Groundwater Quality

The groundwater quality parameters to be monitored at each of the monitoring sites are outlined below in **Table 4.2**. These parameters are based on RMS *Guideline for Construction Water Quality Monitoring* (RTA, undated), the requirements of the Brief (RMS, 2012) and other literature.

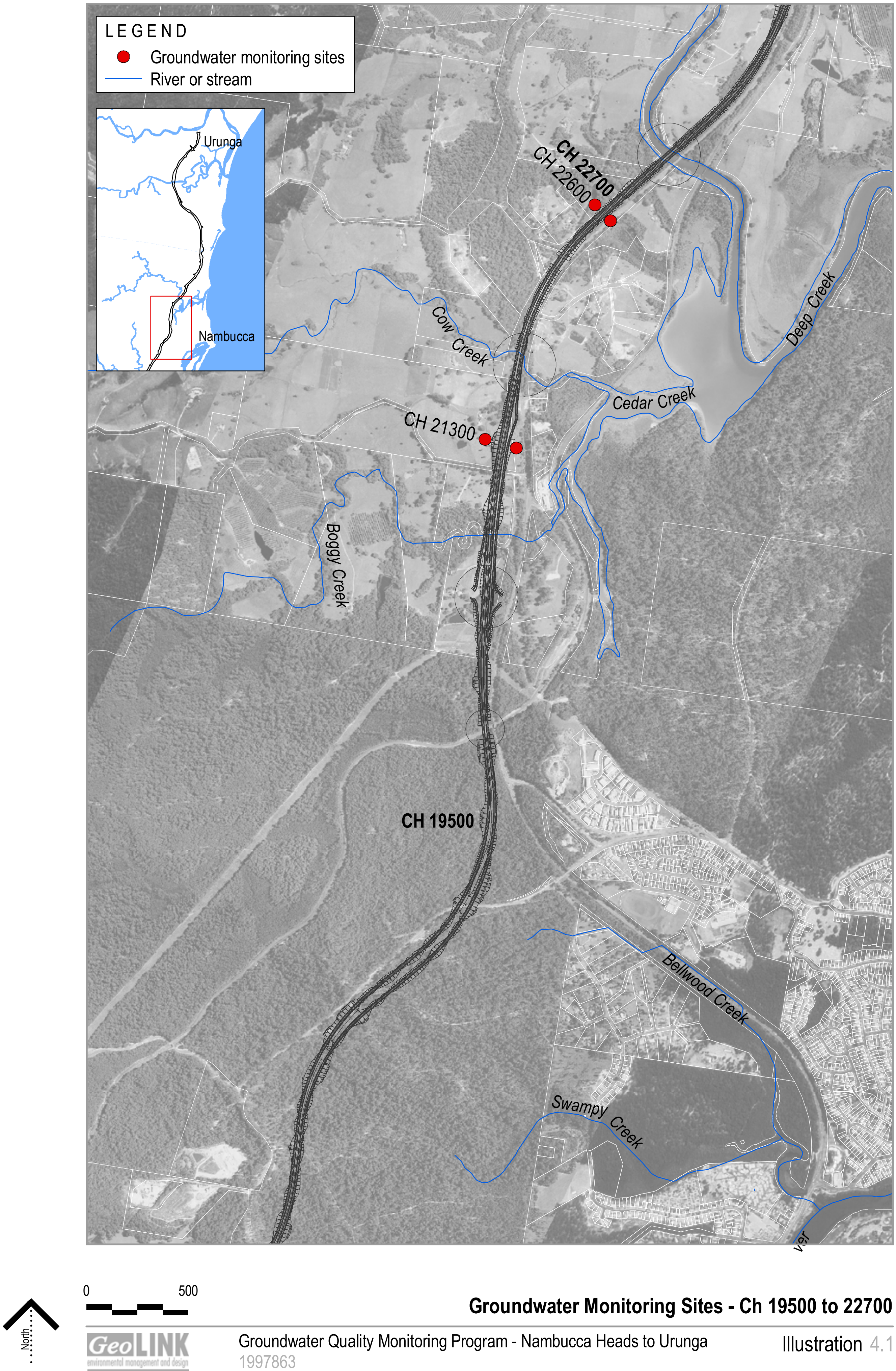
Table 4.1 Groundwater Quality Monitoring Parameters

Indicators / Parameters	*Analytical Group*	*Analytes*	*Analysis Method*
Groundwater Quality Indicators	Physical and chemical properties	pH, Electrical Conductivity (EC), Temperature	Field measurement
Groundwater Quality Parameters	Physical properties	Total dissolved solids (TDS)	Laboratory analysis
	Hydrocarbons	Total petroleum hydrocarbons (TPH)	Laboratory analysis
	Heavy Metals	Aluminium (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), Zinc (Zn)	Laboratory analysis
	Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Ammonia (NH_3), Total Phosphorus (TP), Phosphate (PO_4)	Laboratory analysis
	Major Anions[1]	chloride (Cl^-), sulfate (SO_4^{2-}), bicarbonate (HCO^{3-}), nitrate (NO^{3-})	Laboratory analysis
	Major Cations[1]	sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+})	Laboratory analysis

Notes: 1. Based on Sundaram *et. al.,* (2009) – these listed species represent the majority of ions in groundwater

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: June 2012
Source of base data: Roads and Maritime Services



Groundwater Monitoring Sites - Ch 19500 to 22700

GeoLINK environmental management and design

Groundwater Quality Monitoring Program - Nambucca Heads to Urunga
1997863

Illustration 4.1

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: June 2012
Source of base data: Roads and Maritime Services

