GREAT WESTERN HIGHWAY UPGRADE,
MOUNT VICTORIA TO LITHGOW ALLIANCE

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FORTY BENDS UPGRADE – REVIEW OF ENVIRONMENTAL FACTORS

TECHNICAL PAPER 6

WATER QUALITY

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NSW GOVERNMENT Transport Roads & Maritime Services

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Contents

Executive Summary

1. Introduction 1

1.1. Background 1
1.2. Proposal description 1
1.3. Proposal site 4
1.4. Purpose of this study 4

2. Policy Setting 7

2.1. Statutory requirements 7
2.2. Water quality guidelines 8
2.3. Water quality objectives 10
2.4. The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 12

3. Existing environment 13

3.1. Surface water context 13
3.2. Environmental values 13
3.3. Existing water quality data 14
3.3.1. Soil erodibility 15
3.4. Sensitivity of receiving environments 15

4. Potential water quality impacts 17

4.1. Construction phase impacts 17
4.1.1. Surface water quality 18
4.1.2. Drinking water catchment 18
4.1.3. Soil erodibility 18
4.1.4. Works within or adjacent to waterways 19
4.1.5. Existing dams 20
4.1.6. Large excavations and fills 21
4.1.7. Acid sulfate soils and acid sulfate rock 21
4.1.8. Stockpiles 22
4.1.9. Site compounds 23
4.2. Operational phase impacts 24
4.2.1. Surface water quality 24
4.2.2. Accidental spills 25
4.2.3. Drinking water catchment and NorBE 26

5. Safeguards and management measures 27

5.1. Construction phase 27
5.1.1. Procedural controls 28
5.1.2. Site management erosion controls 29
5.1.3. Physical controls 30

5.1.4. Monitoring 31
5.1.5. Specific mitigation measures 31
Soil erodibility 31
Works within or adjacent to waterways 31
Existing farm dams 31
Acid sulfate soils and acid sulfate rock 32
Stockpiles 32
Site compounds 33
Spills 34
5.2. Operational phase 34
5.2.1. Physical water quality controls 35
5.2.2. Procedural water quality controls 36
5.2.3. Monitoring 36
6. Design methodology 37
6.1. Locating construction phase sediment basins 37
6.2. Sizing construction phase sediment basins 37
6.3. Sizing operational phase water quality controls 40
7. Further Assessment 43
7.1. Next Steps 44
8. References 45
Appendix A Sydney Catchment Authority drinking water catchment 51
Appendix B Impact and environmental safeguards matrix 53
Appendix C Standard water quality management measures 61
C.1 Construction phase 61
C.1.1 Erosion and sediment controls 61
Sediment basins 61
Catch and diversion drains 66
Check dams 66
Level spreader 66
Sediment fencing and filters 67
C.1.2 Management and maintenance 67
C.2 Operational phase 68
C.2.1 Water quality ponds 68
C.2.2 Accidental spill containment 69
C.2.3 Grassed swales 70
C.2.4 Constructed Wetlands 72
C.2.5 Biofiltration Basins 72
C.2.6 Biofiltration swales 74
Appendix D Sediment basins and water quality ponds 75
Appendix E Examples of typical water quality controls 77

Appendix F Soil test results 83

Appendix G NorBE Assessment 89

G.1 Qualitative assessment 89
G.2 Quantitative assessment on an example catchment 101
G.3 NorBE conclusions 102

Appendix H Existing and proposed transverse drainage catchments 105

Executive Summary

The Water Quality Technical Paper has been prepared as part of the concept design to identify the potential impacts on water quality associated with the construction and operation of the Forty Bends Upgrade, and to outline the environmental safeguards required to minimise the likelihood of these impacts occurring.

A list of the statutory requirements and guidelines for water quality management during the construction phase and the operational phase of the highway upgrade is included in this report**.** The requirements of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 are also discussed- whereby a proposed development within the Sydney Catchment Authority (SCA) drinking water catchment must have a neutral or beneficial effect on water quality (NorBE).

This report describes the existing surface water conditions of the Forty Bends area. Runoff from the highway upgrade flows to the Sydney drinking water catchment and as such, discussions with the Sydney Catchment Authority have confirmed that all waterways within the upgrade area are considered to be sensitive waterways.

The report details the potential impacts of construction on the water quality in the area, including impacts on surface water quality, on the drinking water catchment and the impacts of soil erodibility on downstream watercourses as a result of working in waterways, constructing large excavations and embankments, stockpiles and the site compound. Safeguards against these include procedural controls, such as the development of a Soil and Water Management Plan (SWMP) and Erosion and Sediment Controls Plans (ESCP), sequencing controls, such as limiting the extent and duration of exposed topsoil, physical controls, such as onsite sediment basins, and water quality monitoring.

Accidental spills, contaminated atmospheric deposition and vehicle pollutants could be washed off the impervious surfaces of the highway during operation and impact on downstream watercourses. Treatment trains would be designed to minimise the likelihood of this occurring, and involve water quality ponds and, where feasible, grassed swales. Biofiltration swale and dry basins are also being considered.

The water quality objectives, design criteria and design methodology are set out within this report. A unit rate approach has been used to estimate sediment basin and water quality pond volumes based on catchment areas and other factors. A list of basins with estimates of the size and location of the basins is included in **Appendix D**.

The management of potential water quality impacts would be further developed following comments received from the public and the stakeholder agency consultation process. Detailed erosion and sediment control plans and operational stormwater management strategies would be developed during detailed design. During the development of the detailed design, the sizes, locations and footprints of the proposed sediment control basins and water quality ponds would be reviewed and updated.

1. Introduction

1.1. Background

The Great Western Highway upgrade is part of the NSW and Australian Governments' commitment to improve road safety and accessibility to communities in the Blue Mountains and central west region of NSW. Investigations for the upgrade started in May 2008 to determine the preferred route corridor for the project which was announced in May 2010.The Forty Bends upgrade (the Proposal) is progressing to detailed design and construction. This report assesses the potential water quality impacts of the proposed Forty Bends upgrade as part of the Review of Environmental Factors (REF) for the proposal.

1.2. Proposal description

Roads and Maritime Services (RMS) proposes to upgrade and widen about 2.8 kilometres of the Great Western Highway at Forty Bends to three lanes with a central median along the majority of its length. The proposed upgrade extends from a point about 470 metres east of the eastern end of Forty Bends Road to a point about 250 metres west of McKanes Falls Road (the proposal).

The proposal forms part of a series of ongoing upgrades of the Great Western Highway. The Great Western Highway is the main road link between Sydney and Lithgow and beyond to the Central West of New South Wales. The Great Western Highway serves as:

- A key freight route between Sydney and the central west of NSW, including the timber industry in the Oberon area.
- A tourist route with destinations including the Blue Mountains, historic Hartley, Jenolan Caves, Mudgee and Bathurst.
- A connection between the many towns and villages along its length.

The proposal is needed to improve the road safety and traffic capacity along this section of road and would be consistent with other road improvement activities along the Great Western Highway. The existing alignment has a limited number of opportunities for passing.

Key features of the proposal are:

- The proposal has been developed based on the concept design that has been prepared using the available information and current design standards and criteria for the Great Western Highway upgrade program. Some elements of the design may be further refined during detailed design. The key elements of the Construction of a new road alignment consisting of generally three lanes with two lanes eastbound to the east of Whites Creek and two lanes westbound to the west of Whites Creek. Lane widths would be 3.5 metres with shoulder widths typically varying between 1.0 metres and 2.5 metres. The upgrade alignment would diverge up to 40 metres south of the existing Great Western Highway in the vicinity of Whites Creek.
- The design speed for the alignment would be 100 kilometres per hour east of McKanes Falls Road and 80 kilometres per hour west of McKanes Falls Road. The posted speed limit for the whole of the new highway alignment would be 80 kilometres per hour.
- Widening of the existing alignment predominantly to the south of the Great Western Highway. The total proposal footprint of the widening works would vary from about 40 metres to 90 metres.
- A central median along the length of the proposal of varying widths, ranging up to 9.5 metres. Carriageways would be separated by a combination of vegetated, depressed and paved medians.
- Construction of new twin, five-span bridges, about 150 metres in length across Whites Creek. The new bridges would comprise four lanes, each 3.5 metres in width, with two lanes carrying traffic in each direction. The total width of the two bridges would be about 30 metres. Shoulders on the bridges would be between 2.5 and 3.25 metres (off-side) and 1.0 metres on the near side.
- Rehabilitation works along the existing alignment of Whites Creek following the removal of the redundant section of the existing Highway. This would include creating a rehabilitated, natural creek bed in this location linking the existing alignment of Whites Creek prior to passing under the new Whites Creek bridge.
- Upgrades to four existing local road intersections, including two intersections with Forty Bends Road, Daintree Close and McKanes Falls Road, to provide connection to the upgraded highway and property access points. Upgrades would include minor widening and u-turn facilities located along the western end of Forty Bends Road and about 150 metres south of the intersection of the Great Western Highway and McKanes Falls Road.
- New or improved access from the existing highway to nine properties along the length of the proposal. The proposal includes provision of new or reconstructed driveways to retain existing property access.
- Closure and relocation of two intersections of Forty Bends Road with the Great Western Highway. These include:
    - Closure of the existing intersection at the eastern end of Forty Bends Road to general traffic (except for emergency vehicles) and a new cul-de-sac constructed on Forty Bends Road.
    - Relocation of the existing intersection at the western end of Forty Bends Road to a point about 200 metres west of the existing intersection.

- Five major cuts 14 metres to 19 metres in height located on the northern side of the proposed alignment.
- Five major fill embankments 10 metres to 15 metres in height located predominantly on the southern side of the proposed alignment.
- Three retaining walls would be required at the following locations
    - Retaining wall 1 – between approximate chainages 32080 and 32190 (about 110 metres long and up to 7.0 metres high).
    - Retaining wall 2 – between approximate chainage 32560 and 32725 (about 165 metres long and up to 5.6 metres high).
    - Retaining wall 3 – between approximate chainage 33040 and 33240 (about 200 metres long and up to 7.0 metres high).
- Removal of about 300 metres of redundant Great Western Highway pavement from about 100 metres east of Whites Creek to about 200 metres west of Whites Creek, and associated culvert. This would include rehabilitation works to link this area to the existing alignment of Whites Creek.
- Construction of three temporary and five permanent construction basins in addition to temporary access tracks along the length of the proposal.
- Construction of nine new culverts along the length of the proposal to manage cross-drainage flows and six new culverts across access roads and service roads as part of the proposal. One existing culvert would be retained at the western end of the proposal. A total of 23 existing drainage culverts under the Great western Highway would be either decommissioned or removed.
- Measures to mitigate the formation of black ice, including the relocation of the road alignment to the south away from the Hassans Walls escarpment in key locations and an active maintenance program.
- A main compound site located east of the western end of Forty Bends Road, in addition to smaller stockpile areas along the length of the proposal during construction.
- A combination of wildlife crossing structures, which would include three fauna underpasses (box culverts), canopy rope bridges at Whites Creek and the western underpass and glider poles located at Whites Creek and near the western fauna underpass.
- Relocation of the existing intersection at the western end of Forty Bends Road to a point about 200 metres west of the existing intersection.

1.3. Proposal site

The proposal is located within the Lithgow local government area (LGA). The proposal site is about five kilometres south of Lithgow. The region is characterised by its natural features including the Hassans Walls Reserve to the north of the proposal and the Blue Mountains National Park and the Blue Mountains World Heritage Area about 14 kilometres to the east. The region includes a large variety of land uses that include residential and rural residential villages, agriculture and a number of tourist attractions.

The proposal passes through a variety of different vegetation types, including native open forest communities (generally to the north of the proposal at the base of the escarpment) and cleared/modified land (generally to the south of the proposal). Scattered private residences are located generally to the south of the existing highway. An electricity easement also crosses the existing and proposed alignment of the highway towards the western end of the proposal.

Refer to Figure 1-1 for the study area as well as Appendix A for the regional context of the drinking water catchment.

1.4. Purpose of this study

This report documents the water quality investigations that have been undertaken as part of the concept design. It includes:

- A review of existing water quality and assessment of relevant criteria.
- An assessment of potential impacts from the construction and operation of the proposal on water quality within the vicinity of the study area.
- Description of a conceptual erosion and sediment control design strategy to indicate key water quality control requirements for the construction phase.
- A figure of locations where sediment basins are required during the construction phase.
- Description of a water quality management design strategy for the operational road.
- A figure of locations where operational water quality controls would be provided.
- A Neutral or Beneficial Effects (NorBE) assessment.

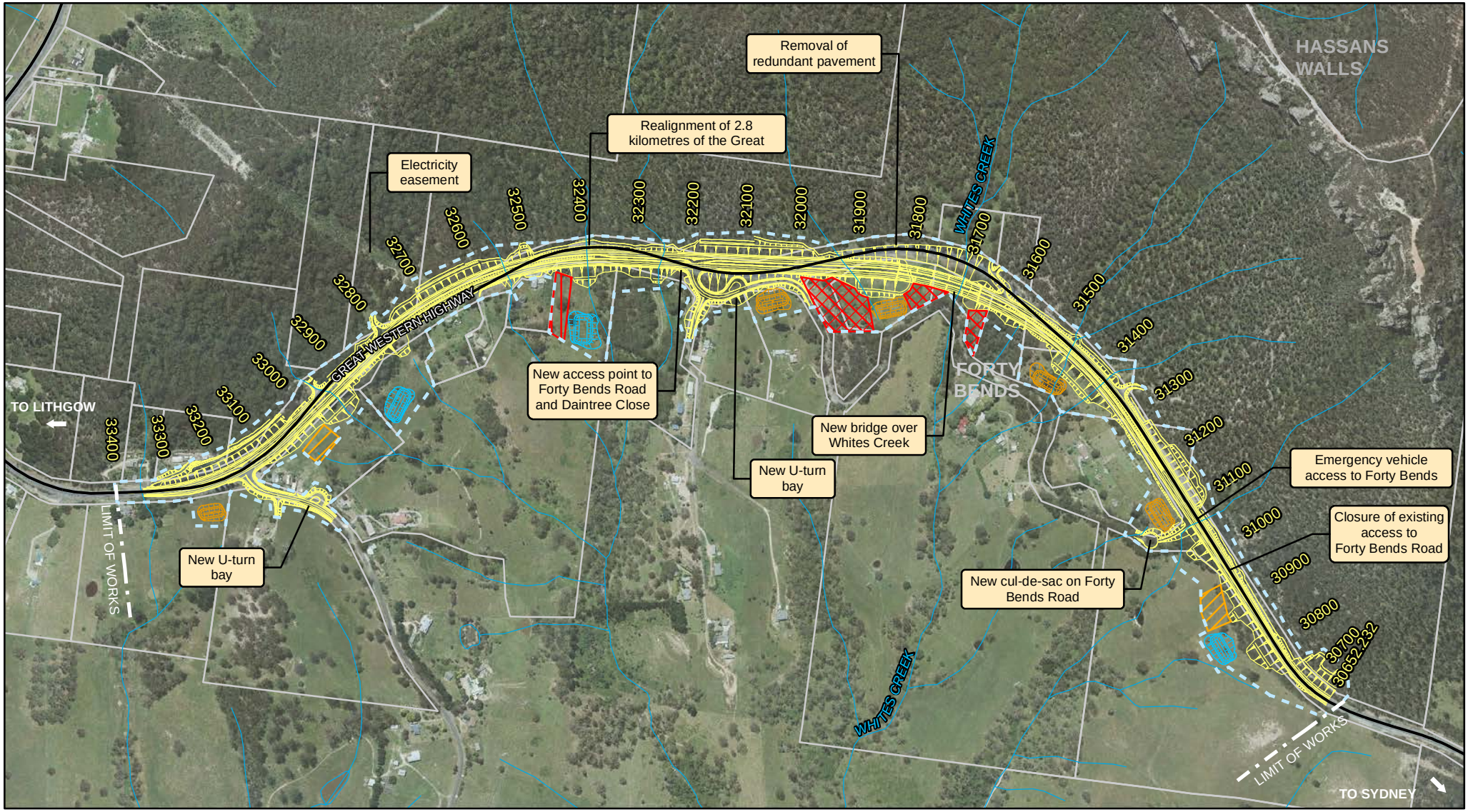

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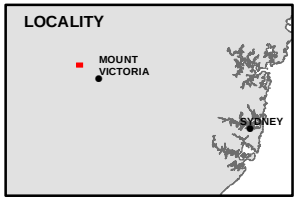
Figure 1-1 Forty Bends proposal

Mt Victoria to Lithgow: Great Western Highway Forty Bends upgrade

LEGEND

- 31900 Chainage
- Proposal
- Proposal site
- Existing highway
- Waterways
- Property boundary
- Permanent sedimentation basins
- Temporary sedimentation basins
- Compound site and stockpile locations
- Potential compound
- Potential stockpile
- Potential stockpile and compound

LOCALITY



GDA 94 | MGA 56

0 200

Metres

Aerial Photograph:AUSIMAGE/SKM 2011

2. Policy Setting

2.1. Statutory requirements

The following NSW legislation and statutory requirements are considered in the water quality assessment work:

- ***Protection of the Environment Operations Act 1997*** (POEO Act), which sets the framework for environment protection during the construction and operation of a development or undertaking of an activity. The POEO Act consolidates key pollution statutes relating to air, water and noise pollution and environmental offences, and establishes a duty to notify either the Environmental Protection Authority (EPA) or the local council where incidents are likely to cause material harm to the environment. As the proposal would not result in a main road of four or more traffic lanes for greater than three to five kilometres (Clause 35 of Schedule 1 (Road construction)), the proposed works are not classified as a scheduled activity under the POEO Act. The proposal would therefore not involve undertaking any scheduled activities and would not require an environmental protection licence (EPL).
- ***Protection of the Environment Administration Act 1991.*** The Act establishes the Environment Protection Authority (now part of the Office of Environment and Heritage) to provide integrated administration for environment protection, and perform particular tasks in relation to the quality of the environment, environmental audit and reports on the state of the environment (SCA, 2011c).
- ***NSW Fisheries Management Act 1994*** (FM Act), which provides for the protection of threatened fish and marine vegetation and is administered by the Department of Primary Industries. The FM Act, in conjunction with the TSC Act, aims to conserve, develop and share fishery resources and conserve marine species, habitats and diversity. The proposed alignment would cross Whites Creek. Waterway crossings would be designed where possible according to NSW Fisheries (part of NSW Department of Primary Industries – DPI) guidelines (*Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings, DPI, 2003)* and in consultation with NSW Fisheries staff to ensure minimal impact on aquatic habitats and species protected under the Act.
- ***Water Management Act 2000.*** The Act provides for the protection of river and lakeside land in NSW and aims to provide for the sustainable management of the water resources throughout NSW. It identifies provisions relating to 'controlled activities' which includes (among other definitions) the carrying out of any activity that affects the quantity or flow of water in a water source' or affects land fronting a waterway.

However, in accordance with clause 39A(1) of the Water Management (General) Regulation 2004, the RMS is permitted to undertake works within 40 metres of a watercourse without obtaining a permit under the Water Management Act 2000.

- ***The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011*** (the Drinking Water SEPP) (Refer to Section 2.4 for details) .

2.2. Water quality guidelines

The following design guidelines and management procedures are relevant in determining the appropriate water quality management and mitigation measures to be implemented during the construction and operational phases of the proposed upgrade.

Water Quality

- ANZECC/ARMCANZ, 2000, *National Water Quality Management Strategy*, Australian and New Zealand Environment and Conservation Council.

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have formulated the National Water Quality Management Strategy (NWQMS) with the objective of achieving sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

The NWQMS contains guidelines for setting water quality objectives to sustain current or likely future environmental values for water resources (ANZECC & ARMCANZ, 2000). These guidelines have been used to determine the existing condition of rivers and creeks along the highway upgrade.

Construction phase

- NSW DECCW 2008, *Managing Urban Stormwater-Volume 2D Main Road Construction,* NSW Department of Environment, Climate Change and Water.
- Landcom 2004, *Managing Urban Stormwater- Soils and Construction,* Volume 1, 4th Edition (referred to as the Blue Book).
- Roads and Traffic Authority 1999, *Code of Practice for Water Management - Road Development and Management*, Roads and Traffic Authority.
- Roads and Traffic Authority 2001, *Stockpile Site Management Procedures,* Roads and Traffic Authority.
- Roads and Traffic Authority 2003b, *Road Design Guideline: Section 8 Erosion and Sediment,* Roads and Traffic Authority.

