6 Design considerations

6.1 Design criteria

Together with the characteristics discussed in **Chapter 5**, the design considerations form the basis of the guidelines and parameters to which the upgrade must attain. This chapter presents the design criteria that apply to this project.

6.1.1 Engineering design criteria

Standard national and state guidelines apply to the design, construction and operation of any new or upgraded road and cover categories including:

- RMS corporate policies
- Occupational health and safety
- Road design
- Traffic
- Environmental policies
- Road safety.

6.1.2 Design life

Design life (being the duration that the upgrade should last for) has not been considered at this early stage of the project.

The economic analysis of the route options as part of the next phase of options analysis will consider design life of various infrastructure assets that comprise the upgrade. This provides a basis for whole of life cost analyses. The design life requirements will be developed and applied to all further stages of the project including concept design, detailed design and construction.

6.1.3 Flood immunity

The design must ensure that the appropriate level of flood immunity is provided. RMS guidelines require that the pavement wearing surface of at least one carriageway remains above the water level during the design flood event. This project requires:

- A target of 100 year average recurrence interval (ARI) design flood event for new alignments
- For routes following the existing alignment, the minimum target is at least a 20 year ARI design flood event.

6.2 Technical criteria

RMS stipulated minimum technical criteria for the upgrade. These incorporate standards and design guidelines required to achieve the project objectives. The stipulated technical criteria for the upgrade are summarised in **Table 6-1**. The original criteria required the design of the main carriageways and any ramps, including bridges, comply with the Network Planning Targets (NPT) in **Table 6-1**.

At the Internal Technical Workshop (ITW) (refer to **Section 7.4**), workshop participants agreed that consideration should be given to varying some of the design criteria set out by the NPT to make this route more consistent with the usage of the topography. RMS sought and was granted internal approval to adopt revised design criteria for the shortlisted options as shown in **Table 6-1**.

When the recommended preferred option was investigated later in the project (refer to **Chapter 9**), RMS sought and was granted internal approval to adopt further revised design criteria as shown in **Table 6-1**.

Table 6-1 Technical criteria

Design criteria	Original design requirement		Revised design requirement	
	Minimum requirement	NPT	Minimum requirement for initial shortlisted options	Minimum requirement for options 7a & 7b
Horizontal alignment - design speed	100 km/h	110 km/h	100 km/h	100 km/h
Absolute minimum horizontal curve radius	460m	460m	As per Austroads Guidelines – Minimum radius	As per Austroads Guidelines – Minimum radius
Vertical alignment – design speed	100 km/h	110 km/h	100 km/h	90 km/h
– Crest "K"	61	98	61	43
– Sag "K"	35	35	35	21
Maximum vertical grade	6.0%	6.0%	8.0%	9.0%
Stopping sight distance – reaction time (RT)	2.0 sec	2.5 sec	2.0 sec	2.0 sec
Horizontal	165 m	210 m	165 m	165 m
Vertical	165 m	210 m	165 m	140 m
Maximum superelevation	6.0%	6.0%	6.0%	6.0%
Number of lanes on each carriageway	Minimum of one lane southbound and one northbound, with consideration of overtaking lanes in each direction	Not specified	Two southbound and one northbound	One southbound and one northbound
Lane widths, including ramps and auxiliary lanes	3.5 m	3.5 m	3.5 m	3.5 m
Nearside (outside) shoulder width - main carriageway - ramp	 2.5 m 2.5 m	 2.5 m 2.5 m	 2.5 m 2.5 m	 2.0 m 2.0 m
Outside (median) shoulder width - ramp	 1.0 m	 1.0 m	 1.0 m	 1.0 m
Clearance from edge of travel lane to safety barrier - nearside	3.0 m	3.0 m	3.0 m	2.0 m
Outside verge (adjacent to 4 to 1 or flatter batters), excluding rounding Outside verge (adjacent barrier)	0.5 m 1.0 m	0.5 m 1.0 m	0.5 m 1.0 m	0.5 m 1.0 m

