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OXLEY HIGHWAY TO KEMPSEY

WATER QUALITY MONITORING PROGRAM

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GLOSSARY

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid sulfate soil
ASR	Acid sulfate rock
CEMP	Construction Environmental Management Plan
CoAs	Minister's Conditions of Approval
DO	Dissolved oxygen
DP&I	Department of Planning and Infrastructure
DPI	Department of Primary Industries (Fishing and Aquaculture)
EC	Electrical Conductivity
EEC	Endangered Ecological Community
EPA	Environmental Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
GDE	Groundwater Dependent Ecosystem
mAHD	Metres Australian Height Datum
mBMP	Metres below measuring point
NATA	National Association of Testing Authorities
NOW	NSW Office of Water
NTU	Nephelometric Turbidity Units (a unit of measurement for the turbidity of water)
pH	A measure of acidity and alkalinity that uses a number scale from 0 to 14 where 7 is neutral, lower numbers indicate acidity and higher numbers indicate alkalinity
PMHC	Port Macquarie-Hastings Council
RMS	Roads and Maritime Services
SEPP	State Environmental Planning Policy
SoCs	Statement of Commitments
SWMP	Soil and Water Management Plan
TDS	Total Dissolved Solids
The Project	Oxley Highway to Kempsey Pacific Highway upgrade
The Project Boundary	The area in which the Project will be constructed as marked on Figure 5
The Project Area	The area within Project Boundary
The Project EA	Oxley Highway to Kempsey - Upgrading the Pacific Highway, Environmental Assessment (GHD 2010)
TPH	Total petroleum hydrocarbons
TSS	Total Suspended Solids
WQMP	Water Quality Monitoring Program

1 INTRODUCTION

The purpose of this document is to detail the Water Quality Monitoring Program (WQMP) for the Oxley Highway to Kempsey Pacific Highway upgrade (the Project) in accordance with the Minister's Conditions of Approval. The document outlines the water quality monitoring locations, parameters and frequencies for both surface and groundwater monitoring along the length of the Project.

The monitoring program covers three key phases (pre-construction, construction and operations) and will establish baseline water quality data that can be used to track changes in surface and groundwater quality and groundwater levels over the duration of the Project.

The objective of the monitoring program is to observe and assess the extent of potential impacts from the Project on the water quality in the surrounding environment, including creeks, rivers, wetlands and surface and groundwater dependent ecosystems.

The information collected as part of the monitoring program will be used to inform Project management responses aimed at managing any significant adverse impacts observed in the monitoring results. The document will guide water quality monitoring during each Project phase and will form part of the Construction Environmental Management Plan (CEMP) and be managed by Roads and Maritime Services (RMS) during the operational phase.

1.1 PROJECT BACKGROUND

The Oxley Highway to Kempsey section of the Pacific Highway is a key link in the overall framework of the transport corridor between Sydney and Brisbane. In the local areas, this section of the existing Pacific Highway connects the region's two largest urban settlements, Port Macquarie and Kempsey.

The Project is 37 kilometres in length, commencing approximately 700 metres north of the Oxley Highway interchange, tying in with the existing dual carriageways to the south and continuing northwards to tie in at Stumpy Creek with the dual carriageways of the approved Kempsey to Eungai Pacific Highway upgrade (see Figure 1). The Project involves the duplication of the existing highway, except for sections in the vicinity of the Hastings River and Wilson River which deviates from the existing highway, and a bypass of Telegraph Point. The existing highway will be retained wherever possible for use as a service road or local road connection.

As identified in the Project's environmental assessment (the Project EA), the main benefits of the Project include:

- Provision of a safer section of the Pacific Highway.
- Provision for growth and improved conditions for economic development in the immediate and surrounding areas.
- Improved transport efficiency including reduced freight costs and improved travel times.
- Improved water quality in areas adjoining the existing Pacific Highway through the use of permanent basins to capture highway runoff and spills from crashes.
- Provision of better connectivity and contiguity for settlements along the route (GHD 2010).

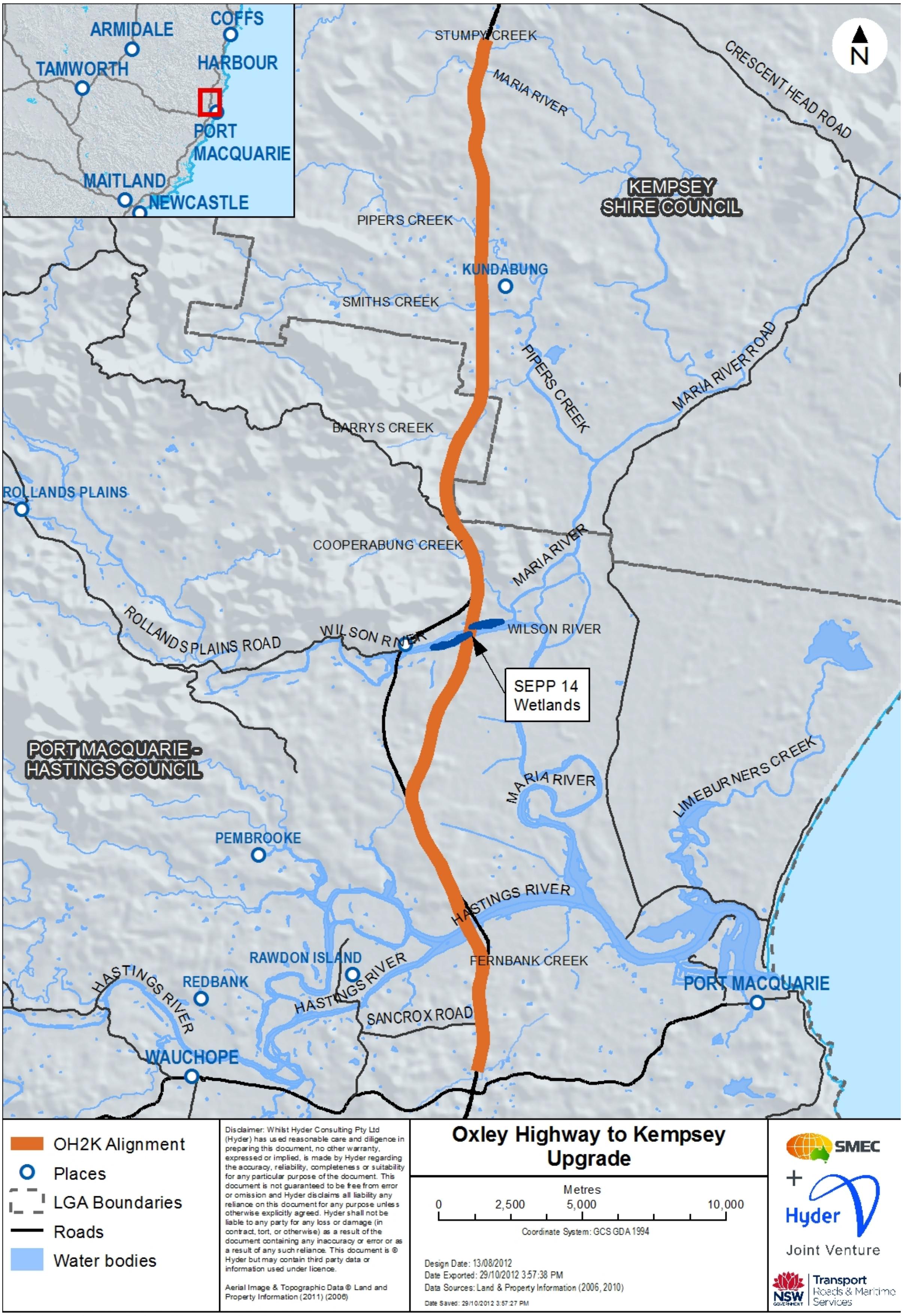


Figure 1 – Project location

1.2 REGULATORY CONTEXT

1.2.1 ENVIRONMENTAL ASSESSMENT

The Project was declared a Part 3A project under the *Environmental Planning and Assessment Act 1979* (EP&A Act) by the Minister for Planning in December 2006. In accordance with the EP&A Act, RMS completed an environmental assessment of the Project (the Project EA) in 2010. The Project EA identified a range of environmental, social and planning issues associated with the construction and operation of the Project and proposed measures to mitigate or manage those potential impacts.

The Project EA was publicly exhibited in September 2010 for a period of 30 days. Following public exhibition, submissions from stakeholders were received and addressed by RMS in the Submissions Report which was lodged with the Director-General in February 2011. As part of the Submissions Report, a revised Statement of Commitments was provided by RMS, the details of which are outlined in Section 1.2.3.

After consideration of the Project EA and Submissions Report, the Minister for Planning and Infrastructure approved the Project under part 75J of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 8 February 2012 subject to the Minister's Conditions of Approval (CoA) being met. The CoAs relevant to this WQMP are outlined in Section 1.2.2.

1.2.2 CONDITIONS OF APPROVAL

The Minister's Conditions of Approval relate to a broad range of environmental, social and economic factors. The conditions relevant to the WQMP are reproduced in Table 1.

Table 1 – Conditions of Approval

Outcome	Ref #	Key Action	Timing	Reference document	Addressed in section
Minimise water quality impacts.	**B17**	*"The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface and groundwater quality and resources and wetlands, during construction and operation. The Program shall be developed in consultation with the EPA, DPI (Fishing and Aquaculture) and NOW and shall include but not necessarily be limited to:* *a) identification of surface and groundwater quality monitoring locations (including watercourses, waterbodies and SEPP14 wetlands) which are representative of the potential extent of impacts from the project;* *b) the results of the groundwater modelling undertaken under condition B16;* *c) 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 of potentially affected waterways, including the risks to oyster farming in the Hastings River;* *d) development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Australian and New Zealand Environment Conservation Council, 2000);* *e) representative background monitoring of surface and groundwater quality parameters for a minimum of twelve months (considering seasonality) prior to the commencement of construction, to establish baseline water conditions, unless otherwise agreed by the Director General;*	Pre-construction, construction, operations	*Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction.* *Managing Urban Stormwater: Soils and Construction, Volume 1.* *The RTA's Code of Practice for Water Management – Road Development and Management.* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	a) Section 4.1 and section 4.2. b) Section 2.7.2. c) Section 2.4 to 2.7. d) Section 3.4, Section 4 and Section 5. e) Section 4.

Outcome	Ref #	Key Action	Timing	Reference document	Addressed in section
Minimise water quality impacts.	**B17**	*f) a minimum monitoring period of three years following the completion of construction or until the affected waterways and/ or 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);* *g) contingency and ameliorative measures in the event that adverse impacts to water quality are identified; and* *h) reporting of the monitoring results to the Department, EPA and NOW.* *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 the EPA, DPI (Fishing and Aquaculture) and NOW prior to its implementation".*	Pre-construction, construction, operations	*Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction.* *Managing Urban Stormwater: Soils and Construction, Volume 1.* *The RTA's Code of Practice for Water Management – Road Development and Management.* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	f) Section 4, Section 5.2, the SWMP and CEMP. g) Section 5 and Section 6. i) Section 5.2 and Section 8

Outcome	Ref #	Key Action	Timing	Reference document	Addressed in section
	B16	Prior to the commencement of construction, unless otherwise agreed by the Director General, the Proponent shall in consultation with the EPA and NOW, undertake groundwater modelling on the concept design for the project, subject to the modelling being revised should the detailed design have a significantly different impact on groundwater than the concept design. The modelling shall be undertaken by a suitably qualified and experienced groundwater expert and assess the construction and operational impacts of the proposal on the groundwater resources, groundwater quality, groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures in the groundwater management strategy required under condition B31[d](vii).	Pre-construction, construction, operations	*Guidelines for Groundwater Protection in Australia, ANZECC, 1995.* *Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction.* *Managing Urban Stormwater: Soils and Construction, Volume 1.* *The RTA's Code of Practice for Water Management – Road Development and Management.* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	Section 2.7.2.

1.2.3 STATEMENTS OF COMMITMENTS

The Statement of Commitments (SoCs) applicable to this WQMP are presented in Table 2. The SoCs represent the broad and overarching measures proposed by RMS to minimise potential impacts from the Project.

Table 2 - Statement of Commitments

Outcome	Ref #	Key Action	Timing	Reference document	Addressed in section
Minimise water quality impacts.	SGW3	Water quality will be monitored upstream and downstream of the Project site during construction to determine the effectiveness of mitigation strategies. The monitoring program will be developed in consultation with DECCW.	Pre-construction and construction.	*Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction.* *Managing Urban Stormwater: Soils and Construction, Volume 1.* *The RTA's Code of Practice for Water Management – Road Development and Management.* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	Section 3.5, Section 4 and Section 8.
Minimise water quality impacts.	SGW6	The potential for changes in the groundwater table will be further investigated before any major earthworks (defined as a cut or fill with a depth or height exceeding five metres) are undertaken. Where a potential for change is identified, the significance of the change and any resultant impacts will be determined. Where necessary, measures to manage the changes will be designed and implemented.	Pre-construction and construction.	*The RTA's Code of Practice for Water Management – Road Development and Management.* *RTA QA Specification G38 Soil and Water Management (Soil and Water Management Plan).*	Section 2.7 and Section 4.

1.2.4 LINKS TO OTHER MANAGEMENT PLANS

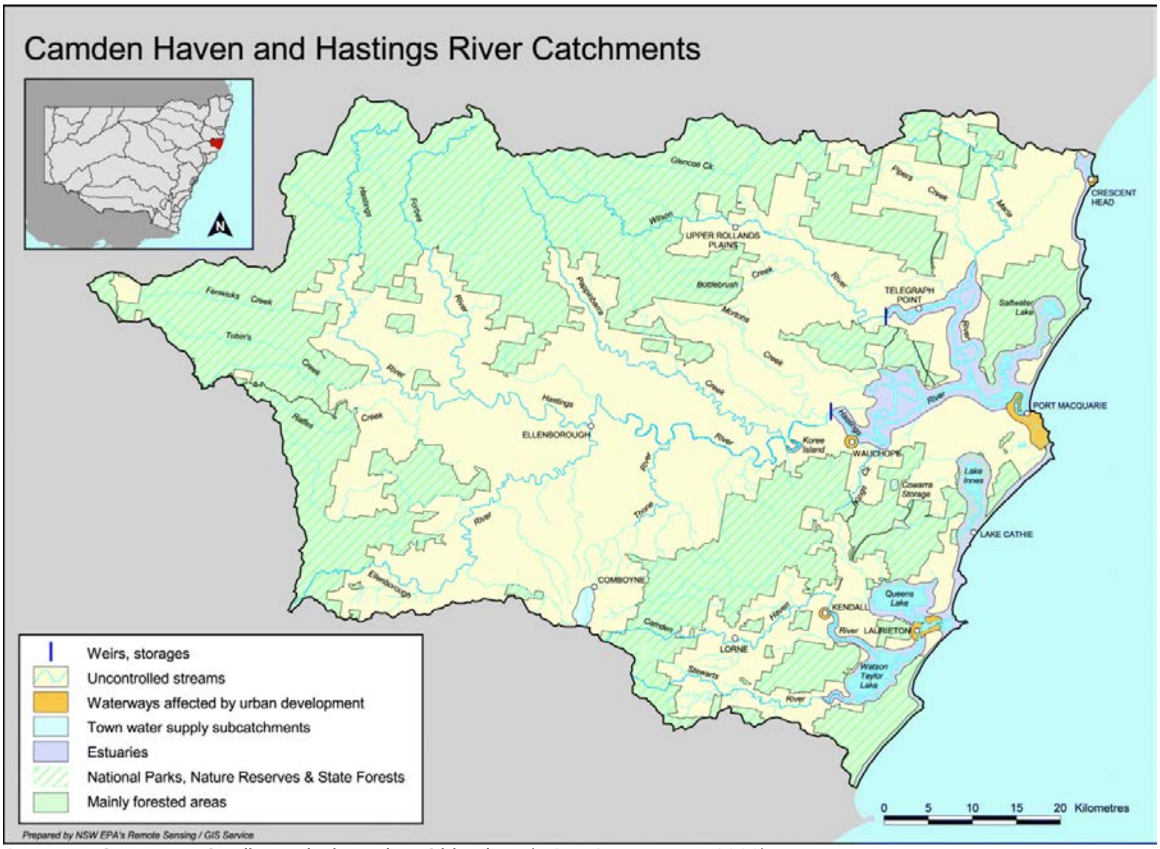
This WQMP is a key part of the environmental management system for the Project and has been designed to be implemented as part of the full suite of environmental management protocols. The program is linked to the Construction Environmental Management Plan (CEMP) and the Construction Soil and Water Quality Management Sub-Plan (including an Acid Sulfate Materials Management Strategy).

2 EXISTING ENVIRONMENT AND POTENTIAL IMPACTS

This section outlines the existing surface and groundwater environment and the potential impacts and risks from construction and operation of the Project. The purpose of this section is to provide context for the WQMP outlined in Section 4. The background information contained in this section is primarily based on the Project EA.

2.1 CATCHMENT OVERVIEW

The Project falls within the Hastings River catchment on the north coast of New South Wales (NSW) and incorporates the Maria and Wilson River sub-catchments. The catchment drains an area of approximately 3700 square kilometres (GHD 2012: 286) and falls within two council areas; Port Macquarie-Hastings Council (PMHC) to the south, and Kempsey Council to the north. The border between the two council areas is located near Mingaletta Road. All rivers flow in a generally eastward direction, with the Maria and Wilson Rivers flowing south to join with the Hastings River before it discharges into the Pacific Ocean at Port Macquarie (see Figure 2).



Source: *NSW Water Quality and River Flow Objectives* (NSW Government 2006).

Figure 2 – Catchment characteristics within the Hastings River Catchment

2.2 SURFACE WATER ENVIRONMENT

Three major rivers (the Hastings, Wilson and Maria Rivers) and a number of smaller creeks (including Fernbank, Cooperabung, Barrys, Smiths, Pipers and Stumpy Creek) will be intersected by the Project. The Project will also cross a SEPP 14 wetland located at the Wilson River. The location of these waterways is summarised in Table 3 and shown in Figure 1.