- Roads and Traffic Authority 2003c, *Guideline for Construction Water Quality Monitoring,* Roads and Traffic Authority.
- Roads and Traffic Authority 2005, *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze*, Roads and Traffic Authority.
- Roads and Traffic Authority 2009a, *Erosion and Sediment Management Procedure*, Roads and Traffic Authority.
- Roads and Maritime Services 2011a, *Technical Guideline: Temporary Stormwater Drainage for Road Construction*, Roads and Maritime Services.
- Roads and Maritime Services 2011b, *Technical Guideline – Environmental Management of Construction Site Dewatering*, Roads and Maritime Services.
- Roads and Maritime Services 2012, *Environmental Direction: Management of Tannins from Vegetation Mulch*, Roads and Maritime Services.

These guidelines seek to minimise land degradation and water pollution from road construction sites in New South Wales. The guidelines have been used to identify appropriate management procedures during construction works and physical controls to minimise erosion and to prevent sediment moving off site during the construction phase of development.

Operational phase

- Austroads 2001*, Road Runoff and Drainage: Environmental Impacts and Management Options,* Austroads AP-R180.
- Austroads 2003, *Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure*, Austroads AP-R232.
- Austroads 2010, *Guide to Road Design, Part 5: Drainage Design*.
- New South Wales Department of Environment and Climate Change 2008, *Managing Urban Stormwater, Soils and Construction, Volume 2, Main Road Construction*, New South Wales Department of Environment and Climate Change.
- Roads and Traffic Authority 1997, *Water Policy*, Roads and Traffic Authority.
- Roads and Traffic Authority 1999, *Code of Practice for Water Management - Road Development and Management*, Roads and Traffic Authority.
- Roads and Traffic Authority 2003a, *Procedures for Selecting Treatment Strategies to Control Road Runoff*, Roads and Traffic Authority.

- Sydney Catchment Authority 2011b, *Neutral or Beneficial Effect on Water Quality Assessment Guideline*, Sydney Catchment Authority.
- VicRoads 2011, *Integrated Water Management Guidelines,* VicRoads.

These documents provide guidance on water management and conservation practices related to the design, operation and maintenance of the roads and traffic system in order to protect waterways and water quality where practicable and feasible. In addition they provide guidance on designing permanent water quality treatment in a consistent and practicable manner. The design for the proposed upgrade would address the sensitivity of receiving waters and local environment along the highway upgrade.

2.3. Water quality objectives

Recommended water quality objectives, based on concentration, applicable to waterways in the study area have been established by the NSW Healthy Rivers Commission (HRC, 1998) and ANZECC (2000). The HRC recommendations and ANZECC/ARMCANZ Guidelines provide benchmarks for assessing existing water quality according to the established environmental values.

In accordance with the HRC and ANZECC/ARMCANZ guidelines, the assessment of water quality in this report is made in accordance with chemical and physical stressor trigger values for slightly disturbed upland river aquatic ecosystems. The HRC recommendations and the ANZECC/ARMCANZ guideline trigger values for water quality parameters that have been used are shown in Table 2-1.

Table 2-1 Recommended water quality objectives for the proposed highway upgrade

Table 2-1 Recommended water quality objectives	HRC Recommendation (Mixed use rural areas and sandstone plateau)	ANZECC (2000) Trigger Value for Aquatic Ecosystems (upland river)
Temperature (°C)		N/A
Turbidity (NTU)		2-25 NTU
Dissolved Oxygen (% saturation)		90 – 110% saturation
Electrical Conductivity (µS/cm)		30 – 350 µS/cm
pH		6.5 – 8.0
Ammonia (mg/L)		0.013 mg/L
Oxidised Nitrogen (mg/L)		0.015 mg/L
Total Nitrogen (mg/L)	0.7 mg/L	0.25 mg/L
Orthophosphate (mg/L)		0.015 mg/L
Total Phosphorus (mg/L)	0.035 mg/L	0.02 mg/L
Chlorophyll-α (µg/L)	2 - 7	N/A

These objectives are applicable prior to construction, during construction and during operation of the proposed highway upgrade at Forty Bends.

Current water quality management practices in road design uses load-based objectives rather than concentration to demonstrate water quality outcomes. This is further discussed in Section 6.3.

The key water quality objective is to minimise the likelihood of potential impacts from surface runoff generated from the upgrade, during construction and operational phases, on downstream waterways. This is consistent with the ANZECC Guidelines. Other objectives include:

- Minimising impacts of construction on downstream waterways and riparian vegetation.
- Where possible, preservation of existing elements such as natural channels.

To achieve these objectives, the following tasks are required:

- Development of a design strategy to manage operational stormwater outlining treatment options for stormwater runoff, which aims to achieve stormwater runoff quality as close to its source as possible. Potential treatments include grassed swales with rock check dams at the toe of batters that lead to water quality ponds. This would aim to treat stormwater runoff in a manner that would result in the least practicable change to the existing water regime and current nutrient loads. A preliminary design was undertaken during the concept design phase. A more detailed strategy would be produced as the detailed design progresses.
- Development of a construction stormwater management design strategy, such as an Erosion and Sediment Control Plan, during detailed design.
- Integration of construction and operational phases within the design so that the total drainage infrastructure is minimised. Access is required to all devices requiring ongoing maintenance during both the construction phase and subsequent operational maintenance phase. This treatment system should also be capable of containing accidental spills on the highway.

2.4. The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

The SEPP commenced on 1 March 2011 and lies under the *Environmental Planning and Assessment Act 1979*. This policy replaced the Drinking Water Catchments Regional Environmental Plan No 1.

The SEPP states that a proposed development within the Sydney Catchment Authority (SCA) drinking water catchment must have a neutral or beneficial effect on water quality (NorBE). The NorBE assessment needs to be undertaken in line with the *Neutral or Beneficial Effect on Water Quality Assessment Guidelines 2011* (SCA, 2011b) and the *Neutral or Beneficial Effect on Water Quality Assessment Tool 2011.* This would apply for projects that are being assessed under Part 4 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). Although the proposed Forty Bends upgrade will be assessed under Part 5 of the EP&A Act, RMS would still consider the NorBE assessment in determining the proposal.

The proposal is located within the catchment of the Coxs River, and is within the boundary of the Warragamba Drinking Water Catchment. Consequently, the SEPP (Sydney Drinking Water Catchment) is applicable to the proposal. A qualitative NorBE assessment has been undertaken to assess whether the proposed highway upgrade at Forty Bends is likely to have a neutral or beneficial effect on water quality within the SCA drinking water catchment. Appendix A shows the boundaries of the drinking water catchment and Appendix G is the qualitative NorBE assessment for the proposed upgrade.

The qualitative NorBE assessment has been performed on a sample catchment to demonstrate the effectiveness of the proposed water quality control measures in reducing pollutant loads for the existing and upgraded conditions. The assessment demonstrates that there would be a neutral effect on water quality. Further detailed assessment including water quality modelling would be undertaken during development of the detailed design.

3. Existing environment

3.1. Surface water context

One main drainage line, Whites Creek, crosses through the proposal site in addition to a number of other ephemeral drainage lines that occur off Hassans Walls escarpment (refer to Figure 1-1). Whites Creek, and the other drainage lines are part of the Whites Creek catchment, a sub-catchment of Sydney's drinking water supply hydrologic catchment that flows to Warragamba Dam and is subject to State Environmental Planning Policy (SEPP) (Sydney Drinking Water Catchments) 2011. **0** contains an overview plan of Sydney's drinking water catchments. Whites Creek is the main watercourse flowing through the study area whose junction with the Coxs River is approximately 3.5 kilometres downstream of the Great Western Highway. It is an ephemeral watercourse that does not contain sensitive aquatic habitats. The exiting natural catchments in the area are shown in **Appendix H.**

The northern section of the study area is characterised by the steep escarpment of Hassans Walls. Runoff from the densely forested areas flows towards the highway, passing through numerous culverts and eventually feeding to Whites Creek.

The lower lying areas of the study area, to the south of the escarpment and the highway, are predominantly lands cleared for agricultural purposes, owned by private occupants. There are a number of farm dams used for domestic stock purposes within and in the vicinity of the proposal site.

3.2. Environmental values

Existing environmental values of the surface waters within the study area were obtained from literature prepared by the HRC (1998), SCA (2007), the Hawkesbury Nepean Catchment Management Authority (2007), Lithgow City Council, and Blue Mountains City Council.

From the Office of the Hawkesbury-Nepean Catchment Management Authority (undated), the key environmental values within the study area include:

- Protection of aquatic ecosystems.
- Secondary contact recreation (boating, wading, fishing etc.).
- Visual amenity.

Further information regarding these environmental values is provided in the HRC 2008 report.

3.3. Existing water quality data

In this report, existing water quality data are assessed against default trigger values for chemical and physical stressors for the protection of aquatic ecosystems (specifically slightly disturbed estuarine and upland river ecosystems) for south-east Australia, as outlined in the National Water Quality Management Strategy (ANZECC & ARMCANZ 2000).

No water quality data are currently available for Whites Creek. Water quality data was obtained from the SCA for samples collected in River Lett at the intersection of the Great Western Highway, approximately 4.7 kilometres east of Whites Creek by Lithgow Environment Group for the SCA's Streamwatch program. Test results were obtained for five samples collected from April to October 2008. The land use upstream of River Lett is agricultural, whereas the land use upstream of Whites Creek is forested, so it is expected that the water quality of Whites Creek would be better than that of the River Lett. A summary of the data is contained in Table 3-1.

Factors affecting water quality in the catchment include:

- Atmospheric deposition.
- Land use activities in the catchment, such as agriculture and livestock farming.
- Climatic conditions.
- Topography and soil conditions.
- Vegetation cover.

Table 3-1 Existing water quality test results – River Lett at Great Western Highway

Sample Details			Water Quality Parameters						
No.	Date Collected	Dry / Wet	Temp (ºC)	Turbidity (NTU)	Ortho-phosphate (mg/L)	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH
1	1/04/08	Dry	11.5	-	0.01	140	4.3	39	7
2	31/05/08	Dry	7.5	-	0.12	200	7.3	61	7
3	31/07/08	Wet	5	10	-	190	7.4	58	7
4	30/09/08	Wet	13	10	0.04	140	6.5	62	7
5	31/10/08	Dry	19	10	0.07	130	6.4	69	7

The available test results when compared with the ANZECC trigger values indicate:

- All available sampling data for turbidity, electrical conductivity, and pH are within the ANZECC recommended ranges.
- One result for orthophosphate is below the ANZECC recommendation of 0.015 mg/L. The remaining three available results exceed the orthophosphate trigger value.
- All results for percentage saturation of dissolved oxygen are below the recommended ANZECC range of 90-110 per cent saturation.

There are no data available for total nitrogen, total phosphorus, and chlorophyll-α to allow a comparison with the HRC recommendations, as this information was not included in the SCA collected data.

Existing water quality data for Whites Creek would be reviewed when available from the SCA and would be included in the detailed design water quality modelling.

3.3.1. Soil erodibility

Soil testing has shown that erodibility along the highway upgrade is moderate. The results of the analysis are given in Table 3-2.

Table 3-2 Soil erodibility – site specific soil testing results

Sample ID	Chainage (m)	K factor	Rating
TP142: 0.2 - 0.4m	30000 [1]	0.038	Moderate
TP151: 0.2 - 0.4m	31570	0.034	Moderate

Note 1 - Outside highway upgrade, which commences at approximate chainage 33350 (refer to Figure 1-1)

3.4. Sensitivity of receiving environments

Table 6.1 of the Blue Book (DECC, 2008) states that a sensitive receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality.

Whites Creek is an ephemeral creek without sensitive aquatic habitats; however it lies within a drinking water catchment. The environmental values of the waterway were provided in Section 3.2. Consultation with the SCA in May 2011, followed by additional coordination with the SCA in May 2012, resulted in the decision to treat all waterways in the drinking water supply catchment as sensitive receiving environments. A description of the drinking water supply catchment location and regulations were previously discussed in Section 2.4.

4. Potential water quality impacts

In this section, the potential impacts of construction and operation of the proposed highway upgrade at Forty Bends are explored. **0** provides this information in a matrix that summarises the potential impacts and the environmental safeguards which would be adopted to minimise these impacts.

4.1. Construction phase impacts

The construction phase of the proposal presents a high risk to downstream water quality if management measures are not implemented, monitored and maintained throughout the construction process.

The highest risk to water quality would occur through the following construction activities:

- Construction near Whites Creek, such as construction of bridge abutments and piles.
- Construction of in-stream structures in waterways (for example culverts).
- General earthworks, including stripping of topsoil, excavation or raising.
- Construction of drainage devices.
- Stockpiling of topsoil and vegetation.
- Transportation of cut and/or fill materials.
- Movement of heavy vehicles across exposed earth.
- Removal of riparian vegetation.
- Construction in steep areas.
- Construction in areas upstream of sensitive receiving environments.
- Construction in highly erodible areas, if present.
- Construction in acid sulfate rock, if present.

Construction activities for the proposed highway upgrade would result in considerable disturbance to soils, which have the potential to impact water quality unless appropriately managed through erosion and sediment control measures.

4.1.1. Surface water quality

The potential impact of unmitigated construction activities on receiving surface waters include:

- Increased sediment loads from exposed soil during rainfall events and dust blown off site causing high sediment loads to be washed or deposited into nearby creeks.
- Increased sedimentation of downstream watercourses smothering aquatic life and affecting the ecosystems of downstream sensitive waterways, wetlands and floodplains.
- Increased levels of nutrients, metals and other pollutants, transported via sediment to downstream water courses.
- Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways.
- Increased levels of litter from construction activities polluting downstream watercourses.
- Tannin leachate from clearing and mulching.

The surface waters of Whites Creek are at the greatest risk of pollution during bridge construction and road construction due to the close proximity to the proposed road construction works.

4.1.2. Drinking water catchment

The consequences of the impact of unmitigated construction activities on the water quality of receiving surface waters are higher in drinking water catchments than in catchments that do not flow to drinking water sources. As outlined in Section 3.1, the proposed highway upgrade at Forty Bends is located within the Whites Creek catchment, a sub-catchment of Sydney's drinking water supply hydrologic catchment that flows to Warragamba Dam. The proposed highway upgrade therefore has the potential to impact upon Sydney's drinking water supply catchment, in the modes described in Section 4.1.1, if appropriate management measures are not implemented.

4.1.3. Soil erodibility

In areas where soil erodibility is moderate, as identified in Table 3-2, if mitigation measures are not established during construction, sediment would be more easily eroded and transported into waterways than in areas where soil is not as erodible.

4.1.4. Works within or adjacent to waterways

Temporary diversions of waterways, the construction of permanent waterway diversions and the construction of in-stream structures in waterways (for example culverts) may all disturb the bed and banks of the waterway and may result in soil and streambank erosion, leading to high volumes of sediment entering and polluting the waterways. Construction of these structures may also impact on aquatic plants and habitats in the vicinity of the works. This is assessed in Technical Paper 1 – Biodiversity as part of the REF (Volume 2). In-stream activities need to be carefully managed in order to reduce the risk of these impacts.

Works that may require in-stream construction include:

- Decommissioning of existing culverts.
- Construction of new culverts.

The locations of existing and proposed culverts crossing the Great Western Highway are given in Table 4-1. The relevant chainage locations are shown on Figure 1-1. Additional minor culverts may be required across property access at certain locations and this would be confirmed during detailed design. Also, as detailed design progresses, the number and location of culverts may change.

Table 4-1 Locations of existing and proposed culverts

Chainage of existing culverts (m [1])	Decommissioned (D) / Retained (R) / New (N) / Altered (A)	Chainage of proposed culverts (m)	Decommissioned (D) / Retained (R) / New (N)
30800	D	30740 - 30800	N
30940	D	31040 - 31060	N
31044	D	31410 - 31460	N
31060	D	32250 - 32300	N
31210	D	32360 - 32380	N
31360	D	32520 - 32540	N
31470	D	32710	N
31700	D	32800 - 32820	N
31790	D	32960 - 33000	N
31880	D		
31910 - 31930	D		
32040	D		
32080	D		
32230	D		
32300	D		
32380	D		

Chainage of existing culverts (m [1])	Decommissioned (D) / Retained (R) / New (N) / Altered (A)	Chainage of proposed culverts (m)	Decommissioned (D) / Retained (R) / New (N)
32530	D		
32710	D		
32760	D		
32780	D		
32970	D		
33100 - 33110	D		
33230	D		
33350	R		

Note 1 – Refer to Figure 1-1 for chainage locations

Works that require construction adjacent to a waterway include the construction of the bridge over Whites Creek. It would involve:

- Construction of abutments and piles.
- Backfilling behind abutments.
- Placing new girders using a crane.
- Constructing deck and kerbs.

Without mitigation, the earthworks and concreting activities could result in slurry and excavated material entering Whites Creek.

4.1.5. Existing dams

Construction of the proposal could change the proportion of pervious areas in a catchment, altering the flow patterns of the catchment, depending on the construction staging adopted by the contractor. Temporary diversions of offsite flow, excavations and embankments could also alter flow patterns, change the shape of the catchment and change the amount of water flowing to existing farm dams.

Changes to flow regimes can impact water quality in waterways and dams by changing the volumes and flow rates of water. A reduction in flow and volume of water could lead to stagnation of a waterway. It may also lead to changes in levels of turbidity, nitrogen and phosphorus.

In this case, flows to existing dams are primarily derived from upstream catchments and changes in flow regimes from the road construction area during the construction stages are not substantial, as shown by the proposed catchments in Appendix H.

4.1.6. Large excavations and fills

Construction of large excavations and embankments, exceeding a single bench (generally seven metres for cuts and 10 metres for fills) pose an elevated risk to water quality in downstream waterways through the increased likelihood of movement of sediment off steep slopes.

A review of the design has been undertaken to locate such areas that may impact water quality outcomes. These are identified in Table 4-2.

Table 4-2 Locations of large cuts and embankments

Locations of large cuts (Chainage [1] in metres)	Locations of large fill embankments (Chainage* in metres)
31100-31200	31800-31890
31980-32190	32380-32420
32560-32700	32900-32980

Note 1 – Refer to Figure 1-1 for chainage locations

4.1.7. Acid sulfate soils and acid sulfate rock

Construction activities such as drainage, excavation, dewatering and land clearing pose an environmental risk when they are carried out in areas of actual or potential acid sulfate soils (ASS) (soils and sediments containing iron sulphides). The activities could disturb and expose ASS to oxygen, which could generate sulphuric acid and toxic quantities of aluminium and other heavy metals. These could be readily released into the surrounding environment, polluting surface water and groundwater.

There are currently no known areas of ASS along the highway upgrade. Geotechnical investigations are not yet complete, but based on the surface elevation, which is greater than 800 metres AHD, ASS are not anticipated. ASS are typically found in low lying sections of coastal flood plains, rivers and creeks where surface elevations are less than around 5 metres AHD. Consequently, the Australian Soil Resources Information System (ASRIS) data indicates a low probability of occurrence. Notwithstanding this, the proposal site is underlain by Berry Siltstone, which can have acid sulfate rock (ASR) potential. ASR contains sulfide and sulfate minerals which result in acid formation and acid rock drainage when exposed to oxygen and water, such as in cuttings. Runoff from these areas could pollute waterways. Confirmation of the presence of ASR forms part of the geotechnical component of the detailed design development.

4.1.8. Stockpiles

Storage of earthwork materials, crushed rock, mulch and vegetation would be done using stockpiles. In general, stockpiling causes a risk to water quality of downstream watercourses during rainfall if the stockpiles are not managed appropriately. Large amounts of sediments from the stockpiles could wash into waterways, increasing levels of turbidity if no controls are in place.

Approximately eight hectares of vegetation would be cleared for the proposal. Stockpiling vegetation from cutting of trees and slashing of shrubs is not expected to cause a risk of tannins leaching into waterways as the type of vegetation in the proposal area is not likely to generate excessive tannins. According to the RMS *Environmental Direction: Management of Tannins from Vegetation Mulch* (RMS, 2012), the main concern with the discharge of water that is high in tannins is that it may increase the biological oxygen demand (BOD) of the receiving environment, resulting in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility and light penetration and change the pH of receiving waters.

The potential locations of stockpiles sites are given in Table 4-3, but designated stockpiles sites would be finalised during the detailed design process. Smaller stockpile and storage areas may also be required along the length of the proposal site. Once the contractor has a preferred location for the stockpile areas, consultation with RMSs Senior Regional Environmental Officer would be undertaken prior to any stockpile works in those locations to determine suitability of the location and if any additional environmental assessment is required.