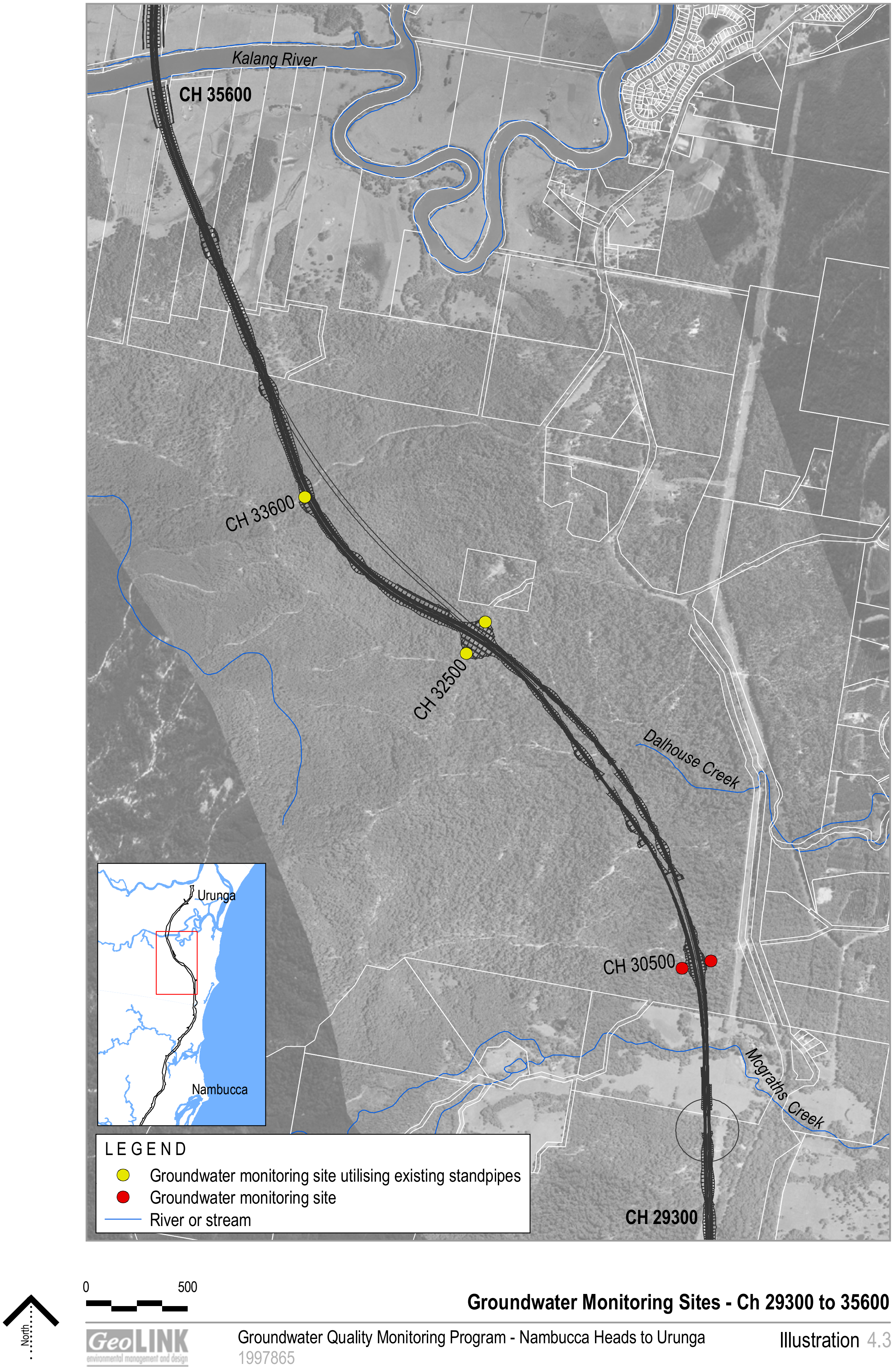
Groundwater Monitoring Sites - Ch 22700 to 29300

GeoLINK environmental management and design

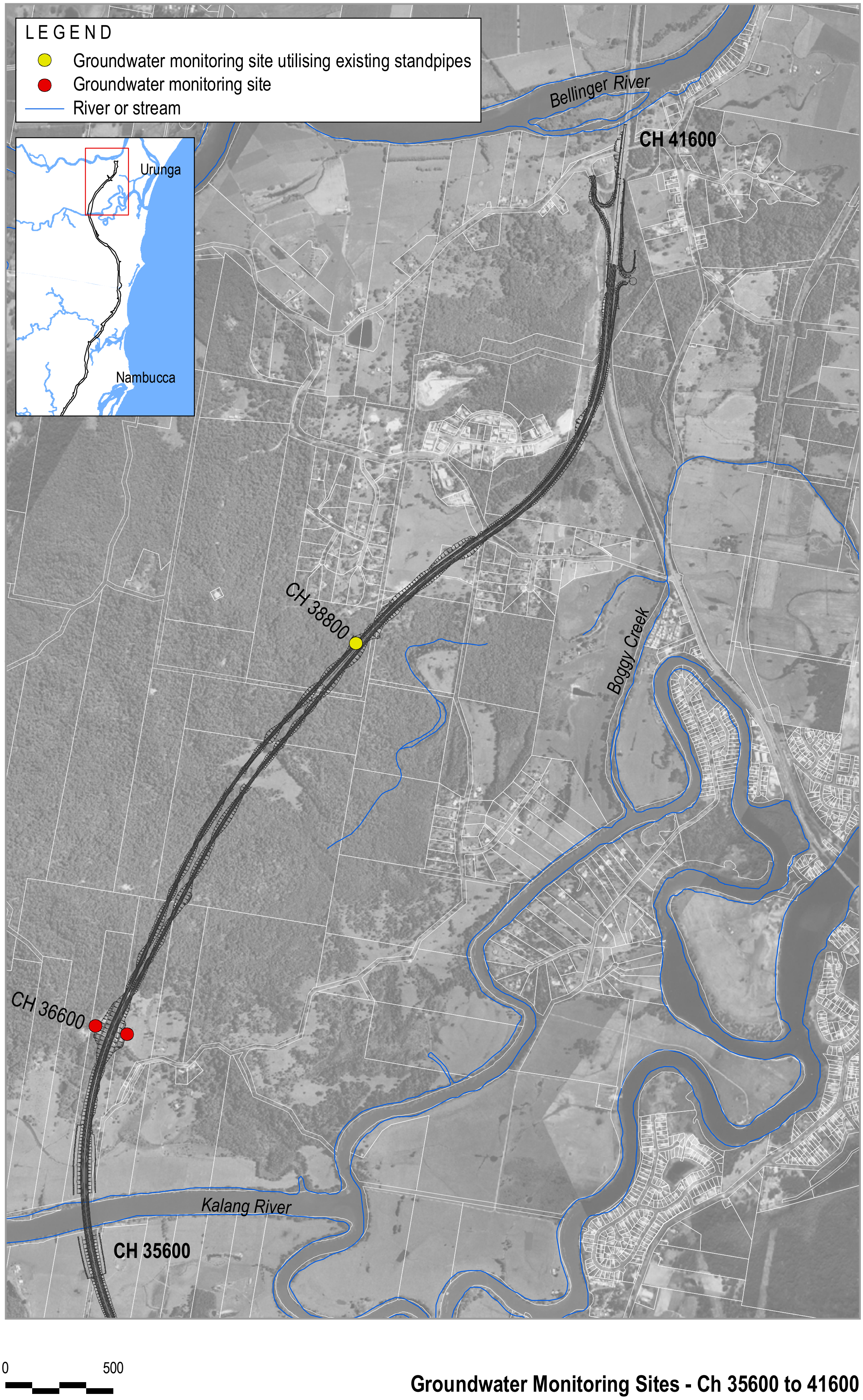
Groundwater Quality Monitoring Program - Nambucca Heads to Urunga