Table 3 - Rivers and creeks intersected by the Project

Station*	River, Creek or Wetland	Waterway type	Stream order
4640	Fernbank Creek	Lowland river / freshwater	2
5600	Hastings River	Estuarine	5+
16450	Wilson River	Estuarine	5+
16600	SEPP 14 Wetlands (# 484f on Dalhunty Island and #484e on northern bank of Wilson River)	Estuarine	NA – wetland area
19660	Cooperabung Creek	Lowland river / freshwater	3
23800	Barrys Creek	Lowland river/ freshwater	2
28300	Smiths Creek	Lowland river / freshwater	3
30680	Pipers Creek	Lowland river / freshwater	3
3688o	Maria River	Lowland river / freshwater	3
37750	Stumpy Creek	Lowland river / freshwater	2

* NB: where a river or wetland is of significant width, only the southernmost chainage is listed.

Under the *NSW Water Quality and River Flow Objectives* (NSW Government 2006), various parts of the catchment fall into distinct areas, as shown in Figure 2. The Project will traverse the Hasting and Wilson Rivers in their estuary reaches, with the remainder of the highway crossing lowland rivers that are either in mainly forested areas (e.g. the Maria River) or areas of uncontrolled streams. Historically, the Hastings and Wilson river floodplains were forested areas however agricultural activities resulted in clearing for grazing purposes. The floodplains are generally less than 3 metres above sea-level and water quality in these rivers continues to be influenced by ongoing grazing.

2.2.1 SURFACE WATER QUALITY

The water quality objectives for the Hastings River catchment are shown in Table 4 below. These values are taken from the *NSW Water Quality and River Flow Objectives* (NSW Government 2006) and are generally consistent with the ANZECC water quality guidelines.

Table 4 – Water quality objectives for the Hastings River catchment

Parameter	Estuaries	Lowland River
Phosphorus	30 µg/L	25 µg/L
Nitrogen	300 µg/L	350 µg/L
Turbidity	0.5 to 10 NTU (nephelometric turbidity units)	6 to 50 NTU
Salinity	Not applicable	125 to 2200 microsiemens per centimetre
Dissolved oxygen	80% to 110%	85 to 110%

Parameter	Estuaries	Lowland River
pH	7.0 to 8.5	6.5 to 8.5

Source: *NSW Water Quality and River Flow Objectives* (NSW Government 2006) cited in GHD 2010: 286.

Existing water quality data was reviewed during development of the Project EA and compared with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC Guidelines) (ANZECC/ARMCANZ 2000a) and the NSW Water Quality and River Flow Objectives for the Hastings River Catchment to determine existing river health. While a number of organisations and community groups had recorded water quality in the region (including the Former Department of Water and Energy, Manly Hydraulics Laboratory, Healthy Rivers Commission and local and anecdotal water quality records), the Project EA found that the most extensive water quality program was that which had been undertaken by the Port Macquarie-Hastings Council (in association with Kempsey Council).

The review of the data found that, bar some episodic variations, the water quality was largely consistent with the objectives for the Hastings River catchment. The Project EA noted that any exceedances of the water quality objectives were relatively minor and that the water quality within the catchment is, by and large, fairly good.

Given that the Hastings River hosts a number of oyster aquaculture leases (located approximately 1 kilometre upstream and approximately 2.5 kilometres downstream of the Project), the water quality guidelines established by the *NSW Oyster Industry Sustainable Aquaculture Strategy* (the Aquaculture Strategy) are also relevant to this Project (GHD 2010). A number of the acceptable values for water quality parameters under this strategy are the same as, or more flexible than, those identified in the Table 4 above. Therefore, only the more stringent or additional considerations are included in the table below.

Table 5 – Water quality objectives for oyster aquaculture

Parameter	Guideline
Faecal coliforms	43 MPN (most probable number) or 21 MF (membrane filtration) per 100 millilitres for 90th percentile
Aluminium	Less than 10 µg/L
Iron	Less than 10 µg/L

Source: Department of Primary Industries 2008 cited in GHD 2010: 286.

The review of available water quality data for the Hastings River collated as part of the Project EA found that faecal coliforms were above the acceptable levels identified in the Aquaculture Strategy (GHD 2010).

More detailed information about the existing surface water quality can be found in Section 2.8.

2.3 GROUNDWATER ENVIRONMENT

The Project EA established the existing groundwater environment through reference to a range of information sources including the Port Macquarie-Hastings and Kempsey Council State of the Environment Reports, NSW Office of Water borehole records and a number of geotechnical and water quality reports prepared as part of the Project EA.

Since completion of the Project EA, further assessment has been undertaken into the hydrogeological environment along the Project route; the results of this work (where applicable) have been reported in the *Groundwater Review* (SHJV 2012). The information provided below is based on both the Project EA and the Groundwater Review.

There are two main aquifer types in the Project area; alluvial aquifers which can be both (unconfined and confined) and fractured rock aquifers. The alluvial aquifers are found under the floodplains of the Hastings and Wilson rivers and adjacent to other waterways such as Cooperabung Creek, Smiths Creek, Pipers Creek and the Maria River. The fractured rock aquifers are located under the entire Project route and most likely to be intersected in the Cooperabung Hill and Maria River State Forest areas (see Figure 3) (SHJV 2012).

Groundwater within the fractured rock aquifers generally flows from areas of high elevation, the recharge zones, to areas of low elevation, the discharge zones. Within the Project area, Cooperabung Hill, Cairncross State Forest and the Maria River State Forest are likely areas of recharge for the bedrock aquifers with discharge trending towards the Hastings and Wilson Rivers (SHJV 2012).

Movement of groundwater through the alluvial aquifers is from recharge zone down gradient towards a stream or river for discharge. Recharge to the alluvial aquifers occurs through the land surface area from rainfall and laterally from bedrock aquifers (SHJV 2012) additional recharge (and discharge) may occur through tidal influences. In the Project Area, the Project road alignment and the groundwater flow generally run parallel with each other towards the rivers.

The Hastings and Wilson River floodplains have been identified as having acid sulfate soil (ASS) or acidic soil in the upper 1 metre of soil and there is a high risk of occurrence of ASS at depths greater than 1 metre (GHD 2010). Soft soils have also been identified in the Hastings and Wilson River floodplains. These soil characteristics are relevant in the context of groundwater monitoring as they may influence any potential groundwater impacts during construction and operation of the Project. Potential groundwater impacts are described in Section 2.5.

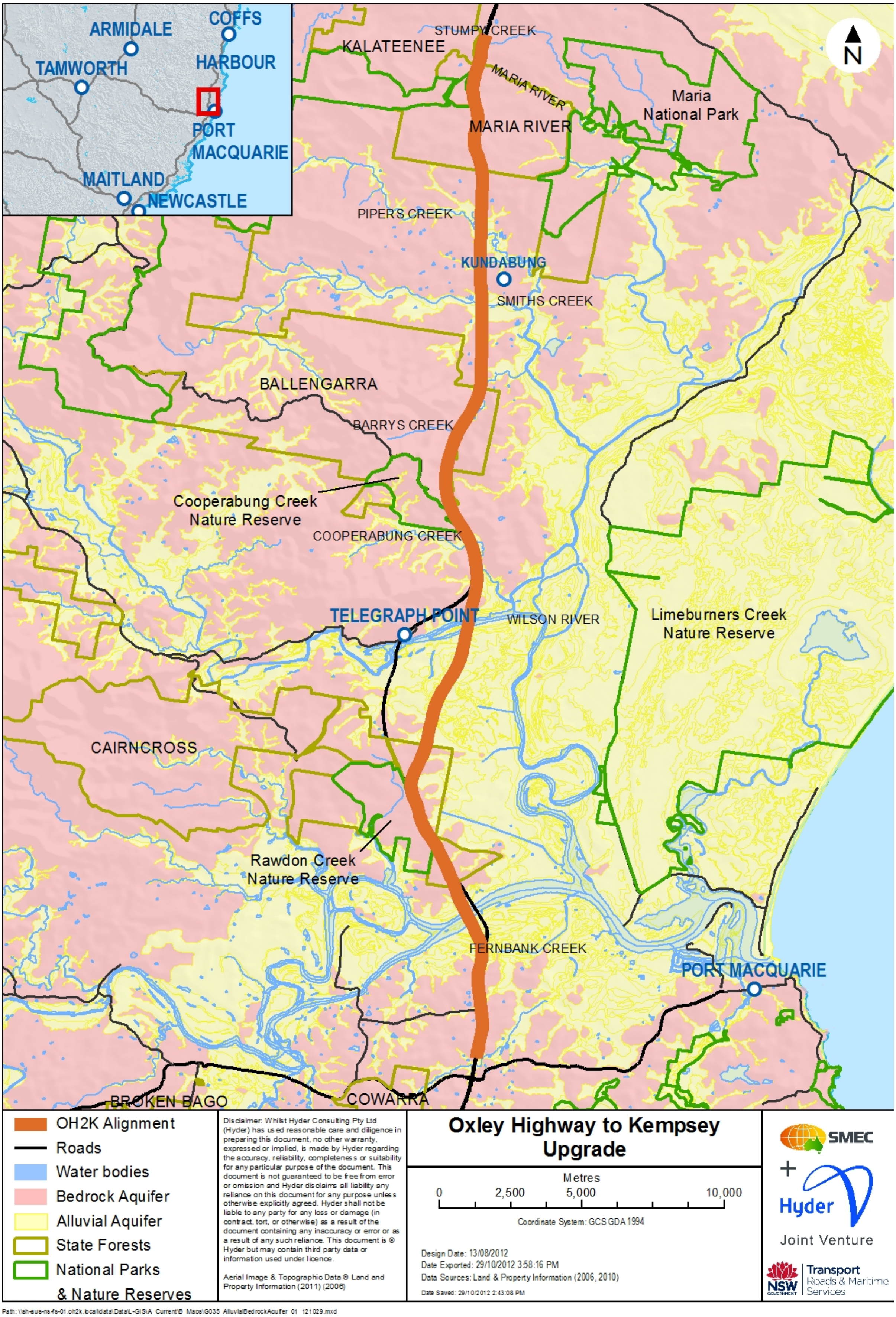


Figure 3 – Groundwater aquifers in the Project Area

2.3.1 GROUNDWATER QUALITY

The Project EA noted that limited data was available on the groundwater quality within the Project area however provided the following information (GHD 2010: 302):

Salinity:

- Salinity concentrations ranged from 547 microsiemens per centimetre to 4688 microsiemens per centimetre within the Cooperabung Hill and Maria River State Forest fracture rock aquifers.
- Within the alluvial aquifers, reported salinity concentrations ranged between 781and 5938 microsiemens per centimetre however groundwater in the alluvium was noted as being highly variable.
- Local geological conditions influence the groundwater quality and were considered responsible for observed spatial variations in quality across the catchment. For example, some bores 300 metres away from the Hastings and Wilson Rivers supplied somewhat fresh water however bores at greater distances from these rivers supplied brackish water. The groundwater in the estuarine reach of the Hastings River (approximately 2 kilometres upstream of the existing highway crossing) has been found to be primarily saline.
- No spatial trend in groundwater quality is evident based on the available information (GHD 2010).

pH:

- The Maria River floodplain and sections of the Hastings and Wilson Rivers floodplains have low pH values. This is likely due to impacts from the draining of acid sulfate soils on agricultural land and/or related to fertilizer application.
- Fernbank Creek, Partridge Creek and low lying land near Rawdon Island have previously discharged acidic water (Tulau 1999 cited in GHD 2010: 302).

2.3.2 GROUNDWATER LEVELS

The Project EA identified the alluvial aquifers of the Hastings and Wilson Rivers as having groundwater levels usually less than 1.5 metres below ground level, whereas other smaller alluvial aquifers have groundwater levels up to 5 or 6 metres below ground because of the steeper banks of these waterways (GHD 2010).

The groundwater level in the fractured rock aquifers is generally a subdued version of topography. The depth to water is generally deeper in recharge areas, hills and elevated ground, and shallower in discharge areas (i.e. at lower elevations) along drainage lines. Within the fractured rock, water levels measured (SHJV 2012) range between from just below the surface to 30 metres below ground level.

Groundwater levels in the fractured rock have variable response to rainfall depending on the location and depth to water. Where the water table is shallow and or in a recharge area the response may be pronounced. Where the water table is deep the response to rainfall is generally limited, delayed or may just be a general trend representing wetter or dryer periods with rising or falling levels respectively.

2.3.3 GROUNDWATER DEPENDENT SURFACE FLOWS

Where rivers or creeks receive most of their water from groundwater discharges they are described as having groundwater dependent surface flows. In the Project area, groundwater discharge to waterways accounts for only a minor portion of flow, with rainfall and overland flows being the primary contributor to surface flows. Potential impacts on any groundwater dependent surface flows would primarily result from cuttings in the bedrock aquifers in the Cooperabung Hill and Maria River State Forest areas, however, this impact is expected to be very minor (GHD 2010). Potential impacts on groundwater dependent surface flows are discussed in Section 2.5.

2.3.4 GROUNDWATER DEPENDENT ECOSYSTEMS

The species composition and ecological processes of some ecosystems are determined by groundwater; these systems are described as groundwater dependent ecosystems (GDEs) and they can differ considerably in their degree of groundwater dependence (Department of Land and Water Conservation 2002 cited in GHD 2010).

The Project EA identified the following four vegetation communities as having a high likelihood of being groundwater dependent (GHD 2010):

- Paperbark swamp forest.
- Swamp mahogany/ forest red gum swamp forest.
- Freshwater wetlands.
- Swamp oak forest.

In the Project area, these communities directly correlate with the following endangered ecological communities shown in Figure 5 in Section 4:

- Swamp Sclerophyll Forest on Coastal Floodplain.
- Swamp Oak Floodplain Forest.
- Freshwater Wetlands on Coastal Floodplains.

The remaining vegetation communities identified in the study area were described as having a “limited” or “very unlikely” probability of groundwater dependence (GHD 2010). Potential impacts on GDEs with a high likelihood of groundwater dependence are discussed in Section 2.5.

2.4 POTENTIAL SURFACE WATER IMPACTS

The potential surface water impacts identified in the Project EA are summarised in the following sections.

2.4.1 CONSTRUCTION PHASE

Potential water quality impacts from the Project are most likely to occur during the construction phase. The most significant construction risk is an increased potential for soil erosion, leading to sedimentation of sensitive environments including rivers, creeks and wetland areas.

Water quality risks posed by the Project can be both short-term and long-term. Potential short-term impacts include:

- Soil erosion.
- Sedimentation of receiving waters.
- Exposure of acid sulfate materials causing acidic runoff or leachate.
- Dewatering from excavations and/or release of groundwater from soft soil treatments.
- Temporary works within waterways.
- Potential exposure of unidentified contaminated material.
- Altered drainage patterns.

- Removal of riparian vegetation causing bank instability/erosion.
- Accidental chemical or fuel spills that can runoff into adjacent watercourses.
- General construction site waste (e.g. litter) entering watercourses (GHD 2010).

2.4.2 OPERATIONAL PHASE

A summary of the potential impacts on surface water quality during the operational phase of the Project is provided below:

- Increased presence of heavy metals and oils on the road surface as a result of increased vehicle movements. This would increase the potential for heavy metals and oils to enter adjacent waterways and degrade in-stream water quality.
- Soil erosion downstream of culverts if flow velocities are not appropriately controlled.
- Erosion and sedimentation caused by altering the direction and nature of surface runoff.
- Overland runoff of exhaust emissions and contaminants from tyre wear and petrol drips.
- Chemical and fuel spills from vehicle incidents on the highway entering receiving watercourses.
- Changes to river/creek geomorphology due to bed and bank erosion from bridge and culvert construction may cause ongoing sedimentation.
- Continued pollution from soil erosion and runoff as sediment moves downstream.
- Continued pollution from exposed acid sulfate soils (GHD 2010).

The abovementioned construction and operational phase activities may affect surface water quality in surrounding waterways and have the potential to impact on oyster farms in the Hastings River. Management of potential surface water impacts is discussed in Section 2.6.

2.5 POTENTIAL GROUNDWATER IMPACTS

2.5.1 CONSTRUCTION PHASE

Potential groundwater impacts that could occur during the construction phase include:

Cuttings:

- Drawdown of the water table resulting in changes to the flow pattern. This may induce flow towards the cut or intercept groundwater which may otherwise support Groundwater Dependent Ecosystems, beneficial users or base flows to creeks and rivers.
- Exposure of potential acid sulfate rock. This may result in generation of acidic discharges to cuts which may either flow to the surface environment or contaminate the groundwater through reinfiltration.
- Potential for contamination due to shortening of the separation between the land surface and the water table. By cutting down to or into the water table potential contaminants (fuel, oils etc.) may have a shortened path with less chance of attenuation.

Embankments:

- Changes to the groundwater flow path and gradient. Consolidation of sediments under embankments may alter the hydraulic properties resulting in reduced flow (decreased permeability).
- Pressure dissolution (increase in pressure leading to dissolution) of ASS components leading to acid generation. Consolidation of sediments containing ASS may lead to

pressure dissolution of pyrite (the main acid generation mineral) with subsequent mobilisation due to migration of water out of the area of settlement.
- Water logging up gradient or water level drawdown on the down gradient side of embankments. This may lead to salinisation of water logged soils or oxidation of acid sulfate soils.

In regards to the potential for drawdown of groundwater that could impact existing users, the State of Environment Reports from the two councils identified 1,690 licensed groundwater bores in their combined local government areas which (in the Project area) are mainly located around Kundabung and the Hastings and Wilson Rivers (GHD 2010). The sixteen bores identified in the Project EA as being located within 250 metres of the Project are considered the most susceptible to groundwater impacts.