In order to minimise the transport of sediments from stockpile sites, the sites are best located on flat ground that does not require vegetation clearance, away from overland flowpaths and in areas of high topography with minimal upstream catchment. Table 4-3 provides information on the locations of the sites in relation to these factors.

Table 4-3 Locations of stockpiles

Stockpile location (chainage in metres)	Vegetation clearance required?	Ground slope	Impact on overland flow paths	Downstream watercourse
30900	N	1:4	Temporary diversion could be required.	Ephemaral tributary of Whites Creek.
31650	Some	1:7	No issues	Whites Creek
31750 – 32000	N	1:4	Temporary diversion would be required in location of permanent diversion.	Whites Creek
33000 – 33500	N	1:5	Temporary diversion would be required.	Farm dams and ephemeral tributary of Coxs River.

4.1.9. Site compounds

Site compounds are likely to include sites and activities that have a high potential to impact downstream water quality, if unmitigated, through spills of pollutants flowing to downstream watercourses. These include:

- Storage of chemicals.
- Vehicle washdown areas.
- Vehicle refuelling areas.
- High frequency of vehicle movements.

The potential locations of site compounds are given in Table 4-4. In order to minimise the transport of sediments and pollutants from site compounds, the sites are best located on flat ground that do not require vegetation clearance, away from overland flowpaths and in areas of high topography with minimal upstream catchment. Figure 1-1 and Table 4-3 provides information on the indicative locations of potential site compounds in relation to these factors.

Table 4-4 Locations of potential compound sites (chainage in metres)

Compound location (chainage in metres)	Vegetation clearance required?	Ground slope	Impact on overland flow paths	Downstream watercourse
31650	Some	1:7	No issues	Whites Creek
31750 – 32000	N	1:4	Temporary diversion would be required in location of permanent diversion.	Whites Creek
32400	N	1:6	No issues	Ephemeral tributary of Whites Creek

4.2. Operational phase impacts

During the operational phase of the proposal, the roads would be sealed and the embankments are landscaped. It is assumed that there would be no exposed topsoil along the highway. Hence, risks are no longer due to sediment loading but are instead due to pollutants from atmospheric deposition, vehicles and motorists.

4.2.1. Surface water quality

Once the highway upgrade is complete and the new highway becomes operational, the main risk to water quality is surface runoff from impervious surfaces and concentration of runoff by drains and kerbs. This can result in the build up of contaminants on road surfaces, median areas, rest areas and roadside corridors in dry weather which, during rainfall events, can be transported to surrounding watercourses or infiltrate into the groundwater system.

The contaminants of most concern relating to road runoff are:

- Suspended sediment from the paved surface and landscaped batters during the establishment period.
- Heavy metals attached to particles washed off the paved surface.
- Oil, grease and other hydrocarbon products.
- Litter from the road corridor.
- Nutrients – from biological matter
- Sodium chloride from de-icing activities

In addition, nutrients such as nitrogen and phosphorus are also found in road runoff due to natural atmospheric deposition of fine soil particles.

The water quality of nearby creeks and streams during the operation of the highway has the potential to be affected and could result in:

- Increased sediment loads reducing light penetration through the water column, impacting aquatic flora and fauna.
- Decay of organic matter and some hydrocarbons which can decrease dissolved oxygen levels affecting fish and aquatic life.

- Increased nutrients (nitrogen and phosphorus) stimulating the excessive growth of algae and aquatic plants leading to toxic conditions.
- Increased levels of heavy metals (including aluminium and iron) which are toxic to aquatic biota and fish.
- Increase concentrations of chloride that may have adverse effects on land and aquatic plants and invertebrates if de-icing activities are frequent and salt is used in high volumes.
- Silting of waterways and associated smothering of aquatic flora and fauna.
- Increased levels of litter, oils and grease.

Other potential effects of the new road on water quality include:

- Increased volume of highway runoff associated with the introduction of additional impervious surfaces, which would potential increase scouring and therefore impacting water quality.
- Alteration of the water Table and changes to local hydrology, potentially leading to stagnation of a waterway or changes in levels of turbidity, nitrogen and phosphorus.
- Those associated with maintenance practices such as herbicide use, mowing, road surface cleaning and reparation.

4.2.2. Accidental spills

There is potential for accidental spillage of hazardous materials during the operational stage of the proposal. Without satisfactory means of containment, the spillage of contaminants could pass rapidly into the drainage system and impact downstream ecosystems. Spills of chemicals or petrol in accidents can impact the ecology of waterways and terrestrial ecosystems.

The likelihood of a potential spill of hazardous substances would be lessened as a result of the highway upgrade and the higher road design standards proposed. The impact of a potential spill would be reduced by inclusion of spill containment in the highway design, compared to the current situation where there is no existing spill containment present.

4.2.3. Drinking water catchment and NorBE

As stated in Section 2.4, under the SEPP, a proposed development within the SCA drinking water catchment must have a neutral or beneficial effect on water quality. The detailed design would include a NorBE assessment in line with the *Neutral or Beneficial Effect on Water Quality Assessment Guidelines 2011* (SCA, 2011b) and the *Neutral or Beneficial Effect on Water Quality Assessment Tool 2011*. As part of this report, a qualitative assessment has been undertaken. The results of the assessment support the expectation that the SCA's NorBE requirements, of having a neutral effect on water quality, would be met by meeting the RMS's water quality design criteria on reductions in Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) for this proposal listed later in this report in Table 6-3. Further details of the assessment are provided in Appendix G.

5. Safeguards and management measures

The key water quality objective is to ensure downstream waterways are protected against potential impacts from surface runoff generated during the construction and operational phases of the proposal. This is consistent with the ANZECC Guidelines and National Water Quality Management Strategy (ANZECC, 2000).

In this section, the safeguards and management measures required during construction and operation are outlined. 0 summarises this information in a matrix of potential impacts and the environmental safeguards required to minimise the likelihood of these occurring.

5.1. Construction phase

The overall erosion and sediment control design strategy for the proposal is primarily to prevent or reduce erosion and sediment impacts during construction. Where erosion does occur, the aim is to capture it as close to this source as practicable. Water quality during construction would be managed using:

- Procedural controls.
- Site management controls.
- Physical controls.
- Monitoring.

Water quality would be managed within the area bounded by the proposal site, including, but not limited to:

- Access and haulage tracks.
- Earthworks stockpile and storage areas.
- Vegetation stockpile areas.
- Compound areas, such as the Contractor's and the Principals facilities.
- Washdown facilities.
- Temporary sediment ponds.

5.1.1. Procedural controls

A Soil and Water Management Plan (SWMP) would be developed to manage disturbed excavated and imported materials and prevent erosion and sediment impact throughout construction. It would be applicable to all activities during the construction phases of the proposal. Its key objective is to ensure that impacts to soils and water quality are minimised.

A soil conservationist from the RMS Erosion, Sediment and Soil Conservation Consultancy Services Register would be engaged during detailed design to develop an Erosion and Sediment Management Report which would inform the SWMP and would regularly inspect works throughout the construction phase.

The SWMP would be prepared and implemented in consultation with relevant government departments and councils as part of the Contractor Environmental Management Plan (CEMP).

The SWMP would be prepared, in consultation with the SCA, as part of the CEMP for the proposal prior to the commencement of construction in accordance with RTA specification G38. The Soil and Water Management Plan would address the RTA's *Code of Practice for Water Management* (1999) and incorporate specifications outlined in the *Urban Erosion & Sediment Control, Technical Handbook No. 2* (Quilty, 1978). It would be reviewed by RMS's Environmental Officer, Western Region prior to commencement of works.

The plan would include the following items relevant to water quality:

- Erosion and Sediment Control Plans (ESCPs) for all progressive stages of construction.
- Consideration of the impacts soil erodibility.
- Sediment basin construction and management.
- Protection of waterways.
- Detailed consideration of measures to reduce water quality impacts.
- Acid sulfate soil issues.
- Management of stockpiles.
- Tannin leachate management control.
- Chemical water quality controls.
- Water quality monitoring and checklists.

Environmental management during construction would also be undertaken in line with RMS specifications. Those relevant to water quality include:

- RMS QA Specification G36 – Environmental Protection (Management System).
- RMS QA Specification G38 – Soil and Water Management (Soil and Water Management Plan).
- RMS QA Specification G40 – Clearing and Grubbing.

5.1.2. Site management erosion controls

Construction activities would be should be sequenced and managed to minimise potential water quality degradation due to erosion. Management would include:

- Early installation of physical controls, including cross drainage to convey clean water around or through the site.
- Minimising the duration of exposed topsoil by retaining topsoil cover, grassed drainage lines and shrub cover on the soil surface for as long as possible minimising the extent of disturbed areas.
- Minimising stockpiling.
- Minimising the lengths of slopes through limiting the extent of excavations and the use of diversion drains to reduce water velocity over disturbed areas.
- Where possible cleared native vegetation and native mulch would be used to reduce erosion and contain sediment during construction through use of small vegetation filter windrows placed across the contour in drainage lines, below fill batters, below cutting works at the head of cleared minor drainage lined and before the inlet to sediment basins and waterways. In accordance with RMS guidelines (RMS, 2012) mulch should not be used for surface cover or sedimentation controls in any low lying areas of the site that remain consistently wet. Alternative controls such as geofabric (for surface protection) or sediment fence will be required in these areas. Unprotected mulch sedimentation controls should not be placed in concentrated flow lines where mulch may be washed away. Mulch may be protected by wrapping it with geofabric or other materials to provide a sTable control. All temporary catch dams constructed from mulch must have a sTable outlet to minimise the washing away of mulch in high rainfall events, and the possible failure of the control.
- Where possible, constructing working platforms from rock fill so that bare earth is not exposed.
- Progressive rehabilitation or sealing of works areas.

5.1.3. Physical controls

Physical controls that would be used to reduce potential water quality degradation due to erosion and sediment during construction include the use of:

- Offsite diversion drains to collect clean runoff from upstream of the construction area and divert it around or through the site without it mixing with construction runoff.
- Lining of channels and other concentrated flowpaths.
- Sediment fences and filters to intercept and filter small volumes of construction runoff.
- Rock check dams that are built across a swale or diversion channel to reduce the velocity of flow in the channel and thus reduce erosion of the channel bed, as well as trapping sediment.
- Level spreaders to convert erosive, concentrated flow into sheet flow.
- Scour protection devices such as energy dissipaters to reduce flow velocity and potential scouring, erosion and sedimentation of existing natural channels and vegetation, where required. Hard scour protection measures would be avoided wherever possible.
- Onsite diversion drains that collect construction runoff and direct it to treatment facilities.
- Sediment basins to capture sediment and associated pollutants in construction runoff, along with a permanent supply of gypsum flocculent agent available on site (further information on the location and sizes of sediment basins is provided in Section 6 and Appendix D).
- Specific measures and procedures for works within waterways such as the use of silt barriers and temporary creek diversions. Details of some of these measures are covered in detail in the RMS document: *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (RMS, 2011a).

Where construction does not result in a high potential for erosion, such as resurfacing existing roads, only local sediment controls, such as sediment fences or filters logs, would be required.

These techniques, controls and required maintenance procedures are described in 0.

5.1.4. Monitoring

Prior to construction, water quality monitoring would need to be undertaken at sites where the most recent sampling data is over one year old to provide assurance of compliance with regulatory requirements. This sampling is required to assess the existing conditions of waterways potentially impacted by the highway upgrade. Sampling locations and monitoring methodology would be determined during the detailed design stage.

Monitoring would also be undertaken during the construction to immediately detect any environmental degradation as a result of the works.

5.1.5. Specific mitigation measures

The impacts of construction discussed in Section 0 would generally be mitigated using the procedural, sequencing, physical and monitoring controls discussed. Additional, specific measures are required for mitigation are outlined below.

Soil erodibility

The highway upgrade is located in moderately erodible soils. To prevent excess erosion during construction, the ESCPs should focus on preventing erosion altogether, or minimising erosion through at-source physical controls as a priority over water quality treatment.

Works within or adjacent to waterways

The locations of works within or adjacent to waterways were given in Section 4.1.4. Where piling, concreting, earthworks, scour protection or other works are required within or adjacent to a waterway, a silt barrier such as a boom, bund or curtain would be installed either downstream of the work site and / or around the piles themselves prior to the commencement of works.

To facilitate any excavation work and to minimise the local impact of sediment immobilisation, the waterway flow may be temporarily diverted around the works, by either pumping or channelling the flow.

Details of some of these measures are given in the in *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (RMS 2011a).

Existing farm dams

Construction sequencing and temporary diversions of water during construction should be developed and designed to consider the impact of change on flow regimes and to minimise these changes throughout the full phase of construction.

Acid sulfate soils and acid sulfate rock

Should acid sulfate rock be encountered a management plan would be prepared in accordance with the relevant guidelines, including:

- *Acid Sulfate Soil Manual* (Acid Sulfate Soil Advisory Committee, 1998).
- *Acid Sulfate Soils Assessment Guidelines* (NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC), 1998).
- *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (RTA, 2005).
- *The Environmental Guidelines-Acid Sulfate Soils* (EPA, 1998).
- *Waste Classification Guidelines Part 4: Acid Sulfate Soils Part 4* (NSW Department of Environment and Climate Change, 2008b).

An ASS Management Sub Plan would include a contingency plan to deal with the unexpected discovery of acid rock or ASS.

Stockpiles

During the construction phase, cut and fill material would generally not be locally stockpiled, but would be removed from the site of excavation and transported directly to the construction face for immediate reuse as compacted. Fill or excavated material that cannot be immediately reused would be transported to identified locations within the road corridor to be stockpiled for reuse. Potential locations were provided in Section 4.1.8.

The maintenance of established stockpile sites during construction is to be in accordance with the *RTA Stockpile Site Management Guideline* (2011), in order to prevent erosion of the stockpile flowing into downstream waterways. These, and additional recommendations include:

- Inclusion of stockpile sites within the ESCP.
- Diverting runoff around stockpiles sites where required, as identified in Table 5-1.
- Minimising the number and size of stockpiles.
- Lining the base of stockpiles if they are located over a shallow water table.
- Treating stockpiles at the source by covering with plastic sheets.
- Establishing effective sediment control works to contain any runoff including cut-off drains, vegetation and silt fences to minimise risk of sediments entering waterways.

- If the above local controls are not implemented, and where required, treating with a construction or stockpile-specific sediment basin (as identified in Table 5-1) and monitoring the sediment basin for parameters such as dissolved oxygen levels and organics to determine suiTable discharge to the environment (such basins would be considered once stockpile locations have been finalised).

Any material found to be unsuiTable for reuse would be disposed of in accordance with the *Waste Classification Guidelines* (DECCW 2008).

Table 5-1 Requirements for mitigation of impact of stockpile sites

Stockpile location (chainage in metres) [1]	Potential mitigation of overland flow paths	Nearest sediment basin
30650 – 30750	None	B3088L
30800 – 30900	Temporary diversion.	B3088L
31750 – 32000	Temporary diversion in location of permanent diversion.	B3382L
33000 – 33500	Temporary diversion	Potentially require stockpile-specific sediment basin.
33200 – 33300	Temporary diversion	B3330L

Note 1 – Refer to Figure 1-1 for proposed sedimentation basin locations

Site compounds

Management of runoff through or from site compounds would be included in the ESCP. The indicative locations were provided in Table 4-4. In general, mitigation would be similar to general construction site mitigation, with additional factors, such as:

- Restricting vehicle movements to designated pathways where feasible.
- Paving areas that would be exposed for extended periods, such as carparks and main access roads, where feasible.
- Diverting offsite runoff around stockpiles sites where required, as identified in Table 5-2.
- If the above local controls are not implemented, and where required, treating onsite runoff with a construction or compound-specific sediment basin (as identified in Table 5-2) and monitoring the sediment basin for parameters such as dissolved oxygen levels and organics to determine suiTable discharge to the environment (such basins would be considered once compound locations have been finalised).

Table 5-2 Requirements for mitigation of impact of sites compounds

Site compound location (chainage in metres) [1]	Potential mitigation of overland flow paths	Nearest sediment basin
30650 – 30750	None	B3088L
31750 – 32000	Temporary diversion in location of permanent diversion.	B3382L
32400 – 32500	None	B3241L

Note 1 – Refer to Figure 1-1 for proposed sedimentation basin locations

Spills

An Emergency Spill Plan would be developed and incorporated in the CEMP. This would include measures to avoid spillages of fuels, chemicals, and fluids into any waterways. The storage, handling and use of the materials would be undertaken in accordance with the *Occupational Health and Safety Act 2000* and Workcover's *Storage and Handling of Dangerous Goods Code of Practice* (Workcover, 2005).

Procedures would include:

- All fuels, chemicals, and liquids would be stored at least 50 metres away from any waterways or drainage lines and would be stored in an impervious bunded area within the compound site.
- Bunded areas for refuelling and washdown.
- Sediment basins with sufficient storage capacity to capture spills.
- Spill kits.
- Training of staff.

5.2. Operational phase

The ANZECC Guidelines (ANZECC & ARMCANZ, 2000) indicate that several physical-chemical and toxicant parameters need to be controlled to maintain the required protection level for aquatic ecosystems during the operational phase of the proposed highway upgrade. Some of these parameters include nutrients (total phosphorus and nitrogen), suspended solids, oils and greases, petroleum hydrocarbons and several heavy metals including copper, lead, zinc, cadmium and chromium which are commonly found in stormwater runoff from roads.

Any future increase in traffic volumes beyond 30,000 Average Annual Daily Traffic (AADT) on the main highway would be likely to cause a corresponding increase in nutrients and heavy metals (RTA, 1995), however a large proportion of these pollutants are bound to particles and can be controlled by water quality ponds, wetlands and grassed swales alongside the carriageway that intercept stormwater flows.

For this site, the predicted traffic numbers through to 2041 are unlikely to exceed this trigger level for water quality treatment. However, given the presence of the SCA catchment and sensitivity of areas adjacent to the proposed highway upgrade, full load-based water quality controls are included in the 20 percent design submission, including water quality ponds and accidental spill management.

5.2.1. Physical water quality controls

For the operational phase of the proposal, rainfall runoff and accidental spills would be treated and contained through the provision of a water quality treatment train combining grassed swales (where possible) leading to permanent water quality ponds or spill containment basins. The treatment train would be designed to meet the water quality objectives in Section 2.3 and the design criteria given in Section 6.3.

The detailed design would include mitigation against scour in areas where scour is possible, such as downstream of water quality ponds or around pier location at Whites Creek bridge. At Whites Creek bridge, the abutment spill-through embankments would be surfaced with stone pitching or similar to prevent erosion. The creek line would be treated with rip rap or similar, following consultation with urban design and landscaping. This detail will be progressed as part of the 80% detailed design.

Where traffic loads are low, such as on local roads, the level of pollutant loading would also be low and consequently permanent water quality control measures would not be provided.

Mitigation against the impact of de-icing activities, additional to the water quality treatment that would be designed for other contaminants, is not deemed to be required. This is because the use of de-icing salt on the full length of the Great Western Highway between Mt Victoria and Lithgow in its current state is infrequent – values are shown in Table 5-2. Furthermore, the upgraded road includes measures to reduce the potential for ice in key risk areas, which is likely to further reduce the need for de-icing.

Table 5-3 Number of times de-icing activities were undertaken on the Great Wester Highway between Mt Victoria and Lithgow (RTA, 2009b)

Year	Number of de-icing activities
2005	30
2006	9
2007	14

Details of the operational water quality controls including water quality ponds, spill basins, grassed swales with rock check dams and biofiltration basin and swales are given in 0. A list of the proposed water quality ponds is given in Appendix D. Typical details are provided in 0.

5.2.2. Procedural water quality controls

A SWMP would be prepared and implemented as part of the CEMP. The plan would include:

- Operational water management controls.
- A maintenance and inspection program for operational controls.

5.2.3. Monitoring

Operational phase monitoring would be undertaken in order to:

- Assess and manage impacts on the receiving waters as the site stabilises.
- Assist in deciding when the site has stabilised.
- Identify water quality conditions after development.

Monitoring would be undertaken in line with the RMS Guidelines (RTA, 2003c). The parameters that are to be monitored are described in this document.

6. Design methodology

6.1. Locating construction phase sediment basins

A geographic assessment has been undertaken to determine existing catchments along the proposal, using the 12D modelling software. A further assessment of the catchments has been undertaken based on the proposed upgraded road alignment. The locations of the sediment basins have been selected to best capture runoff from these catchments throughout the full construction process, using gravity driven diversion drains to divert runoff to the basins.