1997864

Illustration 4.2



Groundwater Monitoring Sites - Ch 29300 to 35600



Groundwater Monitoring Sites - Ch 35600 to 41600

4.2.3 Daily Rainfall

Daily rainfall figures from the construction site / nearest Bureau of Meteorology sites should also be recorded as part of the monitoring program for correlation with groundwater level monitoring.

4.3 Monitoring Duration

The durations of the various phases of the monitoring program are:

- Pre-construction phase: a minimum of six months;
- Construction phase: for the duration of the construction period; and
- Operational phase: a minimum of three years following completion or until any disturbed waterways/ groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition (refer to Condition of Approval B17 in **Section 1.2.3** of this report).

It is noted that monitoring of the moderate-risk cutting sites (Chainages 32500, 33600 and 38800) may be discontinued after the pre-construction phase if the results indicate there will be no significant risk to groundwater associated with construction / operation (e.g. if the groundwater depths are significantly below the depth of proposed cuttings). This is discussed further in **Section 5.1.2**.

4.4 Sampling Frequency

The sampling frequencies are outlined in **Table 4.2**. The recommended frequencies for groundwater levels and groundwater quality indicators for the construction period may be reduced following construction of the cuttings / embankments if the results indicate no significant variation between sampling events. A reduction in the proposed frequency below should be discussed and determined at the Environment Review Group meetings.

Table 4.2 Monitoring Frequency at Each Site

Parameter	*Pre-Construction*	*Construction*	*Operation*
Groundwater Levels	Automatic water level recorders set to take readings at a maximum of 1 hour intervals with a maximum 3 monthly period between downloads and calibration[1]		
Groundwater Quality Indicators[2]	Fortnightly	Monthly[1]	Quarterly
Groundwater Quality Parameters[2]	Monthly	Quarterly	Six monthly

Notes: 1. refer to discussion in paragraph above the table;
2. refer to **Table 4.1** for associated parameters.

4.5 Sampling Protocol

Monitoring of the quality of groundwater involves techniques different from those used for surface water quality investigations because groundwater, by its very nature, cannot be sampled without some disturbance from the construction of a bore or other access hole and the effects of sampling devices and procedures. These may also cause chemical and biological contamination unless stringent precautions are taken. Hence sampling staff must make extreme effort to ensure that the samples are representative of the water in the aquifer. Groundwater sampling should generally be carried out by experienced field staff or in close consultation with experts to ensure sample integrity (ANZECC ARMCANZ, 2000b:4-7).

4.5.1 Groundwater Level Measurements

The total depth of the bore and depth to the water level is to be measured within the bore before any purging and sampling. All depth measurements are to be related back to Australian Height Datum (AHD).

The total depth of the bore is required as the base of the monitoring bores can silt up, and this can occur to the top of the slotted/screened interval. Comparing the measured total depth reading with the depth documented at the time of construction can be useful to determine the status of the bore (Sundaram *et. al.,* 2009:24).

The depth to the water level in the bore is to be measured and recorded before every sampling event.

4.5.2 Groundwater Quality Sampling Collection

There are two main methods of sampling that can be employed to obtain a representative groundwater sample. These are the bore purging method and the low flow sampling method. The type of method to be used is determined by the pump design (Sundaram *et. al.,* 2009:27). Sample collection is to comply with the NSW EPA's *Approved Methods for the Sampling and Interpretation of Results of Water Pollutants in NSW* (Department of Environment and Conservation, 2004). Reference should also be made to Geoscience Australia's *Groundwater Sampling and Analysis – A Field Guide* (Sundaram *et. al.,* 2009).

Protocols to include the following basic precautions for avoiding contamination during sample collection:

- field measurements to be made on separate sub-samples of water;
- new or reused sample containers must be appropriately cleaned (use of containers supplied by the analytical laboratory is recommended);
- all field equipment is pre-cleaned to the same standard as the containers;
- sample bottles suitable for each parameter to be used;
- containers are uncapped or removed from their transport bags for minimum amounts of time;
- containers that were filled with water as part of the preparation protocol are emptied well away from and downstream of the sampling location before being rinsed with sample and refilled; and
- sampling staff should use plastic disposable gloves when handling sample containers at every stage during sampling (to avoid touching the sample, and the insides of caps or containers) ANZECC ARMCANZ (2000b:4-11,4-14).

4.5.3 Field Measurements

Some parameters (e.g. temperature) can only be measured in the field. For other parameters (e.g. dissolved oxygen), field measurements are highly desirable because the value of the parameter might change in the sample after collection ANZECC ARMCANZ (2000b:4-1). The following parameters are to be measured in the field:

- Electrical Conductivity (EC);
- Temperature; and
- pH.