Design criteria	Original design requirement		Revised design requirement	
	Minimum requirement	NPT	Minimum requirement for initial shortlisted options	Minimum requirement for options 7a & 7b
Cutting berm width (adjacent SO gutter)	2.0 m	2.0 m	2.0 m	2.0 m
Outside clear zone	7.0 m	9.0 m	9.0 m	9.0 m
Bridges				
Width between kerbs Length of bridge (between abutments) > 50m	10.5 m	10.5 m	10.5 m	10.5 m
Length of bridge (between abutments) < 50m	11.0 m	11.0 m	11.0 m	11.0 m
Lane numbers per carriageway and widths	2 x 3.5 m	2 x 3.5 m	2 x 3.5 m	1 x 3.5 m
Offside shoulder width	1.0 m	1.0 m	1.0 m	1.0 m

6.3 Flooding and drainage

Flood investigations have been undertaken to develop an understanding of the existing flood behaviour and extents and the potential impact of the project. These investigations also relate to the flood immunity design criteria outlined in **Section 6.1.3**. The investigations involved numerical flood modelling where required within the study area.

Background information on the regional catchment and drainage context for the study area can be found in **Chapter 5** (**Section 5.2.2**).

Details on flooding and drainage can be found in the Preliminary Hydrology / Hydraulics Report in **Appendix C**.

6.3.1 Peak flow determination

Using topographical survey, available geographic information system (GIS) information and information collected during a site inspection in September 2012, local catchment delineation through the study area was undertaken.

Hydrological modelling for the study area was undertaken using the software *xp-rafts* (version 2009, XP Software). The hydrological model combines rainfall information with local catchment characteristics to estimate a runoff hydrograph.

Design rainfall depths and temporal patterns for the 100 year Average Recurrence Interval (ARI) event were developed using standard techniques provided in *Australian Rainfall and Runoff* (AR&R) (Engineers Australia, 1999). Based on the catchment type, available information and recommendations in AR&R (Engineers Australia 1999), rainfall losses were incorporated into the model.

No data was available for the calibration of the model and parameters in the model were based on experience and standard practice for similar catchment types.

6.3.2 Existing conditions flood level and extent determination

A hydraulic model converts runoff calculated using the hydrological model into water levels and velocities throughout the major creek systems and gullies in the study area. The model simulates the hydraulic behaviour of the water within the study area by accounting for flow in potential flow paths. It relies on boundary conditions, which include the runoff hydrographs produced by the hydrologic model and downstream conditions (commonly a water level or the characteristics of a hydraulic ‘control’ such as a bridge or weir).

Two dimensional (2D) hydraulic modelling was carried out to estimate the overland flow behaviour and the *Tuflow* 1D/2D modelling package (version Sept 2011, BMT WBM) was used for this study.

Two dimensional (2D) modelling requires a hydraulic roughness map that characterises ground surface roughness based on land use. In this assessment, surface roughness was characterised as bushland, open space and road land types based on aerial photography and information collected during the site visit.

No data was available for the calibration of the model and parameters in the model were based on experience and standard practice for similar floodplain types.

Figure 6-1 shows the results of the existing conditions modelling for the 100 year ARI flood extent.

6.3.3 Road level and watercourse crossing requirements

The proposed routes (**Chapter 7**) cross several watercourses. This provides an opportunity to control the flow during flood events with the provision of drainage structures (such as culverts and bridges) within the road embankment to ensure upstream water levels (afflux) are mitigated to acceptable levels. For some minor tributaries, there may be opportunity to mitigate downstream water levels by redirection of the tributary.

Where the route options preliminary designs crossed watercourses, bridge lengths were conservatively based on the 100 year ARI flood extent shown in **Figure 6-1** (ie to ensure clear passage of flood flows up to the 100 year ARI flood with no impediments such as bridge piers). In the assessment of the preferred option, bridges and culverts will be included in hydraulic models and limited techniques used to determine the required crossing opening requirements.