Where possible, existing natural features have been incorporated into the treatment system. Furthermore, all attempts have been made to avoid properties and sensitive areas when locating sediment basins.

This assessment has identified locations for the construction phase sediment basins. The site topography is such that a very large number of basins would be required to treat every section of the construction area throughout all stages of the work. In steep areas, the placement of basins may also result in an undesirable and oversized footprint. In order to minimise the number of basins and the impact of the construction of these basins on the local natural environment, the catchment and flowpath to each basin has been maximised. In some locations this may require temporary drainage lines outside the construction boundary, filling low points or using other temporary works to achieve a continuous flowpath to the basins.

6.2. Sizing construction phase sediment basins

The design criteria for the temporary water quality treatment controls used during the construction phase are aimed at achieving the water quality objectives and meeting the performance objectives described in Section 2.3.

The preliminary sediment basins have been designed as Type D or F as per the Blue Book (Landcom, 2004) classifications and the site specific soil test results (refer to Appendix E). The basins provide a volume for settling and storage. The settling zone volume has been estimated using the appropriate design rainfall depth and catchment areas. The storage zone has been estimated using the Revised Universal Soil Loss Equation (RUSLE). The parameters used to size the sediment basins are outlined in Table 6-1.

Using the technical criteria in Table 6-1, a simplified method to size preliminary sediment basins along the proposed highway upgrade has been derived. This takes into account key elements of each contributing catchment, such as catchment area, steepness of slopes and the presence of significant areas of either cut or fills in the catchment.

Table 6-1 Design criteria for sizing the sediment basins

Parameter	Value	Comments
Rainfall Parameters		
Rainfall depth duration (days)	2 and 5	5 day adopted as standard duration
Rainfall percentile	80th or 85th	85th adopted for sensitive receiving environments in a drinking water supply catchment with construction duration between 6 months and 3 years.
Rainfall Depth (mm) – 5 Day	80th = 23.6 mm 85th =29.4 mm	For Lithgow
Rainfall Depth (mm) – 2 Day	80th = 14.0 mm 85th =18.3 mm	For Lithgow
Volumetric Runoff Coefficient, Cv	0.42 to 0.56	0.8 adopted for expected type of activities on site and compacted surfaces.
Rainfall intensity for 2 year ARI, 6 hr duration	9.54 mm/hr	Refer to Rainfall Erosivity below
RUSLE Parameters		
Soil/sediment Type	C, D or F	Varies along the route. Mainly type F, type D, and small localised pockets of type C. Type D has been adopted for deeper subsoils as per soil test results in Appendix E.
Erodibility, k	0.02 to 0.08	K=0.06 was adopted based on soil test results. Refer to Appendix E. (conservative assumption)
Rainfall Erosivity, R	2037	For Mt Victoria to Lithgow based on site specific rainfall intensity
Hydrologic Soil Group	D	For high runoff potential, Ref: Appendix F of Blue Book
Soil Cover, C	1	Corresponding to expected type of activities on site
Soil Conservation Practices, P	1.3	Corresponding to expected type of activities on site
Length Slope Factors, LS	Variable	Determined separately for main road way; and steeper embankment areas (cut and fill)
Sediment Yield Time Period (months)	2 to 6	Depending on site constraints

Sediment basin volume-per-unit-area rates were estimated using the Blue Book sediment basin sizing methodology and a range of parameters described below and listed in Table 6-2.

The three key design elements for sizing each sediment basin are:

1) Catchment area contributing to sediment basins (excludes any diverted offsite/clean runoff).
2) Longitudinal alignment slope of the catchment (generally flat is less than one per cent, mild ranges between one to five per cent and steep is greater than five per cent).
3) The percentage of the total contributing catchment area that is either “cut” or “fill”. These are batters/embankments areas that could be as high as 60 per cent in some catchments, but are generally in the order of 15 per cent. This parameter has been split into two categories for the purposes of the simplified basin sizing method, 15 per cent representing a range of 0 per cent to 30 per cent, and 45 per cent representing a range of 30 per cent to 60 per cent.

From these key elements, the derived rates to size the basins are shown in Table 6-2.

The Table includes volume-per-unit-area rates for the 80th percentile and a 2-day rainfall depth which may be used during the detailed design stages in some areas with severe space limitation constraints. It is anticipated that for the majority of sediment basins, the 85th percentile 5-day rainfall depth rates shown in bold in Table 6-2 would be applied in the detailed design. For the concept design, 85th percentile 5-day rainfall depth rates have been applied for all sediment basins.

Table 6-2 Derived volume-per-unit-are rates used to size sediment basins along alignment (m^3/ha)

Longitudinal slope	**Flat (<1%)**				**Mild (1% to 5%)**				**Steep (>5%)**			
% of contributing catchment in Steep areas (Cut or Fill)	<30%		>30%		<30%		>30%		<30%		>30%	
Downstream waterways sensitivity and %’ile for rainfall depth	low 80%	high 85%	low 80%	high 85%	low 80%	high 85%	low 80%	high 85%	low 80%	high 85%	low 80%	high 85%
Estimated basin volume for 5-day rainfall depth (m^3/ha)	200	250	265	310	270	315	310	355	375	420	385	430
Estimated basin volume for 2-day rainfall depth (m^3/ha)	125	160	185	220	190	225	235	270	300	330	310	340

The required volume of each sediment basin has been determined according to an estimate of the maximum catchment area that would drain to the basin during the various stages of the construction and the design parameters identified in Table 6-1.

Locations and sizes of temporary sediment basins for the construction phase are presented as a list in Appendix D.

The design and the location of the road have a significant effect on the size and location of the basins. Changes to the road design in the future may result in the addition of new basins, the removal of other basins and various changes to the sizes and location of the basins.

6.3. Sizing operational phase water quality controls

Water quality objectives were outlined in Section 2.3, based on levels of concentration. The load-based water quality objectives and design criteria are listed in Table 6-3. For the concept design basins volumes have been sized without considering the effects of additional treatment measures such as grassed swales. This is deemed a conservative approach, as the size of some of the water quality ponds would decrease when additional measures such as swales are introduced during development of the detailed design.

Table 6-3 Operational water quality control treatment target guidelines

Pollutant	Minimum reduction of the annual average load
Total suspended solids (TSS)	80%
Total nitrogen (TN)	45%
Total phosphorous (TP)	45%
Oil and grease	None visible

A water quality assessment was required to attain water quality pond volume-per-unit-area rates to meet the criteria in Table 6-3 for the anticipated range of catchment percentage imperviousness (20 per cent to 100 per cent) for the highway upgrade. The tool used for this was the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC). It used an iterative process to find the basin volume needed to achieve the required water quality treatment for the road catchment. This modelling was undertaken for five ranges of impervious area within each catchment. The water quality pond volume-per-unit-area rates determined are shown in Table 6-4.

Table 6-4 – Operational phase water quality basin volume requirements per unit area (m^3/ha)

Catchment Imperviousness (%)	Basin volume (m3/ha)
0-20%	336
20-40%	340
40-60%	348
60-80%	352
80-100%	364

The locations and space requirements for water quality controls for the operational phase of the proposed highway upgrade have been identified based on the concept design. The locations and sizes of temporary sediment basins for the construction phase are presented as a list in Appendix D**.**

Future changes to the road and drainage design would affect the size, location and number of permanent water quality ponds required. Any changes to basin sizes and/or locations would be undertaken in consultation with other relevant environmental disciplines to ensure that other environmental considerations are also taken into account.

For the concept design, treatment through the use of water quality ponds has been assessed. Other water quality controls such as swales have not been included in this water quality assessment but would be considered during the development of the detailed design where individual modelling of each water quality controls would be undertaken. The assessment undertaken in this report is considered to be a conservative approach, as the size of some of the water quality ponds would decrease when additional measures such as swales are introduced.

The concept design incorporates emergency spill containment into the operational water quality ponds. If runoff is redirected during the development of the detailed design so that it does not flow to a water quality pond, a 60 cubic metre spill basin that can store 20 cubic metres of spilled runoff must be incorporated into the detailed design.

Along the majority of the proposed highway upgrade, water quality ponds are the most effective and efficient water quality control measure, especially in steep terrain areas. Where possible, construction stage sediment basins would be located and sized so that they can be retained as water quality ponds for the operational phase of the proposed highway upgrade. Along sections of the upgrade that traverse regions with flat terrain, water quality treatment options such as grassed swales may be adequate to meet the treatment guidelines, reducing or possibly negating the need for a water quality basin.

In addition, the inclusion of biofiltration basins, artificial wetlands, swales with or without rock check dams and the use of existing farm dams would be investigated during the development of detailed design. These water quality measures would provide adequate protection to the surrounding environments, including the Greater Blue Mountains World Heritage Area, the hanging swamps, national parks and private farmland and properties.

Examples of typical water quality controls have been included in 0.

7. Further Assessment

Erosion and sediment control measures would be proposed for the exposed areas during the construction stage that include catch and diversion drains, sediment basins, stabilisation of exposed faces, and local controls such as sediment fences, check dams, windrows and sumps.

Permanent water quality controls would include the use of permanent water quality ponds that incorporate spill containment as well as a biofiltration component to meet the water quality design criteria. Grassed swales would be considered for additional water quality management where feasible as part of the development of detailed design. Artificial wetlands, rock check dams and biofiltration basins would also be investigated as part of the permanent water quality management design strategy, in order to achieve a varied design that has a neutral or beneficial effect on water quality as well as fitting aesthetically into the local environment.

During the development of detailed design, safety of the operation and maintenance of the water quality control infrastructure needs to be considered. This would include aspects such as access to basins for maintenance, restricting public access by installing fences and consideration of the need to bench the side slopes of basins for safety purposes. The boundary around the concept design basins has included an allowance for additional space to accommodate future safety aspects. Details of safety around basins would be provided at the detailed design stage.

Further assessments would be undertaken throughout the detailed design phase to ensure the SCA's NorBE requirements are met. As part of this report, a preliminary, qualitative NorBE assessment has been undertaken. Further details of the assessment are provided in Appendix G. It is currently assessed that by meeting the RMS water quality design criteria previously listed in Table 6-3, the proposal would have a neutral effect on water quality. This would be analysed further throughout the detailed design process.

The number, sizes, locations and footprints of the proposed sediment control basins and water quality ponds would be based on the road and drainage designs. The values listed in Appendix D are subject to finalisation during detailed design. Also, changes to the road and drainage designs would likely result in changes to the size, location and footprint of some basins and may result in basins extending outside the current proposal site. As such it should be stressed that the boundaries remain flexible in order to produce the best possible water quality design and to minimise the potential impact of the proposed upgrade on the surrounding built and natural environment.

Where more than minor changes occur, consultation with the RMS Senior Regional Environmental Officer would determine if any additional environmental impact assessment is required.

7.1. Next Steps

The management of potential water quality impacts would be further developed following comments received from the public and the stakeholder agency consultation process. In addition, as the concept and detailed design for the proposed highway upgrade are progressed, water quality management measures would be amended to suit the changes. For example, the number, location and design of proposed sediment basins would be reviewed continuously as the detailed design is developed to provide optimal environmental and design solutions.

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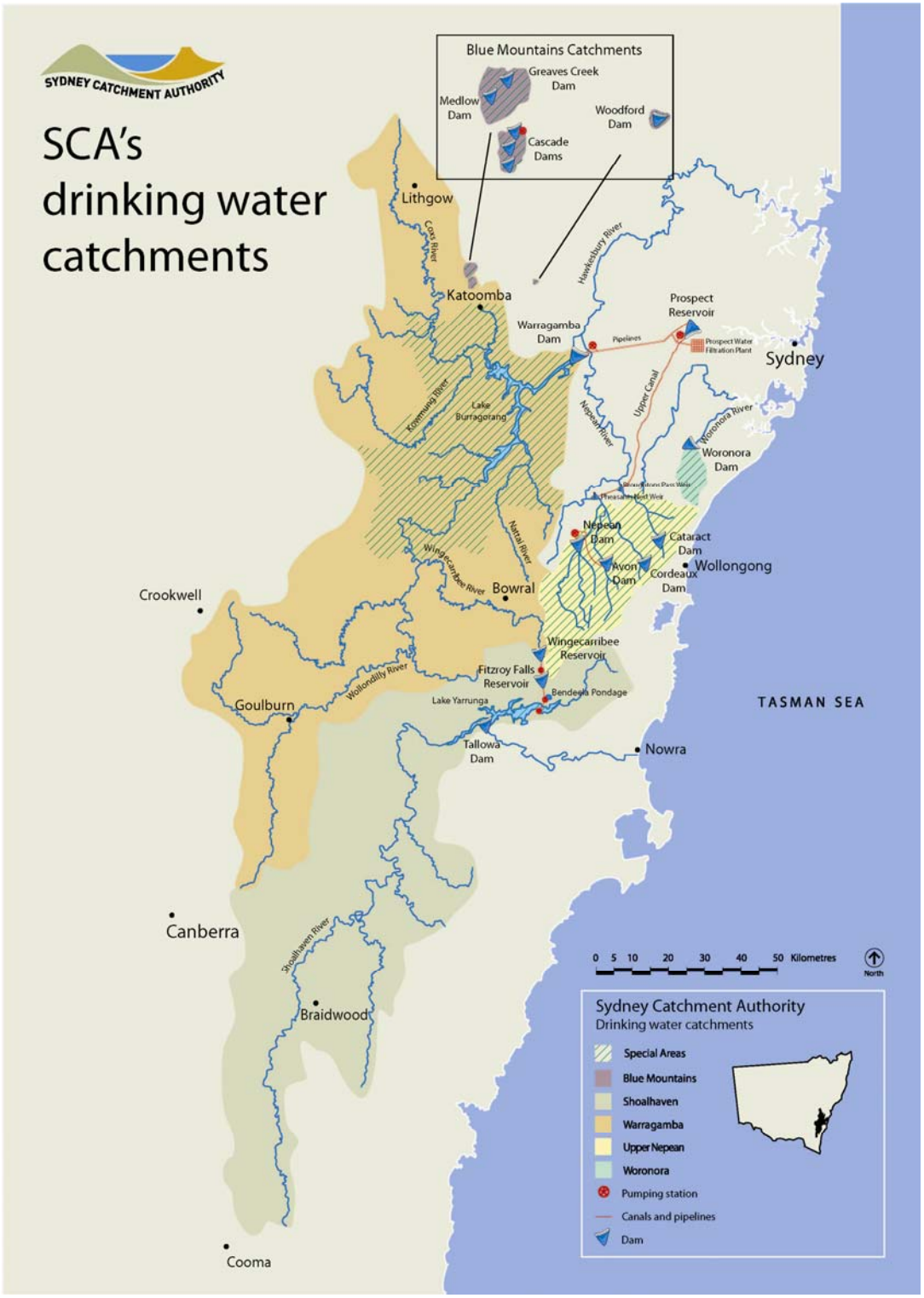
Appendix A Sydney Catchment Authority drinking water catchment



Appendix B Impact and environmental safeguards matrix

No.	Timing	Subject	Potential Impact	Environmental safeguards
1	Construction	Surface water quality	Exposed soil during rainfall events causing high sediment loads to be washed into downstream watercourses.	■ Develop SWMP. ■ Develop ESCPs. ■ Minimise extent and time of exposed soil through construction sequencing. ■ Minimising the lengths of slopes through limiting the extent of excavations to reduce water velocity over disturbed areas. ■ Divert offsite runoff around or through the site so that it does not mix with onsite construction runoff using temporary or permanent diversion drains to minimise the volume of flow through the construction area. ■ Install physical controls in line with the ESCPs, including: sediment fences, sediment filters, rock check dams, level spreaders, onsite diversion drains. ■ Line channels and other concentrated flowpaths. ■ Revegetate exposed soils as soon as possible. ■ Line exposed batters if required. ■ Capture runoff from exposed areas in sediment basins that provides treatment to reduce sediment to the required level prior to discharging into downstream waterways.
2	Construction	Surface water quality	Dust blown off exposed soil causing sediment to be deposited into nearby creeks.	■ Minimise extent and time of exposed soil through construction sequencing. ■ Dust suppression to be undertaken during periods of dry weather. ■ Revegetate exposed soils as soon as possible. ■ Line exposed batters if required.
3	Construction	Surface water quality	Increased levels of nutrients transported via sediment to downstream water courses.	■ Capture runoff from exposed areas in a sediment basin that provides treatment to reduce nutrients to the required level prior to discharge into downstream waterways. ■ Where feasible, grassed swales would be incorporated into the treatment train design to provide additional nutrient reduction.

No.	Timing	Subject	Potential Impact	Environmental safeguards
4	Construction	Surface water quality	Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways	▪ Develop a SWMP, that includes an Incident Emergency Spill Plan. ▪ Develop ESCPs. ▪ Store chemicals and other pollutants in a bunded or sealed area. ▪ Divert offsite runoff around or through the site so that it does not mix with onsite construction runoff using temporary or permanent diversion drains, to minimise the volume of flow through the construction area. ▪ Install physical controls in line with the ESCPs, including onsite diversion drains. ▪ Capture construction runoff in sediment basins that provides treatment to reduce pollutants to the required level prior to discharging into downstream waterways. Include capacity for spills in the sediment basin design volume.
5	Construction	Surface water quality	Increased levels of litter from construction activities polluting downstream watercourses.	▪ Litter to be managed on site by construction team. ▪ Sediment basin design to include trash racks to collect litter prior to entering basins. Regular maintenance of trash racks to be undertaken.
6	Construction	Surface water quality	Contamination of water by disturbance of contaminated land.	▪ Refer to Contamination chapter of the REF.
8	Construction	Surface water quality	Hydrologic and hydraulic disturbance through the changing of surface and subsurface flows and altering the volume and timing of water flows.	▪ Changes in flow regimes that include peak flows and volumes to surface runoff are not significant. Detention is not normally provided on RMS highway construction projects for the reduction of peak flows. Changes to ground water (subsurface flows) are described in the Groundwater Technical Paper
9	Construction	Drinking water catchment	Increased levels of sediments, chemicals, nutrients , heavy metals, oils, grease, litter and other pollutants flowing to the Sydney's drinking water supply catchment.	▪ Safeguards as per all previous items. ▪ Increase the design requirements of the sediment basins from the 80th percentile five day rainfall value adopted by the Blue Book, to the 85th percentile rainfall value.
10	Construction	Soil erodibility	Moderate levels of soil erodibility increasing the likelihood and severity of sediment erosion during rainfall events.	▪ Safeguards as per items 1 and 2.

No.	Timing	Subject	Potential Impact	Environmental safeguards
11	Construction	Modifications to waterways	Temporary diversions of waterways, the construction of permanent waterway diversions and the construction of in-stream structures in waterways disturbing the bed and banks of the waterway, causing soil and streambank erosion.	■ Develop ESCPs. ■ Construction should be in line with RMS' *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (2011).
12	Construction	Existing dams	Changes to the proportion of pervious areas in a catchment, altering the flow patterns of the catchment.	■ Flows to existing dams are primarily derived from upstream catchments and changes in flow regimes from the road construction area during the construction stages are not significant.
13	Construction	Existing dams	Temporary diversions of offsite flow, excavations and embankments altering flow patterns, changing the shape of the catchment and changing the volume and timing of water flowing to existing farm dams.	■ Flows to existing dams are primarily derived from upstream catchments and changes in flow regimes from the road construction area during the construction stages are not significant.
14	Construction	Large excavations and embankments	Construction of large excavations and embankments causing an elevated risk to water quality in downstream waterways through the increased likelihood of movement of sediment off steep slopes.	■ Safeguards as per item 1. ■ Revegetate exposed batters.
15	Construction	Acid sulfate soils	Construction in acid sulfate soils (ASS) disturbing and exposing ASS to oxygen, resulting in the generation of sulphuric acid and toxic quantities of aluminium and other heavy metals. These could be released into the surrounding environment, causing acidification of receiving surface waters and groundwater.	■ ASS should be managed in accordance with the relevant guidelines. ■ Develop a SWMP, that includes an ASS Management Sub Plan ■ Should ASS be detected where excavation is required, works would proceed according to the sub plan and would involve: – Capping of exposed surfaces with clean fill to prevent oxidation. – Place excavated ASS separately in a lined, bunded and covered area. – Neutralising ASS for reuse by using soil additives such as lime. – Disposal of ASS where necessary in accordance with the relevant guidelines ■ The management of ASS during construction that may impact on the acidity of the receiving waterways would be described in the Geotechnical Technical Paper.