As predicted in the Project EA, there have been some minor design refinements which have resulted in some of the major cuttings being made deeper to cater for the Project's earthworks requirements. In some locations this has altered the likelihood of intersecting groundwater. The Groundwater Review (SHJV 2012) considered the impacts of the design refinements and re-categorised the cuttings based on detailed design. It should be noted that the number of cuts has increased from 21 (identified in the Project EA) to 25 due to the design refinements. Table 6 presents the revised list of cuttings and their likelihood of intersecting groundwater.

The cut categories assigned within Table 6 are as follows:

- Category A – likely to intercept groundwater.
- Category B – minimal potential to intercept groundwater.
- Category C – unlikely to intercept groundwater.

Table 6 – Location of Cuts and Assessed Groundwater Risk Category

Cut No	Chainage	Max Cut Depth (m)	Cut Category
1	1330 to 1495	3	B
2	1735 to 1945	4.1	B*
3	2825 to 3385	7	A*
4	3160 to 3385	4.9	B
5	6470 to 7235	6	C*
6	7360 to 8080	4	A*
7	8290 to 9040	4.3	A*
8	9200 to 9585	1.1	B*
9	9820 to 10120	3.8	C*
10	10120 to 10500	7.6	A*
11	11290 to 11620	5.8	B*
12	11770 to 12005	0.8	C
13	17370 to 17575	4.5	B*
14	17800 to 18185	9.3	A
15	18300 to 18560	3.6	A*
16	20595 to 21225	31.3	A
17	21355 to 21470	4.0	B*
18	21600 to 21745	6.2	B*
19	21800 to 22110	9.2	B*
20	22415 to 22885	13.1	A
21	33515 to 33990	9.4	A
22	34120 to 34560	7	B*

Cut No	Chainage	Max Cut Depth (m)	Cut Category
23	34880 to 35395	12	A
24	35760 to 36120	6.9	A
25	37000 to 37295	4.8	A

* Indicated groundwater information is potentially insufficient and the Cut Category is subject to change. Source: SHJV 2012: 12.

2.5.2 OPERATIONAL PHASE

Potential operational impacts detailed in the Project EA are summarised below. The majority of these impacts are relevant to the alluvial aquifers, as impacts on the bedrock aquifers expected to be minor and localised.

Potential operational impacts on aquifers include:

- Altered aquifer characteristics (e.g. a decrease in permeability and storage capacity).
- Altered hydraulic conductivity from soil consolidation caused by the embankments on the river floodplains. Consolidation could potentially cause a build-up of water on the upgradient side of the embankment and a drop in water levels on the downgradient side which could lead to salinisation and oxidation of acid sulfate soils respectively.
- Ongoing impacts from oxidation of acid sulfate soils.
- Changes in groundwater flow patterns and levels.

2.6 MANAGEMENT OF POTENTIAL SURFACE WATER IMPACTS

The impact mitigation strategies outlined in the Project EA are summarised in the following Sections and have been incorporated into a range of project management plans and sub-plans as outlined in Section 1.2.4.

2.6.1 CONSTRUCTION PHASE

Management of potential surface water quality impacts during the construction phase will include:

Erosion controls:

- Embankment stabilisation and installation of drains above cut batters as soon as practical following construction to minimise erosion across batter slopes.
- Re-direction of overland surface water flows from uphill of the construction site to minimise the volume of clean water crossing the construction zone and increasing erosion and sedimentation.
- Stockpiling of vegetation during clearing so that it mulched and used to minimise erosion.
- Use of temporary erosion controls during clearing and earthworks to reduce the release of sediment to the surrounding environment.

Water capture and treatment:

- Temporary sediment basins to be designed and installed in line with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom 2004) *and Managing Urban Stormwater: Soils and Construction, Volume 2D, Main Road Construction* (DECC 2008b) (these documents are commonly referred to as the Blue Book).
- Water from the temporary sediment basins will be treated where required before release to meet the licensed water quality criteria for these basins. The size, shape

and location of the permanent basins is outlined in the Soil and Water Management Sub-Plan.

Industry best practice management practices including:

- Refuelling of plant and machinery within bunded areas (or offsite where possible).
- Conducting geotechnical assessments during the initial works on the floodplains to quantify the risk of disturbing acid sulfate soils with a particular focus on any excavations. If disturbance of ASS is unavoidable, construction techniques should comply with the Acid Sulfate Soils Management Strategy.

2.6.2 OPERATIONAL PHASE

The general strategy for the treatment of road runoff during the operational phase of the Project is summarised below:

- Permanent sediment basins will be located in key sensitive areas to capture and treat runoff from the highway. The sediment basins which will be designed in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom 2004) and *Managing Urban Stormwater: Soils and Construction, Volume2D, Main Road Construction* (DECC 2008b) and will include capacity *to contain a major accidental spill from a traffic* accident.
- Operational water quality basins will also be provided at key environmentally sensitive locations. This includes capturing pavement runoff prior to direct discharge into any Class 1 and Class 2 waterways as defined in the *NSW Fisheries Policy and Guidelines for Bridges, Roads, Causeway Culverts and Similar Structures, 1999*. Basins shall be sized to contain a 40, 000 litre spill. The size, shape and location of the permanent basins will be agreed with RMS and outlined in the Soil and Water Management Sub-Plan.
- At cuttings and some fill embankments, kerbs and benching will be used to reduce surface flow and/or erosion on the batter faces.
- In areas of lower environmental sensitivity, open drains will direct water to adjacent waterways. The drains will be grass lined to improve water quality prior to discharge to local watercourses.

2.7 MANAGEMENT OF POTENTIAL GROUNDWATER IMPACTS

Management of potential groundwater quality impacts during the construction phase will include:

- Reducing the ASS exposure (e.g. minimise the rate of de-watering in areas of potential ASS) and ensuring appropriate design of water storage and temporary drainage systems.
- If disturbance of ASS is unavoidable, construction techniques should comply with the Acid Sulfate Materials Management Strategy which provides procedures to investigate, handle, treat and manage these materials including any runoff.
- Avoid or minimise reduction in groundwater availability (e.g. minimise de-watering excavations in alluvial aquifers).
- Avoid or minimise impediments to groundwater flow or altering flow patterns.
- Ensure design of temporary drainage systems is appropriate for de-watering.
- Minimise the depth and size of excavations where practical by staging earthworks.
- Diverting runoff away from excavations.
- Prevent groundwater contamination through recharge of the groundwater from contaminated surface flows (e.g. by capturing/treating overland flows).
  - Minimising the use of alluvial aquifer water for construction.
  - Carrying out vehicle refuelling and store chemicals within bunded areas.

- o Appropriately store, treat and dispose of extracted groundwater.
- o Minimising excess groundwater and discharge in accordance with EPA requirements.

2.7.1 REFINING GROUNDWATER INFORMATION

The Project EA identified 16 private boreholes within 250 metres of the new highway that could potentially be impacted by construction and operation of the Project (GHD 2010) and the Groundwater Review (SHJV 2012) identified up to 51 groundwater piezometers along the alignment corridor. It is also possible that there are numerous unregistered private bores in the region. Boreholes in the vicinity of the Project will be ground-truthed prior to construction to confirm the number and location of existing bores. Landholders with licensed bores and bores predating licensing requirements will be given the chance to have their bores surveyed to establish baseline data against which project impacts can be assessed.

2.7.2 GROUNDWATER MODELLING

Groundwater Modelling Requirements
As detailed in Section 1.2.2, Condition of Approval B16 requires that groundwater modelling be undertaken on the concept design to assess the construction and operational impacts of the Project on the groundwater resources, groundwater quality, groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures for inclusion in this WQMP. This WQMP was originally prepared prior to the groundwater modelling being undertaken. The section below summarises the results of the groundwater modelling undertaken in mid-2013 (SHJV 2013).

Groundwater Modelling Results
The Modelling Report provided updated information related to groundwater interception and drawdown impacts associated with cuttings along the proposed highway alignment. The key findings of the report, considered relevant to this WQMP, are noted below.

- Eleven cuts were modelled as part of the assessment. The modelling identified that seven of these cuts are “likely” to intercept the water table and four “may” intercept the water table. Drawdown of the water table surrounding cuts will generally be limited to a few metres due to the limited water table intersection, with the exception of Cuts 5/6, 8 and 9 (where around 10 metres and six metres respectively of drawdown may be experienced immediately adjacent to the cut).
- Cuts are located at the top of hills or through elevated areas which naturally form recharge areas. As the water table in these locations is elevated with respect to the surrounding land, impacts are generally localised.
- Impacts to existing private bore users are expected to be minimal with only two bores potentially experiencing 1.8m to 2.1m drawdown requiring some form of mitigation, and a further four bores possibly experience between 1m and 1.6m drawdown. However all bores appear to have sufficient depth to allow lowering of the pump intake should mitigation be required.
- The report identified two broad areas where drawdown impacts may occur in the vicinity of potential GDEs. Impacts to GDEs are expected to be low to negligible as there are no known and few potential GDEs within the area of potential drawdown of cuts. In addition, the percentage of reduction in groundwater baseflow is estimated to be very low.
- The report also identified one spring fed dam on private property which may be impacted and recommended monitoring the dam.

An assessment has been undertaken to consider whether these findings necessitate changes to the groundwater monitoring locations proposed in this WQMP; see Section 4.2 for further information.

2.8 PREVIOUS SURFACE WATER MONITORING

As described in Section 2.2.1, the Project EA investigated the previous surface water monitoring that had been undertaken in the Hastings River Catchment by the Port Macquarie-Hastings Council (in association with Kempsey Council). The detailed findings of this investigation are described below in Sections 2.8.1 and 2.8.2. Also included below are the results from water quality monitoring undertaken by the Kempsey Bypass Alliance at Stumpy Creek as part of the construction water quality monitoring program for the Kempsey Bypass stage of the Kempsey to Eungai Pacific Highway Upgrade project.

More recent surface water quality monitoring has been undertaken by the Port Macquarie-Hastings Council for their State of the Environment Report (Thor Aaso, pers. comms 2012). The results of this monitoring were not available at the time of writing however are likely to become available in late 2010 (i.e. during the pre-construction monitoring period). These results should be accessed and reviewed for relevance to the Project as they are likely to form a useful reference for confirming baseline water quality throughout the catchment.

2.8.1 PREVIOUS SAMPLING LOCATIONS AND DATES

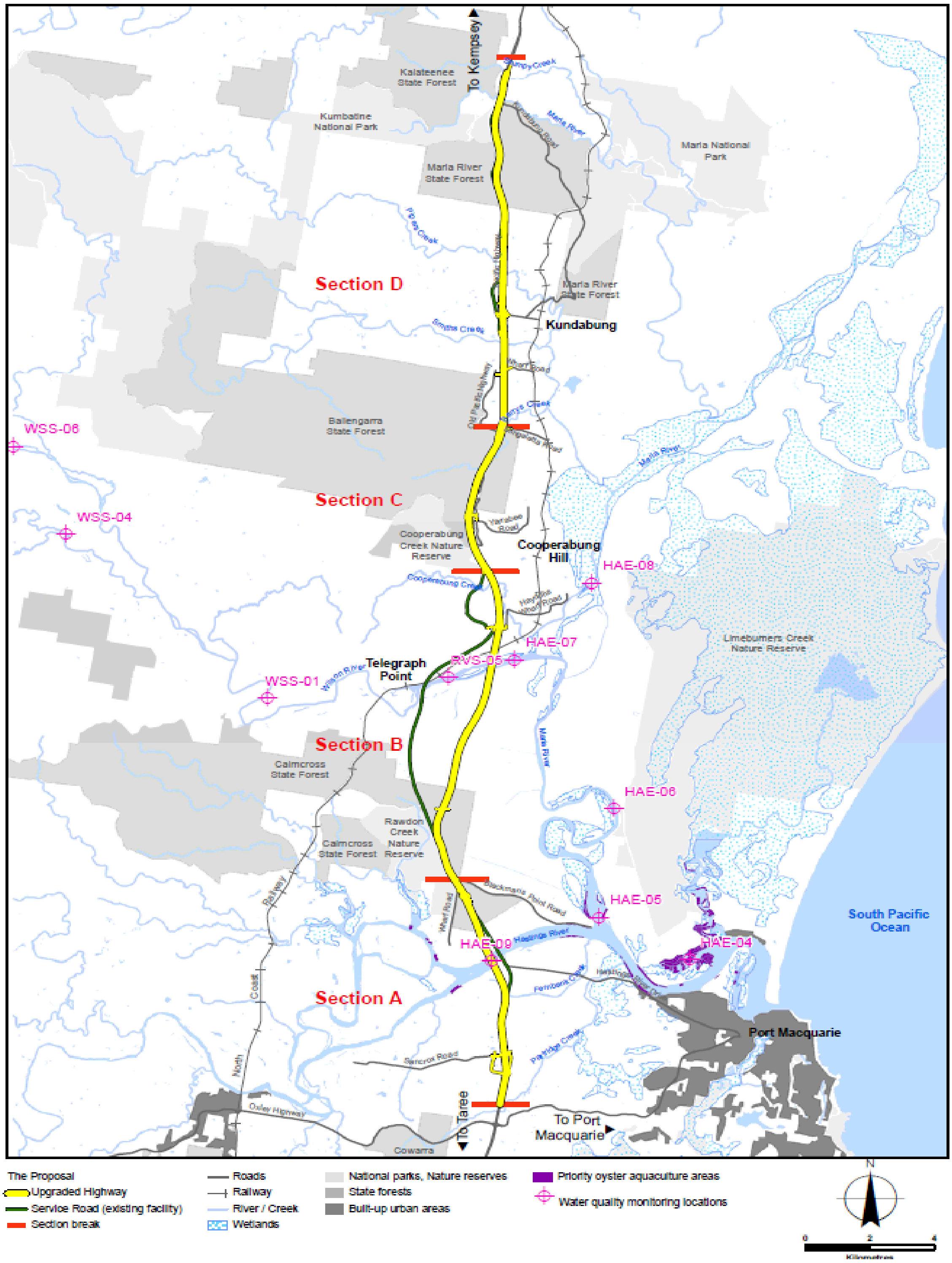
The Project EA reviewed the Port Macquarie-Hastings Council data obtained for the Hastings, Wilson and Maria Rivers from 2004, 2006, October 2007 to December 2007, January 2008 to June 2008 and March 2009 (GHD 2010). The locations that are relevant to the Project are described in Table 7 and marked on Figure 4.

Water quality monitoring by the Kempsey Bypass Alliance at Stumpy Creek began in September 2011 and has continued through to July 2012. The location of Stumpy Creek is shown on Figure 4 at the northern end of the Project and results presented in Table 9.

Table 7 - Port Macquarie-Hasting Council water quality monitoring locations relevant to the Project

Water course	Monitoring point	Location description
Hastings River	HAE-09	Approximately 300 m upstream of the Dennis Bridge.
	HAE-04	Big Bay, approximately 9.5 km downstream of the Proposal.
Wilson River	WSS-01	Telegraph Point, approximately 7 km upstream of the Proposal.
	WSS-04	Bril Bril Creek and the Wilson River, approximately 16 km upstream of the Proposal.
	WSS-06	Upper Wilson River, approximately 19 km upstream of the Proposal.
	RVS-05	Wilson River, west of Dalhunty Island, approximately 1.5 km upstream of the Proposal.
	HAE-07	Wilson River, approximately 750 m downstream of the Proposal.
Maria River	HAE-05	Confluence of Maria River and Hastings River, approximately 4 km east of the Hastings River crossing.
	HAE-06	Adjacent to the “Hatch”, approximately 10 km downstream of the Wilson River crossing.
	HAE-08	Local government boundary, approximately 3 km upstream of the confluence with the Wilson River.

Source: GHD 2010: 284



Source: GHD 2010: 285.

Figure 4 – Port Macquarie-Hasting Council water quality monitoring locations relevant to the Project

2.8.2 PREVIOUS MONITORING RESULTS

Analysis of water quality monitoring results from the Port Macquarie-Hastings Council

The Port Macquarie-Hastings Council water quality data was collected at regular periods across the catchment and the weather conditions, timing of monitoring and activities being undertaken in the catchment would have directly influenced the values obtained in the monitoring (GHD 2010).

The monitoring results are described in Table 8 in relation to the NSW Water Quality and River Flow Objectives (NSW WQOs) and the associated default trigger values from the ANZECC Water Quality Guidelines (ANZECC Guidelines) for slightly disturbed aquatic ecosystems in south-east Australia (ANZECC/ARMCANZ 2000b). The acceptable values from the NSW WQOs and the ANZECC Guidelines are collectively referred to within Table 8 as ‘the Guidelines’.

Table 8 – Previous surface water quality monitoring results for the Hastings, Wilson and Maria Rivers

Parameter	Hastings River	Wilson River	Maria River
Phosphorus (TP)	TP levels are compliant with the Guidelines with a mean value at the two assessed monitoring sites (HAE-04 and HAE-09) of 22 µg/L (micrograms per litre).	TP readings were generally compliant with the ANZECC Guidelines with mean levels between 10 and 28 µg/L at WSS-06, WSS-04 and WSS-01. In the estuarine reach values were 30 µg/L (i.e. within the Guidelines).	Several TP samples in the lower catchment exceeded (i.e. did not comply with) the Guidelines (mean value for HAE-06 of 34 µg/L). TP values upstream generally complied with the ANZECC Guidelines with a mean value at HAE-08 of 29 µg/L.
Nitrogen (TN)	TN levels were generally compliant with the Guidelines although there were some notable elevated results across the catchment. The mean values were between 280 and 300 µg/L at the two points (HAE-04 and HAE-09) located near the bridge site and towards the river mouth in the estuary (i.e. mean values complied with the Guidelines).	The majority of TN observations complied with the Guidelines with a mean value 320 µg/L recorded at WSS-04 and 200 µg/L recorded at WSS-01, and 248 µg/L recorded at WSS-06. The site in the estuarine reach (HAE-07) also complied with the Guidelines (average value of 300 µg/L).	Several TN samples near the boundary with Kempsey local government area exceeded (i.e. did not comply with) the Guidelines (e.g.HAE-08, in the estuarine reach of the river, had a mean value of 670 µg/L). Several TN samples downstream also did not comply with the Guidelines (e.g. HAE-06 had a mean of 501 µg/L). By the time this reached the confluence of the Maria and Hastings rivers the values were back within the Guidelines. Generally TN was higher in the Maria River than the Hastings and Wilson Rivers.
Turbidity (NTUs: nephelometric turbidity units)	No observations were significantly elevated for turbidity with the bulk of the monitoring data meeting the Guidelines. The mean values for the Hastings River were between 1.6 and 5.9 NTUs at the two points located near the bridge site and towards the river mouth in the estuary (HAE-04 and HAE-09).	Turbidity readings complied with the Guidelines with a mean of between 3.6 and 6.8 NTUs for the three sites at WSS-06, WSS-04 and WSS-01 within the lowland rivers reach and 6.9 NTUs in the estuarine reach at Dalhunty Island.	Turbidity was slightly above (i.e. did not comply with) the Guidelines with a mean of 12 NTUs above the confluence of the Maria and Wilson rivers. The values downstream met the Guidelines.