It is recommended that field parameters be measured 'down hole' or in a flow cell to avoid contact between the groundwater and the atmosphere.

4.5.4 Sampling for Groundwater Quality Parameters

Sampling protocol to follow standard procedures as outlined in documents such as Australian Standard AS/NZS 5667 and *Australian guidelines for water quality monitoring and reporting* (ANZECC ARMCANZ, 2000b).

4.5.5 Field Observations

At each visit, the following information is to be recorded on a field-record sheet (based on information in ANZECC ARMCANZ, 2000b):

- the exact locations of sampling sites;
- weather conditions;
- the date and time when samples are taken (standard or daylight-saving time);
- any other observations or information on the conditions at the time of sampling that may assist in interpretation of the data; and
- photographic records are also highly desirable for future reference.

4.5.6 Replicate Water Samples

It is recommended that one blind replicate water sample is collected for each monitoring event. This is based on the general requirement of one blind sample for every 20 samples.

4.5.7 Tracking Samples and Field Data

During sampling or field measurements, it is important to fill in a field data sheet or similar record that describes the samples taken, their labels and other relevant details (see **Section 4.4.5** - Field Observations). All field data and instrument calibration data are recorded on this sheet. All field records must be completed before leaving a sampling station. Any observations or information on the conditions at the time of sampling that may assist in interpretation of the data should be noted on a field-record sheet. Chain of custody documentation to be recorded as part of the sampling program is listed in **Table 4.5**.

Table 4.3 Sampling Dates for Previous Water Quality Monitoring Sites

Process Step	***Quality Assurance Procedure***
Field sampling	Field register of sample number, site, type/technique, time, date, technician, field data sheet
Sample storage and transport	Field register of transport container number and sample numbers, time, date
Laboratory receipt of samples	Laboratory register of transport container number and sample numbers, time, date
Laboratory storage of samples	Laboratory register of storage location, type, temperature, time, date
Sample preparation	Analysis register of sample (laboratory) number, pre-treatment, date, technician
Sample analysis	Analysis register of instrument, calibration, technician, standard method, date, result

Source: Table 4.6 in ANZECC ARMCANZ (2000b:4-14)

4.5.8 Sample Identification

Sample containers should be marked in a clear and durable manner in order to permit clear identification of all samples in the laboratory. Blind replicate samples should be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

4.5.9 Sample Preservation

Water samples are susceptible to change as a result of physical, chemical or biological reactions which may take place between the time of sampling and the analysis. These changes are often sufficiently rapid to modify the sample considerably in the space of several hours.

All samples are to be stored in a refrigerated state immediately following sampling.

The preservation of samples to be analysed for heavy metals may require acidification in the field (which would necessitate the use of separate sample containers for the heavy metals sample) or acidification in the laboratory within 6 hours of sampling. Liaison with the analytical laboratory should be undertaken to confirm the most appropriate method of preservation of the heavy metals samples.

4.5.10 Sample Transport

Samples will be transported according to the relevant parts of Australian Standard AS/NZS 5667.1:1998. The time between sampling and analysis is to be reported.

4.6 Sample Analysis

Any laboratory used for sample analysis must be National Association of Testing Authorities (NATA) registered for each analysis required.

Parameters that require laboratory analysis are:

- physical properties: Total dissolved solids (TDS);
- hydrocarbons;
- nutrients;
- heavy metals;
- major anions; and
- major cations.

5

Data Analysis and Interpretation

5.1 Data Analysis

5.1.1 Pre-Construction Monitoring Data

Data analysis of the pre-construction monitoring results will aim to establish baseline data and an indication of the degree of variation for groundwater levels and each water quality parameter for existing conditions.

Analysis of the pre-construction data will need to assess the existing variation in groundwater levels and water quality between the upslope and downslope sampling sites (in respect to groundwater gradient) at each monitoring location. This existing variation will then need to be incorporated into the analysis of the construction/operational stage monitoring to ensure it is not misinterpreted as an impact of the highway upgrade.

The location of the monitoring bores at the cutting sites will also need to be reviewed in consideration of the depths to groundwater and proposed depth of cutting, to assess whether the cutting will result in an induced groundwater gradient that will impact on groundwater levels at the monitoring location. If it is considered the monitoring location will be impacted by an induced gradient then the monitoring bore location should be re-established outside the zone of induced gradient.

5.1.2 Continuation of Monitoring of Moderate-Risk Cutting Sites

The monitoring of moderate-risk cutting sites (Chainages 32500, 33600 and 38800) for the pre-construction stage has been selected to test the EA outcomes in regard to classifying these sites as moderate-risk as opposed to high-risk. These moderate-risk sites were also selected for monitoring due to them having existing boreholes with standpipes established during the EA phase.

The pre-construction monitoring results for the moderate-risk cutting sites are to be assessed following completion of the pre-construction phase to determine if there is a significant risk to groundwater at these locations in association with construction / operation phases which would necessitate the need for ongoing monitoring. If this assessment determines there is a need for ongoing monitoring then the adequacy of the location of the existing boreholes / standpipes for construction / operation monitoring will also need to be assessed to determine if new boreholes are required.

5.1.3 Trigger Values

The pre-construction data will provide an indication of baseline conditions and the degree of variation for groundwater levels and each water quality parameter for existing conditions which can be used for comparison with construction and operational sampling results.