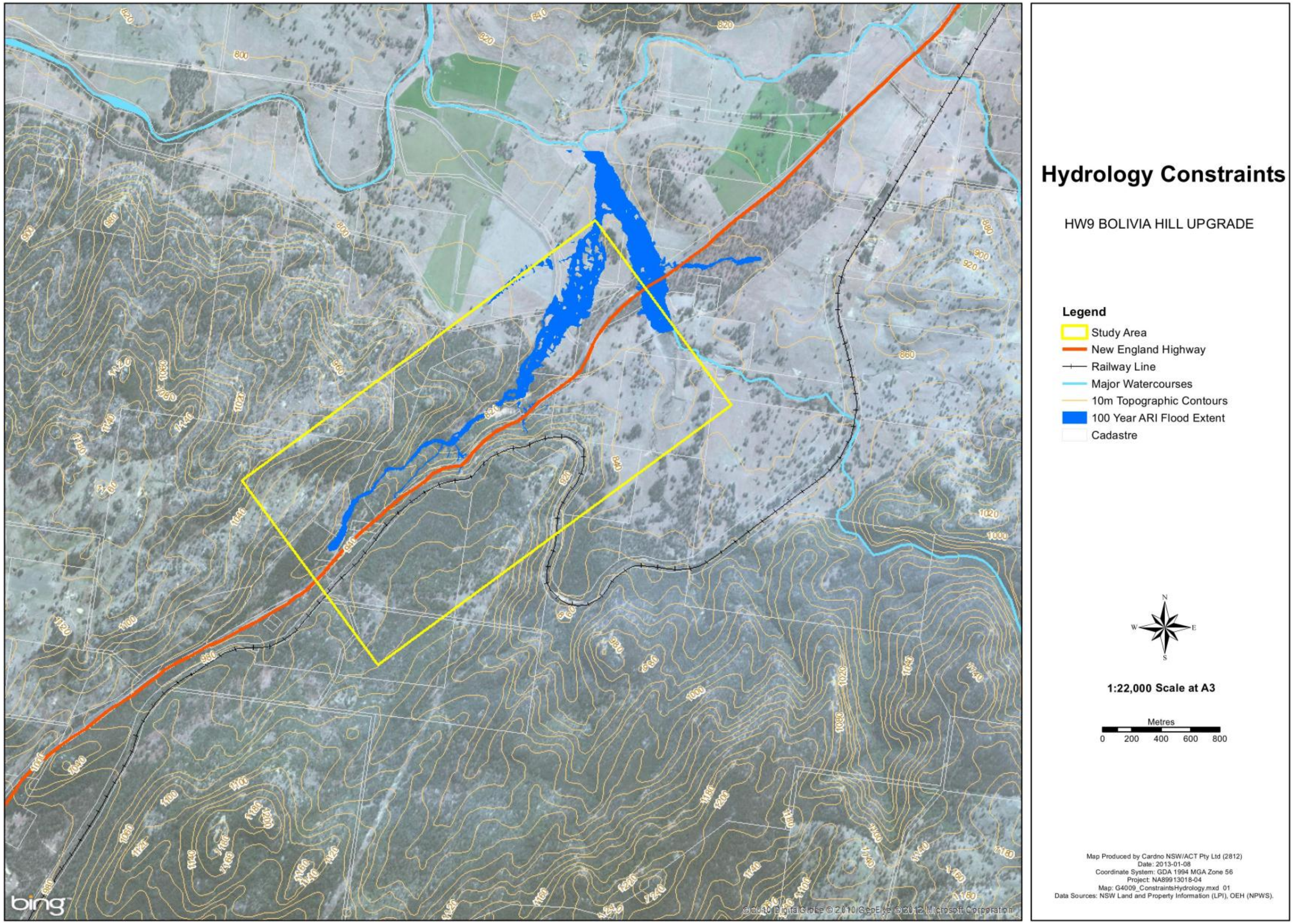

Figure 6-1 Existing 100 year ARI flood extents

6.3.4 Groundwater issues

The potential impacts to groundwater resources from construction of a new road alignment through the study area are considered minor or negligible (**Section 5.2.2.2**).