No.	Timing	Subject	Potential Impact	Environmental safeguards
16	Construction	Stockpiles	Stockpiling of earthworks causing a risk to downstream water quality during rainfall event, through transport of large amounts of sediments from the stockpiles into waterways.	■ Stockpile sites should be included in the ESCPs and management measures should be detailed. ■ The maintenance of established stockpile sites during construction is to be in accordance with the RMS Stockpile Site Management Procedures (2001). ■ Locate stockpiles away from overland flowpaths and in areas of high topography with minimal upstream catchment. ■ Divert runoff around stockpiles sites. ■ Minimise the number and size of stockpiles. ■ Line the base of stockpiles if they are located over a shallow water table. ■ Cover stockpiles with plastic sheets if required. ■ If uncovered, treat runoff from stockpile site with a stockpile-specific sediment basin and monitoring the sediment basin for parameters such as dissolved oxygen levels and organics to determine suiTable discharge to the environment.
17	Construction	Stockpiles	Stockpiling vegetation from cutting of trees and slashing of shrubs causing a risk of tannins leaching into waterways, and increased loads of organics in waterways.	■ Mitigation of tannins leaching from mulch stockpiles into waterways should be in line with RMS *Environmental Direction - Management of Tannins from Vegetation Mulch* (RMS, 2012). ■ Risks of tannin leaching are low as minimal clearing is required.
18	Construction	Site compounds	Site compound areas causing a risk of contaminated spills into downstream waterways.	■ Management of site compound runoff should included in ESCPs. ■ Divert offsite runoff around or through the site compound so that it does not mix with site compound runoff, using temporary or permanent diversion drains to minimise the volume of flow through the area. ■ Plants to be located within a bunded area, preferably away from overland flowpath and in areas of high topography with minimal upstream catchment. ■ Chemicals to be stored within a sealed or bunded area. ■ Line the base of plant areas if they are located over a shallow water table. ■ Treat runoff from site compound with a site specific sediment basin to the required level prior to discharging into downstream waterways.

No.	Timing	Subject	Potential Impact	Environmental safeguards
19	Construction	Site compounds	Storage of chemicals causing a risk of contaminated spills into downstream waterways.	▪ Safeguards as per item 18.
20	Construction	Site compounds	Vehicle washdown areas causing a risk of contaminated spills into downstream waterways.	▪ Safeguards as per item 18.
21	Construction	Site compounds	Vehicle refuelling areas causing a risk of contaminated spills into downstream waterways.	▪ Safeguards as per item 18.
22	Construction	Site compounds	High frequency of vehicle movements disturbing soils and causing sediment loads to be washed into downstream waterways.	▪ Select site compound away from overland flowpaths and in flat areas of high topography with minimal upstream catchment, if possible. ▪ Management of site compound runoff should be included in ESCPs. ▪ Restrict vehicle movements to designated pathways where feasible. ▪ Paved areas that would be exposed for extended periods, such as carparks and main access roads, where feasible. ▪ Install physical controls in line with the ESCPs, including: sediment fences, sediment filters, rock check dams, level spreaders, onsite diversion drains. ▪ Line channels and other concentrated flowpaths. ▪ Treat runoff from site compound with a site specific sediment basin to the required level prior to discharging into downstream waterways.
23	Operation	Surface water quality	Surface runoff from impervious areas and landscaped batters during the establishment period transporting suspended sediments to surrounding watercourses or infiltrate into the groundwater system.	▪ Develop a SWMP, that includes an operational water management controls and an associated maintenance and inspection program. ▪ Design a physical treatment train that includes elements such grassed swales, biofiltration swales, and water quality to ensure total suspended solids are reduced by at least 80% prior to discharging into downstream waterways.
24	Operation	Surface water quality	Surface runoff from impervious areas transporting contaminants such as heavy metals, oil, grease and chemicals attached to particles to surrounding watercourses or infiltrate into the groundwater system.	▪ Safeguards as per item 23. ▪ Treatment train designed to ensure no oil or grease is visible when discharging into downstream waterways.

No.	Timing	Subject	Potential Impact	Environmental safeguards
25	Operation	Surface water quality	Surface runoff from impervious surfaces transporting litter from the road corridor into surrounding watercourses.	▪ Safeguards as per item 23. ▪ Treatment train to include trash racks on water quality ponds to prevent litter entering waterways.
26	Operation	Surface water quality	Surface runoff from impervious surfaces transporting nutrients such as nitrogen and phosphorus to surrounding watercourses or infiltrate into the groundwater system.	▪ Safeguards as per item 23. ▪ Treatment train to provide at least 45% reduction of total nitrogen and 45% reduction of total phosphorus.
27	Operation	Surface water quality	Concentration of runoff by drains and kerbs causing scour.	▪ Outlet structures such as culverts and basin spillways should incorporate lining to avoid scour downstream of the outlet or spillway. ▪ Open drains and channels to be lined with appropriate material to prevent scour as part of the drainage design.
28	Operation	Surface water quality	Erosion through the introduction of additional permanent physical obstructions in waterways, such as bridge piers.	▪ Waterways around any such additional permanent structures would be lined appropriately to avoid erosion
29	Operation	Surface water quality	Increased volume of highway runoff associated with the introduction of additional impervious surfaces.	▪ Any development that includes an increase in impervious areas would produce increases in runoff volumes. There is no practical measure to mitigate against this.
30	Operation	Surface water quality	Maintenance practices such as herbicide use, mowing, road surface cleaning and reparation polluting downstream waterways.	▪ RMS standard maintenance controls would be applied in a manner that would minimise any potential water pollution.
31	Operation	Accidental Spills	Accidental spillage of hazardous materials, could passing rapidly into the drainage system and impacting downstream ecosystems.	▪ Water quality ponds would incorporate accidental spill management containment of spills up to 40,000L through an appropriate baffle arrangement with an underflow or “Ellis” pipes at the outlet end of the pond. ▪ Where water quality ponds are not part of the highway drainage system a dedicated spill would be required.

Appendix C Standard water quality management measures

C.1 Construction phase

C.1.1 Erosion and sediment controls

Sediment basins

Sediment basins are used to improve water quality in runoff from a construction site and reduce the environmental impact by intercepting sediment-laden runoff and retaining the sediment. They can also lessen flooding which is associated with a reduction in a stream's capacity caused by deposited sediment.

Basins are used to trap sediments from disturbed areas in locations where the soil type has annual soil loss is larger than 150m^3/year (Section 6 and Appendix M of the Blue Book, Landcom, 2004).

Sediment basins should be installed prior to any construction activity on a site such as earthworks, and should remain in place until the activity has been completed and the land stabilised. They should be located away from busy construction areas at lower gradients on the construction site just outside of drainage lines, or at some other stormwater collection point where they can trap a high proportion of polluted runoff. Offsite 'clean' runoff from undisturbed catchments should be diverted around the construction site to reduce the required size of the basins.

Sediment basins are used in addition to other on-site control measures such as catch drains, diversion drains, sediment traps at stormwater inlets, erosion measures, topsoiling and progressive revegetation. These measures retain a portion of the sediment carried in runoff and the basin is used as an end of line defence before site runoff enters existing creeks and waterways. Subject to the scale of work, in accordance with the *POEO Act* (1997) an Environmental Protection Licence may be required.

A sediment basin may be either temporary or permanent in terms of design life. However, there is an over-riding need in both cases for adequate design procedures which should consider flows and estimate a reasonable sediment yield from the contributing catchment.

Storage surface area is a critical design feature, and should be maximised within the site constraints. The distance between the basin inlet and outlet should also be the maximum practical, to ensure optimum retention time and hence optimum sediment trapping efficiency.

Basins can be fitted with a dewatering system, such as low flow outlets, which allows the basin to be discharged between rainfall events. Energy dissipaters or scour protection methods would be used to prevent erosion at all basin outlets to protect natural water courses. Provision for flocculation would normally be required for some basins receiving fine and dispersible soils. A permanent supply of gypsum flocculent agent should always be available on site.

Temporary sediment basins have been sized for the highway upgrade based upon design guidelines detailed in **Table 2-1.** These guidelines have developed in accordance with Managing Urban Stormwater guidelines (DECCW, 2008 and Landcom, 2004). The minimum depth of the basins would be 0.6 metres, with an average depth of 1 metre (maximum depth 2 metres), subject to detailed design refinement, land availability and vegetation clearing. Images of sediment basins are provided in Figure C - 1 to Figure C - 5.

Figure C - 1 Example photos of temporary sediment basins on the major Highways (Hunter Expressway and Karuah to Buladelah)

Figure C - 2 Example photos of temporary sediment basins on major highways (Hunter Expressway and Karuah to Buladelah)

Figure C - 3 Basins on either side of a water courses on the Woomargama Alliance project capturing construction runoff

Figure C - 4 Basins on either side of a new bridge under construction capturing runoff from the road construction

Figure C - 5 Images of water quality basins- during construction and after construction during use as a construction phase sediment basin showing growth of vegetation on the basin banks and inlet swale

Catch and diversion drains

Either individually or in combination, these structures are used to intercept and direct runoff water to a desired location. By doing so, sheet flow is converted to concentrated flow, and the time of concentration for runoff is decreased. There are two types of drains for clean and dirty runoff used during the construction phase, and they are often used in conjunction with level spreaders and check dams:

- **Upslope runoff diversion drain (catch drain)**: This diversion drain is an earth channel with lining designed to intercept and direct clean runoff from the undisturbed upstream catchment and divert it to an existing waterway, so that it does not enter the construction site.
- **Onsite runoff diversion drain:** A temporary earth bank located around the perimeter of construction sites or disturbed areas which drain into sediment basins.

Check dams

A check dam is a small, temporary dam built across a swale or diversion channel. Its primary function is to reduce the velocity of flow in the channel and thus reduce erosion of the channel bed. The entrapment of sediment behind these structures is a secondary function. Check dams can be used:

- To protect a grass lined channel during initial establishment of vegetation.
- As a substitute for channel lining in a temporary channel.

Check dams can be constructed by using any materials on the site that can withstand the flow of water. Rock, logs and sandbag check dams can be the sturdiest, if these materials are correctly placed in position. Wire netting, woven brush and straw bales can also be used.

Although check dams are not primarily intended as sediment trapping devices, larger-sized particles would inevitably accumulate behind them. This sediment should be removed before it accumulates to one-half of the original height of the dam, and placed where it would not be washed back into the drainage system.

Level spreader

A level spreader is an excavated outlet constructed with zero grade. It converts an erosive, concentrated flow of runoff into sheet flow, and discharges it at a non-erosive velocity onto an undisturbed area stabilised by vegetation.

Level spreaders may be used as outlets for diversion or perimeter banks or channels, where storm runoff has been intercepted and diverted to sTable areas. They should be used only where the spreader can be constructed on undisturbed soil. The area directly below the spreader sill should be uniform in slope and well vegetated, allowing water to spread out as sheet flow.

The cross-sectional area and length of the level spreader would be designed to be sufficient to discharge the design flow from the selected frequency rainfall event.

Sediment fencing and filters

Sediment fences/ filters and act as sediment mitigation measures for small areas of runoff from disturbed sites that are impracticable to be directed to sediment basins by diversion drains. Sediment fences/ filters function by intercepting and filtering small volumes of runoff, which mainly occur as sheet flow.

C.1.2 Management and maintenance

All erosion and sediment control measures would be regularly inspected and maintained. This would include regular engagement of a qualified soil conservation officer to inspect temporary and permanent erosion and sediment control devices, and to ensure the most appropriate controls are implemented and maintained.

The following management and maintenance procedures for sediment basins would be adopted to ensure effective functioning and compliance with the anticipated Department of Environment, Climate Change and Water (DECCW) Environment Protection Licence (EPL) conditions:

- Inspections would be undertaken at regular intervals and following significant rainfall events to assess available water storage capacity, water quality, structural integrity and debris levels.
- Where appropriate, an approved flocculent would be applied to sediment basins as early as possible so that early mixing of flocculants occurs. Water quality would be tested prior to discharge in accordance with any EPL requirements.
- Where excessive sediment has built up in the basin to a point where greater that 30 per cent of the total capacity has been utilised, sediment would be removed and adequately disposed of.
- A permanent supply of gypsum flocculent agent should always be available on site for use in the sediment basins.
- Water from sediment basins would be utilised for construction purposes such as dust suppression where feasible.

- When sediment basins require pumping out rather than discharge via a flow outlet, a float would be attached to the hose suction or located inside a bucket to ensure that sediment from the basin floor is not discharged.
- Records regarding water quality and functionality or erosion and sediment control devices would be kept, including details of rain events, use of flocculants, discharge, sediment removal and dewatering activities in accordance with DECCW reporting procedures and licence conditions.
- A checklist would be completed when treated water is to be discharged from the basin in accordance with a contractor environmental management plan (CEMP).

C.2 Operational phase

For the operational phase of the proposal, rainfall runoff and accidental spills could be treated and contained through the provision of a water quality treatment train combining grassed swales leading to permanent water quality ponds or spill containment basins

C.2.1 Water quality ponds

Water quality ponds would provide the function of trapping the finer sediments and associated contaminants before stormwater is discharged into the receiving waterways. The ponds would treat road pavement and batter runoff collected by the pavement drainage network. Water quality ponds operate by reducing the flow velocities and promoting the settlement of suspended sediment contained in stormwater runoff.

Examples of completed water quality ponds are provided in Figure C - 6. Measures such as outlet baffles are also incorporated into the design of the ponds to enable the containment of accidental spills such as petroleum hydrocarbons that have a density lower than water. Images of outlet baffles are given in

Figure C - 7.

Figure C - 6 Examples of completed water quality pond showing urban design features

Figure C - 7 Outlet baffles during dry and wet conditions

A number of operational water quality ponds would be converted from proposed temporary sediment basins used during the construction phase. Basins and ponds that are to be used both for construction and operational phases would be designed according to the maximum size requirements (usually the construction phase basins) and the one design would be maintained for both phases.

Maintenance access to water quality ponds must be provided. Access from the main carriageway is only permitted if access from a side road or service road is not available. Fencing of ponds may be required and would be subject to a risk assessment.

Locations and sizing of permanent water quality ponds are provided in **Appendix D**.

C.2.2 Accidental spill containment

All water quality ponds would incorporate accidental spill management containment. Ponds would provide this containment through an appropriate baffle arrangement with an underflow or “Ellis” pipe at the outlet end of the pond. To prevent spillages from reaching downstream ecosystems and waterways these measures are designed to accommodate accidental spills to a volume of 40,000L.

Where pavement runoff discharges to waterways from the main highway without flowing into a water quality basin, a spill basin would be required to protect the sensitive waterways against any accidental spill from the highway.

This mitigation would be effective against insoluble particles, such as hydrocarbons, which are the most common form of spills on highways. The heavy metals bound in particulate form would be captured in water quality ponds. However, if an accident occurred whilst it was raining that resulted in a spill of a soluble material, the material could pass through the water quality pond or spill basin with rainfall overflows. Although it is unlikely that these events would occur simultaneously, overflow containing the soluble spill material could be harmful to the downstream environmental. If a spill was to occur during dry weather, highway maintenance procedures would clean up the spill prior to it flowing to basins and there would be no concern to downstream receivers.

Typical spill basin details are shown in 0.

C.2.3 Grassed swales

Along the majority of the proposal a considerable number of grassed swale drains would be designed to intercept offsite or clean water that is flowing towards the road and divert this water to cross drainage structures where it can be directed past the road, without mixing with road runoff.

Where feasible, grassed swales would also be used as a water quality mitigation method. Often this would be at the base of fill areas where SO gutters on the road are not used, in order to provide effective water quality treatment to the road runoff. As the swales are grass lined they filter suspended solids and their associated pollutants, facilitated by the interaction between the flow and the vegetation along the length of the swale. In addition the vegetation acts to spread and slow flow velocities, which aids the deposition of sediments. Swales do not, however, provide spill containment – this would be done through water quality ponds and spill containment basins.

Biofiltration trenches can be included within grassed swales to increase the level of treatment and extend detention. Examples of a biofiltration and standard grassed median swales are provided in Figure C - 8.

Figure C - 8 Grassed median swales with and without biofiltration

Maintenance of the swales should ensure that grades are maintained and that grass is kept at a length of 200 to 300 millimetres. Weeds, rubbish and sediment should be regularly removed.

In areas of the proposal where available space is constricted and higher levels of water quality treatment are required than provided by typical swales, a swale with rock check dams can be utilised. The dams retain small volumes of water, increasing the proportion of sediment settling from the runoff and improving nitrogen and phosphorous removal. Typical details of a swale with rock check dams are shown in 0.

In some areas where the grades are steeper, grassed swales are inappropriate and drains would be appropriately lined or have adequate erosion protection such as rock. Additional water quality mitigation may also be gained from the inclusion of rock check dams located within the grassed swale, as shown in Figure C - 9.

Figure C - 9 Grassed swale with rock check dams

C.2.4 Constructed Wetlands

Constructed wetlands are well vegetated shallow retention areas that provide water quality treatment to road runoff. They also provide opportunities for improved aesthetics and wildlife habitats. They are suited to flat areas with a constant water supply in order to maintain growth of the vegetation. Inclusion of constructed wetlands on this proposal would be investigated further.

Figure C - 10 Constructed wetland

C.2.5 Biofiltration Basins

Biofiltration basins are used to treat runoff by fine filtration prior to outfall into a drainage system. They can be flexible in design and incorporated into roadside landscaping to from attractive vegetated areas. Examples are given in Figure C - 11 and Figure C - 12. The inclusion of biofiltration basins would be considered further in the next stages of this proposal

Figure C - 11 Example of a dry biofiltration basins and detail of macrophytes (Sydney Desalination Plant)

Figure C - 12 Dry biofiltration basin when wet

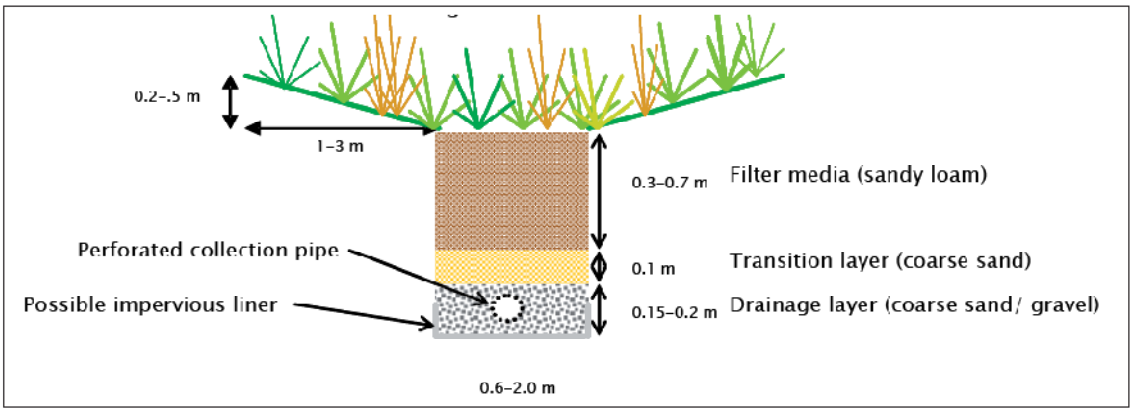
C.2.6 Biofiltration swales

There may also be opportunities to include biofiltration swales through the development of the design. These swales provide both conveyance of stormwater flows and treatment through filtration to remove coarse to medium sediments. A typical biofiltration system consists of a vegetated swale overlaying a filter medium (usually soil-based) with a perforated drainage pipe at the bottom. A typical biofiltration swale design is illustrated in Figure C - 13.

Biofiltration swales would require a higher level of maintenance than grassed swales, to ensure that the filtration media does not become clogged with fine sediment and in need of replacement. The following elements would need to be maintained (Upper Parramatta River Catchment Trust, 2003):

- Flow to and through the system to ensure no blockages.
- Surface vegetation.
- Prevention of undesired overgrowth and weeds.
- Removal of accumulated sediments.
- Removal of debris and litter.