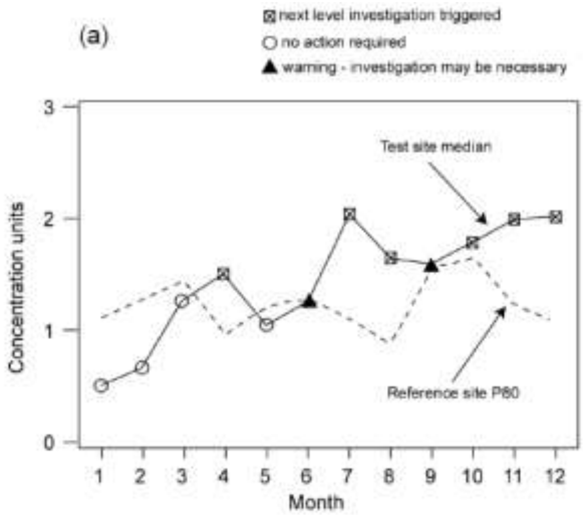
To assist the comparison of construction / operational sampling results with the pre-construction data, a comparison of median data versus 80th percentile data can be employed. This involves comparing the median values of the data hydraulically down-gradient with the 80th percentile of values of the data hydraulically up-gradient at each monitoring location. This comparison is aimed at ensuring the down-gradient median quality values for each parameter are lower than the up-gradient 80th percentile of values (or greater than the up-gradient 20th percentile for parameters such as dissolved oxygen where low values are the problem). Thus the 80th and 20th percentiles can be used as a trigger guide (ANZECC ARMCANZ, 2000b:6-17).

It is noted that the use of the down-gradient median value comparison with the up-gradient 80th / 20th percentiles will need to include consideration of the pre-construction variation (or ‘natural’ difference) in groundwater levels and water quality between the up-gradient and down-gradient sampling sites at each monitoring location as discussed in **Section 5.1.1**.

5.1.4 Comparison of Sampling Data and Trigger Values

The proposed technique for comparing sampling results and baseline data or trigger values is with the use of either tabulated results or control charts (or a combination of both).

An example of the use of control charts for the comparison of down-gradient median value with the up-gradient 80th / 20th percentiles is shown in Plate 5.1. Here, the monthly results for a test parameter for a monitoring location are graphed in a control chart whereby the test site results (at the down-gradient or 'impact' site) are compared to the trigger value using the 80th / 20th percentile from the adjusted reference site data (up-gradient monitoring location).



Source: Figure 6.7 in ANZECC ARMCANZ, 2000b:6-19

Plate 5.1 Example Control Chart

5.2 Data Interpretation

After the data analysis, the results are to be collated into a concise statistical summary and assessed in the context of the monitoring objectives below.

5.2.1 Pre-Construction Stage

Data interpretation for the pre-construction stage monitoring will address:

- establish the relative difference in groundwater levels between the up-gradient and down-gradient side at the monitoring sites (refer to **Section 5.1.1**);
- establish if there is any significant difference in groundwater quality between the up-gradient and down-gradient side at the monitoring sites (refer to **Section 5.1.1**);
- adjustment of control site data to accurately account for the difference in the pre-construction monitoring results between the upslope and downslope side at the selected cutting sites (refer to **Section 5.1.1**); and
- establishment of baseline groundwater levels and quality data for the project.

5.2.2 Construction Stage

Data interpretation for the construction stage monitoring will address:

- identification of impacts of the highway upgrade construction on groundwater levels and quality; and
- refinement of construction groundwater management measures.

5.2.3 Operational Stage

Data interpretation for the operational stage monitoring will address:

- identification of impacts of the highway upgrade operation on groundwater levels and quality; and
- adjustment of operational groundwater management measures and stabilisation works.

5.3 Reporting

5.3.1 Pre-Construction Stage

At the completion of the pre-construction stage monitoring a report is to be produced containing full and complete details of all aspects of the study. The report will include:

- introduction and background: description of the program and objectives and delineating the study boundary;
- experimental detail, describing the study location and study design, including detail of the sampling locations so they can be unambiguously identified, e.g. GPS directions and descriptions of methods of sampling and analysis;
- presentation, interpretation and discussion of the results including addressing the items outlined in **Section 5.2.1** and compliance with the Statement of Commitments;
- review and recommendations for the monitoring program for the construction and operational stages, including recommendations as to whether ongoing monitoring at the moderate-risk cutting sites is required; and
- appendices, providing laboratory reports, data tables or other relevant information.

5.3.2 Construction Stage

Reporting during the construction stage will include interim reports, annual reports and a final report at the completion of the construction stage.

Interim reports will be produced on a monthly basis to provide the results of the monitoring during the past month. This may comprise a simple but clear tabulation of the monitoring results to be tabled at the Environmental Review Group meetings. The report may include any relevant discussion of the results to inform the ongoing management of the groundwater management measures or this discussion may simply be verbalised and minuted at the Environmental Review Group meetings.

Annual reports will be of a similar format to that outlined in **Section 5.3.1**.

Similarly, the final report at the completion of the construction stage will be of a similar format to that outlined in **Section 5.3.1** but including recommendations for the operational monitoring program.

5.3.3 Operational Stage

Reporting during the operation stage will also include interim reports, annual reports and a final report at the completion of the first three years of operation.

Interim reports will be produced on a six-monthly basis to provide the results of the monitoring during the past six months and any relevant discussion of the results to inform the ongoing management of the permanent groundwater management strategies and stabilisations works.

Annual reports will be of a similar format to that outlined in **Section 5.3.1** for the pre-construction stage but excluding recommendations for the operational monitoring program.

Similarly, the final report at the completion of the first three years of operation will be of a similar format to that outlined in **Section 5.3.1** but including recommendations for a continued operational monitoring program if deemed appropriate.

6

Management Actions

The Groundwater Monitoring Program will form part of the Construction Environmental Management Plan (CEMP) and the Operational Environment Management System and as such will be reviewed annually as part of the CEMP review.

6.1 Management Actions

During the construction stage the monthly interim reports will be discussed at Environmental Review Group meetings to provide input to the potential refinement of groundwater management measures or other relevant measures/procedures in the CEMP.

Similarly, during the operational stage the interim and annual reports outlined in the previous section will be assessed to provide input to the potential refinement of groundwater management measures or other relevant measures/procedures in the Operational Environment Management System.

6.1.1 Potential Contingencies for Cuttings

If seepages in the batter face of road cuttings develop due to interception of a permeable layer of soil/rock, sub-horizon drains should be installed to relieve the water pressure in the batter. If seepages develop from interception of a perched water table, engineering mitigation measures need to be installed to transfer the seepage water into the groundwater ecosystem immediately downslope of the cut. These measures should involve collecting the seepage water from the cut face just above the level of the road and piping it under the cut/fill platform to the downslope side of the highway. The water could either be returned to the ground through absorption trenches, or held in water quality ponds to be tested and possibly treated before being discharged back into the surface water system (SKM, 2010c:69).