As the road is a linear feature, it does not cover a large area and is not considered to provide a risk to altering the recharge or water balance of an aquifer system. In addition, in the case of this site, there are no such significant aquifer systems. Specifically:

- Deep cuttings associated with the road alignment, if required, are still not expected to intercept any aquifer
- There are expected to be insignificant impacts to groundwater flow systems and aquifer water balances. Consequently:
  - Impacts to groundwater dependent ecosystems (GDEs) are expected to be small to negligible
  - Impacts to groundwater users will be negligible
  - There is anticipated to be neutral effect on the beneficial usage category of aquifers
- There is expected to be no requirement for substantial dewatering. Any dewatering required is likely to be superficial, associated with management of local and recent rainfall at the worksite.

6.4 Geotechnical considerations

A detailed analysis of the geotechnical considerations can be found in the Preliminary Geotechnical Assessment Report in **Appendix I**. The information following provides an overview of the findings within the Preliminary Geotechnical Assessment Report.

6.4.1 Geotechnical conditions

The geologic and soil conditions over the study area are described in **Chapter 5** and in more detail in **Appendix I**. A discussion of the design considerations associated with the geologic and soil conditions likely to be encountered follows.

6.4.1.1 Soils

Foundation conditions vary across the study area.

Overall, it is expected that any embankments within the hilly (southern) terrain where granite is exposed will require stripping of vegetation, topsoil and any sandy soil material to expose a weathered rock material. Depths of stripping are expected to be no more than one metre in most areas. The topsoil may be stockpiled on site and used for later top-soiling of embankment or cut slopes which should be designed at a slope of 2 Horizontal (H) : 1 Vertical (V) or shallower.

In the flatter terrain over the north end of the study area, removal of vegetation and topsoil will be required and will expose a clayey sandy soil subgrade.

6.4.1.2 Rock

Earth fill or rock fill may be used to construct the embankments. A hybrid embankment using a combination of earth fill and rock fill should be avoided due to the large variation of grading of the material leading to the potential of internal erosion of the embankment.

The design of rockfill embankments is described in *RTA QA Specification R44, Section 5.1.2* (2011).

It is expected that a large proportion of excavated material could be used as rockfill. Specification R44 requires a maximum size of 350 millimetres and therefore crushing and screening of excavated materials will be required to produce suitable rockfill to meet the specification.

6.4.2 Ground treatment options

The use of ground treatment options such as bridging layers, geo-reinforcement and/or stabilisation for the treatment of unstable or unsuitable ground is not expected to be required at this stage. Treatment options may be dependent on climatic conditions prior to and during construction.

6.4.3 Suitability for tunnelling

Rock types observed in surface exposure at Bolivia Hill (refer **Section 5.2.1**) include:

- Distinctly weathered granite with close joint spacing. Predominant joint set strikes north south and is sub-vertical
- Fresh granite (of assessed very high rock strength) with predominant joint set sub-vertical and striking north/south. Exfoliation joints were observed in exposure that parallel the slope surface and are expected to extend to shallow depth only. A two metre wide fresh to slightly weathered basalt dyke was also observed in exposure and has intruded along a north/south striking joint.

Issues to consider for tunnelling would include strength/weathering variations of the granite along the tunnel alignment. Abrupt changes in weathering are possible. The more weathered granite would likely require concrete lining support, while the support requirements for fresh granite would be considerably less. Portal entries are likely to be excavated within weathered granite and would require concrete lining and shotcrete support. It is possible the weathering variations, if encountered along the tunnel alignment, will result in permeability variations and complex hydrogeology where the tunnel is driven below the regional groundwater table. Water inflows and hydrostatic pressures acting on the tunnel face and walls may vary.