Figure C - 13 Example of a biofiltration swale (Landcom, 2009)



Appendix D Sediment basins and water quality ponds

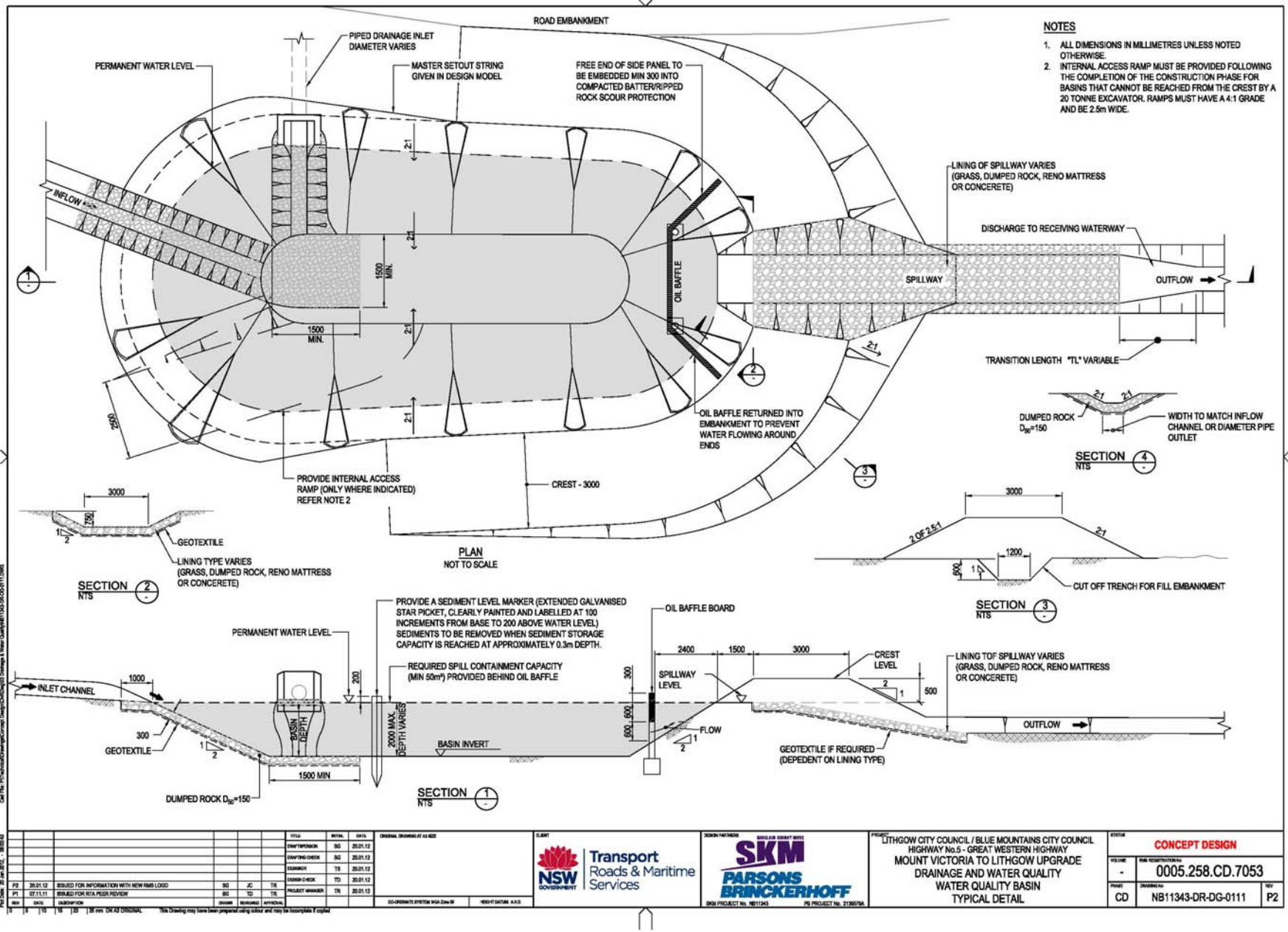
Sediment basins for the proposal that are either temporary or to be retained as permanent water quality ponds are shown in Table D - 1. Sediment basins and water quality pond locations would be reviewed during detailed design development.

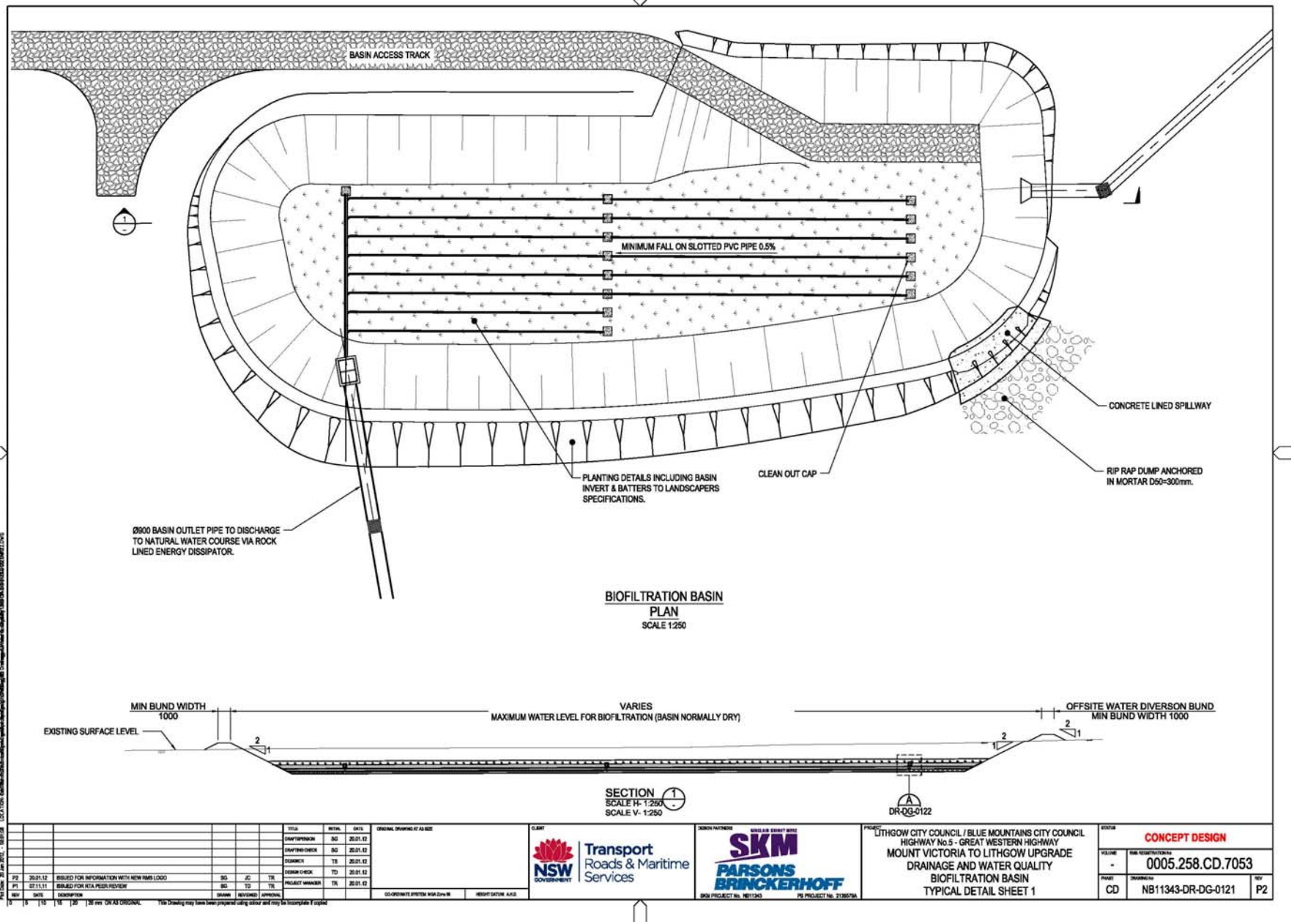
Table D - 1 List of sediment basins and water quality ponds

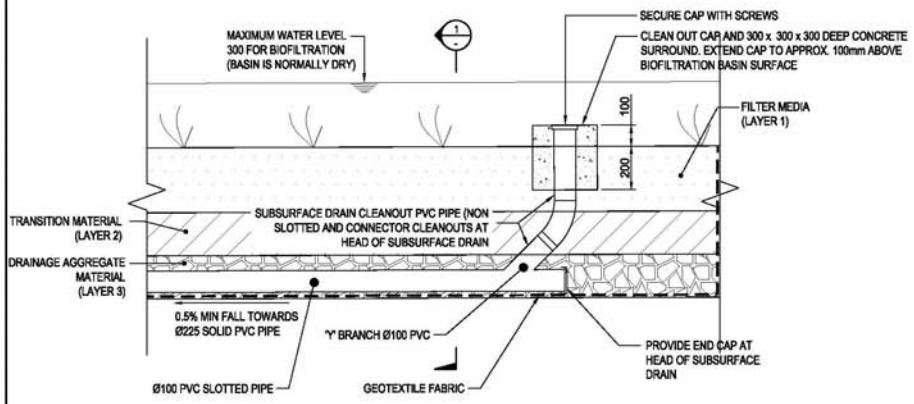
Basins Name	Station (m)	Type of Water Quality Basin	Volume (m^3)
B3088L	30880	Construction	710
B3110L	31100	Construction - operational	831
B3150L	31500	Construction - operational	835
B3182L	31820	Construction - operational	720
B3205L	32050	Construction - operational	1395
B3241L	32410	Construction	1370
B3281L	32810	Construction	1045
B3330L	33300	Construction - operational	300

R = Right, L = Left (using increasing chainage direction)

Appendix E Examples of typical water quality controls


ROAD EMBANKMENT
PIPED DRAINAGE INLET DIAMETER VARIES
PERMANENT WATER LEVEL
MASTER SETOUT STRING GIVEN IN DESIGN MODEL
FREE END OF SIDE PANEL TO BE EMBEDDED MIN 300 INTO COMPACTED BATTER/RIPPED ROCK SCOUR PROTECTION
INFLOW
OIL BAFFLE
1500 MIN.
2500
PROVIDE INTERNAL ACCESS RAMP (ONLY WHERE INDICATED) REFER NOTE 2
CREST - 3000
OIL BAFFLE RETURNED INTO EMBANKMENT TO PREVENT WATER FLOWING AROUND ENDS
PLAN
NOT TO SCALE
NOTES
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. INTERNAL ACCESS RAMP MUST BE PROVIDED FOLLOWING THE COMPLETION OF THE CONSTRUCTION PHASE FOR BASINS THAT CANNOT BE REACHED FROM THE CREST BY A 20 TONNE EXCAVATOR. RAMPS MUST HAVE A 4:1 GRADE AND BE 2.5m WIDE.
LINING OF SPILLWAY VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
DISCHARGE TO RECEIVING WATERWAY
SPILLWAY
OUTFLOW
TRANSITION LENGTH "TL" VARIABLE
DUMPED ROCK D_{50}=150
WIDTH TO MATCH INFLOW CHANNEL OR DIAMETER PIPE OUTLET
SECTION 4 NTS
3000
750
GEOTEXTILE
LINING TYPE VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
SECTION 2 NTS
2 OF 2.5:1
1200
600
CUT OFF TRENCH FOR FILL EMBANKMENT
SECTION 3 NTS
PROVIDE A SEDIMENT LEVEL MARKER (EXTENDED GALVANISED STAR PICKET, CLEARLY PAINTED AND LABELLED AT 100 INCREMENTS FROM BASE TO 200 ABOVE WATER LEVEL) SEDIMENTS TO BE REMOVED WHEN SEDIMENT STORAGE CAPACITY IS REACHED AT APPROXIMATELY 0.3m DEPTH.
OIL BAFFLE BOARD
PERMANENT WATER LEVEL
REQUIRED SPILL CONTAINMENT CAPACITY (MIN 50m³) PROVIDED BEHIND OIL BAFFLE
INLET CHANNEL
1000
300
GEOTEXTILE
BASIN DEPTH
2000 MAX. DEPTH VARIES
BASIN INVERT
1500 MIN
DUMPED ROCK D_{50}=150
2400
1500
3000
SPILLWAY LEVEL
CREST LEVEL
FLOW
GEOTEXTILE IF REQUIRED (DEPEDENT ON LINING TYPE)
LINING TOF SPILLWAY VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
OUTFLOW
SECTION 1 NTS
P2 30.01.12 ISSUED FOR INFORMATION WITH NEW RMS LOGO
P1 07.11.11 ISSUED FOR RTA PEER REVIEW
Transport Roads & Maritime Services
SKM PARSONS BRINCKERHOFF
LITHGOW CITY COUNCIL / BLUE MOUNTAINS CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
MOUNT VICTORIA TO LITHGOW UPGRADE
DRAINAGE AND WATER QUALITY
WATER QUALITY BASIN
TYPICAL DETAIL
CONCEPT DESIGN
0005.258.CD.7053
CD
NB11343-DR-DG-0111
P2


BASIN ACCESS TRACK
MINIMUM FALL ON SLOTTED PVC PIPE 0.5%
CONCRETE LINED SPILLWAY
RIP RAP DUMP ANCHORED IN MORTAR D50=300mm.
PLANTING DETAILS INCLUDING BASIN INVERT & BATTERS TO LANDSCAPERS SPECIFICATIONS.
CLEAN OUT CAP
Ø900 BASIN OUTLET PIPE TO DISCHARGE TO NATURAL WATER COURSE VIA ROCK LINED ENERGY DISSIPATOR.
BIOFILTRATION BASIN
PLAN
SCALE 1:250
MIN BUND WIDTH 1000
VARIES
MAXIMUM WATER LEVEL FOR BIOFILTRATION (BASIN NORMALLY DRY)
OFFSITE WATER DIVERSON BUND MIN BUND WIDTH 1000
EXISTING SURFACE LEVEL
2
1
SECTION 1
SCALE H- 1:250
SCALE V- 1:250
A
DR-DG-0122
Transport Roads & Maritime Services
SKM PARSONS BRINCKERHOFF
LITHGOW CITY COUNCIL / BLUE MOUNTAINS CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
MOUNT VICTORIA TO LITHGOW UPGRADE
DRAINAGE AND WATER QUALITY
BIOFILTRATION BASIN
TYPICAL DETAIL SHEET 1
CONCEPT DESIGN
0005.258.CD.7053
CD
NB11343-DR-DG-0121
P2



DETAIL A
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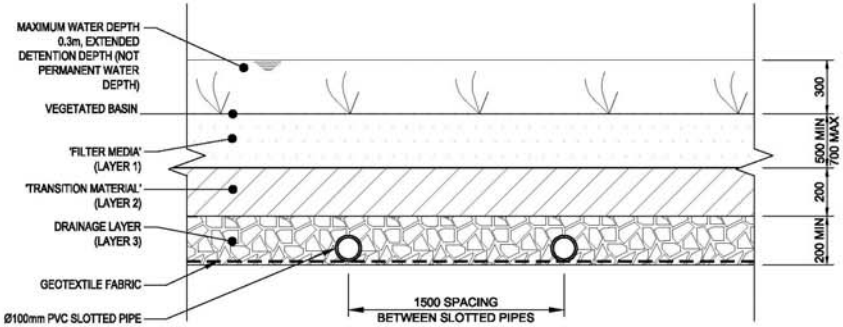


BIOFILTRATION DETAILS

SECTION 1
SCALE 1:20

REV	DATE	DESCRIPTION	DRAWN	REVIEWED	APPROVAL
P2	20.01.12	ISSUED FOR INFORMATION WITH NEW RMS LOGO	SG	JC	TR
P1	07.11.11	ISSUED FOR RTA PEER REVIEW	SG	TD	TR

TITLE	INITIAL	DATE
DRAFTSPERSON	SG	20.01.12
DRAFTING CHECK	SG	20.01.12
DESIGNER	TS	20.01.12
DESIGN CHECK	TD	20.01.12
PROJECT MANAGER	ER	20.01.12

ORIGINAL DRAWING AT A3 SIZE
CO-ORDINATE SYSTEM: MGA Zone 56 HEIGHT DATUM: A.H.D.

0 5 10 15 20 25 mm ON AS ORIGINAL This Drawing may have been prepared using colour and may be incomplete if copied

CLIENT: NSW GOVERNMENT Transport Roads & Maritime Services

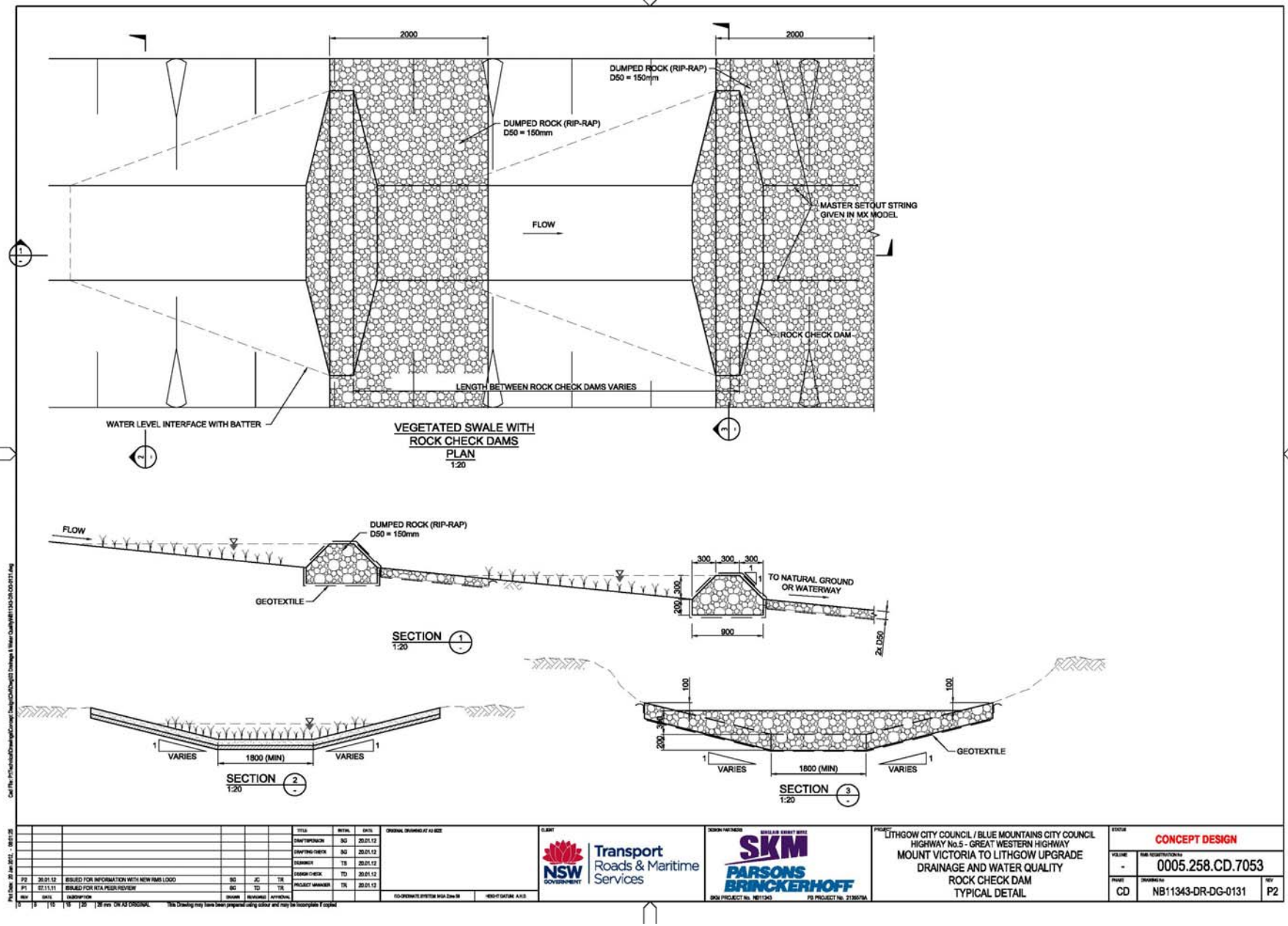
DESIGN PARTNERS: SKM PARSONS BRINCKERHOFF
SKM PROJECT No. NB11343 PB PROJECT No. 213507/A

PROJECT: LITHGOW CITY COUNCIL / BLUE MOUNTAINS CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
MOUNT VICTORIA TO LITHGOW UPGRADE
DRAINAGE AND WATER QUALITY
BIOFILTRATION BASIN
TYPICAL DETAIL SHEET 2

STATUS: CONCEPT DESIGN

VOLUME	RMS REGISTRATION No.
-	0005.258.CD.7053

PHASE	DRAWING No.	REV
CD	NB11343-DR-DG-0122	P2


2000
2000
DUMPED ROCK (RIP-RAP)
D50 = 150mm
DUMPED ROCK (RIP-RAP)
D50 = 150mm
MASTER SETOUT STRING
GIVEN IN MX MODEL
FLOW
ROCK CHECK DAM
LENGTH BETWEEN ROCK CHECK DAMS VARIES
WATER LEVEL INTERFACE WITH BATTER
VEGETATED SWALE WITH
ROCK CHECK DAMS
PLAN
1:20
FLOW
DUMPED ROCK (RIP-RAP)
D50 = 150mm
GEOTEXTILE
300
300
300
TO NATURAL GROUND
OR WATERWAY
300
200
900
2xD50
SECTION 1
1:20
VARIES
1800 (MIN)
VARIES
SECTION 2
1:20
100
100
200
GEOTEXTILE
VARIES
1800 (MIN)
VARIES
SECTION 3
1:20
CONCEPT DESIGN
LITHGOW CITY COUNCIL / BLUE MOUNTAINS CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
MOUNT VICTORIA TO LITHGOW UPGRADE
DRAINAGE AND WATER QUALITY
ROCK CHECK DAM
TYPICAL DETAIL
0005.258.CD.7053
NB11343-DR-DG-0131
P2
CD
Transport Roads & Maritime Services
SKM PARSONS BRINCKERHOFF

Appendix F Soil test results

NSW GOVERNMENT Soil Conservation Service

Experienced people protecting your resources

709 Gundy Road, Scone NSW 2337
PO Box 283, Scone NSW 2337
P: 02 6545 1666
F: 02 6545 2520
M: 0408 446 132

Chris Wing
Mount Victoria to Lithgow Alliance
Level 9, 100 Christie Street
St Leonards NSW 2065

11 August 2011 SCO11/228

Dear Chris Wing

Analysis of sixteen soil samples – PB project no. 2135579A

The Soil Conservation Service has completed the analysis of sixteen soil samples for PB project no. 2135579A (Soil test report SCO11/228R1). The samples were analysed for: pH (1:5 soil to water suspension); particle size analysis-mechanical dispersion (clay, silt, fine sand, coarse sand and gravel); organic carbon (OC); dispersion percentage (D%); Emerson aggregate test (EAT); and saturated hydraulic conductivity. The soil erodibility factor (K factor) has been determined (as described by Rosewell 1993) using the particle size analysis-mechanical dispersion and the organic carbon. The surface soil structure was assumed to be medium granular and the profile permeability was assumed to be slow to moderate.