6.1.2 Potential Contingencies for Embankments

Groundwater barriers can form from construction of in-stream structures such as bridges, or embankments on soft soil which compresses and forms a less permeable layer of soil thereby impacting on groundwater flow. There will be a greater impact on areas with naturally high water tables and saturated soils such as freshwater wetlands and swamps. The provision of minimum design standard drainage structures adjacent to wetlands and saturated soils is expected to mitigate the potential impacts, however if there is a detectable change in groundwater levels from up-gradient to down-gradient levels as a result of the highway construction then engineering mitigation measures need to be installed to enable down-gradient groundwater transfer to re-establish down-gradient groundwater levels. These measures may involve installing ‘conduits’ of higher permeable materials beneath the highway embankment / through the compressed soils.

6.1.3 Potential Contingencies for Accidents and Spills

In terms of protecting water quality from accidents and spills during construction, storage of potentially harmful materials would be undertaken within impermeable, bunded facilities. Spill contingency equipment would also be stored in close proximity. During operation the concept design includes scope for inclusion of spill contingency measures, which capture accidental spillages to ensure that they are not released directly to the environment (SKM, 2010c:69).

6.1.4 Potential Contingencies for Leaching of Acid Sulfate Soils

Disturbance of acid sulfate soils (ASS) can occur during the construction process or through activities which lower the water table such as excavation and dewatering operations. Contingencies measures are to be based on the ASS Management Plan for the project.

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7

Consultation

7.1 Regulatory Agencies

The NSW Environment Protection Authority (EPA), Department of Primary Industries (DPI), and NSW Office of Water (NoW) have been consulted during preparation of this monitoring program (refer to **Appendix A**).

EPA, DPI, and NoW are to be consulted during the implementation of the Groundwater Monitoring Program. As a minimum, this consultation is to include forwarding of all reports (interim, annual and stage completion reports) outlined in **Section 5.3** to NSW EPA.

7.2 Landholders

Landholders relevant to the proposed monitoring sites are to be consulted as required throughout implementation of the Groundwater Monitoring Program in regard to establishment of monitoring sites and ensuring ongoing access to monitoring sites and related matters.

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Project Team

The project team members included:

Tim Ruge
Environmental Engineer

Duncan Thomson
Environmental Engineer

References

ANZECC ARMCANZ (1995). *Guidelines for groundwater protection in Australia*. Australian and New Zealand Environment and Conservation Council (ANZECC), Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

ANZECC ARMCANZ (2000a). *Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The Guidelines*. Australian and New Zealand Environment and Conservation Council (ANZECC), Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

ANZECC ARMCANZ (2000b). *Australian guidelines for water quality monitoring and reporting*. Australian and New Zealand Environment and Conservation Council (ANZECC), Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

AS/NZS 5667.1:1998. Australian / New Zealand Standard™. *Water Quality – Sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*.

AS/NZS 5667.12:1999. Australian / New Zealand Standard™. *Water Quality – Sampling. Part 12: Guidance on sampling of bottom sediments*.

DLWC (1998) *Stressed Rivers Assessment Report. NSW State Summary*. NSW Department of Land and Water Conservation. April 1998.

NSW EPA (2004). *Approved Methods for the Sampling and Interpretation of Results of Water Pollutants in NSW* (Department of Environment and Conservation, March 2004. [Online]. Available: http://www.environment.nsw.gov.au/water/wateranalysis_methods.htm [Accessed 14th March 2012].

NSW Fisheries 1999, *Policy and Guidelines: Aquatic Habitat Management and Fish Conservation*: (1999 update). Smith, A. and Pollard, D.A. (eds) NSW Fisheries, Port Stephens Research Centre.

RMS (2012). *Pacific Highway upgrade – Warrell Creek to Urunga. Brief – Preparation of Water Quality Monitoring Program.* March 2012. Contract No. 12.2544.0085

RTA (1999). *Code of Practice for Water Management. Road Development and Management.* [Online]. Available: http://www.rta.nsw.gov.au/environment/downloads/enviro_wcop_dl1.html [Accessed 14th March 2012].

RTA (2011). *Upgrading the Pacific Highway, Warrell Creek to Urunga. Project Approval Documents*. RTA/Pub.11.282. October, 2011.

RTA (undated). *Guideline for Construction Water Quality Monitoring.* [Online]. Available: http://www.rta.nsw.gov.au/environment/downloads/constrwaterqualmonit_dl1.html [Accessed 14th March 2012].

SKM (2010a). *Warrell Creek to Urunga, Upgrading the Pacific Highway. Environmental Assessment.* Volume 1 Environmental Assessment. January 2010.

SKM (2010b). *Warrell Creek to Urunga, Upgrading the Pacific Highway. Environmental Assessment.* Volume 2 – Working Paper No.1 – Flora and Fauna. January 2010.

SKM (2010c). *Warrell Creek to Urunga, Upgrading the Pacific Highway. Environmental Assessment.* Volume 2 – Working Paper No.5 – Water Quality Impact Assessment. January 2010.

Sundaram, B., Feitz, A., Caritat, P. de, Plazinska, A., Brodie, R., Coram, J. and Ransley, T. (2009). *Groundwater Sampling and Analysis – A Field Guide*. Geoscience Australia, Record 2009/27 95 pp.

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Appendix A

Agency Consultation

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NSW Environment Protection Authority (EPA)

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

Project:	Pacific Hwy Upgrade – Warrell Creek to Urunga		
Document title:	Surface and Ground Water Monitoring Plan		
Revision No.:			
Reviewer name:	S.Garwood	Review date:	July 2012
Responses by:		Response due:	

Thank you for the opportunity to comment on the Project's surface and ground water monitoring plan. Due to resourcing matters, the EPA has not reviewed the surface and ground water monitoring plan and therefore has provided comments specifically referenced to the document.

However in consideration of lessons learnt, best practices, industry standards and monitoring plans developed for previous Pacific Hwy Upgrade projects, the EPA highlights a number of key factors and key principles that should be addressed if not already done so.