A detailed geotechnical investigation would be required to assess rock weathering and strength variations along the tunnel alignment, groundwater conditions and rock mass permeability.

The excavation method for any tunnel will need to be either drill and blast or tunnel boring machine.

6.5 Property and land use impacts

6.5.1 Severance of land uses

Severance of land use occurs if the highway passes through a land holding bisecting the holding into distinct parts (note: this does not include acquisition of land through widening of existing road / rail corridors). The impacts of the severance of land could include (but are not limited to):

- Reduction or elimination of land productivity if commercial activities are interrupted (agriculture, retail, industrial and the like), due either to the reduction in size of the overall holding or restricting access between the two separated parcels of land (eg for stock access or for crop maintenance). There are no retail or industrial uses within the study area
- Creation of residual lots that, due to their small size or characteristics, have little or no productive use (eg steep land that was otherwise used for grazing and now has limited accessibility)
- Increase in highway edge effects, such as an increase of water quality impacts and vehicle emissions, which may be located closer to sensitive land uses (eg organic farms and vineyards).

The proposed upgrade to the New England Highway should avoid fragmentation of productive agricultural land to retain land resource values.

6.5.2 Agricultural land

The Department of Primary Industries classifies land suitable for productive agriculture. Class 1 land is considered the most productive agricultural land. This class of land is protected from the development of other land uses where possible. The Agricultural Land Classification Map, prepared by Department of Primary Industries for Tenterfield Shire in 1991, identifies land within the study area as being classed: Agricultural Class 3, 4 and 5 (refer to **Figure 6-2**). The preferred design option must consider any impacts on agricultural land, having particular regard to land identified as Class 3, which may have potential to be utilised for regular cultivation. There is no Class 1 or Class 2 agricultural land in the study area.

Further, the *New England North West Strategic Regional Land Use Plan* 2012 prepared by the NSW Department of Planning and Infrastructure identifies Strategic Agricultural Land (SAL) within the region. SAL includes both land with unique natural resource characteristics, known as biophysical strategic agricultural land, and clusters of significant agricultural industries that are potentially impacted by coal seam gas or mining development, known as critical industry clusters. To help address the challenge of achieving balanced land use outcomes in the region, areas with particularly high agricultural values have been identified and mapped in consultation with key industry representatives and industry experts. The study area does not contain SAL as shown on the Strategic Agricultural Map as shown in **Chapter 4 (Figure 4-4)** of this report.

6.6 Construction resources and materials

6.6.1 Materials

The construction of the upgrade would require a number of different materials including:

- Earthworks materials
- Pavement materials
- Concrete
- Aggregates for concrete
- Sand
- Water
- Cement, and
- Steel reinforcement.

6.6.2 Sources of construction materials

A detailed analysis of the sources of earthworks and pavement materials can be found in **Appendix I**. The information following provides an overview of the findings within **Appendix I**.

6.6.2.1 Earthworks

From site observations to date, there are potentially three road construction material types available within the study area:

- Soil and completely weathered granite: This material may be suitable for use as earth fill, though quantities are expected to be very low
- Distinctly weathered granite materials: This material is likely to be suitable for use as earth fill, reinforced soil wall backfill, upper zone of formation and possibly select fill in pavements. Crushing and/or breakdown of oversize materials will be required to obtain desired materials grading
- Slightly weathered and fresh granite: This material is likely to be suitable as rock fill material, bridging, drainage material, and select layers. Crushing will be required to obtain the desired material grading.

6.6.2.2 Pavement materials

Crushing of slightly weathered and fresh granite has the potential for production of other pavement materials, subject to laboratory evaluation.

In addition to site won materials, alternate road construction materials suppliers (refer to **Appendix I**) are available in the vicinity of the study area.

6.6.2.3 Other materials

The availability of concrete, aggregates for concrete, sand, water and cement will be investigated in the next stage of the project.