Lab No	Sample Id	K factor	Rating
1	TP105: 1.00 – 1.30m	0.025	Moderate
2	TP109: 1.50 – 1.80m	0.032	Moderate
3	TP112: 1.30 – 1.50m	Not applicable	Not applicable
4	TP118: 0.90 – 1.10m	0.051	High
5	TP120: 0.40 – 0.70m	0.056	High
6	TP121: 0.20 – 0.40m	0.045	High
7	TP129: 0.60 – 0.80m	0.023	Moderate
8	TP137: 0.30 – 0.40m	0.034	Moderate
9	TP138: 0.20 – 0.40m	0.014	Low
10	TR101: 0.90 – 1.30m	0.022	Moderate
11	TP142: 0.20 – 0.40m	0.038	Moderate
12	TP151: 0.20 – 0.40m*	0.034	Moderate

*Within Forty Bends Upgrade. Other samples are outside of the Upgrade area

This interpretation was based on the soil samples being representative, and literature guidelines. If you have any queries, please contact me on (02) 6545 1666.

Yours faithfully

SR Young

References

Rosewell CJ (1993) Soiloss – A program to assist in the selection of management practices to reduce erosion. Department of Conservation and Land Management.

NSW GOVERNMENT | Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO11/228R1
REPORT TO:	Chris Wing Mount Victoria to Lithgow Alliance Level 9, 100 Christie Street St Leonards NSW 2065
REPORT ON:	Sixteen soil samples PB project no. 2135579A
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	10 August 2011
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666 Fax: 02 6545 2520

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO11/228R1
Client Reference: Chris Wing
Mount Victoria to Lithgow Alliance
Level 9, 100 Christie Street
St Leonards NSW 2065

Lab No	Method	C2A/3	C6A/2	P7C/1 Particle Size Analysis – mechanical dis (%)					P8A/2	P9B/2
	Sample Id	pH	OC (%)	clay	silt	f and	c sand	gravel	D%	EAT
1	TP105: 1.00 – 1.30m	5.2	0.12	8	6	20	61	5	33	5/6
2	TP109: 1.50 – 1.80m	5.2	0.26	30	19	26	18	7	41	5
3	TP112: 1.30 – 1.50m	4.9	0.13	na	na	na	7	2	13	6
4	TP118: 0.90 – 1.10m	5.2	0.22	20	23	43	13	1	36	5/6
5	TP120: 0.40 – 0.70m	4.8	0.22	20	33	35	11	1	38	5
6	TP121: 0.20 – 0.40m	6.7	1.21	14	15	49	21	1	52	3(1)
7	TP129: 0.60 – 0.80m	5.4	0.23	38	13	21	23	5	34	5
8	TP137: 0.30 – 0.40m	6.4	0.55	4	7	32	47	10	60	3(1)
9	TP138: 0.20 – 0.40m	8.4	0.12	3	3	8	32	54	58	4
10	TR101: 0.90 – 1.30m	7.6	0.12	10	6	18	41	25	65	2(1)
11	TP142: 0.20 – 0.40m	5.7	0.97	17	20	32	17	14	66	5
12	TP151: 0.20 – 0.40m *	6.1	0.48	9	14	25	40	12	65	3(1)

na = not applicable - material flocculated

*Within Forty Bends Upgrade. Other samples are outside of the Upgrade area

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO11/228R1
Client Reference: Chris Wing
Mount Victoria to Lithgow Alliance
Level 9, 100 Christie Street
St Leonards NSW 2065

Lab No	Method	P17C/1	
	Sample Id	Saturated Hydraulic Conductivity (mm/hr)	BD (t/m^3)
13	TP118: 2.00 – 2.40m	5.3	1.55
14	TP120: 1.90 – 2.10m	27	1.23
15	TP136: 2.00 – 2.40m	79	1.42
16	TR101: 0.90 – 1.30m	8.1	1.46

BD = bulk density at which hydraulic conductivity was determined using rainwater

END OF TEST REPORT

Appendix G NorBE Assessment

A qualitative NorBE assessment has been undertaken and is given in Section G.1. In addition, a quantitative assessment has been undertaken for an example catchment in Section G.2. The conclusions of the two assessments are discussed in Section G.3.

G.1 Qualitative assessment

NorBE Assessment for proposed activities by public authorities that will be assessed under Part 5 of the EP&A Act, 1979, as specified in Cl 12 of State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*
Project Name: *Proposed upgrade of the Great Western Highway at Forty Bends*
Name of catchment/sub catchment: *Sydney Drinking Water Catchment* - the proposed highway upgrade at Forty Bends is located within the Whites Creek catchment, a sub-catchment of Sydney's drinking water supply hydrologic catchment that flows to Warragamba Dam
Project activities: *The proposed upgrade involves the following construction activities:* ▪ Construction near Whites Creek, such as construction of bridge abutments and piles. ▪ Construction of in-stream structures in waterways (for example culverts). ▪ General earthworks, including stripping of topsoil, excavation or raising. ▪ Construction of drainage devices. ▪ Stockpiling of topsoil and vegetation. ▪ Transportation of cut and/or fill materials. ▪ Movement of heavy vehicles across exposed earth. ▪ Removal of riparian vegetation.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
▪ Construction in steep areas. ▪ Construction in areas upstream of sensitive receiving environments. ▪ Construction in highly erodible areas, if present. ▪ Construction in acid sulfate rock, if present. During the operational phase of the project, the roads are sealed and the embankments are landscaped. It is assumed that there would be no exposed topsoil along the highway. Hence, potential water quality risks would be due to pollutants from atmospheric deposition, vehicles and motorists as well as maintenance activities. *Refer to Chapter 3 (Project description) and Section 5.6 (Water Quality) of the Review of Environmental Factors (REF) for further details*	
1. Are there any identifiable potential impacts on water quality? What pollutants are likely? *Major potential pollutants are sediments (fine & coarse), nitrogen, phosphorus, pathogens and hazardous chemicals and contaminants such as oil/fuel.* During construction and/or post construction?	**<u>Construction</u>** **Impacts** The primary potential impacts to surface water quality would be during construction activities and if not mitigated could result in: ▪ Increased sediment loads from exposed soil during rainfall events and dust blown off site causing high sediment loads to be washed or deposited into nearby creeks. ▪ Increased sedimentation of downstream watercourses smothering aquatic life and affecting the ecosystems of downstream sensitive waterways, wetlands and floodplains. ▪ Increased levels of nutrients, metals and other pollutants, transported via sediment to downstream water courses. ▪ Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways. ▪ Increased levels of litter from construction activities polluting downstream watercourses. ▪ Tannin leachate from clearing and mulching.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	Potential construction-related pollutants 1) Sediments (fine and coarse) and suspended solids. 2) Increased levels of nutrients transported via sediment to downstream water courses. 3) Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways Increased levels of litter from construction activities polluting downstream watercourses. 4) Tannin leachate from stockpiling of cleared or mulched vegetation. 5) Acidification of receiving waters from disturbance of acid sulfate soils. 6) General waste and litter.
	<u>Operation</u> **Impacts** Once the highway upgrade is complete and the new highway becomes operational, the main risk to water quality is surface runoff from impervious surfaces and concentration of runoff by drains and kerbs. This can result in the build up of contaminants on road surfaces, median areas, rest areas and roadside corridors in dry weather which, during rainfall events, can be transported to surrounding watercourses or infiltrate into the groundwater system. **Potential operational-related pollutants** 1) Suspended sediment from the paved surface and landscaped batters during the establishment period. 2) Heavy metals attached to particles washed off the paved surface. 3) Oil, grease and other hydrocarbon products. 4) Litter from the road corridor. 5) Nutrients such as nitrogen and phosphorus in road runoff due to natural atmospheric deposition of fine soil particles.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
2. For each pollutant list the safeguards needed to prevent or mitigate potential impacts on water quality (*these may be SCA endorsed current recommended practices (CRPs) and/or equally effective other practices*)?	**<u>Construction</u>** **1) Sediments (fine and coarse), and** **2) Suspended solids and increases levels of nutrients, metals and other pollutants, transported via sediment to downstream water courses** Construction would be undertaken in line with a Soil and Water Management Plan (SWMP) that includes Erosion and Sediment Control Plans (ESCP) for all stages of construction. The SWMP would be prepared and implemented in consultation with relevant government departments and councils as part of the Contractor Environmental Management Plan (CEMP). Construction activities would be sequenced and managed to minimise potential water quality degradation due to erosion. Management would include: ▪ Early installation of physical controls, including cross drainage to convey clean water around or through the site. ▪ Minimising the duration of exposed topsoil by retaining topsoil cover, grassed drainage lines and shrub cover on the soil surface for as long as possible Minimising the extent of disturbed areas. ▪ Minimising stockpiling. ▪ Minimising the lengths of slopes through limiting the extent of excavations and the use of diversion drains to reduce water velocity over disturbed areas. ▪ Where possible cleared native vegetation and native mulch would be used to reduce erosion and contain sediment during construction through use of small vegetation filter windrows placed across the contour in drainage lines, below fill batters, below cutting works at the head of cleared minor drainage lined and before the inlet to sediment basins and waterways. ▪ Where possible, constructing working platforms from rock fill so that bare earth is not exposed. ▪ Progressive rehabilitation or sealing of works areas.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	▪ Restricting vehicle movements to designated pathways and paving vehicle movement areas that will be exposed for extended periods, such as carparks and main access roads, where feasible. Physical controls would be installed to reduce potential water quality degradation due to erosion and sedimentation during construction. Controls include the use of: ▪ Offsite diversion drains to collect clean runoff from upstream of the construction area and divert it around or through the site without it mixing with construction runoff. ▪ Lining of channels and other concentrated flowpaths. ▪ Sediment fences and filters to intercept and filter small volumes of construction runoff. ▪ Rock check dams that are built across a swale or diversion channel to reduce the velocity of flow in the channel and thus reduce erosion of the channel bed, as well as trapping sediment. ▪ Level spreaders to convert erosive, concentrated flow into sheet flow. ▪ Onsite diversion drains that collect construction runoff and direct it to treatment facilities. ▪ Sediment basins to capture sediment and associated pollutants in construction runoff, along with a permanent supply of gypsum flocculent agent available on site. ▪ Specific measures and procedures for works within waterways such as the use of silt barriers and temporary creek diversions. Details of some of these measures are covered in detail in the RMS document: Technical Guideline - Temporary Stormwater Drainage for Main Road Construction (RMS, 2011).

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	3) **Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways** An Emergency Spill Plan would be developed and incorporated in the CEMP. This would include measures to avoid spillages of fuels, chemicals, and fluids into any waterways. The storage, handling and use of the materials would be undertaken in accordance with the *Occupational Health and Safety Act 2000* and *Workcover's Storage and Handling of Dangerous Goods Code of Practice* (Workcover, 2005).Procedures would include: ▪ Bunded storage facilities for chemicals. ▪ Bunded areas for refuelling and washdown. ▪ Sediment basins with sufficient storage capacity to capture spills. ▪ Spill kits. ▪ Training of staff. 4) **Tannin leachate and sediments from stockpiling of earthworks or vegetation** During the construction phase, cut and fill material would generally not be locally stockpiled, but would be removed from the site of excavation and transported directly to the construction face for immediate reuse as compacted fill or would be transported to the crushing and screening area where it would be processed and then stockpiled in a centralised facility. Fill or excavated material that cannot be immediately reused would be transported to identified locations within the road corridor to be stockpiled for reuse.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	The maintenance of established stockpile sites during construction is to be in accordance with the RTA Stockpile Site Management Procedures (2001), in order to prevent erosion of the stockpile flowing into downstream waterways. Also, mitigation of tannins leaching from mulch stockpiles into waterways should be in line with RMS' *Environmental Direction - Management of Tannins from Vegetation Mulch* (2012). These, and additional recommendations include: ▪ Inclusion of stockpile sites within the ESCP. ▪ Diverting runoff around stockpiles sites where required, as identified in Table 5-1. ▪ Minimising the number and size of stockpiles. ▪ Lining the base of stockpiles if they are located over a shallow water table. ▪ Treating stockpiles at the source by covering with plastic sheets. ▪ Establishing effective sediment control works to contain any runoff including cut-off drains, vegetation and silt fences to minimise risk of sediments entering waterways. ▪ Treating with a construction or stockpile-specific sediment basin and monitoring the sediment basin for parameters such as dissolved oxygen levels and organics to determine suiTable discharge to the environment (such basins would be considered once stockpile locations have been finalised). ▪ Acidification of receiving waters from disturbance of acid sulfate soils ▪ Should acid sulfate soils (ASS) be encountered it would be managed in accordance with the relevant guidelines. An ASS Management Sub Plan would be included in the SWMP and would include a contingency plan to deal with the unexpected discovery of actual or potential ASS.General waste All waste materials on site would be disposed of in accordance with the Waste Classification Guidelines (DECCW, 2008). Designated waste storage areas would be implement on site: All working areas would be maintained, kept free of rubbish and cleaned up at the end of each working day.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	<u>Operation</u> **1) Suspended sediment from the paved surface and landscaped batters during the establishment period.** Treatment would be provided to the pavement runoff from the upgraded highway by a treatment train of water quality controls that reduced the annual average load of suspended solids by 80 percent in line with OEH guidelines (EPA, 1998). **2) Heavy metals attached to particles washed off the paved surface**. Water quality ponds or specific spill basins would capture heavy metals from spills for removal by maintenance teams **3) Oil, grease and other hydrocarbon products**. Treatment would be provided through a treatment train of water quality control that reduced the annual average load of oil and grease so that none is visible, in line with OEH guidelines (EPA, 1998). Water quality ponds or specific spill basins would capture oil and other hydrocarbon products from spills for removal by maintenance teams. **4) Litter from the road corridor.** Litter from the road corridor would be capture by trash racks prior to entering water quality ponds and would be periodically removed by maintenance teams.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	5) Nutrients such as nitrogen and phosphorus in road runoff due to natural atmospheric deposition of fine soil particles Treatment would be provided to the pavement runoff from the upgraded highway by a treatment train of water quality controls that reduced the annual average load of nitrogen by 45 percent and phosphorus by 45 percent in line with OEH guidelines (EPA, 1998). In general for the operational phase of the project, where traffic loads are sufficient, rainfall runoff and accidental spills would be treated and contained through the provision of a water quality treatment train combining grassed swales (where possible) leading to permanent water quality ponds or spill containment basins.
3. Will the safeguards be adequate for the time required? How will they need to be maintained?	**<u>Construction</u>** Yes, construction is anticipated to last for 24 months and the Blue Book parameters for the design of sediment basins have been selected based on this time frame. All erosion and sediment control measures would be regularly inspected and maintained. This would include regular engagement of a qualified soil conservation officer to inspect temporary and permanent erosion and sediment control devices, and to ensure the most appropriate controls are implemented and maintained. The following management and maintenance procedures for sediment basins would be adopted to ensure effective functioning and compliance with the anticipated Department of Environment, Climate Change and Water (DECCW) Environment Protection Licence (EPL) conditions: ▪ Inspections would be undertaken at regular intervals and following significant rainfall events to assess available water storage capacity, water quality, structural integrity and debris levels. ▪ Where appropriate, an approved flocculent would be applied to sediment basins as early as possible so that early mixing of flocculants occurs. Water quality would be tested prior to discharge in accordance with any EPL requirements.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	▪ Where excessive sediment has built up in the basin to a point where greater that 30 per cent of the total capacity has been utilised, sediment would be removed and adequately disposed of. ▪ Water from sediment basins would be utilised for construction purposes such as dust suppression where feasible. ▪ When sediment basins require pumping out rather than discharge via a flow outlet, a float would be attached to the hose suction or located inside a bucket to ensure that sediment from the basin floor is not discharged. ▪ Records regarding water quality and functionality or erosion and sediment control devices would be kept, including details of rain events, use of flocculants, discharge, sediment removal and dewatering activities in accordance with DECCW reporting procedures and licence conditions. ▪ A checklist would be completed when treated water is to be discharged from the basin in accordance with a construction environmental management plan (CEMP).
	<u>Operation</u> Yes, the design life of the water quality ponds is between 20 and 50 The maintenance requirements for the various elements of the potential treatment train are provided below. **Water quality ponds** ▪ Removal of rubbish and debris from trash racks. ▪ Removal of sediment at 5 to 10 year intervals. ▪ Maintenance access to water quality ponds would be provided. ▪ Fencing of ponds may be required and would be subject to a risk assessment **Spill basin** Spill basins to be emptied after spills by emergency response team

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
	Swales Maintenance of the swales should ensure that grades are maintained and that grass is kept at a length of 200 to 300 millimetres. Weeds, rubbish and sediment would be regularly removed by maintenance teams. **Biofiltration swales** Biofiltration swales would require a higher level of maintenance than grassed swales, to ensure that the filtration media does not become clogged with fine sediment and in need of replacement. The following elements would need to be maintained (Upper Parramatta River Catchment Trust, 2003): ▪ Flow to and through the system to ensure no blockages. ▪ Surface vegetation. ▪ Prevention of undesired overgrowth and weeds. ▪ Removal of accumulated sediments. ▪ Removal of debris and litter.

NorBE assessment – will there be a neutral of beneficial effect on water quality? *(Assessment must consider surface & ground waters and must consider construction & operational stages.)*	
4. Will all impacts on water quality be effectively contained on the site by the identified safeguards (above) and not reach any watercourse, waterbody or drainage depression? Or will impacts on water quality be transferred outside the site for treatment? How? Why?	**Yes.** All potential impacts as a result of both construction and operation of the proposal would be treated prior to discharge to the surrounding environment or receiving water bodies.
5. Is it likely that a neutral or beneficial effect on water quality will occur? Why?	**Refer to Section G.3 below.**
Prepared by/date	**John Constandopoulos, Mahala McLindin and Carolyn McCallig** **Mount Victoria to Lithgow Alliance** **20 June 2012**

G.2 Quantitative assessment on an example catchment

To further assess the impact of the Forty Bends Upgrade on water quality, a preliminary desktop assessment has been undertaken to give a understanding of the quantitative impact of the upgrade on the water quality in the drinking water catchment.