Report Reference	EPA Comments	Consequent Response / Amendments to Monitoring Program
Consultation	EPA recommends the surface and ground water management plans also be prepared in consultation with key stakeholders such as Council, and relevant uses of the waterways, and aqua-culture industries.	Consultation has been undertaken with NoW, DPI and EPA. Councils have been consulted via review of the environmental management plans for the highway upgrade. Implementation of the monitoring programs will also include consultation with EPA, DPI, and NoW – as a minimum, this consultation is to include forwarding of all reports (interim, annual and stage completion reports)

Report Reference	EPA Comments	Consequent Response / Amendments to Monitoring Program
Guidelines / Standards	EPA recommends the plan be developed in accordance with the ANZECC Guidelines for Water Quality Monitoring and Reporting	The plans have been developed with consideration of ANZECC Guidelines for Water Quality Monitoring and Reporting
Objectives	Imperative the plan addresses surface and ground water objectives in consideration with state, catchment and local water quality objectives and management strategies. This may include addressing existing CMA / Council data, projects, programs. Objectives should be measurable	The primary objectives of the plans are: ▪ Surface Water: to evaluate the impact of the highway upgrade on water quality in the relevant waterways from Nambucca Heads to Urunga ▪ Groundwater: to evaluate the impact of the highway upgrade on groundwater levels and quality in the study area from Nambucca Heads to Urunga The objectives have been developed in consideration of the NSW State Groundwater Policy Framework and RMS Water Policy The objectives are considered measureable
Identifying waterways	The plan should identify and demonstrate the location of all waterways, drainage lines, creeks, wetlands, dams etc in which the project traverses and or falls adjacent to.	All major waterways / wetlands have been identified in the illustrations in the report as well as EEC's / GDE's
Identifying waterways	Each waterway should be characterised and its priorities ranked following a risk assessment. The risk assessment should address values as per ANZECC guidelines and address ecological values. This includes not just the values at the site but also downstream receiving environment. It is expected this would also identify sensitive areas; such swamp sclerophyll EECs, wetlands etc.	The waterways / wetlands characteristics and priorities have been based on information in the environmental assessment by SKM (2010) for the highway upgrade: *Warrell Creek to Urunga, Upgrading the Pacific Highway. Environmental Assessment*. Volume 1 Environmental Assessment. January 2010. (and supporting documents)

Report Reference	EPA Comments	Consequent Response / Amendments to Monitoring Program
Sources of risk - Construction	It is recommended risks associated with; ▪ increased volumes and concentration of tannin leachate; ▪ curing compounds; ▪ rock from working platforms etc; ▪ sludge from basin de-silting; ▪ sludge from under boring ; boring using bentonite; ▪ sedimentation of waterways – not just increased turbidity or sediment laden runoff; ▪ potential exposure/leachate of soil contamination; and ▪ concrete slurry – boring, bridge works. **Imperative the plan addresses primary and secondary impacts from increased sediment loads of sediments.** **It is also important to address how and to what level do these risks pose on local environmental values.**	The risks have been based on the environmental assessment for the highway upgrade by SKM (2010) as noted above. The risks assessed generally cover those listed in the adjoining "EPA comments" column however each specific risk listed is not individually addressed. It is considered that the general risks addressed and the consequent monitoring programs adequately cover the significant risks.
Sources of risk - Operation	It is recommended the plan addresses gross pollutants.	It is proposed that field observation recorded each monitoring period will include notes/photographs regarding gross pollutants such as litter.
Overview of the catchments	The plan should provide an overview of activities within each of the catchments and identify other likely contributing factors and variables.	The reports include an overview of the catchments and the general condition of the relevant waterways / wetlands
Baseline monitoring	It is recommended baseline studies are undertaken at each sensitive receiver and those waterways of medium to high ecological and community values.	The plans include 6 months of baseline monitoring prior to commencement of construction

Report Reference	EPA Comments	Consequent Response / Amendments to Monitoring Program
Baseline monitoring	This would also include surveys of existing sediment / soil profile and establish a series of monitoring stations to **monitor accumulative sediment deposition** into areas sensitive areas adjacent to and downstream of construction. This would include the assessment of ecosystem health, structure etc prior to construction.	Surveys of existing sediment/soil profile are not included in the baseline monitoring or is establishment of a series of monitoring stations to monitor accumulative sediment deposition. It is considered the effectiveness of the proposed water quality measures (eg sediment basins) will be more easily / effectively monitored by targeting TSS in the water column during both wet and dry conditions. In respect to assessment of ecosystem health, structure etc prior to construction, this is not covered by the water quality monitoring plans. It is assumed this is addressed by the ecological monitoring required under *Condition of Approval B10 - Ecological Monitoring*
	In summary, EPA would expect the monitoring plan adequately address the key principles below. 1. **Environmental values and human uses** determined by the community for their waterways 2. **Water Quality Objectives** these represent the community's environmental values for waterways expressed for each catchment in the state 3. **Protection levels** set for each waterway according to its condition: high conservation value; slightly to moderately disturbed; or highly disturbed 4. **Waterway issues and level of risk** What are the issues or problems which might threaten the achievement of local environmental values? What level of risk do these issues pose for local environmental values?	1. **Environmental values and human uses:** the characteristics and general condition of the relevant waterways / wetlands is included in the plan – based on information in the environmental assessment by SKM (2010) for the highway upgrade 2. **Water Quality Objectives:** objectives have been developed in consideration of the NSW State Groundwater Policy Framework and RMS Water Policy. General water quality objectives are to ensure that water quality and quantity impacts to the environment are minimised 3. **Protection levels**: specific protection levels have not been specified. Sampling data will be compared with the baseline data at monthly Environmental Review Group meetings during construction to assess appropriate response measures

Report Reference	EPA Comments	Consequent Response / Amendments to Monitoring Program
	5. **Indicators** Choose the right indicators for the issues or problems for local environmental values 6. **Trigger values** Trigger values for each indicator used to assess the risk to an environmental value	4. **Waterway issues and level of risk** water quality risks are identified in Section 2 of the plans 5. **Indicators** Indicators have been selected based on the identified risks / issues and in consideration of relevant water quality monitoring guidelines 6. **Trigger values** It is difficult to specify meaningful trigger values due to the significant variation in some water quality parameters between monitoring events in each of the waterways. The pre-construction data will provide an indication of baseline conditions and the degree of variation for each water quality parameter for existing conditions which can be used for comparison with construction and operational sampling results. Sampling data will be compared with the baseline data at monthly Environmental Review Group meetings during construction to assess appropriate response measures

Please note that whilst the Environment Protection Authority encourages the use of procedures, EPA maintains its independence in the process in order to effectively discharge our regulatory responsibilities. Therefore, we are prepared to provide comments to assist the proponent in refining the document; however we will not evaluate detailed provisions or endorse any aspect of the documents. In addition, the above comments in no way negate any statutory requirements of conditions of approval.

Department of Primary Industries (DPI)

Consultation

Email from Kristy Harvey (RMS) to James Sakker (DPI) sent Tuesday, 19 June 2012 2:00 PM

Subject: Nambucca Heads to Urunga Water Quality Monitoring Plans

Hi James,

Plans attached to fulfill B17 of attached Conditions of Approval for the NH2U stage 1 of the Warrell Creek to Urunga Project.

Please provide any comments and let me know if you have any questions.

Kind Regards,

Kristy Harvey
Environmental Officer Federal Prgm
Major Projects Northern | Northern Region
Roads and Maritime Services
76 Victoria Street Grafton NSW 2460

File(s) will be available for download until 26 June 2012:

File: Conditions of Approval.pdf, 1,948.41 KB [Fingerprint: 9aeceb79086e1425670140bce6945f0a]

File: 1997303 Surface Water Quality Monitoring Program - Nambucca Heads to Urunga chainage 19500-41300_Final Draft.pdf, 3,271.88 KB [Fingerprint: 7795416e7397087ddf8a1cb22f363191]

File: 1997335 Groundwater Quality Monitoring Program - Nambucca Heads to Urunga chainage 19500-41300_Final Draft.pdf, 7,426.06 KB [Fingerprint: 4394ddd7eb0bf500eb9f1c1a889a1c3a]

File: for client 1997303 Surface Water Quality Monitoring Program - Nambucca Heads to Urunga chainage 19500-41300_Final Draft.docx, 3,435.72 KB [Fingerprint: 15e5520bf599537aa8c3a1a726adae31]

File: for client 1997335 Groundwater Quality Monitoring Program - Nambucca Heads to Urunga chainage 19500-41300_Final Draft.docx, 517.20 KB [Fingerprint: 017c52305e4d15366ae06513a08b135f]

Comments from DPI

No comments received from DPI as of 20/07/2012

Consequent Response/Amendments to Monitoring Program

No amendments to document.

NSW Office of Water (NoW)

Comments from NoW

Groundwater Monitoring Program

1. Consideration should be given to the names of the document in lieu of its content being groundwater monitoring, analysis and interpretation, and management actions. Eg Groundwater Management Plan.
2. Table 2.1. Further information should be provided on the definition of "immediate vicinity" and "significant depth of excavation" for high risk cuttings, as well as "in the vicinity" and "moderate depth".
3. Table 2.1. Has depth to groundwater been used in this classification? A table providing depth to groundwater and cutting depth should be included.
4. Illustrations 2.1 to 2.4 should be provided for review.*[Illustrations in pdf version subsequently sent to NOW]*
5. P24, Section 3.3.1. Control sites should be located at a suitable distance upgradient of cuttings as to not be impacted by the induced gradient that will be formed by the cutting itself. It is also recommended that a project control site be selected well away from any impacts to be used for interpretation of seasonal water levels.
6. Illustrations 4.1 to 4.4 should be provided for review.*[Illustrations in pdf version subsequently sent to NOW]*
7. Table 4.2. The Office recommends that water levels be measured using automatic water level recorders set to take readings at a maximum of 1 hour intervals with a maximum 3 monthly period between downloads and calibration.
8. A section should be included containing suggested groundwater contingencies should unacceptable impacts being identified for both water level and quality.

Please note further comments relating to surface water will be forthcoming from The Office.

Consequent Response/Amendments to Monitoring Program

1. The document titles were not amended as the titles are considered to be consistent with the terminology used in Condition of Approval B17 and consistent with the purpose of the document.
2. Indicative depths of cuttings and indicative distances with respect to "vicinity" for the two categories have been included in Table 2.1
3. Table 2.2 has been included in the report providing depth to groundwater and cutting depth.
4. Illustrations 2.1 to 2.4 were subsequently provided for review.
5. Section 4.1 - Monitoring Site Locations was amended to include the following:
   A monitoring bore is proposed on each side of the highway cutting (the western side and eastern side) at the high risk cuttings and the embankment fill site listed below. The monitoring bores will be located near the project boundary to avoid impacting on construction works and to safeguard against an induced gradient from the cut impacting on groundwater levels at the monitoring location. Based on preliminary information it is estimated that there will not be an impact from induced gradients, however the suitability of the locations will need to be reassessed following review of the pre-construction phase monitoring results (refer to Section 5.1.1)
   Section 5.1.1 - Pre-Construction Monitoring Data was amended to include the following:
   The location of the monitoring bores at the cutting sites will also need to be reviewed in consideration of the depths to groundwater and proposed depth of cutting, to assess whether the cutting will result in an induced groundwater gradient that will impact on groundwater levels at the monitoring location. If it is considered the monitoring location will be impacted by an induced gradient then the monitoring bore location should be re-established outside the zone of induced gradient.
6. Illustrations 4.1 to 4.4 were subsequently provided for review.

7. Table 4.2 was amended to include the following for monitoring frequency of groundwater levels: Automatic water level recorders set to take readings at a maximum of 1 hour intervals with a maximum 3 monthly period between downloads and calibration
8. Section 6 – Management Actions was amended to include potential contingency measures for groundwater risks associated with cuttings, embankments, accidents and spills, and leaching of acid sulfate soils.