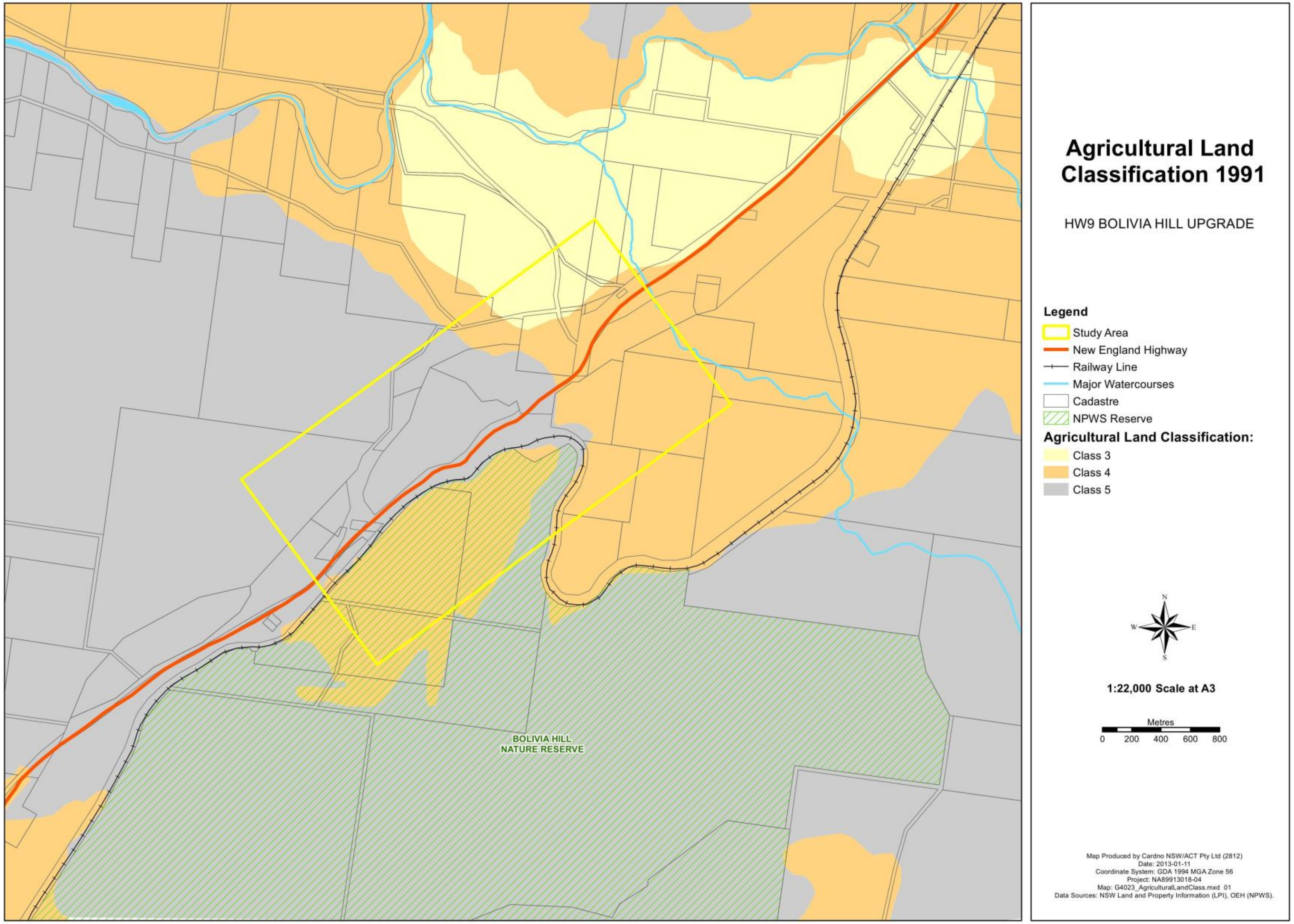

Figure 6-2 **Agricultural land classification**