Parameter	Hastings River	Wilson River	Maria River
Dissolved oxygen (DO)	DO at HAE-09 and HAE-05 meet the Guidelines with mean values of 89 and 94 per cent saturation respectively. DO at HAE-04 was slightly above (i.e. did not comply with) the Guidelines with a mean value of 116 per cent saturation.	DO was below (i.e. did not comply with) the Guidelines for the Wilson River at WSS-01, WSS-04 and WSS-06 with mean values of 79, 63 and 77 per cent saturation respectively in the lowland rivers section of the catchment and 79 per cent in the estuarine section of the catchment.	DO levels were well below (i.e. did not comply with) the Guidelines with mean values upstream of the confluence of the Maria and Wilson rivers being 56 per cent saturation. Those further downstream were recorded at 72 per cent (i.e. did not comply) and 94 per cent saturation (i.e. did comply), with the site just upstream of the Maria River (HAE-05) meeting the Guidelines.
pH	The pH of the monitoring points in the Hastings River indicate compliance with the Guidelines (mean values of 7.4 near the bridge site and 7.62 in the lower reaches).	The pH values at Dalhunty Island complied with the Guidelines (average pH of 6.88) as did the mean pH values for the upper reaches of the Wilson River (6.72 at WSS-01, 6.83 at WSS-04 and 6.95 at WSS-06).	A number of pH values were slightly lower than (i.e. did not comply with) the Guidelines (lowest individual value recorded at HAE-08 had a pH of 4.8). The mean values for HAE-08, HAE-06 and HAE-05 were 6.20, 6.57 and 7.48 respectively. This indicates the Maria River upstream of the confluence with the Wilson River is slightly more acidic than the Guidelines.
General findings	Water quality in the estuary generally complied with the Guidelines. Faecal coliforms in the Hastings River were above (i.e. did not comply with) the acceptable levels identified in the NSW Oyster Industry Sustainable Aquaculture Strategy (GHD 2010).	Water quality generally complied with the Guidelines.	A number of water quality values did not comply with the Guidelines. The elevated TN may be due to the agricultural activities along the Maria River catchment with the extensively modified catchment also contributing to the low pH and DO values.

Source: GHD 2010: 287-290.

Analysis of water quality monitoring results at Stumpy Creek

The monitoring results presented in Table 9 were collected by the Kempsey Bypass Alliance at Stumpy Creek during construction of the Kempsey Bypass and are useful for gaining an understanding of the quality of water in Stumpy Creek and its response to rainfall events.

The upstream water quality results are useful for gaining an understanding of the existing water quality and should be used as part of the pre-construction monitoring required as part of this WQMP. The downstream results should also be used as part of this WQMP because they help identify the influence of construction activities on water quality, however, it must be recognised that the results are unlikely to reflect the natural background water quality.

A brief analysis of the water quality monitoring results at Stumpy Creek is provided below:

- pH results indicate that Stumpy Creek is naturally slightly acidic, with both the upstream and downstream water quality being non-compliant with the Guideline trigger values. The difference in pH values between the upstream and downstream sites is not significant however the downstream sites are generally slightly more acidic. As no pre-construction monitoring data is available at this site it is not possible to indicate whether the up/downstream variation is natural or likely to be project related. The lowest pH recorded followed a significant rainfall event.

- Conductivity at Stumpy Creek generally complied with the Guidelines and was generally within the lower end of the acceptable range. Only two sampling events returned results outside (below) the acceptable range, and in both instances the non-compliance was evident at the upstream site, indicating the result was unlikely to be related to project impacts. Only one sampling event (29/9/2011) recorded relatively high Electrical Conductivity (EC) (although it was within the Guidelines) and this appeared to be in response to the significant rainfall event in the catchment three days earlier. Both the up and downstream sites recorded the same EC in this event which indicates that the project did not increase the EC.

- Total Dissolved Solids (TDS) complied with the Guidelines on all occasions other than on 29/9/2011 where there was a minor exceedance of (i.e. non-compliance with) the upper limit. The exceedance appeared to be in response to the significant rainfall event in the catchment three days earlier. Both the up and downstream sites recorded similar TDS in this event which indicates that the project did not cause an increase in TDS.

- Total Suspended Solids (TSS) remained stable over the various monitoring events with a notable exception on 29/9/2011 where there was a highly elevated result following a significant rainfall event in which the sediment basin overtopped. The results were elevated at both the up and downstream sites however there was a significance increase in TSS between the up and downstream sites reflecting the overflow from the sediment basin).

- Turbidity results (NTU) were above the Guidelines (i.e. non-compliant). In most instances the results did not significantly differ between the up and downstream sites indicating that the construction activities had not generally increase turbidity. The exception to this rule was in the post-rainfall record (1/9/2011) where turbidity increased significantly downstream of the Project site. The NTU reading on 29/9/2011 is unusually low, particularly given the high TDS and TSS results recoded in this sampling event, and therefore have been discounted from this analysis.

In summary, the water quality monitoring results at Stumpy Creek indicate high responsiveness to rainfall events with water quality deteriorating under wet conditions. Further water quality monitoring at Stumpy Creek is required as part of pre-construction,

construction and post-construction monitoring to confirm baseline water quality and to observe and respond to potential project impacts. Given that water in Stumpy Creek has been sampled on eleven separate occasions, only three further samples are required as part of pre-construction monitoring at this site. This will ensure that some more recent samples are incorporated into the monitoring program and that baseline data can be collected at the downstream sampling point.

Table 9 – Stumpy Creek surface water quality monitoring results

Sample date	Upstream/ downstream	PH	Conductivity (EC) (µS/cm)	Total Dissolved Salts (µg/L)	Total Suspended Solids (µg/L)	Turbidity (NTU)	KBA Comments
NSW Water Quality and River Flow Objectives for the Hastings River Catchment for aquatic ecosystems (lowland rivers):		6.5 - 8.5	125 – 2200	No trigger value exists for protection of aquatic ecosystems. The ANZECC default trigger value for Total Dissolved Solids for recreational purposes is 1,000,000 µg/L (2000b: 5-9)	NA - guideline values are in NTU only	6 - 50	NA
1/9/2011	US	5.78	120	84,000	13,000	105	NA
	DS	6.22	210	141,000	86,000	376	A nearby sediment basin received significant rain (107mm) over the fortnight prior to sampling, achieved design capacity during the rain event and overtopped. Release of water from the sediment basin may have impacted the Stumpy Creek downstream result.
29/9/2011	US	4.52	1590	1,082,000	42,000	5	NA
	DS	4.51	1590	1,081,000	360,000	5	Significant rain event occurred on the 26/9/11 (52mm recorded at the Southern interchange). This exceeded sediment basin design criteria and caused overtopping which could have contributed to the turbidity of Stumpy Creek downstream of the project.
27/10/2011	US	6.22	290	199,000	30,000	56	NA
	DS	6.12	300	201,000	31,000	57	NA

Sample date	Upstream/ downstream	PH	Conductivity (EC) (µS/cm)	Total Dissolved Salts (µg/L)	Total Suspended Solids (µg/L)	Turbidity (NTU)	KBA Comments
7/12/2011	US	5.86	130	89,000	33,000	81	NA
	DS	5.75	130	90,000	35,000	82	NA
27/1/2011	US	5.83	90	61,000	11,000	68	NA
	DS	5.62	90	61,000	14,000	69	NA
1/3/2012	US	6.78	170	118,000	22,000	44	NA
	DS	6.68	180	119,000	24,000	45	NA
30/3/2012	US	6.15	190	127,000	20,000	17	NA
	DS	6.08	190	126,000	19,000	17	NA
2/5/2012	US	5.98	140	92,000	14,000	91	NA
	DS	5.92	130	91,000	15,000	91	NA
6/6/2012	US	6.19	170	113,000	185,000	131	Upstream water quality (water coming onto the project) was turbid. The water quality improved as it passed through the project's environmental controls.
	DS	5.98	160	109,000	19,000	47	NA
28/6/2012	US	5.25	320	218,000	15,000	38	NA
	DS	4.87	317	216,000	15,000	50	NA
27/7/2012	US	5.87	200	139,000	27,000	56	NA
	DS	5.89	210	139,000	27,000	58	NA

Note to table: The results highlighted in red exceed the acceptable values in the NSW Water Quality and River Flow Objectives for the Hastings River Catchment and/or the related ANZECC Water Quality Guideline (collectively referred to as the "Guidelines"). Source: Adapted from *Monthly Surface Water Quality Monitoring Spreadsheet* (Kempsey Bypass Alliance 2012).

2.9 PREVIOUS GROUNDWATER MONITORING

The existing groundwater information for the Project has been collected in combination with geotechnical information for design purposes and is available in the following reports:

- Groundwater Review FCONGEO-0006-OH2K-R-01 (SHJV dated 14 August 2012)
- Groundwater Monitoring Report 1 BB278 (GHD dated 6 July 2012)
- Groundwater Monitoring Report 1 – Interpretation and Commentary BB279 (GHD dated 10 July 2012)
- Groundwater Monitoring Report BB316 (GHD dated 24 August 2012)
- Groundwater Monitoring Report 2 – Interpretation and Commentary BB317 (GHD dated 28 August 2012)

In the Project area a total of 51 groundwater monitoring piezometers have been installed during the geotechnical investigation, 27 with pressure transducer logging units. 35 of the groundwater monitoring piezometers, which include the 27 pressure transducer units, have been monitored since April 2012. These monitoring piezometers provide groundwater level, and some groundwater quality data for input into the geotechnical design.

A review of the existing hydrogeological information identified several areas where data gaps existed not only for the purpose of design but also for the pre-construction, construction and operational monitoring period. Some of the existing monitoring piezometers have been installed within the Project construction footprint and are only able to provide monitoring information in the pre-construction phase and for a limited period of time during construction as they are likely to be impacted by construction. New piezometers will be installed during the pre-construction period to establish baseline water quality conditions and will be installed prior to the removal of existing piezometers nearby to enable a correlation to be made between the two bores. This will ensure that the baseline water quality data collected in the original bores can continue to form an important reference point in the WQMP. The new piezometers will be placed outside the construction foot print to maintain continuity of monitoring for the entire monitoring period, from pre-construction up to 3 years post construction.

3 MONITORING PROGRAM OBJECTIVES

3.1 RMS WATER POLICY

This WQMP has been developed in line with the *RTA Water Policy* (the Policy) (no date) which recognises that road projects can alter the natural surface and groundwater drainage patterns. The policy recognises the importance of managing water quality and quantity impacts during the pre-construction, construction and operational phases of a project, and outlines RMS's commitment to water management.

The overarching water Policy is:

> *"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"* (RTA no date: 1)*.*

Given that the planning and design phases are largely complete for the Project, this WQMP primarily relates to the Policy objectives for the construction, operation and maintenance phases.

The Policy states that during the construction phase, potential adverse water quality impacts such as erosion, sedimentation, leakage or spillage of fuels are to be managed with the appropriate, best management control measures. During operation, the Policy indicates that potential impacts from build-up of contaminants on and around the road should be managed by implementation of structural and non-structural run-off controls. During the maintenance phase, the Policy stipulates that the potential for discharge of pollutants from maintenance activities should be managed through application of good work practices.

This WQMP provides for monitoring of potential project impacts and enables adaptive management by ensuring that any adverse impacts are detected early and managed in line with the RMS Water Policy.

3.2 RMS CODE OF PRACTICE FOR WATER MANAGEMENT

The *RMS Code of Practice for Water Management: Road Development and Management* (the Code) (RTA 1999) outlines the principles by which RMS works to achieve the goals of their Water Policy.

> *"The prime objective of the Code of Practice is to provide the links between the outcomes required in the Water Policy and implementation guidelines. It aims to guide staff to the principles that need to be maintained for effective management of water quality during the various stages of road development and management" (RTA 1999).*

The Code recognises that water management is an essential environmental responsibility for RMS and needs to be catered for during planning, design, construction, maintenance and traffic management. The principles outlined in the policy are in line with the principles of ecologically sustainable development and focus on the control and reduction of diffuse and point source water pollution. This WQMP is consistent with the Code in that it promotes monitoring and inspection of potential impacts on surface and groundwater quality, resources and wetlands during all project phases to enable adaptive management.

3.3 NSW STATE GROUNDWATER POLICY

The *NSW State Groundwater Policy* (Department of Land and Water Conservation 1997) (DLWC) sets out the high level objectives for groundwater management in NSW. The Policy includes consideration of groundwater quality protection and the protection of groundwater dependent ecosystems.

The overarching policy objective is to "*manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW*" (DLWC 1997: 7). The policy recognises the need to protect groundwater resources from pollution and ensure that water extraction does result in adverse impacts on the natural environment. The policy encourages the sustainable management of groundwater resources and the application of efficient and ecologically sensitive management practices

This WQMP links with the objectives of the NSW State Groundwater Policy by ensuring the collection of adequate and reliable monitoring data. The information collected as part of the monitoring program will provide information on groundwater levels and quality that will help ensure the effectiveness of the Project's water quality management measures.

3.4 MONITORING OBJECTIVES

The primary objective of this WQMP is to observe and assess the impact of the Project on water quality in the relevant waterways in the Project Area.

To achieve this objective, this document stipulates the monitoring locations, parameters and frequencies for both surface and groundwater monitoring and covers the pre-construction, construction and operational phases of the project. The information collected as part of the monitoring program will be used to inform project management responses aimed at reducing or halting any adverse impacts detected.

3.5 MONITORING STUDY DESIGN

This monitoring program involves repeat sample collection at static locations within the surrounding catchment area. The collection of repeat data over a known time period enables an assessment of changes in water quality that may result from implementation of the project; as such, this program is described by the *Australian Guidelines for Water Quality Monitoring and Reporting* as a "study that measures change" (2000: 3-3). The basic premise of this methodology is that suitable spatial and temporal monitoring is built into the study design.

3.5.1 SURFACE WATER STUDY DESIGN

Condition of Approval B17 requires that the time period for data collection include the pre-construction period. Monitoring during the pre-construction project phase enables a "BACI" (before-after/control-impact) monitoring approach which involves the collection of data "<u>b</u>efore" and "<u>a</u>fter" a known activity has the potential to impact the environment (ANZECC & ARMCANZ 2000b: 3-3).

Additionally, the selection of monitoring locations for surface water has incorporated an upstream (or "<u>c</u>ontrol") site and a downstream (or "<u>i</u>mpact") site (ANZECC/ARMCANZ 2000b: 3-3). This type of monitoring program allows for measurement of trends in water quality and simple correlations between characteristics (e.g. rainfall events and water quality responses, or Total Suspended Solids (mg/L) and Turbidity (NTU) measurements).

The inclusion of control and impact sites means that the study can capture any natural variation in water quality between the upstream and downstream locations. This ensures that there is a causal focus in the monitoring program which avoids inappropriately attributing natural downstream changes in water quality to the Project activities.

3.5.2 GROUNDWATER STUDY DESIGN

Where possible, the groundwater component of this monitoring program has been designed to incorporate upgradient and downgradient monitoring locations. However, to drill and monitor two boreholes at each location of interest may be practically and financially challenging. As stipulated in the RMS *Guideline for Construction Water Monitoring*, "…*it is important that cost and practicality issues are borne in mind when developing water quality monitoring programs*" (RTA no date: 5).

Therefore, rather than sacrifice one area of interest in order to have two boreholes (one upgradient and one downgradient) at another location, the preferred option is to monitor the location (cut or embankment) with at least one borehole at each site. This approach is consistent with Condition of Approval B17 which requires *"identification of … groundwater quality monitoring locations … which are representative of the potential extent of impacts from the project"*.

The groundwater monitoring design is therefore more appropriately characterised as one that enables an "*inference of change over time*" (ANZECC & ARMCANZ 2000b: 3-3). An important component of such a design is the pre-construction monitoring. The incorporation of pre-construction monitoring into the study design will enable the comparison of water quality conditions before, during and after the highway upgrade.

4 MONITORING PROGRAM

4.1 SURFACE WATER MONITORING LOCATIONS

The monitoring locations have been selected to identify potential water quality impacts on:

- Major rivers, creeks and some tributaries.
- The SEPP 14 Wetlands located at the Wilson River on Dalhunty Island and the northern bank of the river to the south of the highway.
- Existing water users, including the oyster leases located approximately 2.5 kilometres downstream of the highway in the Hastings River.

Consideration has also been given to providing appropriate coverage of waterway types and geographic zones within the Project area. In total, 13 different waterways will be monitored as part of the WQMP. While ideally all watercourses selected for inclusion in a WQMP would be permanent waterways, the nature of the existing environment (including the catchment shape, size and rainfall patterns) means that there are a number of sites that may sometimes be dry. It is important that these sites are included in the WQMP even if samples can only be taken following rainfall events. Exclusion of all ephemeral sites would result in too few sites to provide appropriate representation of potential Project impacts.