In this quantitative assessment, an example catchment has been analysed in terms of the change in mean annual pollutant loads resulting from the highway upgrade. The example catchment is located at the western extent of the upgrade between approximate chainage 33160 and 33500. In its existing state, the catchment collects runoff from the steep, forested catchment to the north of the highway, the existing highway, and downstream farmland. In the upgraded state, the catchment would include similar forested and farmland areas but a larger road area. Also, in the upgraded state the road catchment would be collected and treated in a water quality basin that would reduce TSS by at least 80 per cent, TP by 45 per cent and TN by 45 per cent (refer to Section 6.3) to meet the proposal design criteria requirements.

In this example catchment, a doubling of the road pavement width has been adopted, consistent with the general conditions along the upgrade. This is more conservative than using the actual figures for the selected catchment.

The catchments for the existing and upgraded conditions are shown in Figure G- 1 and Figure G- 2, and the catchments sizes are given in Table G- 1.

Table G- 1 Catchment areas for the existing and upgraded conditions

Land use	Existing (ha)	Upgraded (ha)
Forest	6.2	5.9
Roads	0.7	1.3 [1]
Agriculture	10.1	9.8
Total	**17.0**	**17.0** [2]

Note 1: Increased from 0.8ha to double the area of the existing road catchment to better represent the effect of the upgrade along its length

Note 2: Overall size of the catchment maintained by reducing by modifying the agricultural portion of the catchment

Mean annual pollutants loads have been estimated for the varying land uses of the catchments, interpreted from research by the *Cooperative Research Centre for Catchment Hydrology* (Fletcher et al, 2004). They are given in Table G- 2.

Table G- 2 Mean annual pollutant loads estimated for various land uses

Land use	Total suspended solids (kg/ha/year)	Total phosphorus (kg/ha/year)	Total nitrogen (kg/ha/year)
Forest	80	0.15	1.8
Roads	3500	6	25
Agriculture	500	1.7	9.5

The resulting mean annual pollutant loads for the existing and upgraded conditions are given in Table G- 3. It shows that without mitigation, there would be an increase of less than 30 percent in TSS, TP and TN downstream of the highway upgrade for the example catchment. However, as mitigation would be provided to reduce the levels of TSS, TP and TN in road runoff by 20 per cent, one per cent and two per cent respectively, the overall impact for the catchment would be deemed neutral or beneficial to the water quality of the drinking water catchment.

Table G- 3 Mean annual pollutant loads for the existing and upgraded conditions

	TSS (kg/ year)	TP (kg/ year)	TN (kg/ year)
Existing	7,870	22	124
Upgraded (without treatment)	9,977	25	137
Difference (without treatment)	+ 27%	+ 15%	+ 10%
Upgraded (with treatment)	6,286	22	122
Difference (with treatment)	-20%	-1%	-2%

G.3 NorBE conclusions

From the qualitative assessment undertaken in G.1, the proposed highway upgrade at Forty Bends is likely to have a neutral effect on water quality. The existing highway does not incorporate spill containment or water quality treatment for pavement runoff. In its existing state the receiving catchments collect runoff from the steep, forested land to the north of the highway, the existing highway, and downstream farmland. In the upgraded state, the receiving catchments would include similar forested and farmland areas but a larger road area. However, in the upgraded state the road runoff would be collected and treated in water quality basins that would reduce TSS, TP, and TN to meet the project design criteria requirements. In addition the likelihood of a potential spill of hazardous substances would be lessened as a result of the highway upgrade and the higher road design standards proposed. The impact of a potential spill would be reduced by inclusion of spill containment in the highway design, compared to the current situation where there is no existing spill containment present.

For the quantitative assessment of the example catchment in Section G.2, the results can be considered to be typical for the proposed upgrade and can therefore be extrapolated to demonstrate an overall neutral effect on water quality, with a reduction in TSS and very minor reductions in TP and TN due to the treatment controls provided in the design.

Further detailed assessment including water quality modelling using MUSIC would be undertaken during development of the detailed design.

Figure G- 1 Example catchment in the existing condition

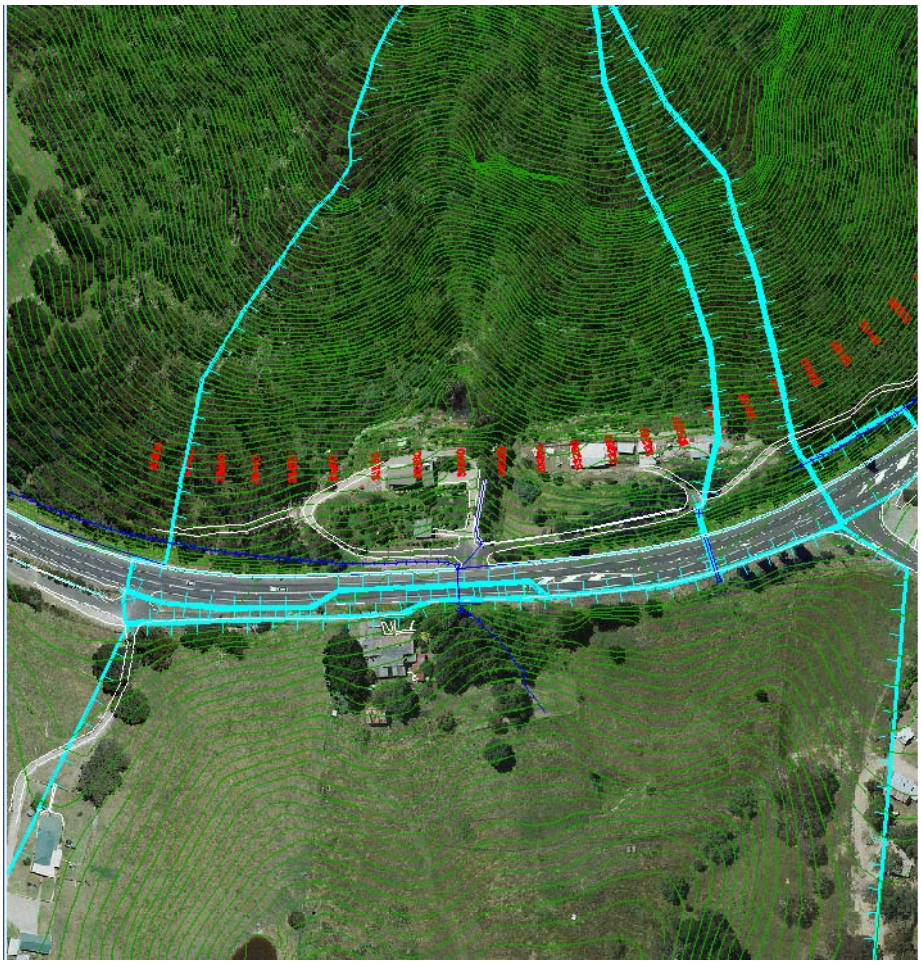
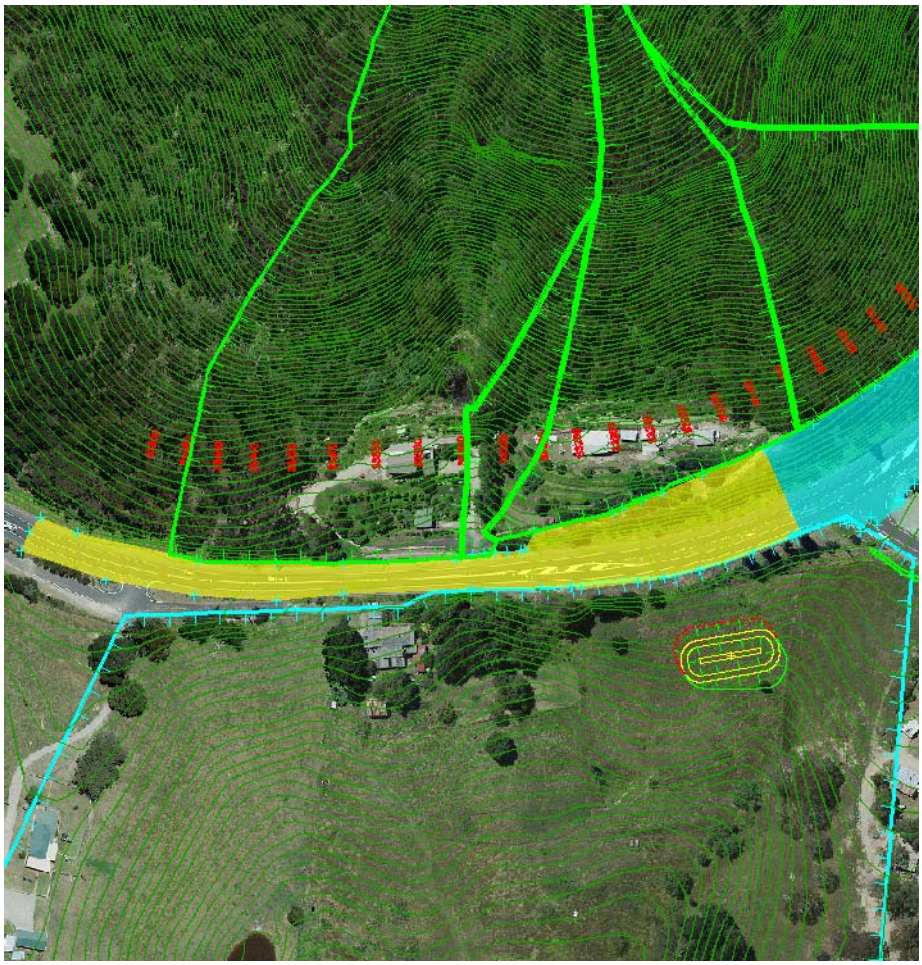
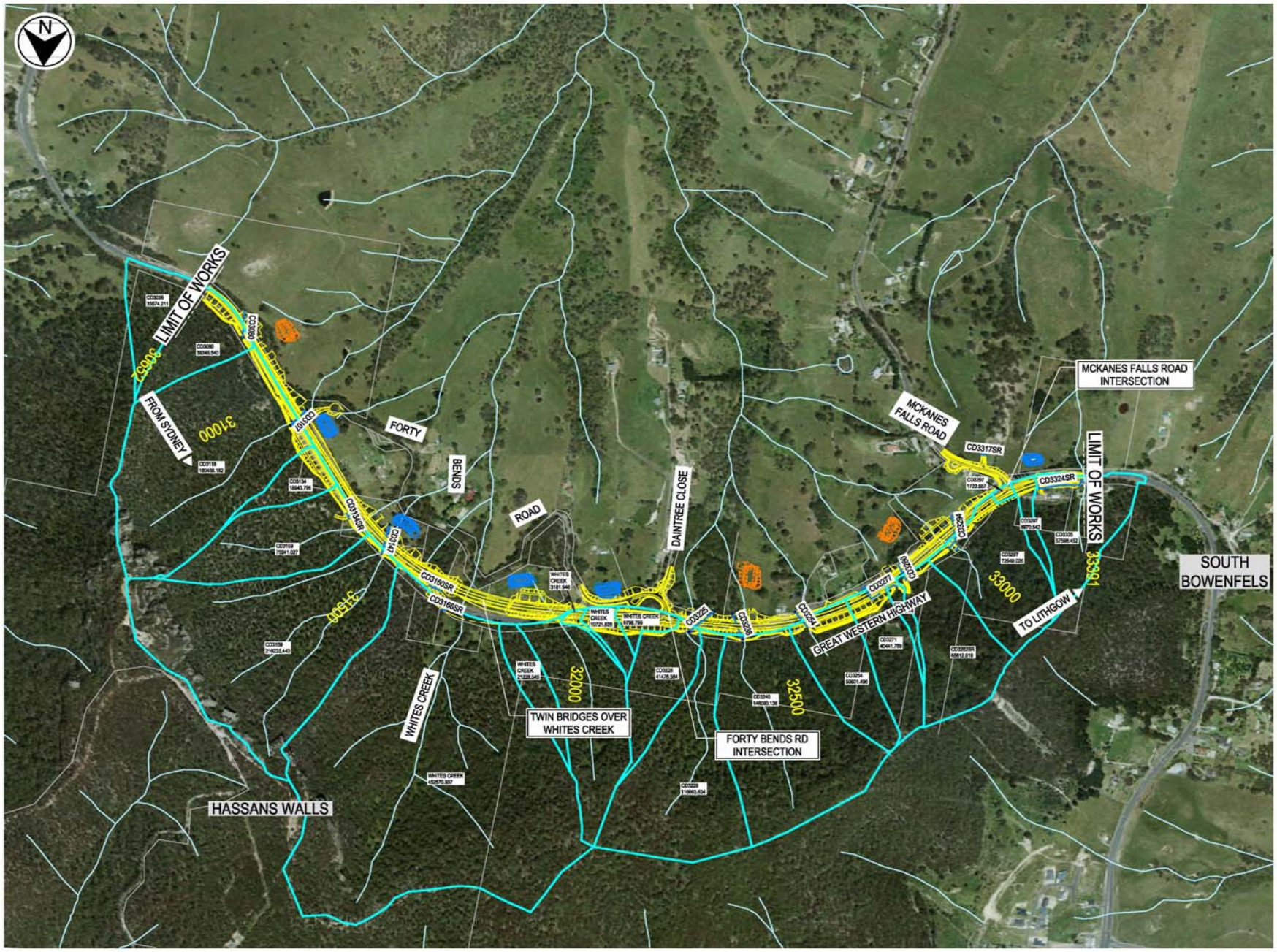


Figure G- 2 Example catchment in the upgraded condition



Appendix H Existing and proposed transverse drainage catchments



LEGEND

SHEET IN COLOUR

A3

- EXISTING TRANSVERSE DRAINAGE CATCHMENTS
- EXISTING CADASTRAL BOUNDARY
- EXISTING WATER COURSES
- TRANSVERSE DRAINAGE
- CD1554 TRANSVERSE DRAINAGE STRUCTURE LABEL
- WATER QUALITY CONTROL BASIN PERMANENT OPERATIONAL *(SOLID LINE)*
- TEMPORARY CONSTRUCTION PHASE ONLY *(DASHED LINE)*

REV	DATE	DESCRIPTION	DRAWN	REVIEWED	APPROVAL
A	23.07.12	ISSUED FOR INFORMATION	SH	TD	TR

TITLE	INITIAL	DATE
DRAFTSPERSON	SH	23.07.12
DRAFTING CHECK	CY	23.07.12
DESIGNER	KC	23.07.12
DESIGN CHECK	TD	23.07.12
PROJECT MANAGER	TR	23.07.12

ORIGINAL DRAWING AT A3 SIZE

SCALE 1:10000 100 0 100 200 AT A3

CO-ORDINATE SYSTEM: MGA Zone 56 HEIGHT DATUM: A.H.D.

CLIENT

NSW GOVERNMENT Transport Roads & Maritime Services

DESIGN PARTNERS

SINCLAIR KNIGHT MERZ SKM PARSONS BRINCKERHOFF

SKM PROJECT No. NB11343 PB PROJECT No. 2135579A

PROJECT

LITHGOW CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
RECONSTRUCTION AT FORTY BENDS
DRAINAGE AND WATER QUALITY
TRANSVERSE DRAINAGE
EXISTING CATCHMENT PLAN

STATUS **SKETCH**

VOLUME

RMS REGISTRATION No. DS2012/000280

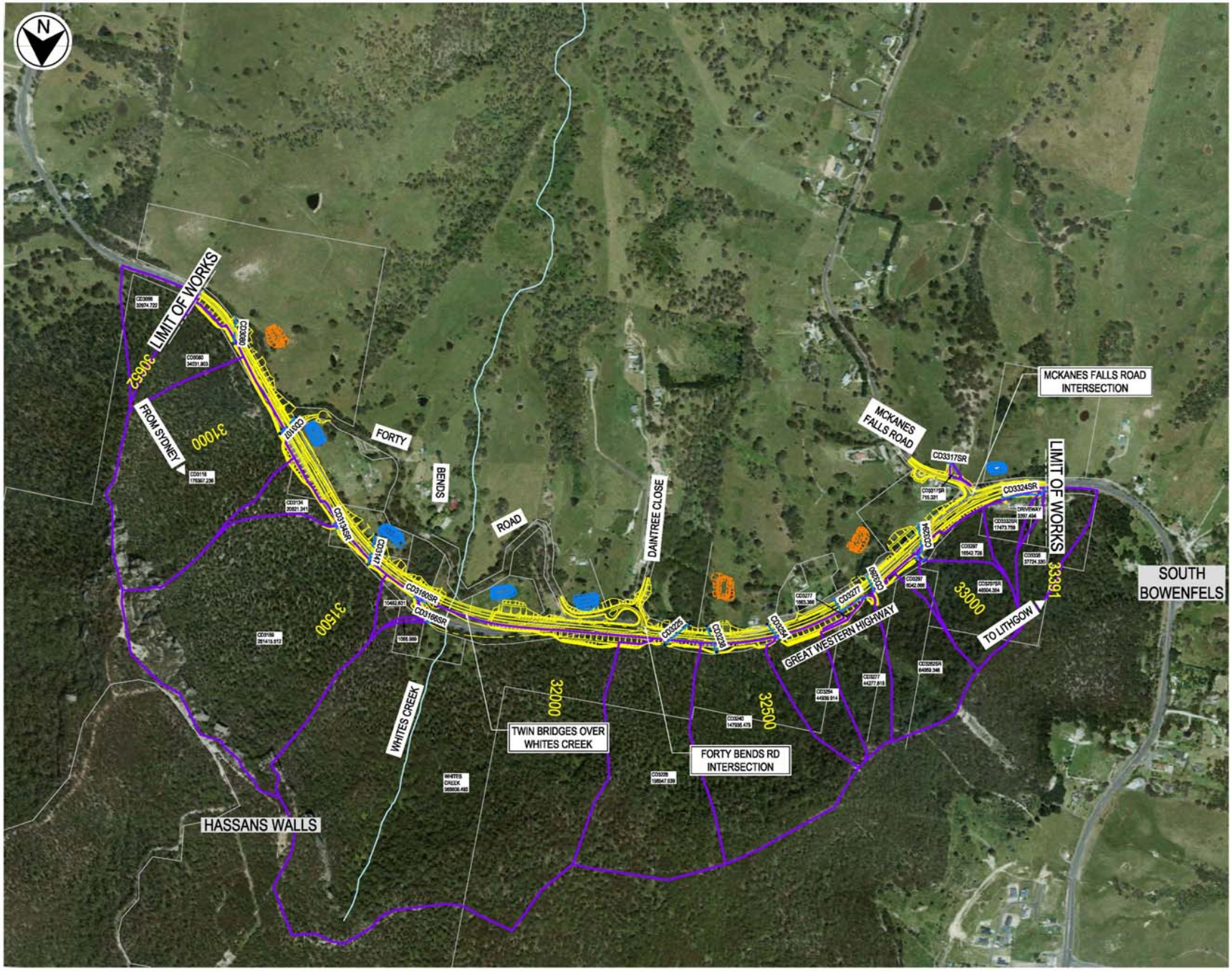
PHASE SK

DRAWING No. NB11343-40BD-DR-SK-0012

REV A

Plot Date: 23 Jul 2012 - 16:48:54

Cad File: P:\40BD\Technical\Drawings\Civil\Sketches\03 Drawings\NB11343-40BD-DR-SK-0012.dwg



LEGEND

SHEET IN COLOUR A3

- TRANSVERSE DRAINAGE CATCHMENTS
- EXISTING CADASTRAL BOUNDARY
- TRANSVERSE DRAINAGE
- CD1554 TRANSVERSE DRAINAGE STRUCTURE LABEL
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DESIGNER	KC	23.07.12
DESIGN CHECK	TD	23.07.12
PROJECT MANAGER	TR	23.07.12

ORIGINAL DRAWING AT A3 SIZE

SCALE 1:10000 100 0 100 200 AT A3

CO-ORDINATE SYSTEM: MGA Zone 56 HEIGHT DATUM: A.H.D.

CLIENT: NSW GOVERNMENT Transport Roads & Maritime Services

DESIGN PARTNERS: SINCLAIR KNIGHT MERZ SKM PARSONS BRINCKERHOFF

SKM PROJECT No. NB11343 PB PROJECT No. 2135579A

PROJECT: LITHGOW CITY COUNCIL
HIGHWAY No.5 - GREAT WESTERN HIGHWAY
RECONSTRUCTION AT FORTY BENDS
DRAINAGE AND WATER QUALITY
TRANSVERSE DRAINAGE
PROPOSED CATCHMENT PLAN

STATUS: SKETCH

VOLUME | RMS REGISTRATION No: DS2012/000280

PHASE: SK | DRAWING No: NB11343-40BD-DR-SK-0013 | REV: A

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