The selection of surface water monitoring sites at the Wilson River considered the location of the SEPP 14 wetlands, with two monitoring sites in the northern channel (one upstream and one downstream) and two in the southern channel (one upstream and one downstream).

The exact location of each sampling point is to be confirmed during the first sampling event and marked with a GPS to ensure continuity of sites throughout the pre-construction, construction and operational phases of the project. Safety (both in terms of vehicle parking and on-foot access) and availability of access for the duration of the monitoring program are to be primary factors in the final site selection. While sites located within the Project boundary are preferable because they would generally fall within RMS owned land (and thereby simplify access arrangement), sites may be selected up to 50 metres upstream and 100 metres downstream of the construction zone. On the upstream side, this will help ensure samples are characteristic of a 'control' site. On the downstream side, this will ensure samples are taken within influence of the discharge of the Project where there is sufficient mixing to show the representative impact of any site discharge on the receiving waters.

If, for safety, access or other reasons, there is a need to alter the sampling location midway through the monitoring program, the change must be discussed with RMS, EPA, DPI (Fishing and Aquaculture) and NOW and captured in the WQMP reports described in Section 5.2.

The surface water monitoring locations for the Project are listed in Table 10 and shown on Figure 5.

Table 10 – Surface water monitoring locations

Site #	Approx. chainage*	Waterway name	Up/downstream & east/west of highway	Reason for site selection and impacts targeted
SW1a	2500	Unnamed tributary of Fernbank Creek	US / west	Industrial land use upstream
SW1b	2600	Unnamed tributary of Fernbank Creek	US / west	Industrial land use upstream
SW1c	2650	Unnamed tributary of Fernbank Creek	DS / east	Industrial land use upstream
SW2a	4620	Fernbank Creek	DS / east	Two EECs in this area (Freshwater Wetland on coastal Floodplain and Swamp Sclerophyll Forest) / ASS
SW2b	4800	Fernbank Creek	US / west	Two EECs in this area (Freshwater Wetland on coastal Floodplain and Swamp Sclerophyll Forest) / ASS
SW3a	6040	Hastings River northern bank	US / west	Major river with oyster aquaculture downstream of the project site
SW3b	6080	Hastings River northern bank	DS / east	Major river with oyster aquaculture downstream of the project site
SW4a	13950	Unnamed tributary of Wilson River	US / east	Creek passing through EEC (Swamp Sclerophyll Forest on Coastal Floodplain) / ASS
SW4b	13950	Unnamed tributary of Wilson River	DS / west	Creek passing through EEC (Swamp Sclerophyll Forest on Coastal Floodplain) / ASS
SW5a	15650	Unnamed tributary of Wilson River (adjacent to wetland just south of Wilson River)	US / east	GDE (EEC Freshwater Wetland on Coastal Floodplain) / ASS
SW5b	15820	Unnamed tributary of Wilson River (adjacent to wetland just south of Wilson River)	DS / west	GDE (EEC Freshwater Wetland on Coastal Floodplain) / ASS
SW6a	16460	Wilson River southern bank	US / west	Major river / SEPP 14 / Floodplain / ASS
SW6b	16600	Wilson River southern bank	DS / east	Major river / SEPP 14 / Floodplain / ASS
SW6c	16830	Wilson River northern bank	US / west	Major river / SEPP 14 / Floodplain / ASS
SW6d	16840	Wilson River northern bank	DS / east	Major river / SEPP 14 / Floodplain / ASS
SW7a	19660	Cooperabung Creek	US / west	EEC (Swamp Sclerophyll Forest on Coastal Floodplain) / tributary to Cooperabung Creek / Giant Barred Frog habitat

Site #	Approx. chainage*	Waterway name	Up/downstream & east/west of highway	Reason for site selection and impacts targeted
SW7b	19660	Cooperabung Creek	DS / east	EEC (Swamp Sclerophyll Forest on Coastal Floodplain) / tributary to Cooperabung Creek / Giant Barred Frog habitat
SW8a	23775	Barrys Creek (south of rest areas)	US / west	EEC (Subtropical Floodplain Coastal Forest) / Giant Barred Frog habitat
SW8b	24000	Barrys Creek (south of rest areas)	DS / east	EEC (Subtropical Floodplain Coastal Forest) / Giant Barred Frog habitat
SW8c	25325	Barrys Creek (north of rest areas near Mingaletta Road)	DS / east	Downstream of rest areas / EEC (Subtropical Floodplain Coastal Forest) / Giant Barred Frog habitat
SW9a	28300	Smiths Creek	DS/ east	EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog Habitat
SW9b	28300	Smiths Creek	US / west	EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog Habitat
SW10a	30700	Pipers Creek	DS / east	EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog habitat
SW10b	30700	Pipers Creek	US / west	EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog habitat
SW11a	34650	Unnamed drainage line	DS / east	Downhill of significant cut site / potential ASR
SW11b	34700	Unnamed drainage line	US / west	Downhill of significant cut site / potential ASR
SW12a	36850	Maria River	US / west	Major river / EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog habitat
SW12b	36850	Maria River	DS / east	Major river / EEC (Subtropical Coastal Floodplain Forest) / Giant Barred Frog habitat
SW13a	37700	Stumpy Creek	DS / east	Major creek / EEC (Subtropical Coastal Floodplain Forest)
SW13b	37750	Stumpy Creek	US / west	Major creek / EEC (Subtropical Coastal Floodplain Forest)

*The exact location of each sampling point is to be confirmed during the first sampling event and marked with a GPS to ensure continuity of sites in future monitoring.

4.2 GROUNDWATER MONITORING LOCATIONS

In selecting groundwater monitoring locations, the aim has been to ensure that information is captured at a number of locations on a diverse range of environmental considerations. The groundwater monitoring locations have been selected to help identify potential construction and operational impacts from cuttings, embankments and the main road alignment on the surrounding environment. The key focus of the groundwater monitoring locations is to capture potential impacts on:

- GDEs.
- SEPP 14 Wetlands.
- EECs.
- Existing groundwater users.

The groundwater monitoring sites are also specifically located to identify the potential impacts from significant cuttings identified as Category A and B cuttings in Section 2.5. Category A (high-risk) cuttings are those which are likely to intercept groundwater and Category B (moderate-risk) cuttings are those with some (although likely minimal) potential to intercept groundwater. These cuttings are generally greater than 3 metres in depth, and some are up to almost 10 metres deep. The monitoring locations have focussed on the cuttings which have a large length or area, are located near EECs, GDEs or are in proximity to existing groundwater users. The sites for Category A cuts have generally been located at the highest point of the cutting where the greatest intersection with the groundwater table is expected.

Monitoring at Category B cuts is aimed at confirming they are moderate-risk (as opposed to high-risk) sites. Should monitoring observations confirm that there are no significant water quality impacts from these sites, the frequency of monitoring at these locations may be reduced or discontinued during the construction or operational phase of the project.

A number of groundwater monitoring locations have also been selected on the Hastings and Wilson River floodplains to identify any potential impacts from the bridge embankments. On the northern floodplain of the Wilson River, the groundwater monitoring location to the east of the highway was selected to ensure that monitoring captures potential project impacts on the SEPP 14 wetland.

To avoid being damaged/destroyed by construction activities, groundwater monitoring bores will be installed within, but as close as possible, to the project boundary and will be clearly marked.

The groundwater monitoring locations are listed in Table 11 and shown on Figure 5.

Table 11 – Groundwater monitoring locations

Site #*	Approx. chainage**	Reason for site selection and impacts targeted
GW01	3020	Category A Cut
GW02	5000	Floodplain / ASS / significant embankment
GW03	5500	Floodplain / ASS / significant embankment
GW04	6140	Floodplain / ASS / significant embankment

Site #*	Approx. chainage**	Reason for site selection and impacts targeted
GW05	6350	Floodplain / ASS / significant embankment
GW06	7620	Category A Cut
GW07	8640	Category A Cut / significant earthworks for intersection / no existing groundwater information in this location
GW08	10360	Category A Cut / no existing groundwater information in this location
GW09	10440	Category A Cut
GW10	11460	Confirm Cut Category B / near EEC & GDE
GW11	13100	Floodplain / near existing groundwater users / near EEC & GDE
GW12	15830	Floodplain / ASS / near EEC & GDE
GW13	16400	Floodplain / ASS / near EEC & GDE / significant embankment
GW14	17080	SEPP 14 / floodplain / significant embankment / ASS / EEC / GDE
GW15	17920	Category A Cut / nearby existing groundwater users
GW16	18390	Category A Cut / near existing groundwater users / near ASS
GW17	20680	Category A Cut
GW18	21050	Category A Cut
GW19	22000	Confirm Cut Category B / near EEC
GW20	22620	Category A Cut
GW21	22620	Category A Cut (and will assist with modelling)
GW22	24800	Significant cut / acid sulfate rock expected in this location / capture impacts from the rest areas
GW23	24800	Significant cut / acid sulfate rock expected in this location / capture impacts from the rest areas
GW24	25900	Cluster of private bores to the east of the highway / next to a cut
GW25	33800	Category A Cut
GW26	34300	Category B Cut
GW27	35150	Category A Cut
GW28	35280	Category A Cut

Site #*	Approx. chainage**	Reason for site selection and impacts targeted
GW29	35900	Category A Cut
GW30	37160	Category A Cut/ near existing groundwater user

* Where an existing piezometer is present in the immediate vicinity of the proposed monitoring location it will be assessed for suitability for use instead of installing a new piezometer. These piezometers may require maintenance before use. In cases where an existing piezometer is used, but will at some point be impacted by construction, new piezometers will be installed prior to the removal of existing piezometers to enable a correlation to be made between the two bores.
** The exact location of each sampling point may be affected by site access constraints and therefore some minor adjustments (generally a move of less than 100 m) may be made during the installation of the groundwater bores. The borehole locations will be recorded with a GPS during installation to aid site identification for future monitoring rounds.

This WQMP was originally prepared prior to the groundwater modelling required by Condition of Approval B16 being undertaken. The groundwater modelling was undertaken in mid-2013 (SHJV 2013). A suitability assessment has been undertaken to consider whether the findings of the modelling necessitate changes to the groundwater monitoring locations proposed in Table 11 above. This assessment involved identifying the locations where the modelling indicated potential drawdown impacts may occur in the vicinity of road cuttings, GDEs, private landholder bores and springs, and then analysing the position of the groundwater monitoring bores proposed in this WQMP to ascertain if sufficient bores have been recommended to monitor the potential impacts.

Potential impacts at road cuttings and on potential GDEs

The modelling identified 11 cuts with potential drawdown impacts and two broad areas where drawdown impacts may occur in the vicinity of potential GDEs. The suitability assessment found that there are sufficient groundwater monitoring bores (proposed in Table 11) to monitor potential impacts in these locations (see the results of the suitability assessment in Table 12 and Table 13 below).

Table 12 - Suitability of WQMP groundwater bores for monitoring potential drawdown impacts at the cuts modelled

Modelling Report cut #	Is there a groundwater monitoring bore proposed for this location? (Y/N / bore # from Table 11)	Distance of proposed groundwater monitoring bore from cut identified in the Modelling Report	Is a new / additional bore required next to this cut?
1	Y/GW01	Immediately adjacent	No
2	Y/06 & 07	Immediately adjacent	No
3	Y/GW10	Immediately adjacent	No
4	Y/GW15	Immediately adjacent	No
5	Y/GW17 & GW18	Immediately adjacent	No
6	Y/GW19	Immediately adjacent	No
7	Y/GW20 & GW21	Immediately adjacent	No
8	Y/GW25	Immediately adjacent	No
9	Y/GW 26 & 27 & 28	GW27 & GW28 are immediately adjacent; GW26 is slightly south of this cut.	No
10	Y/GW29	Immediately adjacent	No

Modelling Report cut #	Is there a groundwater monitoring bore proposed for this location? (Y/N / bore # from Table 11)	Distance of proposed groundwater monitoring bore from cut identified in the Modelling Report	Is a new / additional bore required next to this cut?
11	Y/GW30	Immediately adjacent	No

Table 13 - Suitability of WQMP groundwater bores for monitoring potential drawdown impacts at GDEs

Modelling Report cut # where drawdown may impact GDEs	Is there a groundwater monitoring bore proposed for this location? (Y/N / bore # from Table 11)	Distance of proposed groundwater monitoring bore from cut identified in the Modelling Report	Is a new / additional bore required next to this cut?
8	Y / GW 25	Immediately adjacent	No
9	Y / GW26 (to south) and GW27 & GW28	GW27 & GW28 are immediately adjacent. GW 26 is slightly south of this cut.	No

Potential impacts on private bores

The Modelling Report identified six private bores where mitigation either “may be” or is “likely” to be required due to drawdown impacts. Five of these private bores do not have a groundwater monitoring bore in the immediate vicinity (GW059748, GW065496, GW300094, GW300268, GW302213). Installation of additional bores in these locations are not required from a water quality monitoring perspective, however Roads and Maritime will contact the owners of the six bores which are likely to or may require mitigation to address drawdown impacts and assess the baseline preconstruction conditions. Any assessments will be subject to landowner approval.

Potential impacts on a spring fed dam

The modelling identified potential drawdown impacts to a spring fed dam on private property. The dam will be visually monitored monthly during construction, subject to landowner approval, to provide information on watertable levels that may assist in the development of mitigation measures should impacts be identified at this location. Photographs will be taken from the same point during each monthly monitoring event.

Figure 5-1 – Surface and groundwater monitoring locations

Figure 5-2 – Surface and groundwater monitoring locations

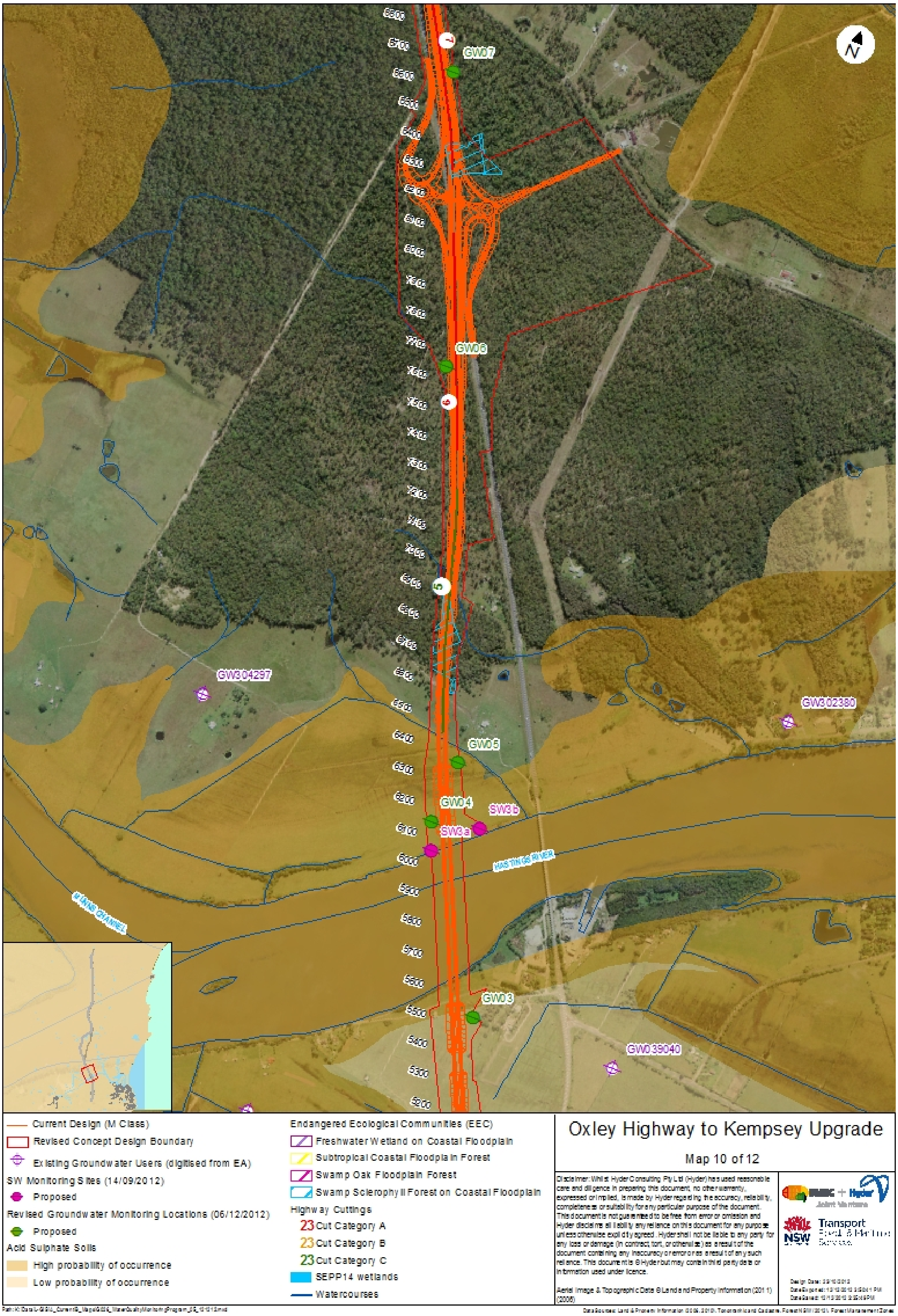


Figure 5-3 – Surface and groundwater monitoring locations

Figure 5-4 – Surface and groundwater monitoring locations

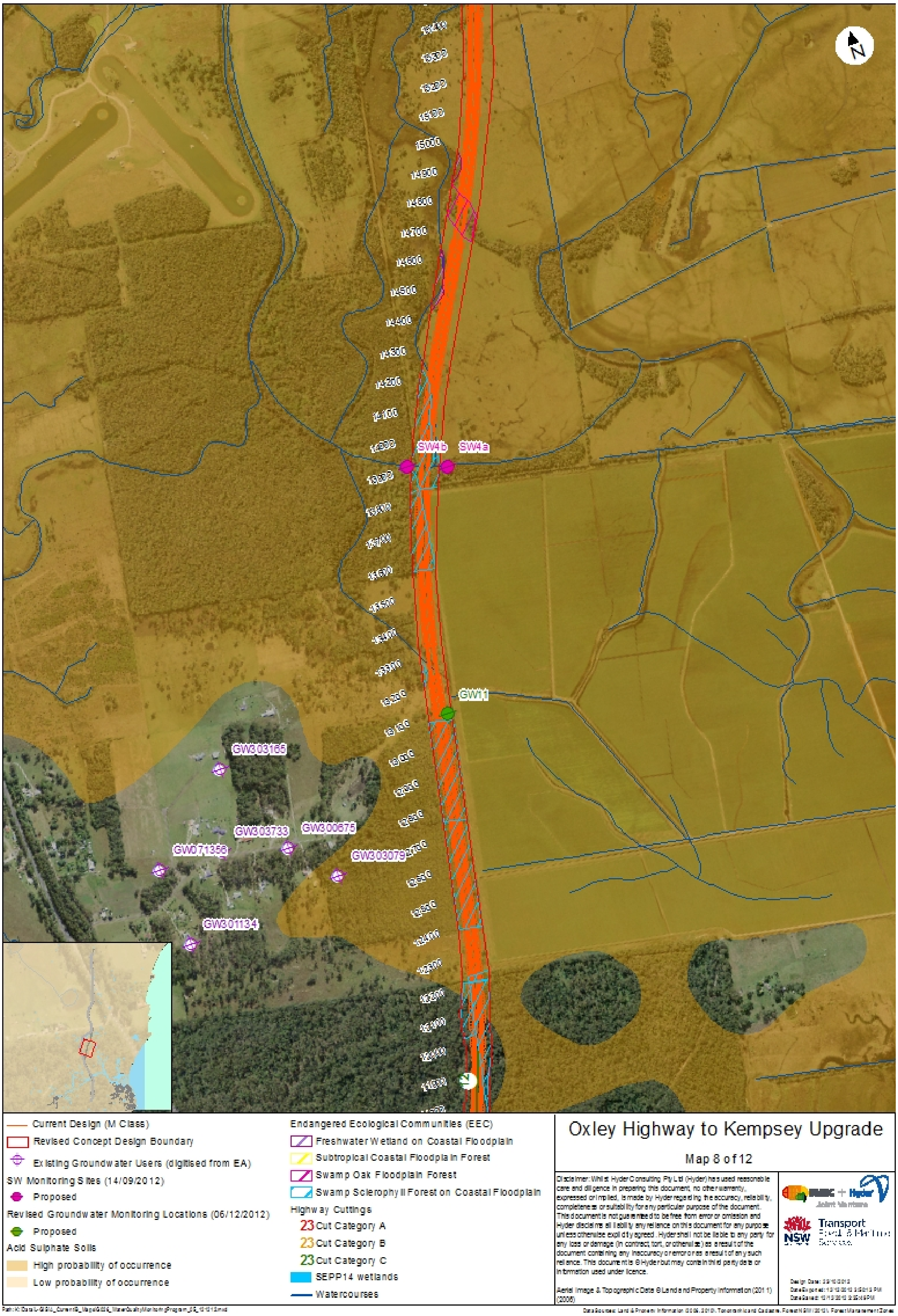


Figure 5-5 – Surface and groundwater monitoring locations

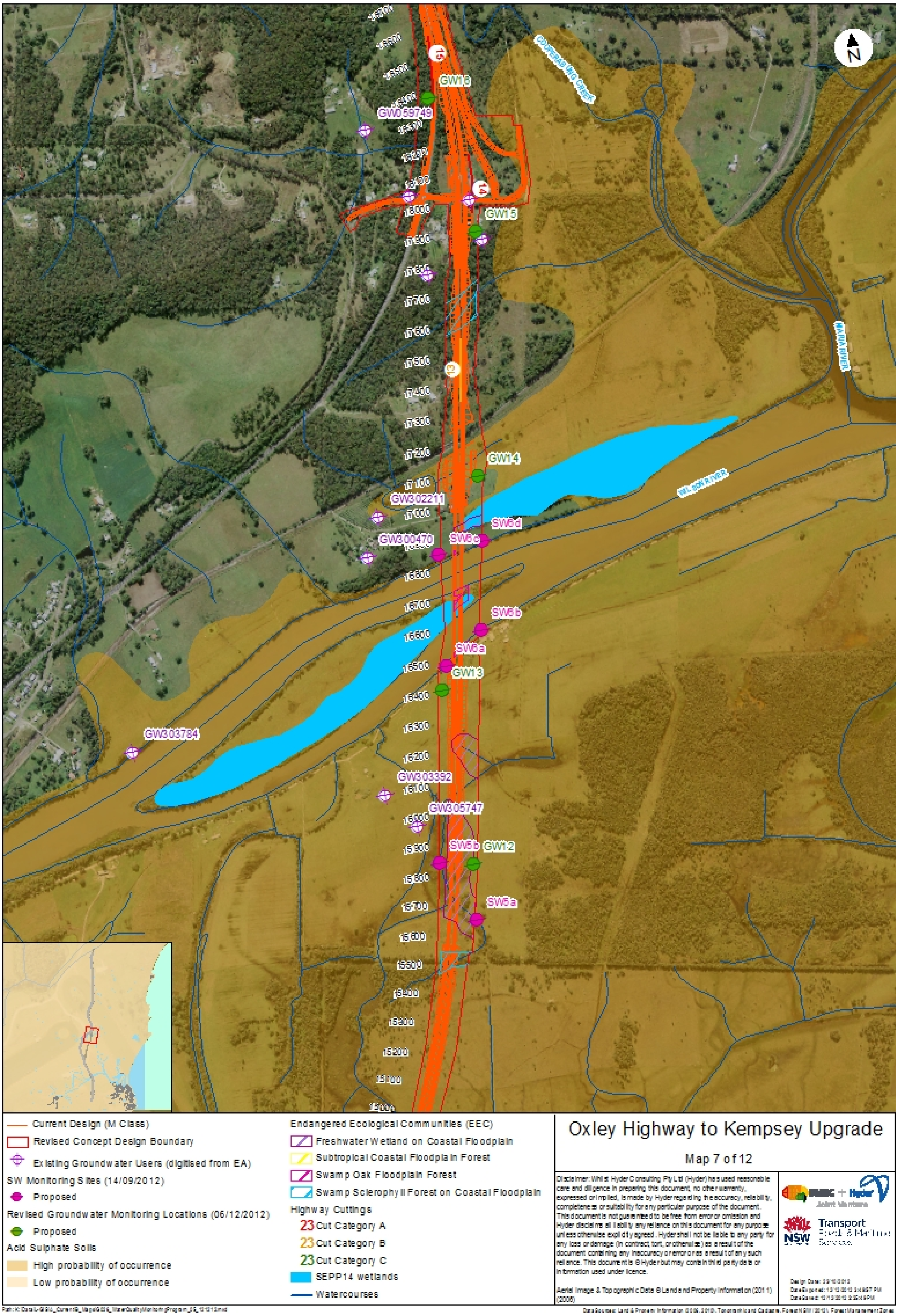


Figure 5-6 – Surface and groundwater monitoring locations

Figure 5-7 – Surface and groundwater monitoring locations

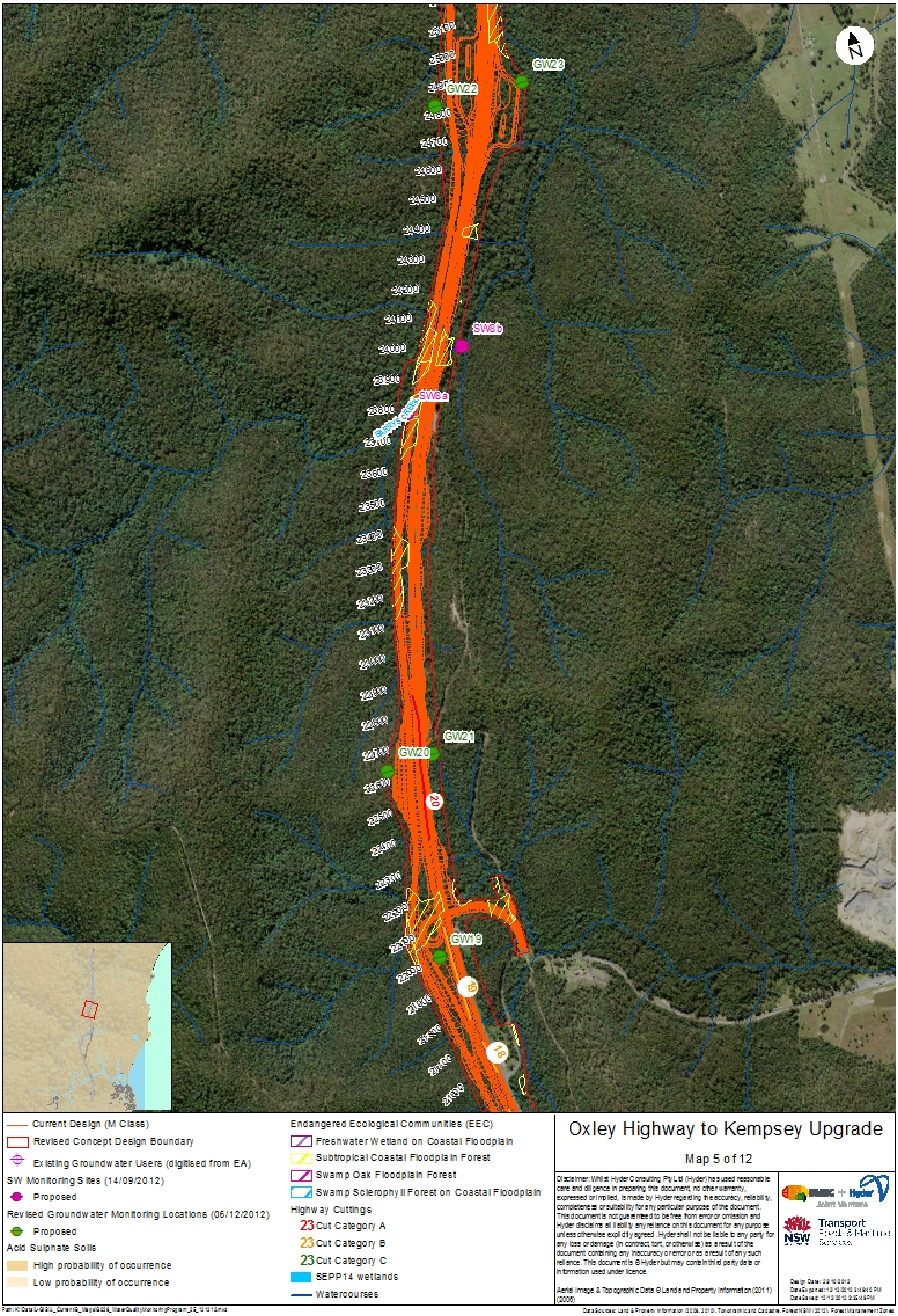


Figure 5-8 – Surface and groundwater monitoring locations

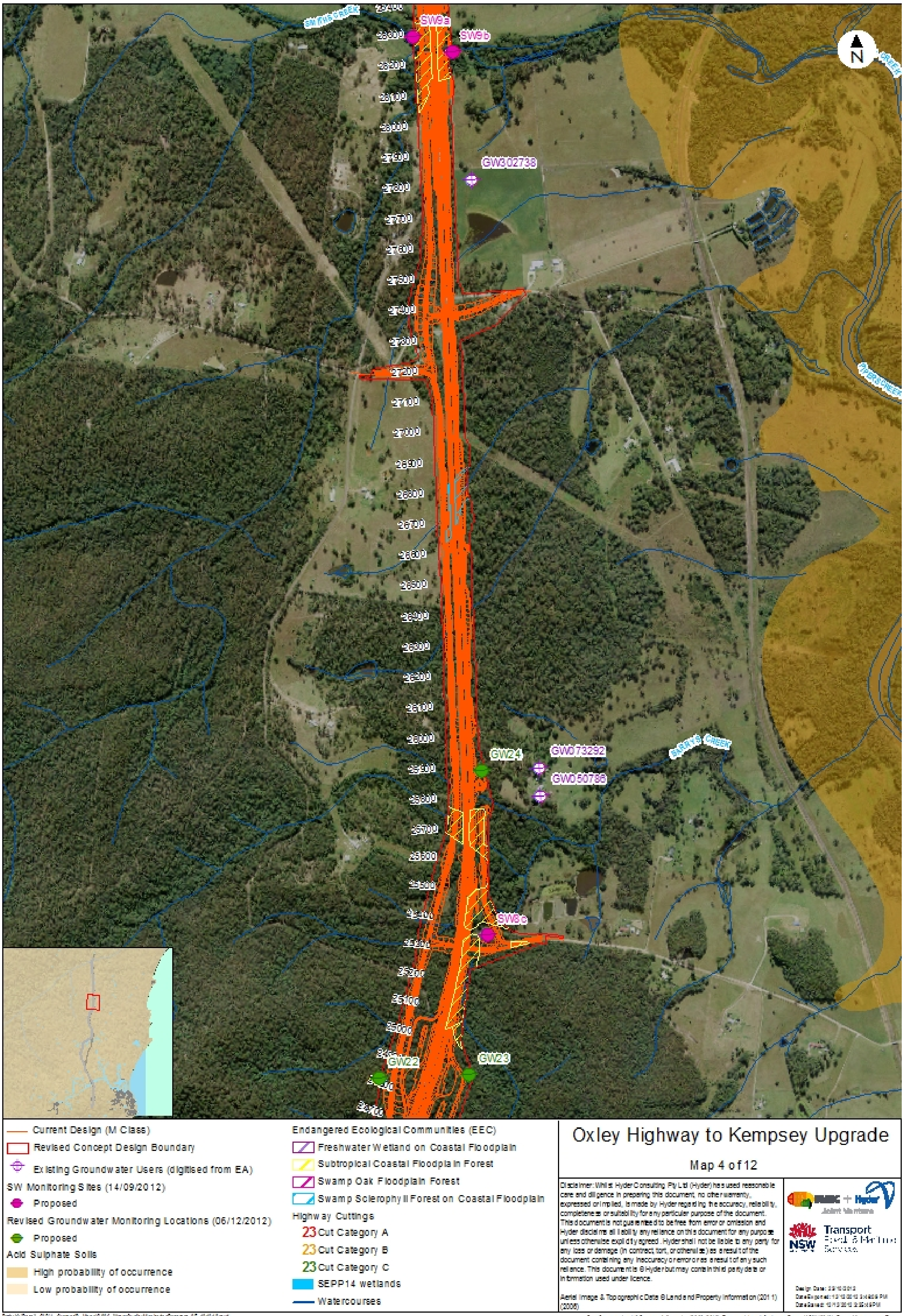


Figure 5-9 – Surface and groundwater monitoring locations

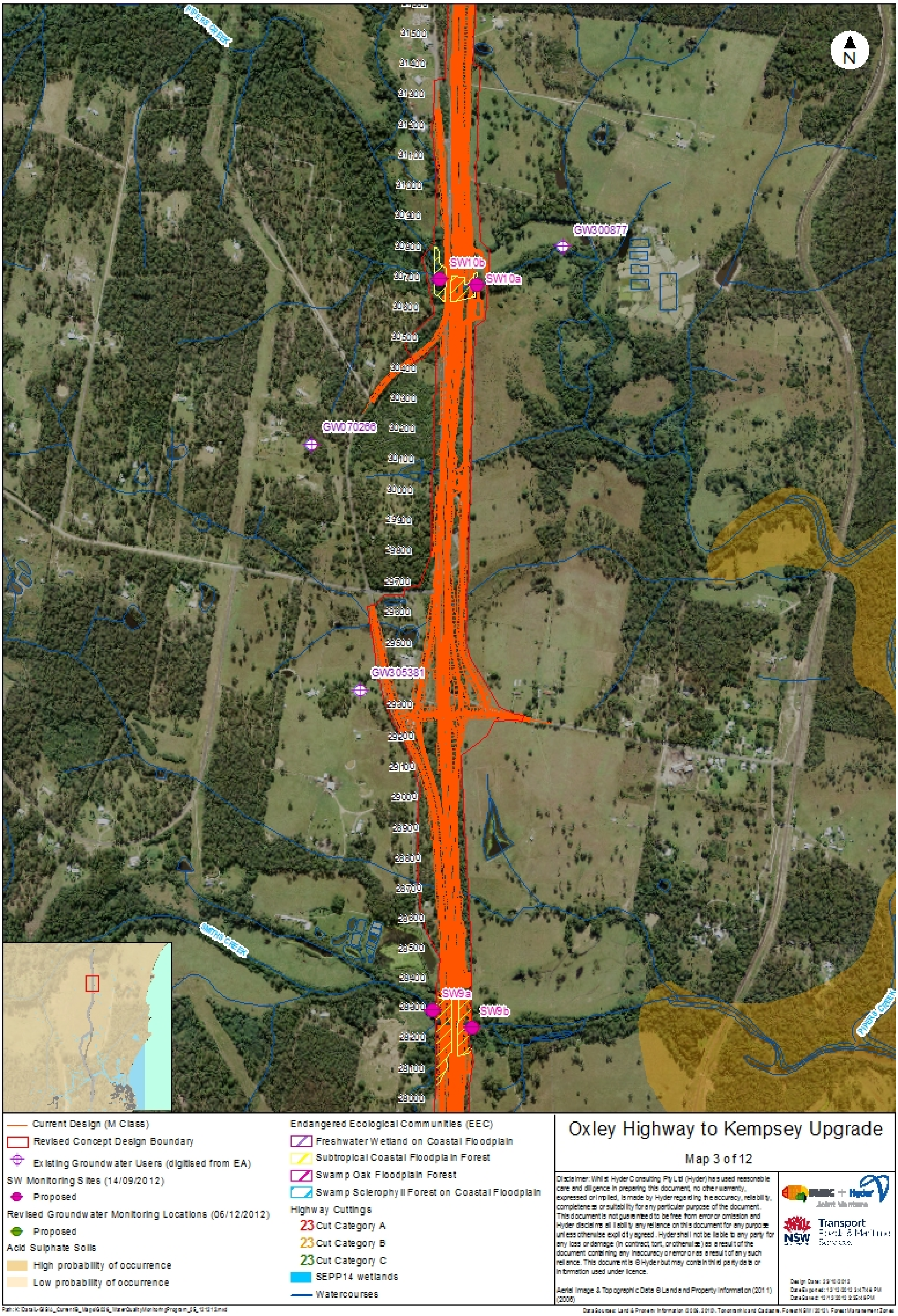


Figure 5-10 – Surface and groundwater monitoring locations

Figure 5-11 – Surface and groundwater monitoring locations

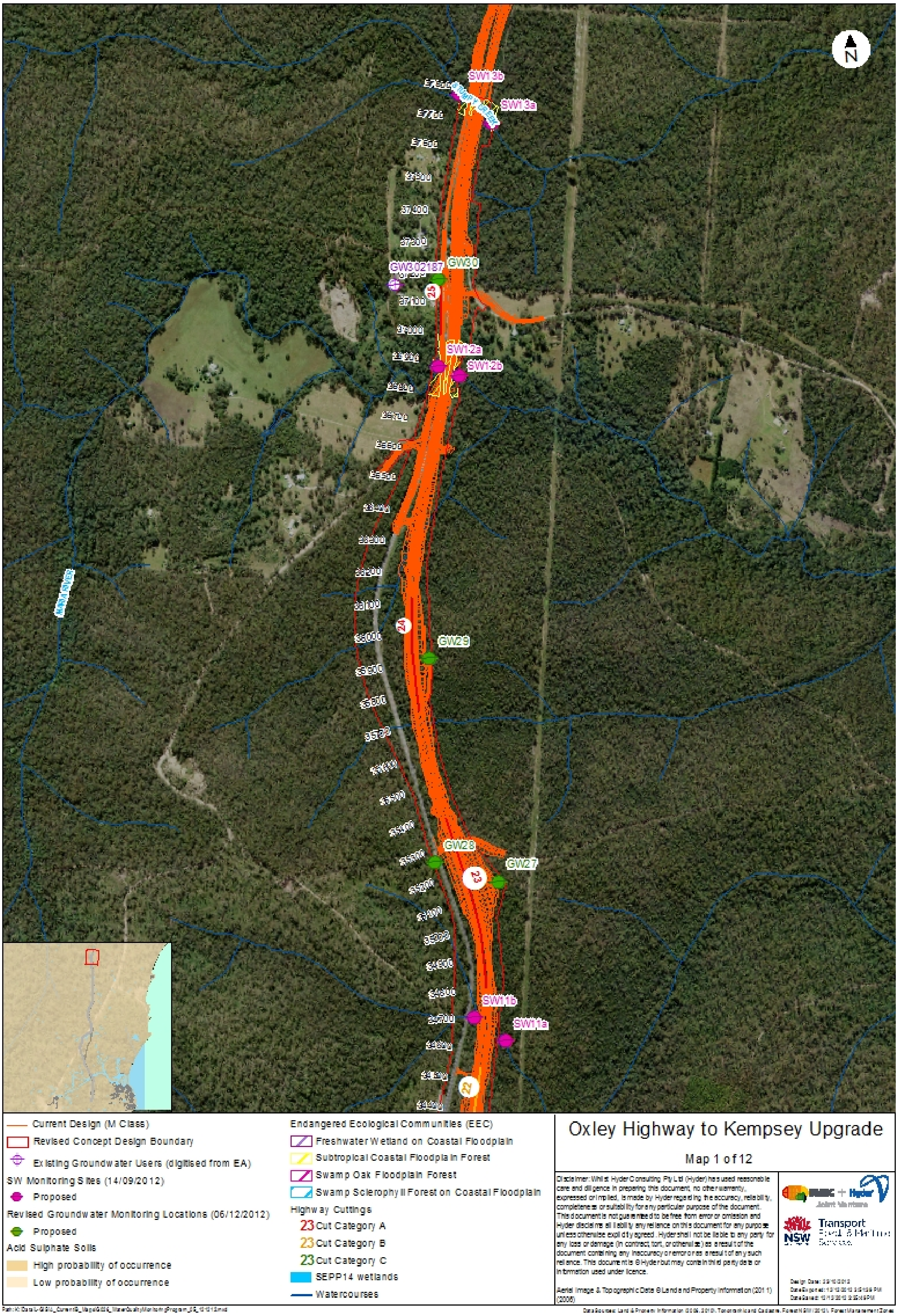


Figure 5-12 – Surface and groundwater monitoring locations

4.3 MONITORING PARAMETERS

The water quality monitoring parameters included in the WQMP have been chosen based on the:

- RMS *Guideline for Construction Water Quality Monitoring* (RTA undated).
- The *Australian guidelines for water quality monitoring and reporting* (ANZECC Monitoring Guidelines) (ANZECC/ARMCANZ 2000b).
- The parameters included in earlier monitoring programs within the region (e.g. by the Port Macquarie Hastings Council and by the Kempsey Bypass Alliance).
- For groundwater, the standard water quality parameters were selected from Appelo & Postma (1993), Driscoll (1989) and Sterrett (2007).

The physical parameters (i.e. pH and EC) and the major anions and cations are sampled in order to assess basic water characteristics as they are the major constituent of water and therefore indicate the quality. Changes in quality resulting from exposure of acid soils or rock would be evident from a change in the major anion and cation ratios. For example, changes to the sulphate, chloride or sodium levels may be observed without a change significant change in pH to indicate the presence/exposure of acid soils or acid rock. Nutrients provide an indication of contamination from organics sources and TPH is an indicator for pollution from hydrocarbons e.g. oils and greases. The metals provided are the most common trace constituents of water and generally form a standard metals analysis suite. They provide an indicator for changes over time, particularly in areas with acid sulphate rock. The Project is not expected to influence faecal coliform counts and therefore this parameter is not included in the monitoring program.

Should monitoring observations at particular sites confirm that no significant water quality impacts are occurring (i.e. water quality is consistently below the trigger values outlined in Section 5 for a minimum period of 3 months), then some parameters may be removed from the monitoring program at those locations (or they may be sampled less frequently).

If individual parameters or sites are to be withdrawn from the program it should be demonstrated that there is no longer an impact over a minimum period of 3 months and that the corresponding construction site catchment is adequately stabilised and permanent works effectively completed. Consultation with the EPA, DPI (Fishing and Aquaculture) and NOW would be undertaken for proposed alterations to the monitoring program (parameters/sites/frequency).

Table 14 outlines the monitoring parameters, the analysis location (i.e. in-field/laboratory), and whether they apply to surface water or groundwater monitoring.

Table 14 – Water quality monitoring parameters

Parameter type	Surface water (SW) or groundwater (GW) monitoring	Parameter	Analysis type
Chemical properties	SW and GW	pH	In field measurement
	SW	Dissolved oxygen (DO)	In field measurement
Physical properties	SW	Electrical conductivity (EC)	In field measurement
	GW	Electrical conductivity (EC)	In field measurement and laboratory analysis
	SW and GW	Temperature	In field measurement
	SW	Turbidity (NTU)	In field measurement

Parameter type	Surface water (SW) or groundwater (GW) monitoring	Parameter	Analysis type
	SW	Total suspended solids (TSS)*	Laboratory analysis
Chemical properties	SW and GW	Total Petroleum Hydrocarbons	In field visual assessment. If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis.
	SW and GW	Trace metals: Aluminium (Al) Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Manganese (Mn) Mercury (Hg) Nickel (Ni) Silver (Ag) Zinc (Zn)	Laboratory analysis
Nutrients	SW and GW	Total Nitrogen (TN)	Laboratory analysis
		Total Phosphorous (TP)	Laboratory analysis
Nutrients	GW only	Ammonia (NH_4) Phosphate (PO_4)	Laboratory analysis
Major Anions	GW only	Bicarbonate (HCO-) Chloride (Cl-) Nitrate (NO3-) Sulfate ($SO4^{2-}$)	Laboratory analysis
Major Cations	GW only	Calcium ($Ca^{2}+$) Magnesium ($Mg^{2}+$) Potassium (K+) Sodium (Na+)	Laboratory analysis
Groundwater levels	GW only	Groundwater levels	In field measurement

* A site-specific correlation between in-field NTU measurements and the laboratory derived TSS results should be established by comparing the results on a site specific basis during the pre-construction and construction phases. This enables a reduction in the frequency of TSS sampling in later project phases which will help reduce project costs.

4.3.1 RAINFALL RECORDS

Rainfall within the catchment can influence the surface and ground water quality detected through the monitoring program. Records of daily rainfall should be obtained from the following stations to enable interpretation of any rainfall influence as required:

- Kempsey (Wide Street) (station number 059017) for the northern part of the Project.
- Telegraph Point (Farrawells Road) (station number 060031) for the middle section of the Project.
- Port Macquarie Airport AWS (station number 060139) for the southern part of the Project.

During construction, the use of site established Automatic Weather Stations may supersede the need to rely on the above Bureau of Meteorology weather stations and would be considered to be more indicative of rainfall experienced on site. Reference to the where rainfall data was obtained will be provided in the reporting detailed in Section 5.2.

4.4 MONITORING DURATION

The monitoring program should run for a minimum of twelve months prior to the commencement of construction (unless otherwise agreed by the Director General) and will continue throughout the construction phase.

The program will run for a minimum period of three years following the completion of construction (or until any affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition).

4.5 SAMPLING FREQUENCY

The proposed sampling frequencies for surface water and groundwater differ because surface water monitoring must consider rainfall events whereas groundwater monitoring can be undertaken at any time. The sampling frequencies for surface water and groundwater are outlined in Table 15 and Table 16 respectively.

4.5.1 SURFACE WATER SAMPLING FREQUENCY

The frequency of surface water sampling has been designed in line with the RMS *Guideline for Construction Water Quality Monitoring* (RTA undated) and includes sampling following “wet events” when water quality impacts from the project are likely to be most evident (for example, due to erosion and sediment loss). A wet event is when 10 millimetres of rain has fallen within a 24 hour period and sampling must occur within 24 hours of this rainfall event.

The sampling frequency has been designed to ensure a comprehensive set of baseline data is established during the pre-construction period. During the construction and operational phases, if repeated results demonstrate that the site or parts of the site have stabilised, sampling parameters, frequencies and locations should be reviewed in order to reduce or discontinue monitoring (RTA undated: 9).

If sampling frequencies are to be reduced, or individual parameters or sites are to be withdrawn from the program, it should be demonstrated that there is no longer an impact over a minimum period of 3 months and that the corresponding construction site catchment is adequately stabilised and permanent works effectively completed (RTA undated: 10).

Any proposed alteration to the sampling frequency would be undertaken in consultation with the EPA, DPI (Fishing and Aquaculture) and NOW.

Table 15 – Surface water sampling frequency

Project phase	Frequency
Pre-construction	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter

Project phase	Frequency
Construction*	All parameters except trace metals: two wet events per month and one dry event per month Trace metals: one wet event and one dry event per month
Operations*	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter

* In this phase of the project, turbidity measurements (NTU) may be substituted for TSS analysis provided a correlation has been established between the two parameters on a site specific basis.

4.5.2 GROUNDWATER SAMPLING FREQUENCY

The groundwater sampling frequency is outlined in Table 16. As noted in Section 4.2, groundwater monitoring at Category B cuts is aimed at confirming they are moderate-risk (as opposed to high-risk) sites. Should monitoring observations from these sites, or other, groundwater monitoring sites confirm that no significant water quality impacts are occurring, the frequency of monitoring at these locations may be reduced or discontinued during the construction or operational phase of the project.

If sampling frequencies are to be reduced, or individual parameters or sites are to be withdrawn from the program, it should be demonstrated that there is no longer an impact over a minimum period of 3 months and that the corresponding construction site catchment is adequately stabilised and permanent works effectively completed, or as otherwise detailed in Table 16(RTA undated: 10).

Any proposed alteration to the sampling frequency would be undertaken in consultation with the EPA, DPI (Fishing and Aquaculture) and NOW.

Table 16 - Groundwater sampling frequency

Project phase	Parameters	Frequency
Pre-construction	In-field parameters	Monthly.
	Laboratory parameters	Minimum 2 samples to be taken during the pre-construction period.
Construction	In-field parameters	Monthly. Manual water level measurements can reduce to every two months where a groundwater level logger is present.
	Anions, cations, ammonia and phosphate	Once in the first quarter then annually.
	All other laboratory parameters	Monthly for the first 3 months, then if no impact detected (between pre-construction and construction phase monitoring) then reduce to quarterly. Reinstate to monthly if trigger values are breached.
Operations	In-field parameters	Quarterly.
	Anions, cations, ammonia and phosphate	Annually.

Project phase	Parameters	Frequency
	Laboratory Analysis	Quarterly for the first year then reduce to once every six months. Reinstate to quarterly if trigger values are breached.

4.6 FIELD MEASUREMENTS AND OBSERVATIONS

4.6.1 FIELD MEASUREMENTS

Electrical conductivity, turbidity (NTU), temperature, pH and dissolved oxygen should be measured in-field because the value of the parameter can change after collection.

All in-filed monitoring equipment should be calibrated once per year by a NATA accredited laboratory. At the start of each day of monitoring appropriately trained water quality monitoring personnel shall calibrate in field equipment according to the manufactures instructions.

An appropriate calibration solution is to be used and a record of calibration kept on file. To avoid contamination, the measurements of each parameter should be undertaken on a separate water sub-sample.

Groundwater level measurements
The standing groundwater level is to be measured manually using an electronic dip meter prior to any purging or sampling and at the time of any logger downloads. The measurement is to be read from the same surveyed reference point on the PVC casing to be related back to metres Australian Height Datum (mAHD). Recorded groundwater levels should be tabulated in both metres below measuring point (mBMP) and mAHD for reference and to assist in early identification of issues.

The total depth of the borehole should be measured periodically to ensure there has not been a build-up of fines in the slotted screen interval. Groundwater monitoring piezometers should be constructed with a sump at the base.

If a pressure transducer logger is present the logger should be downloaded in accordance with the manufactures guidelines after the groundwater level has been measured and returned carefully to the piezometers. It is important to ensure the logger is located in the groundwater column at a depth below expected natural fluctuations (or near the base of the piezometer but within the range of the logging device) and the hanger cable is not tangled or damaged. The cable should also be non-stretch and of braided construction to avoid unwinding.

Tidal influences
The surface and groundwater monitoring locations identified for the Hastings and Wilson Rivers are tidally influenced. The tidal influences extend at least 6 kilometres upstream of the highway crossing in the Wilson River and 12 kilometres upstream of the highway crossing in the Hastings River. To avoid capturing tidal-based variations in water quality, and ensure that the data is comparable between different sampling events, field measurements should be undertaken on a falling tide as close to low tide as possible (where practicable).

4.6.2 FIELD OBSERVATIONS

Field record sheets should capture the following information at each sample site:

- On the first sampling event, the site should be recorded with a GPS and a detailed description of the exact position of each sampling site should be recorded along with the site reference number so that it can be re-visited in subsequent sampling rounds to ensure consistency of data. It is important to use a single coordinate system and to record which coordinate system is used, especially the datum and projection.
- The site number.
- The date and time when samples are taken.
- The name of the person who is taking the sample
- Detailed description of sample.
- Weather conditions.
- Tidal cycle at the Hastings and Wilson Rivers.
- Visual observations of oil / grease in the water.
- Odours
- Any other observations on site conditions that may assist in interpretation of the data.
- Photographic records to be taken at the site during the first sampling event.
- The water depth where samples are collected in shallow water bodies (i.e. less than 250 millimetres).
- Whether the waterbody was moving or still (e.g. in low flow periods only ‘pools’ of water may be available for sampling).

4.7 REPLICATE SAMPLES

Replicate samples are two or more samples collected simultaneously to establish the reproducibility of sampling (ANZECC/ARMCANZ 2000b: 4-16). It is recommended that one blind replicate water sample should be collected for every 20 samples.

4.8 SAMPLING PROTOCOL

The sampling protocols outlined in this section follow the *Australian guidelines for water quality monitoring and reporting* (ANZECC/ARMCANZ 2000b).

4.8.1 SAMPLE COLLECTION

Samples should be collected by methods that obtain a representative water sample and avoid contamination. Where possible, samples should be collected from moving water. Surface water samples should be collected by immersing a sample bottle just below the surface at a depth of approximately 250 to 500 millimetres. In shallow water bodies (i.e. less than 250 millimetres deep) a sample should still be taken however the depth of water should be noted on the field record sheet. Except when sampling for oils and grease, contribution from surface films should be avoided. In some locations the terrain will not permit the sampler to get in reaching distance of the water. At these sites an extension pole will need to be used to reach the water.

The sampling methods employed for both surface and groundwater measurements should observe the following requirements:

- In-filed monitoring equipment should be calibrated once per year by a NATA accredited laboratory and then monthly by appropriately trained water quality monitoring personnel (a calibration record must be kept).
- Use of disposable gloves.

- Field measurements to be made on separate sub-samples of water - each volume of water removed should be kept separate and measured.
- Containers and field equipment must be cleaned before use.
- Sample bottles suitable for each parameter must be used (use of containers supplied by the analytical laboratory is recommended).
- The volumes of water taken should be small and disposal of excess sample water is to be onsite, downhill and way from the relevant stream, river or piezometer.
- Rinse the collection container and field equipment between locations with clean (i.e. non-borehole/river) water.
- Sample bottles are labelled with the date and time and filled according to laboratory instructions (e.g. no headspace for TPH).
- Samples are to be kept chilled whilst in transit to a NATA approved laboratory within holding periods and under chain of custody protocols.
- Sampling staff should be trained and use standard techniques to avoid contamination when handling sample containers (e.g. avoid touching the sample and the insides of caps or containers).
- for groundwater samples:
  - Stabilisation of key indicators (pH, EC), after a period of bailing or pumping before sampling, with readings within 10% for 3 consecutive readings.
  - Recording of the key field indicators and estimation of the volume of groundwater removed.

4.8.2 CHAIN OF CUSTODY INFORMATION

At all points in the sampling process (e.g. in-field, during transport and during laboratory analysis) chain of custody information must be recorded. This enables tracing of any errors during the sampling process and improvement of future protocols where problems are identified.

Table 17 outlines the information that needs to be captured at each point in the monitoring and analysis process.

Table 17 - **Chain of custody information**

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: ANZECC ARMCANZ (2000b:4-14)

To ensure clear identification of all samples in the laboratory, all sample containers must be indicated in a clear and lasting manner. Blind samples should be submitted to the laboratory as individual samples without any indication of which sample they replicate or that it is a replicate.

4.8.3 SAMPLE PRESERVATION

It is usually necessary to preserve water samples to retard chemical and physical changes that can occur after the sample has been removed from the water source (ANZECC/ARMCANZ 200b). The time between sampling and analysis should be minimised wherever possible. Ideally, the samples should be cooled to 4°C and stored in an esky or vehicle refrigerator for delivery to the laboratory.

Laboratory staff should be consulted for advice on the most suitable sample preservation methods, including the selection of appropriate containers and the need for addition of any sample preservatives at time of collection.

4.9 LABORATORY ANALYSIS

The laboratories selected for the monitoring program must be accredited by the National Association of Testing Authorities (NATA).

5 DATA ANALYSIS AND REPORTING

5.1 DATA ANALYSIS

5.1.1 PRE-CONSTRUCTION MONITORING DATA

The pre-construction monitoring data will be analysed to provide an indication of baseline water quality and groundwater levels. The analysis will identify any existing variation in water quality and groundwater levels at each site and (where relevant) between the upstream / upgradient and downstream / downgradient sampling sites at each monitoring location. The existing variation will then be incorporated into the analysis of the construction and operational stage monitoring results to ensure it is not misinterpreted as an impact from the Project.

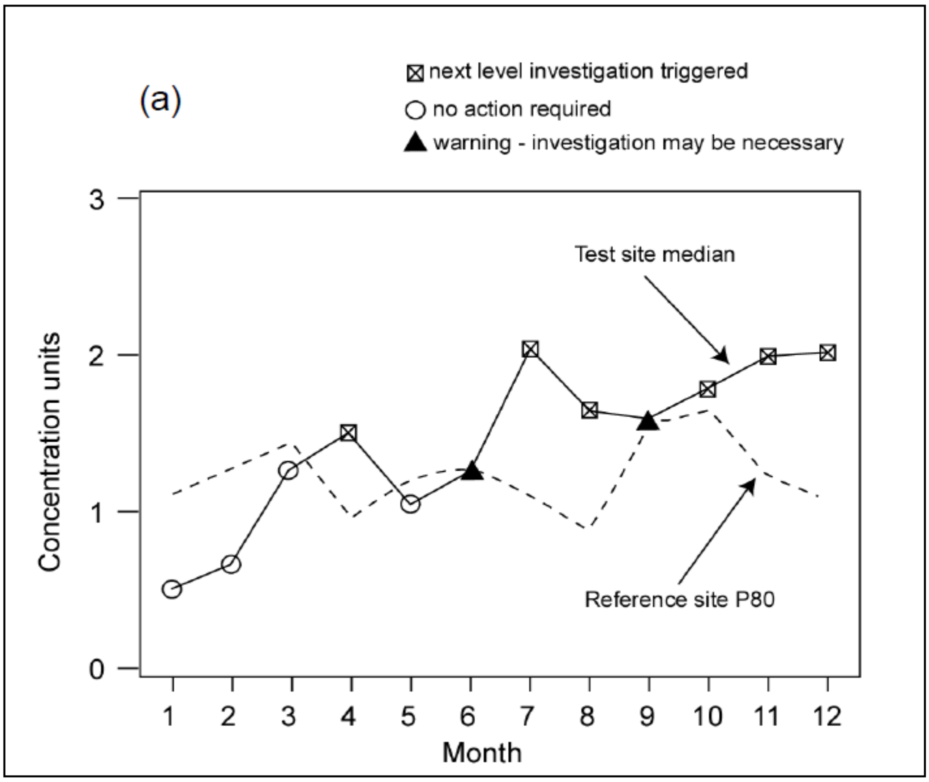
5.1.2 TRIGGER VALUES AND COMPARISON OF SAMPLING DATA

Analysis of surface water monitoring results will be on a comparative basis between the upstream and downstream monitoring sites. The 80^{th} percentile values of the upstream (reference) site are to be used as the trigger value and compared with the median values of the downstream (test) site. Where the median value of the downstream site is *above* the 80^{th} percentile value of the upstream site, the trigger value is considered breached and a review of management actions is required (ANZECC/ARMCANZ 2000b:6-17).

Where low values are the concern, the 20^{th} percentile values of the upstream site will be compared with the median values of the downstream site. Where median values at the downstream site are *below* the 20^{th} percentile value, the trigger value has been breached and a review of management actions is required (refer to Section 6). Where both low and high values of a particular value are of concern (e.g. pH), both the 80^{th} and 20^{th} percentile values of the upstream site can be compared with the median values of the downstream site (ANZECC/ARMCANZ 2000b:6-17).

The results of the analysis can be graphed in a control chart to provide a visual aid for sample analysis as shown in Figure 6.

For groundwater sites where only one borehole is monitored, the comparison will be between the 80^{th} or 20^{th} percentile values collected during the pre-construction monitoring phase and the median values collected during the construction and operational phases.



Source: ANZECC/ARMCANZ 2000b: 6-19.

Figure 6 – Comparison of sampling data with trigger values

5.2 REPORTING

5.2.1 REPORTING SCHEDULE

Reporting will be required during the WQMP to convey the findings of the program and ensure that project management is responsive to the water quality monitoring results. As required by Condition of Approval B17, reporting will include provision of the monitoring results to the Department of Planning and Infrastructure (DP&I), DPI (Fishing and Aquaculture), EPA and NOW.

The proposed reporting schedule outlined in Table 18 is based on the reporting requirements outlined in the *Australian Guidelines for Water Quality Monitoring and Reporting* (2000b). A detailed report format is outlined in Section 5.2.2.

Surface and groundwater monitoring results will ideally be presented in combined reports. However, if the surface and groundwater results are being reported separately (e.g. if the monitoring is being undertaken by separate organisations), it will be important to conduct a combined review of the results to assess any apparent or potential surface water / groundwater interactions that indicate the need for alterations to the monitoring program or water quality management measures.

5.2.2 DETAILED REPORT FORMAT

All reports, other than the monthly updates, will follow the format prescribed in the *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC 2000b) and will generally include:

- *“An **executive summary** that expresses the technical findings in relation to the objectives, succinctly and in words that are understandable by managers unfamiliar with technical detail;*
- *an **introduction**, outlining previous studies in the area or related studies, and delineating the study objectives;*
- ***experimental detail**, describing the study location and study design, including descriptions of methods of sampling and analysis;*
- ***results** - descriptive and detailed presentation of results, sometimes in combination with the discussion section;*
- ***discussion** of the results including data interpretation and implications for management;*
- ***conclusions** drawn from the results;*
- ***recommendations** for future work* [including improvement of water quality management measures and justification of any reduction or discontinuation of monitoring]*;*
- ***reference details** for literature cited in the report;*
- ***appendices**, providing laboratory reports, data tables or other information that is too detailed or distracting to be included in the main body of the report*” (emphasis added) (ANZECC 2000b: 7-2).

Table 18 – WQMP proposed reporting schedule

Project phase	Report timing	Report requirements	Recipients
Pre-construction.	Monthly.	Raw water quality and groundwater level monitoring results from the preceding month. A brief analysis of variation between upstream and downstream water quality at individual surface water monitoring locations (and groundwater locations where relevant) to establish any existing variation between these sites.	RMS
	At completion of the pre-construction phase.	A detailed report on all WQMP results obtained during the pre-construction monitoring period (see "Detailed Report Format"). This report should establish baseline records of water quality and groundwater levels at each monitoring location.	RMS, relevant construction contractor(s), DP&I, DPI (Fishing and Aquaculture), EPA and NOW.
Construction.	Monthly.	Raw water quality and groundwater level monitoring results from the preceding month presented in a brief report including discussion of whether the results indicate adverse impacts on water quality or groundwater levels and a need to improve the existing management measures.	RMS, the relevant construction contractor(s) and presented at Environmental Review Group meetings.
	Six monthly.	A detailed report on all WQMP results obtained during the previous 6 months of the construction monitoring period (see "Detailed Report Format") including discussion of whether the results indicate adverse impacts on water quality or groundwater levels and a need to improve the existing management measures.	RMS, the relevant construction contractor(s), DP&I, DPI (Fishing and Aquaculture), EPA and NOW.
	At completion of the construction phase.	A detailed report on all WQMP results obtained during the construction monitoring period (see "Detailed Report Format"). This report should also provide advice regarding ongoing monitoring (and management) of water quality impacts and groundwater levels during the operational phase of the project.	RMS, the relevant construction contractor(s), DP&I, DPI (Fishing and Aquaculture), EPA and NOW.
Operation.	Six-monthly.	Raw water quality and (where relevant) groundwater level monitoring results from the preceding six months presented in a brief report including discussion of whether the results indicate a need to improve the permanent water quality management measures (e.g. sediment basins and site rehabilitation/stabilisation).	RMS

Project phase	Report timing	Report requirements	Recipients
	Annually.	A detailed report on all WQMP results obtained during the previous 12 months of the operational monitoring period (see “Detailed Report Format”) including discussion of whether the results indicate a need to improve the permanent water quality and (where relevant) groundwater level management measures (e.g. sediment basins and site rehabilitation/stabilisation).	RMS, DP&I, DPI (Fishing and Aquaculture), EPA and NOW.
	At completion of the 3 year operational monitoring period (or when the water resources are certified by an independent expert as being rehabilitated to an acceptable condition).	A final and detailed report on all WQMP results obtained during the operational monitoring period (see “Detailed Report Format”). This report should provide advice regarding the need for any further water quality monitoring and management.	RMS, DP&I, DPI (Fishing and Aquaculture), EPA and NOW.

6 MANAGEMENT ACTIONS

The WQMP will guide water quality monitoring during the pre-construction, construction and operational phases of the project. RMS will be responsible for facilitating the monitoring during each phase of the project and this document will form part of the Construction Environmental Management Plan.

Where adverse water quality impacts are identified in the monthly monitoring reports, the mitigation and management measures outlined in Section 2.6 and 2.7 (as well as in the CEMP and SWMP) must be reviewed and adjusted to ameliorate the identified impacts. Where required, identified impacts would be recorded as environmental incidents in accordance with RMS's Environmental Incident Classification and Reporting Procedure. During the construction phase, the relevant construction contractor will be required to revise and implement the necessary management actions in consultation with RMS, EPA, DPI (Fishing and Aquaculture) and NOW.

During the operational phase of the project RMS will revise and implement, or arrange the revision and implementation of, the necessary management actions.

7 DOCUMENT REVIEW

This document will be reviewed on a yearly basis as part of the review of the Construction Environmental Management Plan. During the operational phase of the project, this document will be reviewed on an annual basis as part of the RMS environmental management systems.

8 CONSULTATION

8.1 REGULATORY AGENCIES

As required under Condition of Approval B17, this WQMP will be submitted to the Director General for approval six months prior to the commencement of construction of the Project, or as otherwise agreed by the Director General, and a copy shall be submitted to the EPA, DPI (Fishing and Aquaculture) and NOW prior to its implementation.

8.2 LANDHOLDERS

The selection of monitoring locations has aimed to place monitoring sites within the Project boundary (and/or on RMS land), however, some monitoring sites fall outside of this area on private land. Consultation will be undertaken with private landholders to arrange access to both the surface water and groundwater monitoring sites for the duration of the pre-construction, construction and operational monitoring periods.

9 REFERENCES

ANZECC/ARMCANZ, 1995, *Guidelines for groundwater protection in Australia*. Australian and New Zealand Environment and Conservation Council (ANZECC) and the 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) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), accessed online, 28 July 2012, at http://www.environment.gov.au/water/publications/quality/nwqms-guidelines-4-vol1.html.

ANZECC/ARMCANZ, 2000b, *Australian Guidelines for Water Quality Monitoring and Reporting*, Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), accessed online, 28 July 2012, at http://www.environment.gov.au/water/publications/quality/pubs/nwqms-monitoring-reporting.pdf.

Appelo, C.A.J., and Postma, D. 1993, *Geochemistry, groundwater and pollutions*, A.A. Balkema, Rotterdam, Brookfield.

Department of Land and Water Conservation 1997, *NSW State Groundwater Policy*, NSW, Australia.

Driscoll, F.G. 1989, *Groundwater and Wells*, second edition, Johnson Filtration Systems, St Paul, Minnesota.

GHD 2010, *Oxley Highway to Kempsey - Upgrading the Pacific Highway, Environmental Assessment*, September 2010.

SHJV 2012, *Groundwater Review*, document reference number FCONGEO-0006-OH2K-R-02, SMEC-Hyder Joint Venture.

SHJV 2013, *Oxley Highway to Kempsey - Road Cutting Groundwater Modelling*, document reference number REPORT NO. FCONGEO-0006-OH2K-R-01, September 2013, SMEC-Hyder Joint Venture.

Kempsey Bypass Alliance 2012, *Monthly Surface Water Quality Monitoring Spreadsheet,* (unpublished), supplied by RMS, August 2012.

NSW Government 2006, *NSW Water Quality and River Flow Objectives*, accessed online, 8 July 2012, at http://www.environment.nsw.gov.au/ieo/index.htm (page last updated 28 June 2006 page last updated 28 June 2006).

RTA, no date, *RTA Water Policy*, Roads and Traffic Authority (RTA), accessed online, 3 August 2012, at http://www.rta.nsw.gov.au/environment/downloads/wpolicy.pdf.

RTA, 1999, *Code of Practice for Water Management: Road Development and Management,* Roads and Traffic Authority (RTA), April 1999, accessed online, 3 August 2012, at http://www.rta.nsw.gov.au/environment/downloads/wcop1.pdf.

RTA, no date, *Guideline for Construction Water Quality Monitoring,* Roads and Traffic Authority (RTA), accessed online, 27 July 2012, at http://www.rta.nsw.gov.au/environment/downloads/constrwaterqualmonit_dl1.html.

Sterrett R.J., 2007, *Groundwater and Wells*, third edition, Johnson Screens, A Weatherford Company, Lithotech, Bloomington Mn.

10 APPENDIX A – FIELD RECORD SHEET

OH2K Water Quality Monitoring Program – Field Record Sheet

General notes:
On the first sampling event, the site should be recorded with a GPS and a detailed description of the exact position of each sampling site should be recorded along with the site reference number so that it can be re-visited in subsequent sampling rounds to ensure consistency of data. It is important to use a single coordinate system and to record which coordinate system is used, especially the datum and projection. Photographic records of the site should also be collected during the first sampling event to provide a visual aid for locating the site for future sampling.

Site reference number: (e.g. SW1a / GW1) __________

Waterway name (if applicable)**:**

____

Name of person who collected sample:

____

Date: ____

Time:Start:________________**Finish:**_______________

Tidal cycle at the Hastings and Wilson Rivers (please circle):

Low tide / high tide / incoming / outgoing_____________

Weather conditions:
(e.g. wind, wind direction, cloud cover, air temperature)

____

____

____

____

Detailed sample description including:

- **Visual observations of oil / grease in the water** (please circle):

  Yes / No

- **Odours present** (please circle. If yes, describe below)**:**

  Yes / No

____

____

____

- **Any other observations on site conditions that may assist in interpretation of the data (please provide below).**
- **Water depth where samples are collected:**

____

- **Was waterbody moving or still** (please circle):

  Moving / Still

Other comments / observations:

(e.g. colour and appearance of water, water flow, presence of organisms (e.g. macrophytes, phytoplankton etc.), presence of floating debris or froth)____

____

Signature:____

Field measurements:

Parameter	Analysis location	Measurement required for: surface water (SW) or groundwater (GW) monitoring	Unit of measurement	Result
pH	In field measurement	SW and GW	Scale 0 to 14	
Dissolved oxygen	In field measurement	SW	Per cent saturation	%
Electrical conductivity	In field measurement	SW and GW	Microsiemens per centimetre	mS/cm
Temperature	In field measurement	SW and GW	°C	°C
Total petroleum hydrocarbons	In field visual assessment. If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis.	SW and GW	N/A – to be sent to lab for measurement	Please circle: Oil/grease observed Oil/grease **not** observed
Turbidity	In field measurement	SW	NTUs	
Groundwater levels	In field measurement	GW only	mAHD*	mAHD
			mBMP*	mBMP

*mAHD = metres Australian Height Datum.

*mBMP = metres below measuring point

Laboratory sample details:

Parameter	Container material	Volume Collected	Preservation	Quality Control
Total suspended solids (TSS)*				
Total Petroleum Hydrocarbons (if oil and grease visually detected)				
Aluminium (Al)				
Arsenic (As)				
Cadmium (Cd)				
Chromium (Cr)				
Copper (Cu)				
Iron (Fe)				
Lead (Pb)				
Manganese (Mn)				
Mercury (Hg)				
Nickel (Ni)				
Silver (Ag)				
Zinc (Zn)				
Total Nitrogen (TN)				
Total Phosphorous (TP)				
Ammonia (NH_4)				
Phosphate (PO_4)				
Bicarbonate (HCO-)				
Chloride (Cl-)				
Nitrate (NO3-)				
Sulfate ($SO4^{2-}$)				
Calcium ($Ca^{2}+$)				
Magnesium ($Mg^{2}+$)				
Potassium (K+)				
Sodium (Na+)				

Quality control remarks: