INLAND RAIL

CHAPTER 15

Land Resources and Contamination

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Contents

Figures

Tables

15. Land Resources and Contamination

15.1 Scope of chapter

This chapter forms part of the Inland Rail proposal's North Star to NSW/Queensland Border project's (the proposal) environmental impact statement (EIS).

The land resources chapter provides an assessment of land resources to evaluate the existing environment, identify and assess the risks arising from the disturbance and excavation of land and the disposal of soil, and determines appropriate mitigation measures to be implemented during construction and operation of the proposal.

To achieve this, an assessment of the existing environment for topography, geology and soils was undertaken, which included contaminated land, biophysical strategic agricultural land and soil properties. The existing environment for the proposed rail corridor and associated study area was investigated through a desktop assessment of existing available information. This information was supplemented by field assessments of soil for salinity, sodicity, dispersiveness and cracking clay, where relevant (refer Section 15.5.2).

A quantitative compliance assessment was undertaken for soil properties, including agricultural and problematic soils. A qualitative assessment of contaminated land within the study area was also undertaken to identify any risks that this may present from a construction or operational perspective.

Following assessment of potential risks for the proposal, appropriate mitigation measures were developed for the proposal.

15.2 Secretary's Environmental Assessment Requirements

This chapter has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) as shown in Table 15.1.

TABLE 15.1 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS COMPLIANCE

	Soils
Desired performance outcome	The environmental values of land, including soils, subsoils and landforms are protected Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.
Current guidelines	*Managing Land Contamination: Planning Guidelines SEPP 55—Remediation of Land* (DUAP and EPA), 1998) *Guidelines for Consultants Reporting on Contaminated Sites* (OEH, reprinted 2011) *Guidelines for the New South Wales (NSW) Site Auditor Scheme* (3rd edition) (EPA, 2017) *Guidelines on the Duty to Report Contamination under the* Contaminated Land Management Act 1997 (EPA, 2015) Urban and regional salinity—guidance given in the *Local Government Salinity Initiative* booklets which includes Site Investigations for Urban Salinity (DLWC, 2002) *Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning* (Australian Geomechanics Society, 2007) *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC, 2000) *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries*) (DECC, 2008) Other guidelines made or approved under section 1–5 of the *Contaminated Land Management Act 1997* (NSW)

SEARs requirement		EIS section
Item 11.1	The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Section 15.5.6 Section 15.6.6 Section 15.6.7 Section 15.7

SEARs requirement		EIS section
Item 11.2	The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the proposal area.	Section 15.5.3.6
Item 11.3	The Proponent must assess the impacts of the Project on soil salinity and how it may affect groundwater resources and hydrology.	Section 15.5.3.6 Section 15.6.5
Item 11.4	The Proponent must assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Section 15.5.3.7 Section 15.6

15.3 Legislation, policies, standards and guidelines

The land resources assessment was undertaken in accordance with Table 15.1 following legislation, policies, standards and guidelines intended to protect and manage land resources.

TABLE 15.2 SUMMARY OF LEGISLATION, POLICIES AND GUIDELINES

Legislation, policy, strategy or guideline	Relevance to the proposal
Commonwealth	
National Environment Protection (Assessment of Site Contamination) Measure 1999 (Amendment 1, 2013)	This national guidance document establishes the assessment framework for site contamination in Australia, which aims to establish a nationally consistent approach to ensure sound environmental management practices are adopted. The desired outcome of the National Environment Protection Measure (NEPM) 2013 is to protect human health and the environment. Contaminated land in NSW is expected to be assessed in accordance with the process and guidance detailed in NEPM 2013.
Guidelines for Surveying Soil and Land Resources (McKenzie et al., 2008)	The guideline aims to promote the development and implementation of consistent methods for conducting soil and land resource surveys in Australia. The guideline provides information on how to best undertake field operations to identify, describe, map and evaluate various soils or land resources.
Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, CSIRO, 2009)	The handbook provides specific methods and terminology for soil and land surveys. It is widely used throughout Australia to provide a standard set of definitions for the characterisation of landforms, vegetation, land surface, soil and substrate.
Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning (Australian Geomechanics Society, 2007)	The guideline considers landslides occurring in natural slopes, from failure-of-construct slopes and on the area to be zoned. During proposal activities the guideline can be used by local, state and national government, geotechnical professionals, land-use planners and project managers to ensure works meet guidelines.
State (NSW)	
Protection of the Environment Operations Act 1997 (NSW)	The Act is a key piece of legislation administered by the Environment Protection Agency (EPA) with the aim of environmental protection. The Act: ▸ Aims to regulate various forms of pollution, including land and water pollution ▸ Aims to regulate waste management ▸ Will require an environment protection licence for the proposal in relation to railway systems activities and possibly also contaminated soil treatment and extractive industries (if appropriate thresholds are reached).
Contaminated Land Management Act 1997 (NSW)	The Act enables the EPA to respond to contamination that could potentially be considered significant enough to warrant regulation and declare land as being contaminated. The Act has the capacity to implement the following activities related to the proposal: ▸ Undertake a preliminary site investigation on suspected land ▸ Order remediation of contaminated land ▸ Duty to notify.

Legislation, policy, strategy or guideline	Relevance to the proposal
Soil Conservation Act 1938 (NSW)	The Act legislates the management of land degradation and erosion, areas of erosion hazard and impact of erosion on waterways. During the proposal construction phase, management measures will be implemented to ensure soil quality is not adversely impacted.
Guidelines for Consultants Reporting on Contaminated Sites (OEH, 2011)	The purpose of the guidelines is to ensure that reports prepared in NSW by consultants for remediation and investigation of contaminated land contain enough and appropriate information to enable efficient review by regulators, the site auditor and other interested parties.
Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997 (EPA, 2015)	The guideline provides information on the duty to report contamination and the duty of landowners and those who have responsibility for contamination to report it to the EPA. The guideline is relevant to the proposal as it: - Explains when contamination should be reported based on the levels of contaminants in the land and other related factors - Describes the steps to take to decide whether contamination should be reported to the EPA - Provides advice on engaging a contaminated land consultant - Describes situations not intended to be captured by the duty to report - Discusses examples of contamination where the duty to report may arise - Sets out the consequences of not reporting contamination when required, including prosecution and the penalty amounts that apply - Outlines how the EPA decides if the contamination is significant enough to need regulation, and what actions the EPA may take.
Sampling Design Guidelines (EPA, 1995)	The guidelines are NSW-specific and are prepared to: - Encourage use of statistically based approach to design sampling plans for contaminated sites and the interpretation of these samples for assessing and validating contaminated sites - Provide a convenient summary of statistical methods - Clarify sample numbers, sampling patterns and sampling depth. The guidelines provide a reliable method for sampling soil and solid media.
Site Investigation for Urban Salinity (DLWC, 2002)	The report details four phases on addressing urban salinity: - Phase 1: Initial site investigation and desktop review - Phase 2: Detailed site investigation - Phase 3: Presentation and interpretation of results - Phase 4: Management and evaluation. The study area is located within a rural area; however, the methods outlined in the report can be used as a reference during the proposal to investigate salinity and adopt best practice management procedures to address any problems encountered to minimise environmental impact.
Dryland Salinity (DECC, 2008)	NSW Environment has published for guidelines for dryland salinity in NSW: - *Book 1: The Basics*—helps understand the basic processes and impacts of dryland salinity - *Book 2: Identifying Saline Sites*—assists in identifying and assessing the extent of dryland salinity to manage affected areas - *Book 3: Investigating and Assessment Techniques*—provides an overview of the issues that need to be considered when investigating and assessing salinity - *Book 4: Productive Use of Saline Land and Water*—describes salinity management options that provide environmental benefits. If the study area encounters areas of potential dryland salinity, the processes detailed in the books will help in identifying, assessing and managing dryland salinity.

Legislation, policy, strategy or guideline	Relevance to the proposal
Acid Sulfate Soils Assessment Guidelines (Acid Sulfate Soils Management Advisory Committee, 1998)	The guidelines outline best practice methods in NSW for assessing the impacts of proposed work in suspected acid sulfate soil (ASS) sites. The guideline will facilitate a uniform method to assess and report actual and potential ASS that may be identified during proposal activities.
Managing Land Contamination Planning Guidelines SEPP 55—Remediation of Land (DUAP and EPA, 1998)	The purpose of the guideline is to establish a best practice procedure for managing land contamination in NSW through the planning and development control process. The guidelines will be implemented during proposal activities to ensure best practice is followed.
Managing Urban Stormwater: Soils and Construction—Volume 1 (DECC, 2004) and Volume 2 (DECC, 2008)	These publications provide guidance on erosion and sediment control during construction and other land disturbance activities. The publication is divided into two volumes: ▸ *Volume 1: Blue Book* ▸ *Volume 2: Installation of services, waste landfills, unsealed roads, main road construction and mines and quarries* The study area is located within a rural area; however, where relevant, the publications will be applied during proposal activities to ensure best practice measures are undertaken for erosion and sediment control.
Contaminated Land Management: Guidelines for the NSW Site Auditor Scheme 3rd edition (EPA, 2017)	The guidelines apply to individuals seeking to be accredited as site auditors in NSW and those already accredited. However, the guideline is also useful to other people with an interest in site contamination, such as consultants, which is relevant for this proposal.
Soil and Landscape Issues in Environmental Impact Assessment (DLWC, 2000)	This guideline considers the impacts caused by soil disturbance during proposal activities. The following impacts of soil disturbance will be relevant to the proposal: ▸ Soil erosion ▸ Stream sedimentation ▸ Mass movement ▸ Soil pollution ▸ Altered hydrological regimes ▸ Environmental degradation.

15.4 Methodology

15.4.1 Assessment methodology

An assessment of land resources was undertaken to identify and assess the risks arising from the disturbance and excavation of land and the disposal of soil. The assessment was conducted in accordance with statutory requirements and guidelines identified for NSW as shown in Section 15.2, and supplemented with Queensland technical information and guidance where appropriate (due to the close proximity to the NSW/QLD border).

Aspects of land resources that were assessed as part of the proposal included:

- Topography
- Geology
- ASS/acid rock
- Naturally occurring asbestos
- Saline, dispersive and reactive soils
- Erosion risk
- Contaminated land
- Biophysical agricultural land
- Unexploded ordnance.

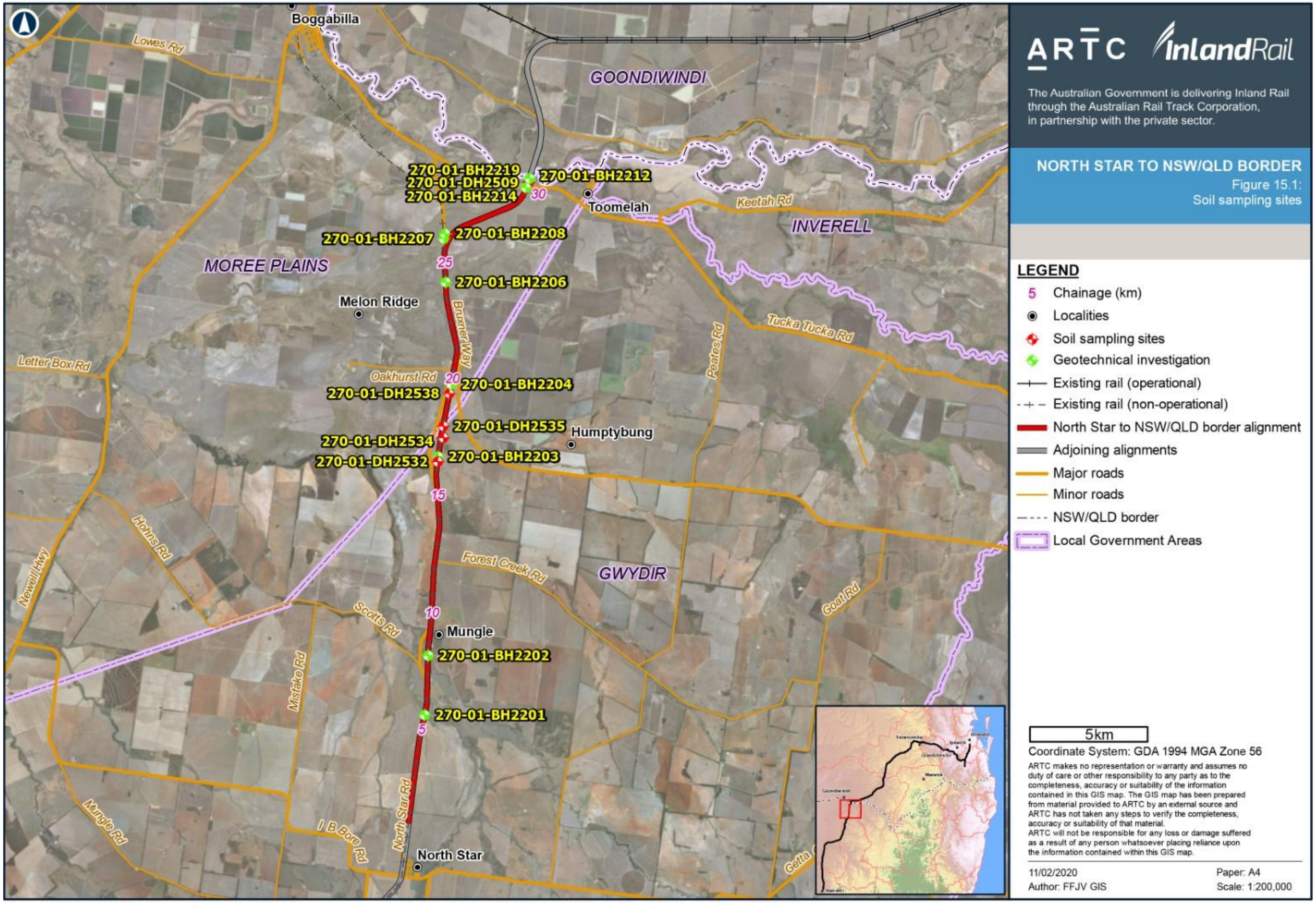
The land resources assessment included a preliminary site investigation (contaminated land assessment) to identify the potential for contamination along the study area. Historical activities and current land uses were identified to assess the likelihood and potential risk to identified ecological and human health receptors from existing land contamination. Geotechnical investigations were also undertaken where soils along the alignment were analysed for physical and chemical properties, as well as hydrogeology, which is further detailed in Chapter 13: Surface Water and Hydrology, and Chapter 14: Groundwater. The assessment of contaminated lands was conducted by a suitably qualified contaminated land consultant.

Other information sources used for the assessment of existing conditions for land resources included:

- *Detailed Solid and Surface Geology*—NSW (Department of Mines, 1972)
- *Atlas of Australian Soils* (Northcote et al., 1960–68)
- *Biophysical Strategic Agricultural Land*—NSW (Department of Planning and Environment, 2013)
- *NSW Topographic mapping* (Department of Finance, Services and Innovation, 2017))
- *Australian Soil Resource Information System* (CSIRO, 2014b)
- Department of Defence *Unexploded Ordnance* website (2017)
- *NSW EPA Contaminated Land Record* (EPA, 2018b).

The geotechnical field assessment included the drilling of five boreholes for soil investigations, with five samples collected at a depth of 0 m to 0.25 m below ground level (refer Figure 15.1). The five soil samples were analysed by a National Association of Testing Authorities (Australia) accredited laboratory, with further details of results provided in Section 15.5.3.1 and Appendix R: Laboratory Certificates.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Geotechnical investigations drilled 10 boreholes and analysed for a suite of analytes, including the following (which are relevant to this chapter):

- Moisture content (84 tests performed)
- Particle size distribution (grading) (84 tests performed)
- Atterberg Limits and Linear Shrinkage (83 tests performed)
- Shrink/swell properties (12 tests performed)
- Emerson Class Number (35 tests performed)
- Aggressivity Testing Suites (30 tests performed).

In addition to the geotechnical assessment, soil samples were analysed for the following analytes:

- Sodium adsorption ratio
- Cation exchange capacity
- Exchangeable sodium percentage.

Laboratory results are included in Appendix R: Laboratory Certificates.

The geotechnical field assessment, soil sampling and laboratory analysis has been used to inform the assessment of existing conditions for problematic soils (saline, dispersive and reactive) and erosion risks, and to supplement the desktop study undertaken using available information. The scope for sampling and analysis included only soil properties and not potential contaminants.

The desktop study and geotechnical field assessments have informed the assessment of potential impacts and development of appropriate mitigation measures, where required.

15.4.2 Study area

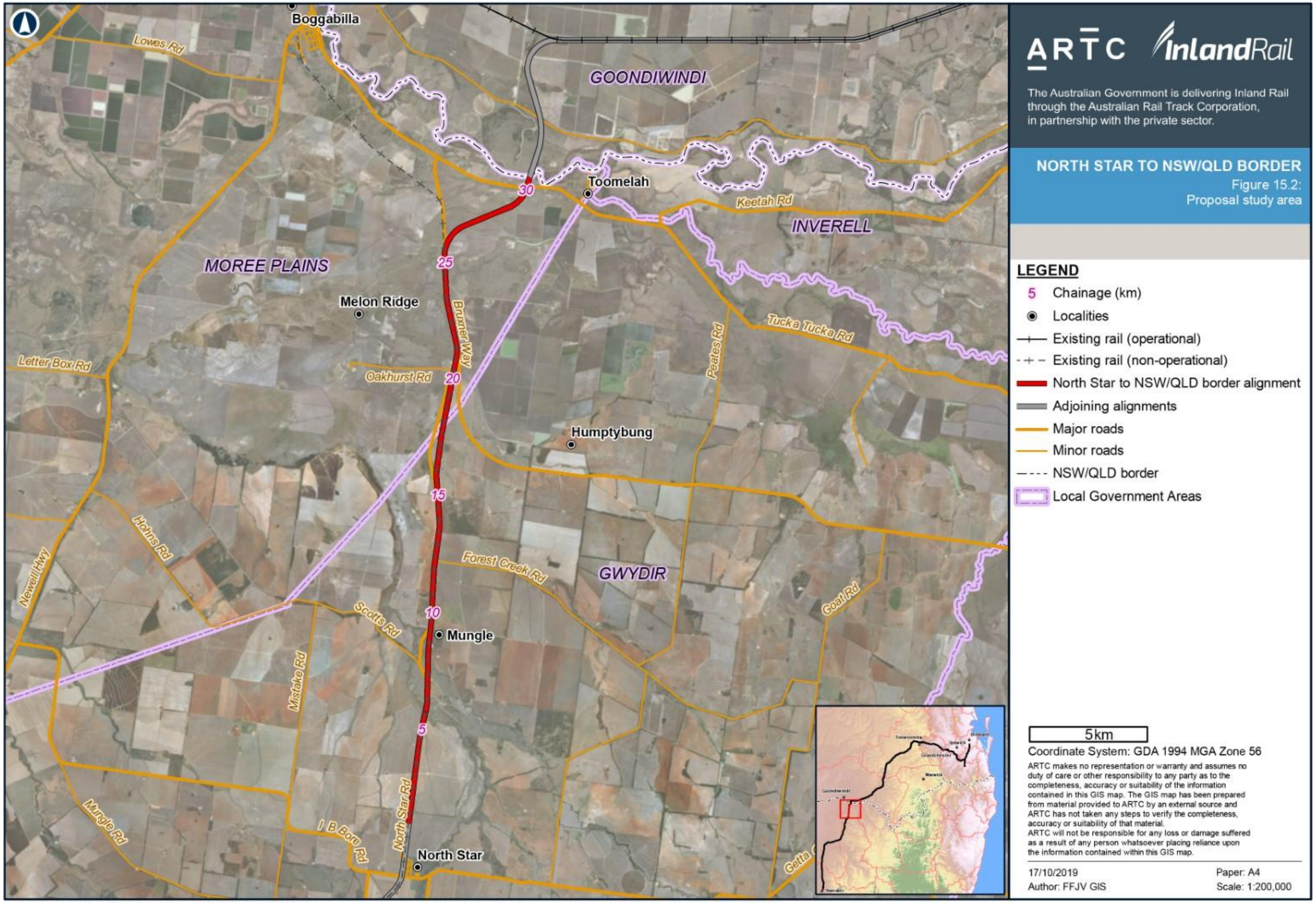
The study area extends from North Star and connects to the NSW/QLD border, spanning 30 km in total length (refer Figure 15.2). The rail alignment will consist of 25 km of new track within the existing non-operational Boggabilla rail corridor and 5 km of new track within a greenfield rail corridor north of Melon Ridge and to the Macintyre River. No significant cuttings greater than 10 m in depth are proposed.

The study area for the proposal and this chapter encompasses the design study area which is a 1–2 km wide corridor and includes the permanent rail corridor, after an initial assessment of additional areas. Additional areas assessed included potential areas for ground disturbance from proposal activities, borrow pits, quarries and two service stations on ARTC's advice outside the study area. Commercially operated quarries and borrow pits are excluded from this assessment as they operate under their own environmental approvals/permits.

15.4.3 Impact assessment methodology

Impact assessment was undertaken using both quantitative compliance assessment and qualitative risk assessment methodologies, assessing potential risks within the study area from both construction and operational perspectives. The operational footprint included the permanent rail corridor, while the construction footprint included temporary laydown areas, borrow pits, temporary access tracks and any other temporary areas used for construction.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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A quantitative compliance assessment was undertaken for:

- Soil properties, including:
  - Erosion and sedimentation
  - Problematic soils (saline, dispersive and reactive soils)

A qualitative assessment was undertaken for:

- Contaminated land, including:
  - Existing known contaminated land
  - Construction risks (e.g. hydrocarbon spills and unexpected finds)
  - Operational risks (e.g. hydrocarbon spills, use of pesticides/herbicides)
- Geology, topography and geomorphology
- Agricultural
- ASS/acid rock
- Naturally occurring asbestos
- Unexploded ordnance.

Following assessment of potential risks for the proposal, appropriate mitigation measures were developed.

15.5 Existing environment

15.5.1 Topographical setting

The study area between North Star and the NSW/QLD border (hereafter referred to as the Macintyre River) is characterised by a general decline in gradient, as seen in Figure 15.3. The corridor reaches its highest elevation at North Star, at 260 m Australian height datum (AHD). It gradually descends from the highlands into the low ridges of the Macintyre River with the point of lowest elevation occurring as the corridor passes over Whalan Creek at 223 m AHD.

The topography of the study area is level to gently inclined floodplains of Quaternary alluvium in higher energy locations, where river systems emerge from bedrock locations.

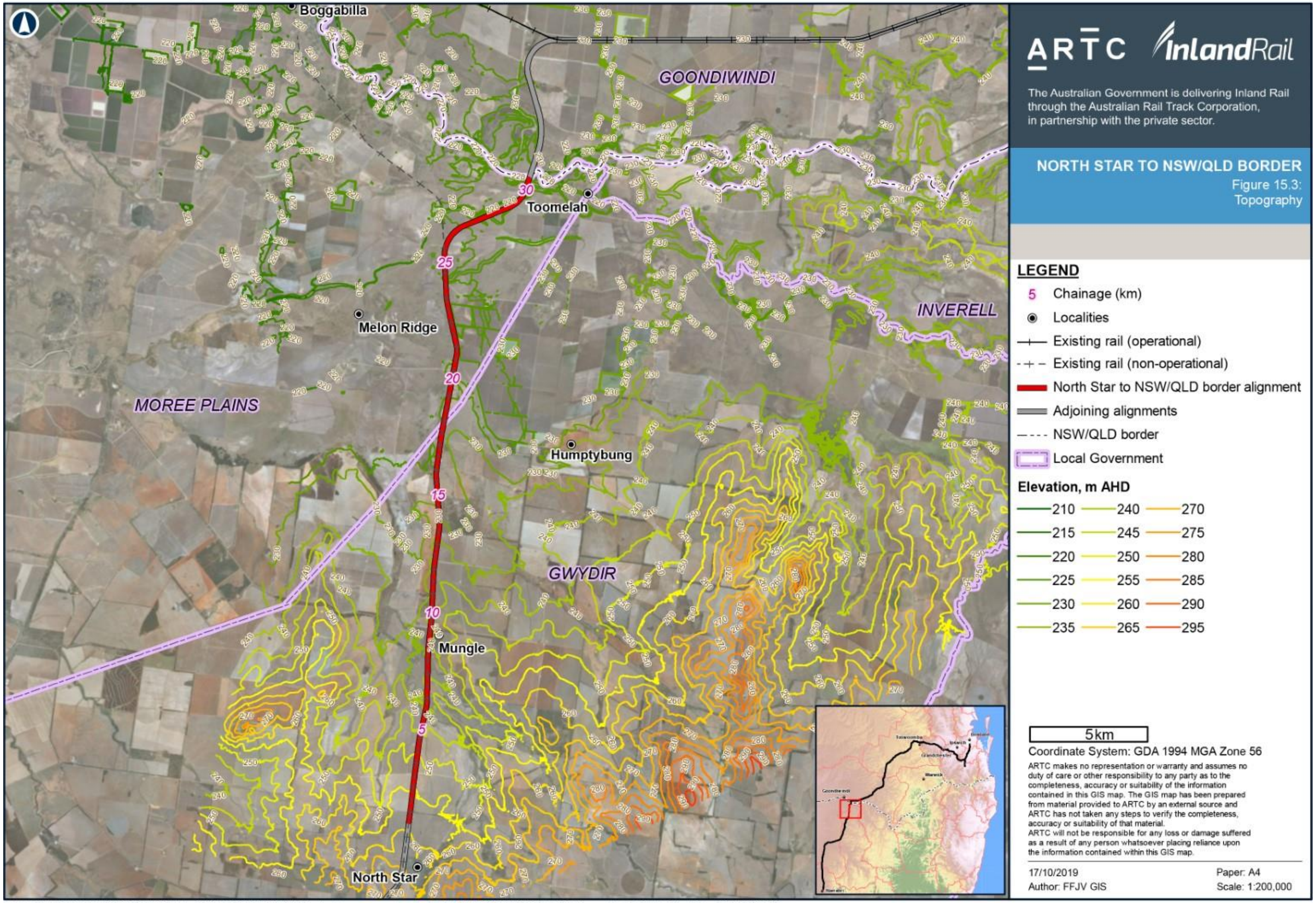
The land use of the North Star area is predominantly cropping with areas having been extensively cleared (Barnes, 2008). As the corridor moves towards Mungle and past Melon Ridge, the landscape changes into floodplains on alluvium lithology and is used primarily for native pasture consisting of timber, scrub and extensively cleared unused areas (Blair 2001a; Blair 2001b). Land uses of the proposal are further discussed in Chapter 22: Land Use and Property.

15.5.2 Geology

15.5.2.1 Summary

The geology underlying the study area for the alignment consists of two Quaternary layers as shown in Figure 15.4 and Table 15.3.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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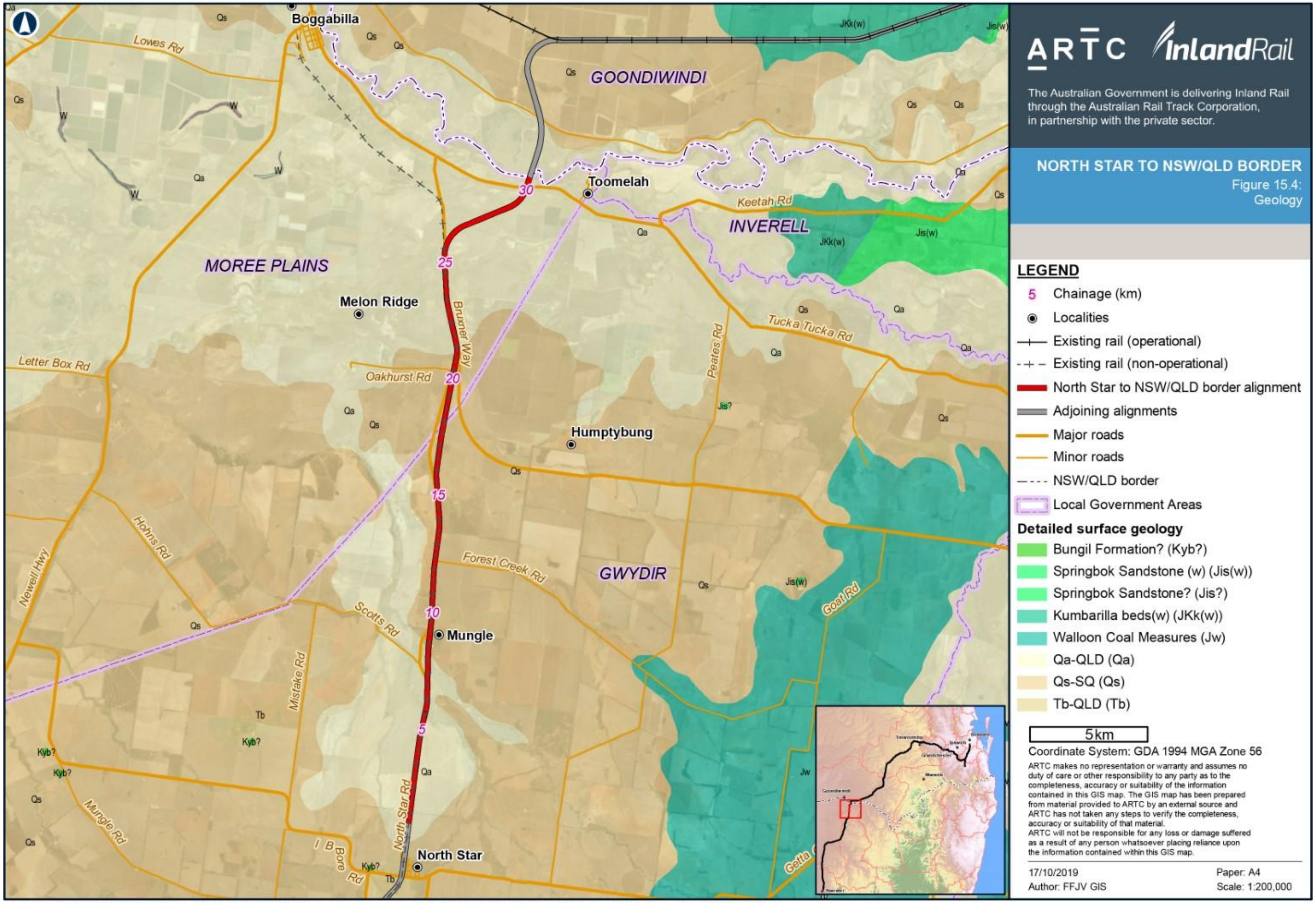
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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None of the boreholes drilled as part of the geotechnical investigation for this proposal encountered rock between the depths of 20 m and 40 m. The main geological unit under the proposal is the Kumbarilla Beds, which is a sedimentary sequence of terrestrial origin (sandstone, siltstone and mudstone). It is not known to be acid producing.

None of the younger sediments (Quaternary alluvium and Quaternary sand/soil) has the potential to be acid forming. Chapter 14: Groundwater contains further information.

TABLE 15.3 GEOLOGICAL UNITS

Geological unit	Location	Age	Description
Quaternary alluvium	▸ North Star to Mungle ▸ Oakhurst road to Kildonan Road	Quaternary	Clay, silt, sand and gravel layer on a floodplain dominated by alluvium.
Quaternary sand/soil	▸ Kildonan road to Kurumul ▸ Mungle to Oakhurst Road	Quaternary	Sand, red sandy soil, silt and some gravel flood out and sheet sand with alluvium.

The geology of the study area indicates a dominant presence of alluvium deposits which are associated with sediments deposited through the transportation of channelled stream water. The main form of alluvium deposit in the Moree Plains and Gwydir region is likely to consist of prairie soils, black earths and grey clays which have developed on finer-grained sediment. Alluvium deposits in the region will potentially result in deposits of sand, silt or silty clay on low ridges along floodplains (DSITIA, 2012). Studies of soil distribution and physical properties indicate that parent material strongly influences soil development in an area.

Sandy soil, gravel and silt also feature heavily within the geological units of the study area. This combination will potentially cause construction problems as after the removal of gravel and sand, silty fine sands have a low wet strength and high erodibility with very low fertility (SESL Australia, 2015).

15.5.2.2 Natural occurring asbestos

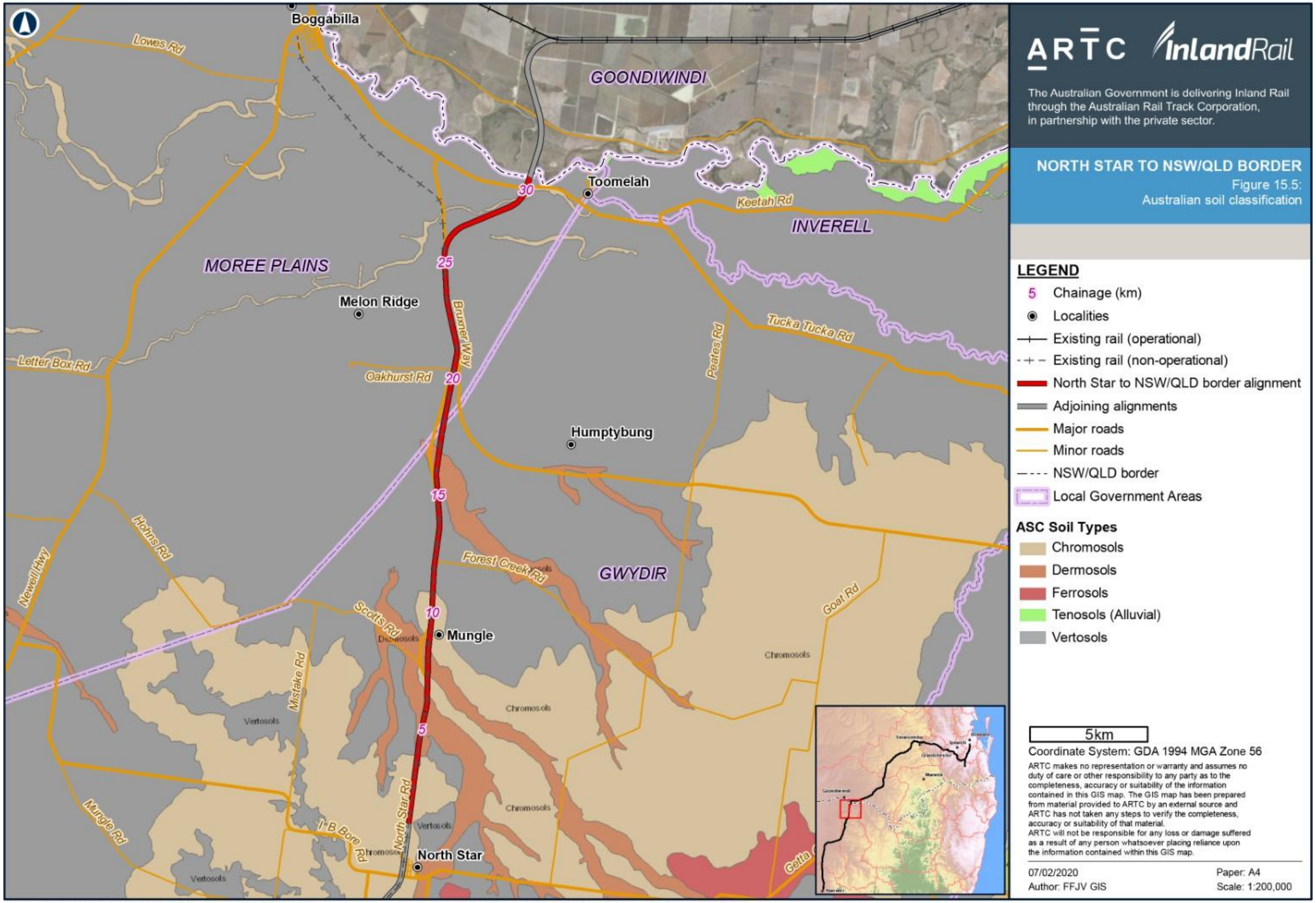
A desktop review of the NSW EPA (2018a) *Naturally Occurring Asbestos* map identified no areas of naturally occurring asbestos within the study area. This was confirmed during the geotechnical investigations undertaken within the study area as part of this proposal which found the study area to overlay a floodplain consisting of alluvium and no evidence of naturally occurring asbestos was identified. Furthermore, no rock or potential silica is expected to be disturbed because of soil depth exceeding the depth of expected earthworks (i.e. soil depth is >10m).

15.5.3 Soil

15.5.3.1 Soil classifications

The Australian Soil Classification map (1:250,000) for NSW (OEH, 2017) revealed several soil types to exist within the study area including vertosols, chromosols and dermosols (refer Figure 15.5).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Transecting layers of chromosol and dermosol underlay the surface of the study area between North Star and the section of the rail west of Humptybung, as well as along the banks of Whalan Creek. The chromosol highlands surrounding North Star are strong soils with a strong texture contrast between A and B horizon, which tends not to be sodic or strongly acidic in the upper 0.2 m of the horizon. The parent material of chromosols ranges usually from highly siliceous to intermediate in composition. These soils are found in imperfectly drained sites where rainfall is between 250 mm and 900 mm (yellow and grey chromosols), while in well-drained sites (brown and red chromosols) rainfall is between 350 mm and 1,400 mm. Chromosols are amongst the most widespread soils used for agriculture in Australia, particularly chromosols with red subsoils, because they have moderate chemical fertility and water-holding capacity. However, the soil is susceptible to soil acidification and soil structure decline (Isbell and National Committee on Soil and Terrain, 2016; Gray and Murphy, 2002).

Areas of alluvial soil, consisting of dermosols, transect layers of vertosols and chromosols along the study area north of Northstar and around Mungle. Dermosols are soils with well-structured B2 horizons, containing low levels of free iron, and lacking strong texture contrast between A and B horizons. The parent material of dermosols ranges from intermediate siliceous to mafic in composition.

The soil is found in imperfectly drained sites (yellow and grey dermosols) in areas of rainfall between 550 mm and 1,350 mm and in well-drained sites, in areas of 450 mm to 1,200 mm rainfall. Dermosols are identified as a good agricultural soil because they have good structure and moderate-to-high chemical fertility as well as water holding capacity (Isbell and National Committee on Soil and Terrain, 2016; Gray and Murphy, 2002).

Vertosol is the dominant soil type along the study area for the proposed rail corridor, heavily featuring between Mungle and the Macintyre River. Vertosols are clay rich soils (>35 per cent) with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. The parent material of vertosols range from intermediate mafic to ultramafic in composition. Vertosols are found in imperfectly drained areas (black vertosols) with rainfall up to 1,150 mm and in well-drained areas (red vertosols) with rainfall up to 900 mm. Because of their high chemical fertility and water-holding capacity, vertosols have high agricultural potential.

A majority of vertosols have neutral or alkaline soil pH and generally have high cation exchange capacity between 30 and 80 millequivalents per 100 grams of soil (meq/100 g). However, the soil requires a significant amount of rainfall before it can make it available to plants, and shrink-swell phenomena could potentially create problems for foundations of structures (Isbell and National Committee on Soil and Terrain, 2016; Gray and Murphy, 2002).

The geotechnical investigation undertaken did not identify any materials of anthropogenic origin (i.e. man-made materials or contaminants). Geotechnical investigations undertaken generally correlate with the mapped soil types reflecting vertosols and sodosols (Golder Associates, 2019).

A comparison between the limited soil laboratory results from field investigations, and Australian Soil Classification mapping in the area indicated a general correlation. Four of the five sampling locations were underlain by vertosols with resulting chemical properties ranging between slightly acidic to alkaline in pH, as well as a cation exchange capacity of approximately 32.3 meq/100 g.

A summary of the available soil chemistry for the land resources study area is provided in Table 15.4.

TABLE 15.4 SOIL CHEMISTRY INVESTIGATION RESULTS

Soil parameter	Range
pH	6.2–9.1
Sodium adsorption ratio	8.03–32.8
Electrical conductivity (µS/cm)[2]	57–291
Exchangeable calcium (meq/100 g)[1]	10.6
Exchangeable magnesium (meq/100 g)[1]	15.7
Exchangeable sodium (meq/100 g)[1]	5.6
Exchangeable sodium per cent (%)[1]	17.3
Cation exchange capacity (meq/100 g)[1]	32.3

Table notes:

1. Denotes results were from a single sampling location DH2509 as no other samples analysed contained results
2. µs/cm = microsiemens per centimetre
3. meq/100g = millequivalents per 100 grams of soil

It should be noted variations between investigation results and mapping can potentially be attributed to scale of mapping, the natural heterogeneity of soil, soil chemistry changing across a landscape due to various factors (e.g. climate, land use) and sampling only capturing a specific point along the land resources study area.

15.5.3.2 Known profile descriptions

The *NSW Soil and Land Information System* (DPIE, 2020) was used to identify two NSW OEH published soil profiles within the study area, as well as an additional soil profile within a 1 km radius of the study area. Table 15.5 provides a detailed description of the soil profiles including soil type, texture and field pH.

TABLE 15.5 SOIL PROFILE DESCRIPTIONS BY NSW SOIL AND LAND INFORMATION SYSTEM

Location	Survey number	Soil profile	Soil description
Within study area—Railway crossing on west side of North Star Road	Goondiwindi Training Area Survey (1004254) Profile 5	0.00 to 0.14 m A1 Horizon	Soil type: Brown chromosol Texture: silty loam Colour: Dark brown (7.5 Yellow Red (YR) 3/4) [moist] Structure: massive structure (subangular blocky, 2 to 5 mm) Soil fauna: no activity Cracks/Macropores: no cracks, no macropores Erodibility Tests: no data Field chemical tests: field pH is 6.5.
		0.14 to 0.30 m A12 Horizon	Texture: loam with weak pedality Colour: Dark reddish brown (5YR 3/3) [moist] Structure: subangular blocky, 2 to 5 mm Soil fauna: no data Cracks/Macropores: no data Erodibility Tests: no data Field chemical tests: field pH is 6.5.
		0.30 to 0.65 m B2 Horizon	Texture: medium heavy clay Colour: Dark reddish brown (5YR 3/4) [moist] Structure: moderate pedality (subangular blocky, 2 to 5 mm) Soil fauna: No activity Cracks/Macropores: no data Erodibility Tests: no data Field chemical tests: field pH is 7.0.
		0.65 to 0.95 m B23 Horizon	Texture: medium silty clay Colour: reddish brown (5YR 4/8) [moist] Structure: moderate pedality (polyhedral, 2 to 5 mm) Soil fauna: no activity Cracks/Macropores: no data Erodibility Tests: no data Field chemical tests: field pH is 9.
		0.95 to 1.10 m B3 Horizon	Texture: medium heavy silty clay Colour: yellowish red (reddish brown) (5YR 4/6) [moist] Structure: moderate pedality (polyhedral, 2 to 5 mm, smooth-faced peds) Soil fauna: No activity Cracks/Macropores: no data Erodibility Tests: no data Field chemical tests: field pH is 8.5.

Location	Survey number	Soil profile	Soil description
Within study area—50 m south of road crossing of Back Creek on west side of road	Goondiwindi Training Area Survey (1004254) Profile 6	0.00 to 0.03 m	Soil type: Brown dermosol Texture: medium silty clay Colour: dark brown (10YR 3/3) [moist] with no recorded mottles Structure: weak pedality (crumb, 1 to 2 mm) Soil fauna: no activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb Emerson Aggregate Test (EAT) test showed no change, Field chemical tests: Field pH is 8.0 (Not recorded), $AgNO_3$ test showed no precipitate, HCl test showed slightly audible but no visible effervescence.
		0.03 to 0.29 m	Texture: medium silty clay Colour: dark brown (10YR 3/3) [moist] with no recorded mottles Structure: weak pedality (subangular blocky, 2 to 5 mm) Soil fauna: No activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates disperse Field chemical tests: Field pH is 8.0 (Not recorded), $AgNO_3$ test showed no precipitate, HCl test showed slightly audible but no visible effervescence.
		0.29 to 0.60 m	Texture: medium silty clay Colour: dark brown (10YR 3/3) [moist] with no recorded mottles Structure: weak pedality (subangular blocky, 2 to 5 mm) Soil fauna: No activity Cracks/Macropores: No cracks, No macropores Erodibility Tests: Crumb (EAT) test showed aggregates disperse Field chemical tests: Field pH is 8.0 (Not recorded), $AgNO_3$ test showed no precipitate, HCl test showed slightly audible but no visible effervescence.
		0.60 to 0.95 m	Texture: medium silty clay Colour: dark yellowish brown (dark brown) (10YR 3/4) [moist] with no recorded mottles Structure: moderate pedality (polyhedral, 5 to 10 mm) Soil fauna: No activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates slake Field chemical tests: $AgNO_3$ test showed light precipitate, HCl test showed slightly audible but no visible effervescence.

Location	Survey number	Soil profile	Soil description
Within study area—50 m south of road crossing of Back Creek on west side of road	Goondiwindi Training Area Survey (1004254) Profile 6	0.95 to 1.13 m	Texture: silty clay loam Colour: brown (greyish brown) (7.5YR 4/2) [moist] with no recorded mottles Structure: massive Soil fauna: No activity Cracks/Macropores: No cracks, macropores are nil Erodibility Tests: Crumb (EAT) test showed aggregates disperse Field chemical tests: Field pH is 9.0 (Not recorded), $AgNO_3$ test showed no precipitate, HCl test showed slightly audible but no visible effervescence, Layer Notes: Thin bands of lamellae.
		1.13 to 1.58 m	Texture: medium silty clay Colour: brown (7.5YR 4/3) [moist] with no recorded mottles Structure: moderate pedality (subangular blocky, 10 to 20 mm) Soil fauna: No activity Cracks/Macropores: No cracks, No macropores Erodibility Tests: Crumb (EAT) test showed aggregates slake Field chemical tests: Field pH is 9.0 (Not recorded), $AgNO_3$ test showed no precipitate, HCl test showed slightly audible but no visible effervescence.
		1.58 to 1.90 m	Texture: medium silty clay Colour: dark greyish brown (greyish yellow brown) (10YR 4/2) [moist] with 20 per cent to 50 per cent gley mottles Structure: moderate pedality (subangular blocky, 10 to 20 mm) Segregations: very few (< 2 per cent), ferromanganiferous Soil fauna: No activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates slake, Field chemical tests: Field pH is 9.0 (Not recorded), $AgNO_3$ test showed light precipitate, HCl test showed slightly audible but no visible effervescence, Layer Notes: Possibly strong for structure, but dry.
Outside study area—2 km east along Forest Road on south side of the road	Goondiwindi Training Area Survey (1004254) Profile 7	0.00 to 0.09 m	Soil type: Red chromosol Horizon: A 0.00 to 0.09 m Colour: dark reddish brown (5YR 3/4) [moist] with no recorded mottles Structure: massive (fabric is earthy) Soil fauna: Ni activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates slake, field dilatency was rapid Field chemical tests: Field pH is 6.0 (Raupach), $AgNO_3$ test showed no precipitate, HCl test showed no effervescence.

Location	Survey number	Soil profile	Soil description
Outside study area—2 km east along Forest Road on south side of the road	Goondiwindi Training Area Survey (1004254) Profile 7	0.09 to 0.32m	Horizon: A3 0.09 to 0.32 m Texture: silty loam Colour: dark reddish brown (5YR 3/4) [moist] with no recorded mottles Structure: massive (fabric is earthy) Coarse Fragments: very few (< 2 per cent), not identified, Soil fauna: No activity Cracks/Macropores: No cracks, No macropores Erodibility Tests: Crumb (EAT) test showed aggregates disperse, field dilatency was rapid Field chemical tests: Field pH is 6.5 (Raupach), $AgNO_3$ test showed no precipitate, HCl test showed no effervescence.
		0.32 to 0.50 m	Horizon: B1 0.32 to 0.50 m Texture: medium silty clay loam Colour: reddish brown (dull reddish brown) (5YR 4/4) [moist] with no recorded mottles Structure: weak pedality (subangular blocky, 2 to 5 mm) Coarse Fragments: few (2–10%), not identified Soil fauna: No activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates disperse, field dilatency was none Field chemical tests: Field pH is 7.0 (Raupach), $AgNO_3$ test showed no precipitate, HCl test showed no effervescence.
		0.50 to 0.88 m	Horizon: B22 0.50 to 0.88 m Texture: medium silty clay Colour: yellowish red (reddish brown) (5YR 4/6) [moist] with no recorded mottles Structure: weak pedality (subangular blocky, 2 to 5 mm) Soil fauna: Noactivity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates disperse, field dilatency was none Field chemical tests: Field pH is 8.5 (Raupach), $AgNO_3$ test showed light precipitate, HCl test showed slightly audible but no visible effervescence.
		0.88 to 1.45 m	Horizon: B23 0.88 to 1.45 m Texture: light medium silty clay Colour: yellowish red (bright reddish brown) (5YR 5/6) [moist] with 20 per cent to 50 per cent unspecified yellow mottles, and 20 per cent to 50 per cent unspecified orange subdominant mottles Structure: moderate pedality (polyhedral, 5 to 10 mm) Coarse Fragments: very few (< 2%), not identified Segregations: ferromanganiferous, Soil fauna: No activity Cracks/Macropores: No cracks, no macropores Erodibility Tests: Crumb (EAT) test showed aggregates slake, field dilatency was none Field chemical tests: Field pH is 7.0 (Raupach), $AgNO_3$ test showed light precipitate, HCl test showed slightly audible but no visible effervescence.

Source: Blair (2001a, 2001b), Barnes (2008).

15.5.3.3 Soil acidity

An assessment of surface soil pH for the study area using data from the OEH (2017) revealed slightly acidic soil underlaying the region (refer Figure 15.6). The soil pH of the study area between North Star and east of Melon Ridge, ranges between 6 and 6.5 and features small patches of more acidic soil (pH 5.5 to 6) scattered within the study area. The study area beyond Melon Ridge towards the Macintyre River contains more neutral soil, with patches of 6.5 to 7 pH soil meandering through a landscape dominated by pH 7 to 7.5 soil. The dominant land use between North Star and the alignment east of Melon Ridge is dryland cropping, while the study area beyond Melon Ridge towards the Macintyre River contains small sections of land used for intensive animal and plant production (OEH, 2017).

Soil sampling within the study area indicated the pH to range between 6.2, slightly acidic, and 9.1, alkaline. Field soil pH strongly correlated with data from OEH (2017).

15.5.3.4 Acid sulfate soils

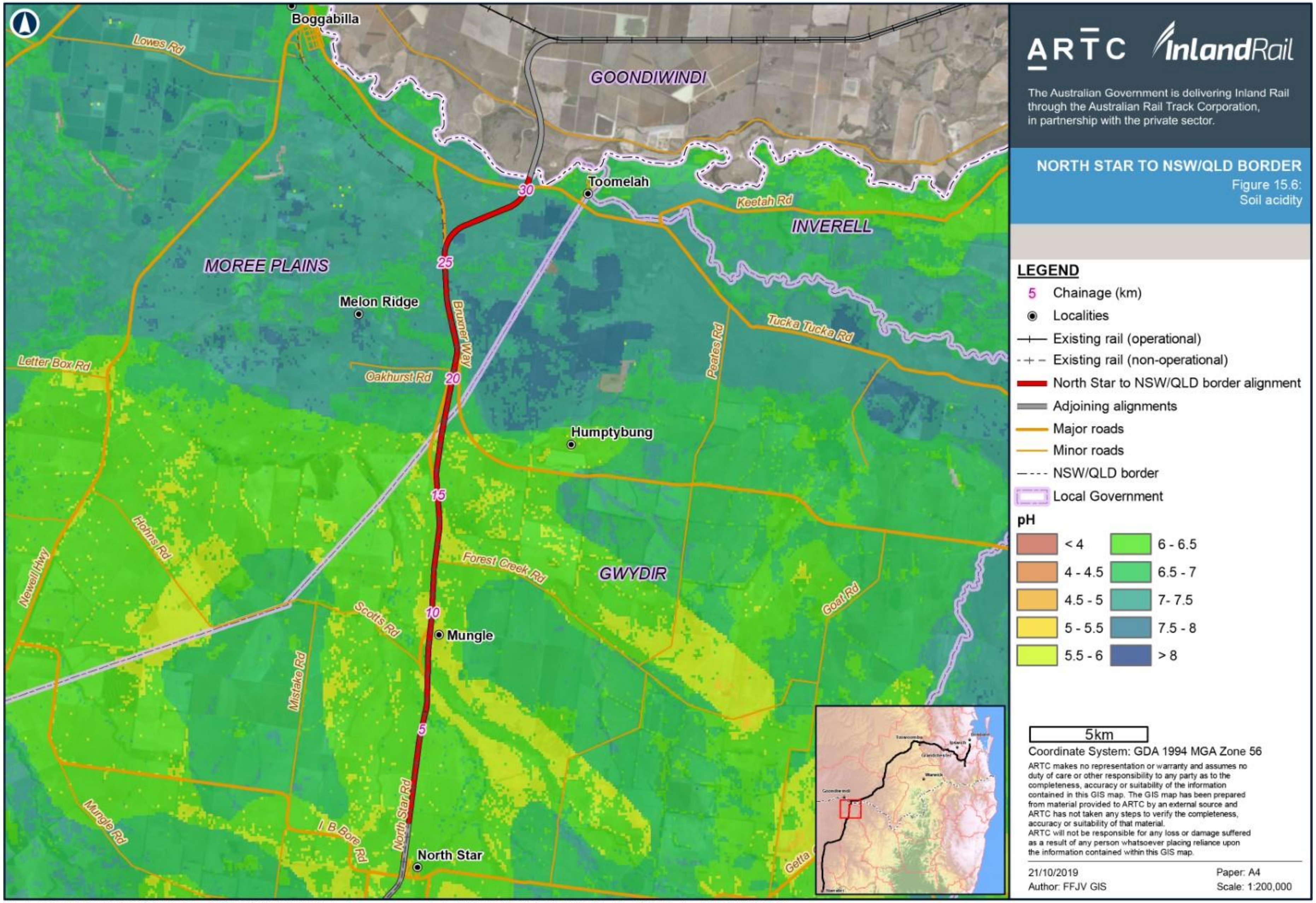
Assessment of acid sulfate soils (ASS) potential within the study area using the CSIRO (2014) *Atlas of Australian Acid Sulfate Soils* map indicated low probability of ASS occurring between North Star and the alignment west of Humptybung, and extremely low probability of ASS occurring for the remaining study area. The ASS mapping along the study area is provided in Figure 15.7.

ASS is often associated with low-lying areas below 5 m AHD, such as alluvial plains where groundwater generally is close to the surface and materials in reducing condition along coastal regions. ASS can also be found in parts of inland NSW in inland waterways, wetlands and drainage channels. ASS develop in waterlogged, saline and anaerobic conditions (DSITIA, 2012; DPIE, 2019).

No ASS data was available from the OEH (1998) (accessed through NSW eSPADE), further indicating low probability of ASS being present, as areas of potential elevated risks were prioritised for assessment. No sampling has been undertaken in the study area by NSW Government as it is beyond the limit of Holocene, estuarine, sulfidic sediments. This further indicates a low probability of ASS being present within the study area.

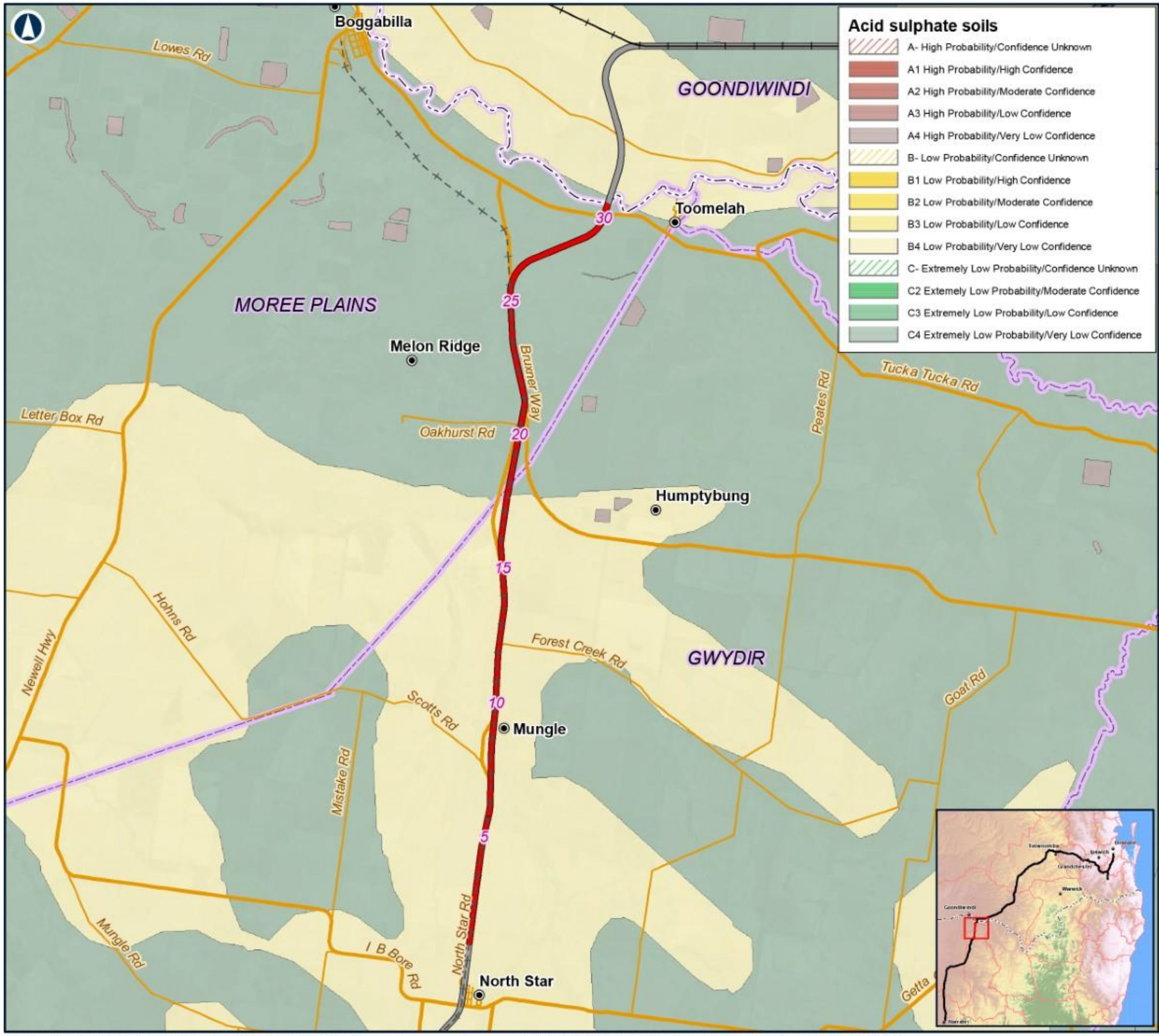
The southern portion of the study area traverses the Gwydir Local Government Area until approximately 900 m south of the intersection between Edward Street and Bruxner Highway, while the remainder of the study area lies within the Moree Plains local government area.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: NCW/MEF/GN Z:\GIS\GIS_270_NS2B\Tasks\270-EAP-201909051232_100pc_Land_resources_and_contamination\270-EAP-201909051232_Fig15.6_Soil_acidity_ARTC_A4L_v2.mxd Date: 22/10/2019 12:38

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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NORTH STAR TO NSW/QLD BORDER

Figure 15.7: Acid sulfate soils

LEGEND

- 5 Chainage (km)
- Localities
- Existing rail (operational)
- Existing rail (non-operational)
- North Star to NSW/QLD border alignment
- Adjoining alignments
- Major roads
- Minor roads
- NSW/QLD border
- Local Government

5km

Coordinate System: GDA 1994 MGA Zone 56

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Inland ASS/potential inland ASS risk mapping is generated by local governments, as required (i.e. where ASS risks have potential to occur), using OEH data. No inland ASS/potential inland ASS risk mapping is available for councils within the Gwydir and Moree Plains Local Government Areas, indicating no presence of inland ASS or potential risks.

No indicators of ASS or acid rock, which are generally igneous rocks containing greater than 65 per cent silica, were observed during the geotechnical investigation. The investigation identified the lowest elevation for the alignment as being approximately 223 m AHD (Golder Associates, 2019). However, in the unlikely event ASS is present during the construction phase of the proposal, an unexpected-finds protocol/procedure will be implemented (refer Section 15.7.2).

15.5.3.5 Soil texture

Data from the Office of Environment and Heritage (OEH, 2017) revealed the study area between North Star and the Macintyre River consisted of predominantly clay and sand in the upper 30 cm of soil. Clay content between 30 to 40 per cent dominates the upper soil horizon of the study area between North Star and the proposed rail corridor as it passes east of Melon Ridge. The remainder of the study area consists of soils with a greater clay content between 40 to 50 per cent. Sand content between North Star and the proposed rail corridor as it passes east of Melon Ridge contained 40 to 50 per cent sand, with the remainder of the study area containing lower levels of sand, between 30 to 45 per cent. Low levels of silt, between 15 to 25 per cent, exists throughout the study area. As a result, the surface soil of the study area is expected to contain predominantly a clay texture (Isbell and National Committee on Soil and Terrain, 2016).

Geotechnical investigations undertaken along the alignment found the topsoil thickness to vary between 0.25 and 0.3 m with orange–brown sandy clay to clay prominent in the terrace areas, while dark-grey clayey topsoil featured in the floodplains.

The southern portion of the alignment was found to consist of stiff to hard, dark orange–brown clay, silty clay, sandy clay, dense sand and clayey sand soil textures.

Where black soils feature along the alignment, predominantly along drainage lines and typically underlain by the Qs geological layer, a pale grey soil with a dense to hard consistency between a depth of 4 and 7 m exists.

The alignment adjacent the Macintyre River was found to be underlain by stiff to hard alluvial clay soils in dry conditions to a depth of approximately 7 m. The soil ranges from high to very high plasticity and consists of very high shrink–swell potential. Beyond 7 m, sandy gravelly and clayey interbeds were found.

The geotechnical investigations also undertook statistical analysis of percentages fines in the main geological units present along the alignment, as well as an Emerson Class Test. Mean percentage of fines in the main geological layers exceeded 50 per cent, classifying the soils as fine-grained. Findings from the analysis are further detailed in Table 15.6.

TABLE 15.6 STATISTICAL ANALYSIS OF PROPERTIES RELATED TO MAIN GEOLOGICAL UNITS UNDERLYING ALIGNMENT

Geological layer	Property	No. of values	Mean	Lower quartile	Median
Quaternary age alluvium (Qa)	Percentage fines (%)	27	56	21	67
	Emerson class	14	3	3	3
Tertiary age sediment (Qs)	Percentage fines (%)	55	64	54	72
	Emerson class	26	3	2	3

Source: Golder Associates (2019)

15.5.3.6 Salinity hazard

Salinity hazard assessment

Salinity presents a major land degradation issue which can cause land salinisation, increased in-stream salt loads and increased in-stream salt concentrations. In NSW, catchment management authorities produced salinity risk rankings within each catchment (catchment management authorities are now part of the local land services). This ranking has been developed considering several variables including salt stores, salinity outbreaks, surface water quality, aquifer type and groundwater quality (NSW DPI, 2013).

Salinity expresses itself in the landscape in a variety of ways. Some landscapes are more hydrologically sensitive and susceptible to salting than others. Identification of these landscapes helps to determine which management strategies will be effective in combating salinity. The *Salinity Management Handbook* describes several models that provide an excellent conceptual basis for describing different landscapes and different forms of salinity. These models provide and aid both the prediction of where salinity many occur, and the description of possible contributing factors. However, they do not provide a definitive answer to the cause of all salt outbreaks, and for conclusive proof, detailed site investigations will always be required.

A desktop salinity hazard assessment was undertaken within the study area to understand the existing primary salinity within the landscape, as well as potential for secondary salinity formation as a result of proposal activities. In accordance with *Book 3 Dryland Salinity* (Investigating and Assessment Techniques) (Department of Environment and Climate Change, 2008), the desktop assessment undertaken is considered an indirect technique for salinity measurement. Generally, these approaches measure parameters that are indicators of salts and, from this information, the existence of salinity and the level at which it is present may be inferred. Indirect methods are often used for mapping salinity in soil, water and the subsurface when funds are limited. Indirect methods can be used to assess large areas of land and provide a representation of the characteristics of salinity (Department of Environment and Climate Change, 2008a).

Primary salinity is the presence of salts within a landscape where salts are stored within the geology or soils and moved by the water that flows through a catchment area. Each catchment has a different level of stored salts, and how each landscape is managed will depend on the severity of salinity. Predicting areas at risk from salinity is a complex exercise, which requires both determining the inherent salinity hazard in a landscape and the effects of past, present and future land management practices.

A desktop salinity hazard assessment was conducted adopting the assessment methodology described in *Strategic Salinity Risk Assessment for the Condamine Catchment* (Searle et al., 2007).

The approach adopted for the proposal to find overall salinity hazard included collecting and analysing data that relates salinity risk to biophysical hazard. Biophysical hazard is the inherent capacity of the landscape to develop salinity and is often determined through factors such as geology, soil, topography, and groundwater availability or flow. Five factors were used to relate salinity risk to biophysical hazard which included soil salt store, basalt contact potential expression areas (PEA), catena PEA, artificial restriction PEA and confluence of streams PEA.

The study area was broken down by the *Australian Hydrologic Geospatial Fabric Catchment GIS* layer (Australian Government, 2015), into smaller sub-catchments to enable a more precise analysis of the proposal. Consideration was given to how proposal construction activities may alter the hydrology of the study area.

Inherent soil salt store

The *Australian Soil Classification* map for NSW (OEH, 2017) was intersected with the sub-catchments layer to identify which soils were dominant in each of the sub-catchments. The dominant soil type in these sub-catchments was derived through GIS analysis. Inherent salt store ratings for each soil type were adopted from Searle et al., (2007) and applied to give a low, moderate, or high rating. This salt store categorisation is summarised in Table 15.7 and illustrated in Figure 15.8.

TABLE 15.7 SOIL TYPE AND SOIL SALT STORE CATEGORY

Soil type	Soil salt store risk category
Black dermosols	Low
Black vertosol	Moderate
Grey vertosol	High
Chromosol	High

Source: Searle et al., 2007

Potential expression areas of basalt and sandstone contact

The underlying geology of the study area features PEAs of basalt and sandstone contact. These PEAs result in salts being transported through underlying basalt layers towards surface soils in an area of basalt and sandstone contact (Department of Environment and Resource Management, 2011). Salinity in a basalt layer forms when both recent and highly weathered layers overlay a less permeable sandstone and mudstone layer at shallow depths. Seepage and the visible expression of salt occurs at the contact point between the two rock types.

The percentage of basalt and sandstone contact PEAs for each sub-catchment within the study area was calculated and is illustrated in Figure 15.9, with further detail provided in Table 15.8.

Calculation of basalt and sandstone contact was based on an analysis of the 25 m digital elevation model developed for the proposal. Three derivatives were used: tangential curvature, relative elevation (kernel size 90) and slope percentage. These derivatives were calculated using ArcGIS Spatial Analyst functions.

The basalt and sandstone contact PEAs are predicted to be where the following occurs (Searle et al., 2007):

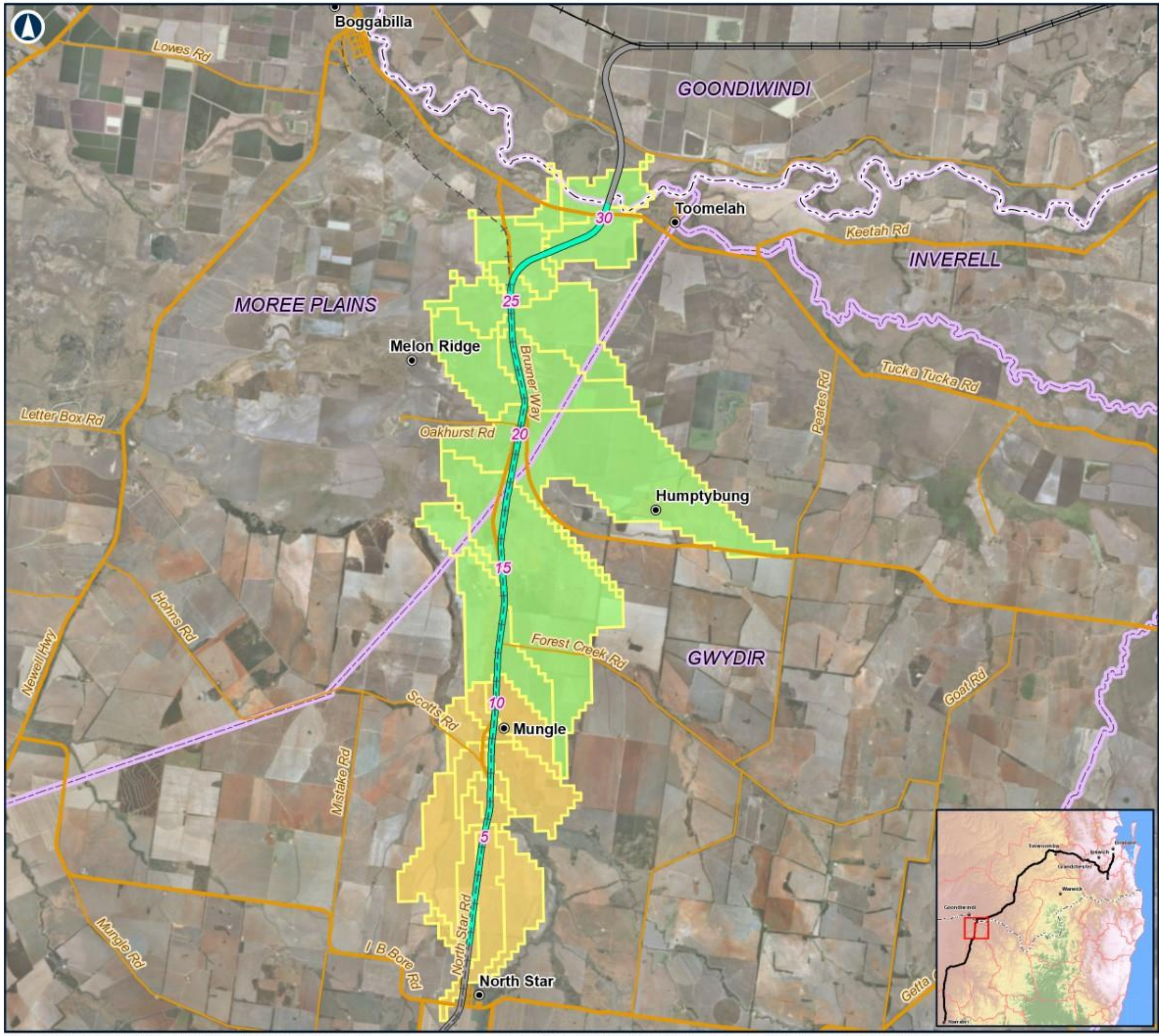
- Tangential curvature is less than 0 (i.e. the downhill slope shape is concave—flow tends to slow and converge)
- Relative elevation is greater than two (i.e. there is typically a distinct break of slope)
- Slope is greater than 1 per cent and less than 10 per cent (i.e. typically mid-slope positions).

TABLE 15.8 POTENTIAL EXPRESSION AREAS OF BASALT AND SANDSTONE CONTACT

Percentage of each sub-catchment containing basalt and sandstone contact PEAs (%)	Risk category
0	None
0 to 2	Low
2 to 5	Moderate
Greater than 5	High

Source: Searle et al., 2007

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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NORTH STAR TO NSW/QLD BORDER

Figure 15.8: Inherent salt store

LEGEND

- 5 Chainage (km)
- Localities
- Existing rail (operational)
- Existing rail (non-operational)
- North Star to NSW/QLD border alignment
- Adjoining alignments
- Major roads
- Minor roads
- Sub-catchments
- Local Government Areas
- NSW/QLD border

Soil salt store

- Low (vertosol, kurosol)
- Moderate (tenosol, ferrosol, chromosol, dermosol)

5km

Coordinate System: GDA 1994 MGA Zone 56

11/02/2019 Paper: A4
Author: FFJV GIS Scale: 1:200,000

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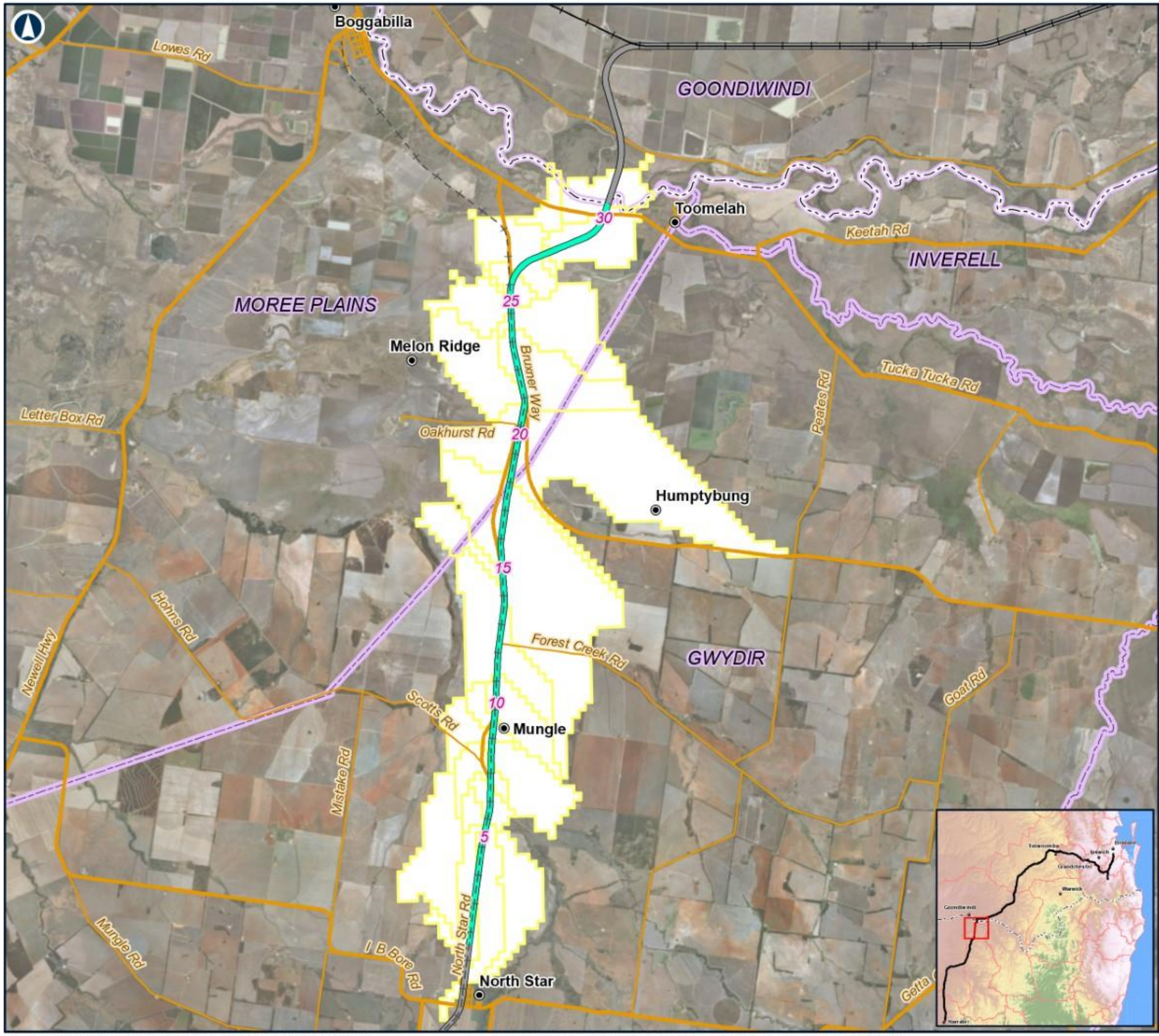
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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NORTH STAR TO NSW/QLD BORDER

Figure 15.9: Potential expression area: Basalt/sandstone contact

LEGEND

- 5 Chainage (km)
- Localities
- Existing rail (operational)
- Existing rail (non-operational)
- North Star to NSW/QLD border alignment
- Adjoining alignments
- Major roads
- Minor roads
- Sub-catchments
- NSW/QLD border
- Local Government Areas

PEA of basalt/sandstone contact

- None
- Low: <2
- Moderate: 2-5
- High: >5

5km

Coordinate System: GDA 1994 MGA Zone 56

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Potential expression area of catena form

The study area also features PEAs of catena form. Catena form PEAs occur when shallow soils located upslope overlie weathered parent material which then extend out into flat heavy clay alluvial areas. These alluvial areas are characterised by high sodicity due to restricted permeability and result in the formation of salt as well as changing soil properties and water movement (Department of Natural Resources, 1997).

The percentage of catena form PEAs for each sub-catchment within the study area was calculated and is shown in Figure 15.10. Calculation of catena form was based on an analysis of the 20 m digital elevation model developed for the proposal. Two digital elevation model derivatives were used in this analysis, one being slope per cent and the other a Multi Resolution Valley Bottom Floor index which was described by Gallant and Dowling (2003). The Multi Resolution Valley Bottom Floor index identifies areas that are both relatively flat and low in the landscape at different scales, which is interpreted as a map of valley bottom areas. This index is used to separate upland terrain dominated by erosional processes from lowland depositional terrain (Searle et al., 2007).

The analysis was applied only to basalt and sandstone layers identified to underlay the proposal study area, as these are the areas considered to be most susceptible to catena form salinity.

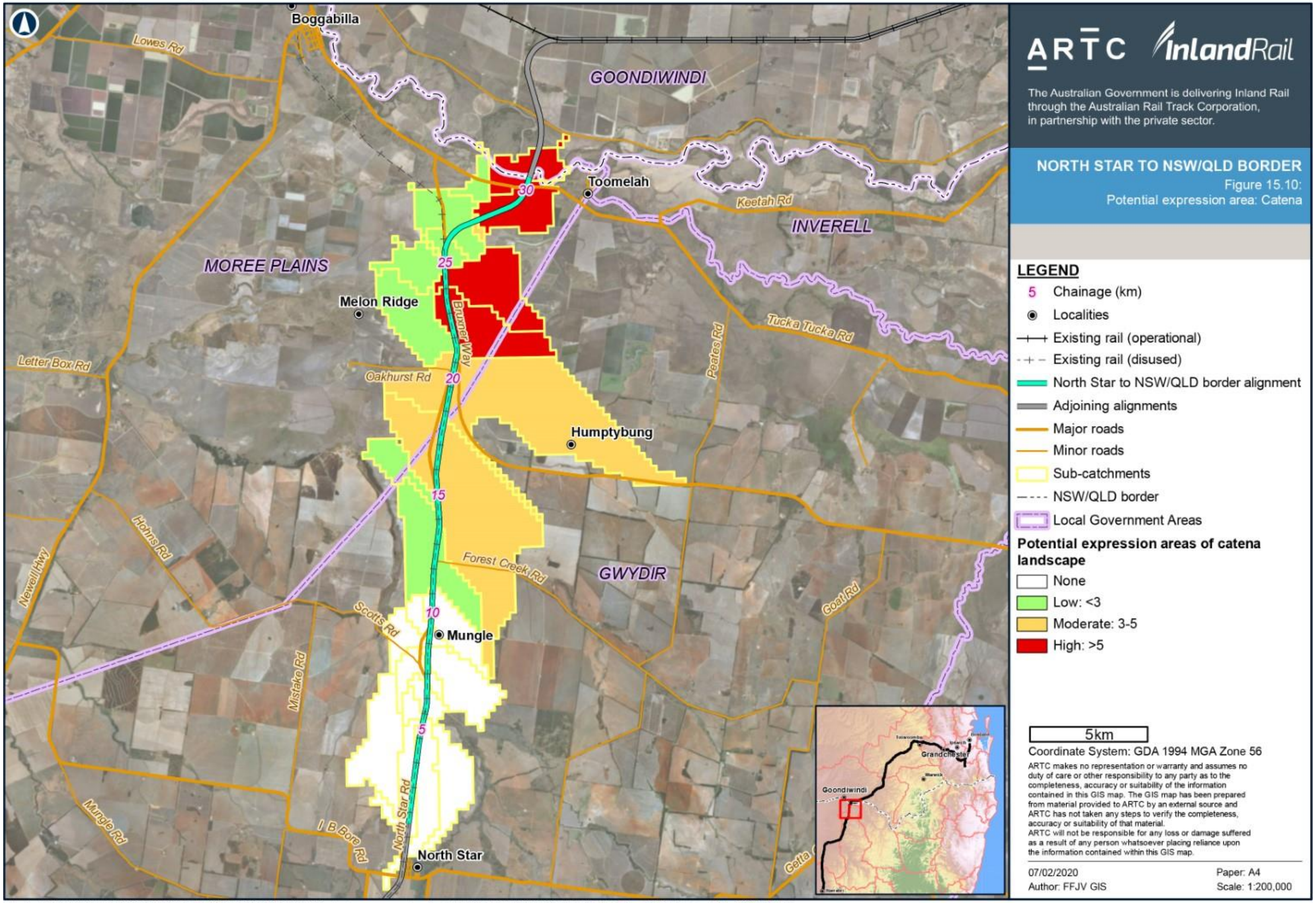
When analysing the risk of the catena landform within the sub-catchments a low to high hazard category rating was applied as shown in Table 15.9.

TABLE 15.9 POTENTIAL EXPRESSION AREA OF CATENA FORM

Percentage area of sub-catchments containing catena PEAs (%)	Risk category
0	None
1 to 3	Low
4 to 5	Moderate
Greater than 5	High

Source: Searle et al., 2007

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Potential expression areas of artificial restriction (roads)

The placement of roads within a landscape can restrict water flow as well as impede the soils ability to transmit water, leading to the uprising of groundwater with dissolved salts and waterlogging. This form of salinity is often associated with hillslopes consisting of textural contrast soils or shallow, sandy soils within drainage lines (Searle et al., 2007).

A 25 m digital elevation model was used with two derivatives to assess where the construction of roads in the landscape could potentially create salinity. The two derivatives are (Searle et al., 2007):

- Compound Topographic Index. The Compound Topographic Index delineates those areas in a landscape that have high contributing area and relatively low slopes. In a general sense, these would tend to be the wetter areas within a landscape
- Slope (per cent).

Figure 15.11 presents the potential risk of salinity development with road placement. The digital elevation model was generalised to 200 m for the slope calculations and 1,000 m for the Compound Topographic Index calculations. The analysis selected the areas that are generally low slope and where there is a general convergence of flow, low in the landscape. These areas are predicted to occur where:

- Slope is greater than one per cent
- Compound Topographic Index is greater than two.

The hazard category of the artificial restrictions was given a low to high rating, and these ratings are presented in Table 15.10.

TABLE 15.10 NUMBER OF ROAD POTENTIAL EXPRESSION AREAS ALONG STUDY AREA CATEGORIES

Number of road PEAs within sub-catchments	Risk category
0	None
1 to 50	Low
51 to 100	Moderate
> 100	High

Source: Searle et al., 2007

Potential expression area confluence of streams

The confluence-of-streams form of salinity relates to where a major stream intersects with a minor stream. This intersection can create a reduction in flow velocity and a resultant deposition of the suspended particles at the junction, including a precipitation of salts (Searle et al., 2007).

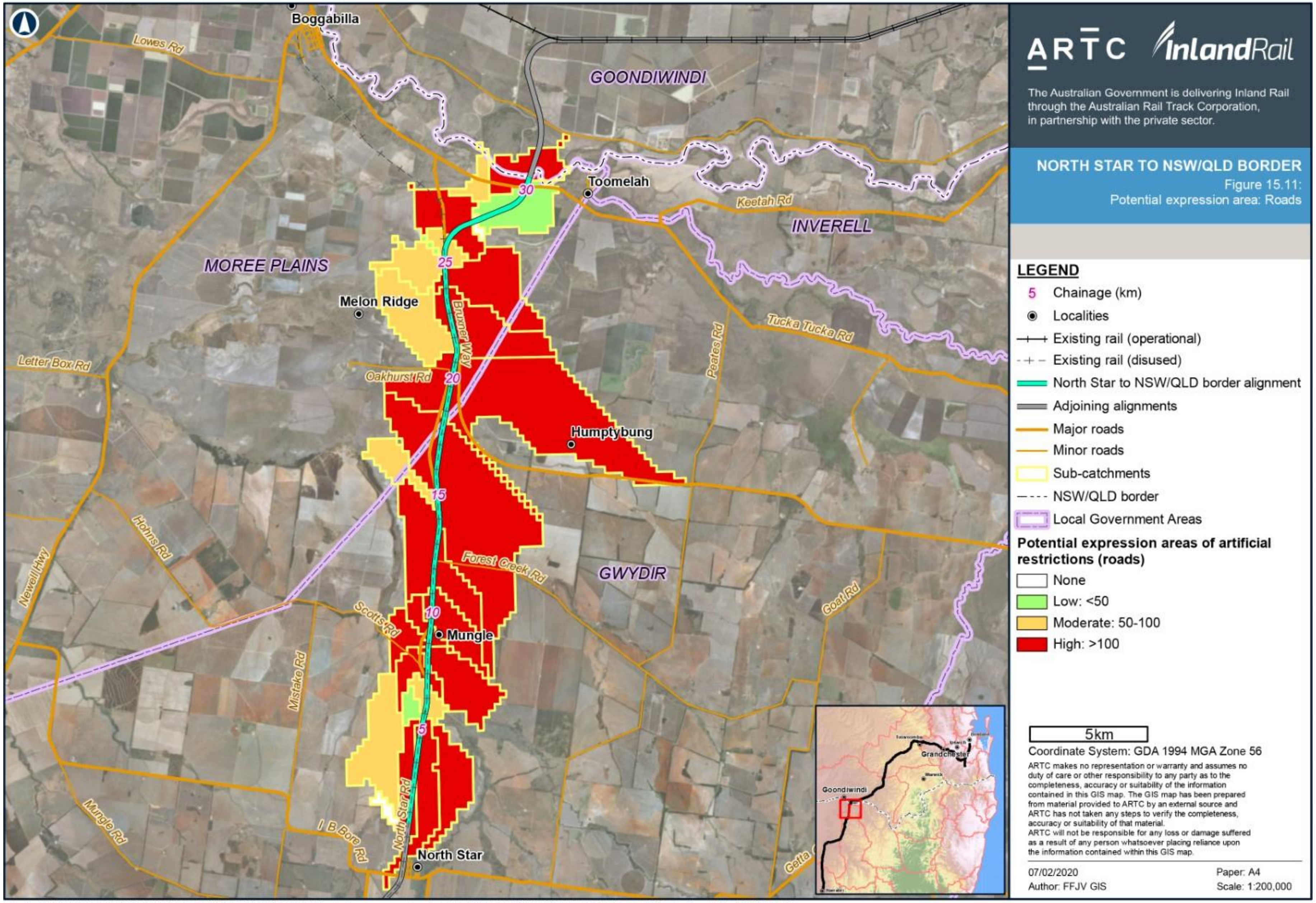
Within each sub-catchment the number of PEAs were identified, and each sub-catchment was given a rating from low to high as shown in Figure 15.12 and Table 15.11.

TABLE 15.11 PERCENTAGE OF STUDY AREA CONTAINING CONFLUENCE OF STREAMS

Percentage of each sub-catchment containing confluence of streams (%)	Risk category
0	None
1 to 3	Low
4 to 5	Moderate
Greater than 5	High

Source: Searle et al., 2007

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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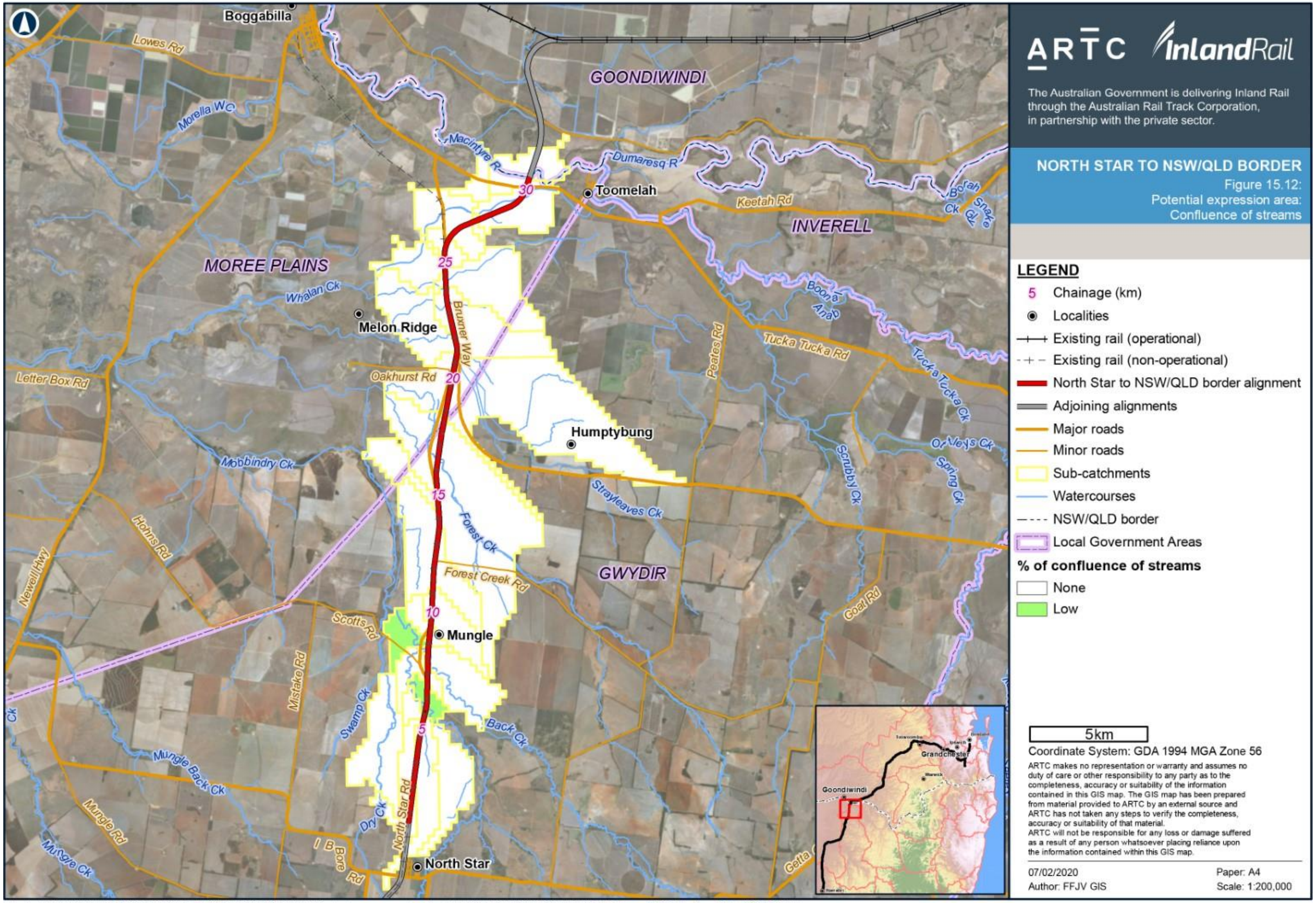
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Overall salinity hazard

Overall salinity hazard of the study area was assessed using a desktop assessment of five factors, potential expression areas, laboratory results from soil samples collected during geotechnical investigations, and from NSW OEH-published soil profiles for salinity.

The desktop assessment of salinity hazard was developed with consideration of inherent soil salt store, basalt and sandstone contact, catena form, artificial restrictions and confluence of streams. The desktop assessment indicated a general medium-to-high potential hazard of salinity occurring within the land resources study area, when risks from each of the five individual potential expression areas was combined (refer Figure 15.13).

The desktop salinity assessment between North Star and west of Humptybung identified a high-risk rated area along the proposal site and is associated with the flat-lying Jurassic-aged strata and residual soils of the Kumbarilla Beds and the Walloon Coal Measures (NSW DPI, 2013). These high-risk areas are particularly evident where stratigraphic changes or breaks in slope occur. A small high-risk area also exists north of Oakhurst Road and CH2500.

Spikes in salinity are known to occur in drainage systems especially during wet climatic cycles when the local system becomes saturated (NSW DPI, 2013). During such conditions, unconfined, shallow aquifers such as the alluvium within Mobbindry and Back Creeks could experience spikes in salinity from surface water recharge. Increases in recharge from irrigation also have the potential to increase salinity risks in these high-risk areas.

The single soil-sampling location which analysed for exchangeable sodium, calcium and magnesium within the soil detected an availability of these salts; however, two NSW OEH-published soil profiles within the study area found no evidence of salting within the profiles during a 2001 investigation (Blair, 2001a, 2001b). Sodium, calcium and magnesium can generally contribute to salinity in high concentrations (OEH, 2018).

15.5.3.7 Soil erosion

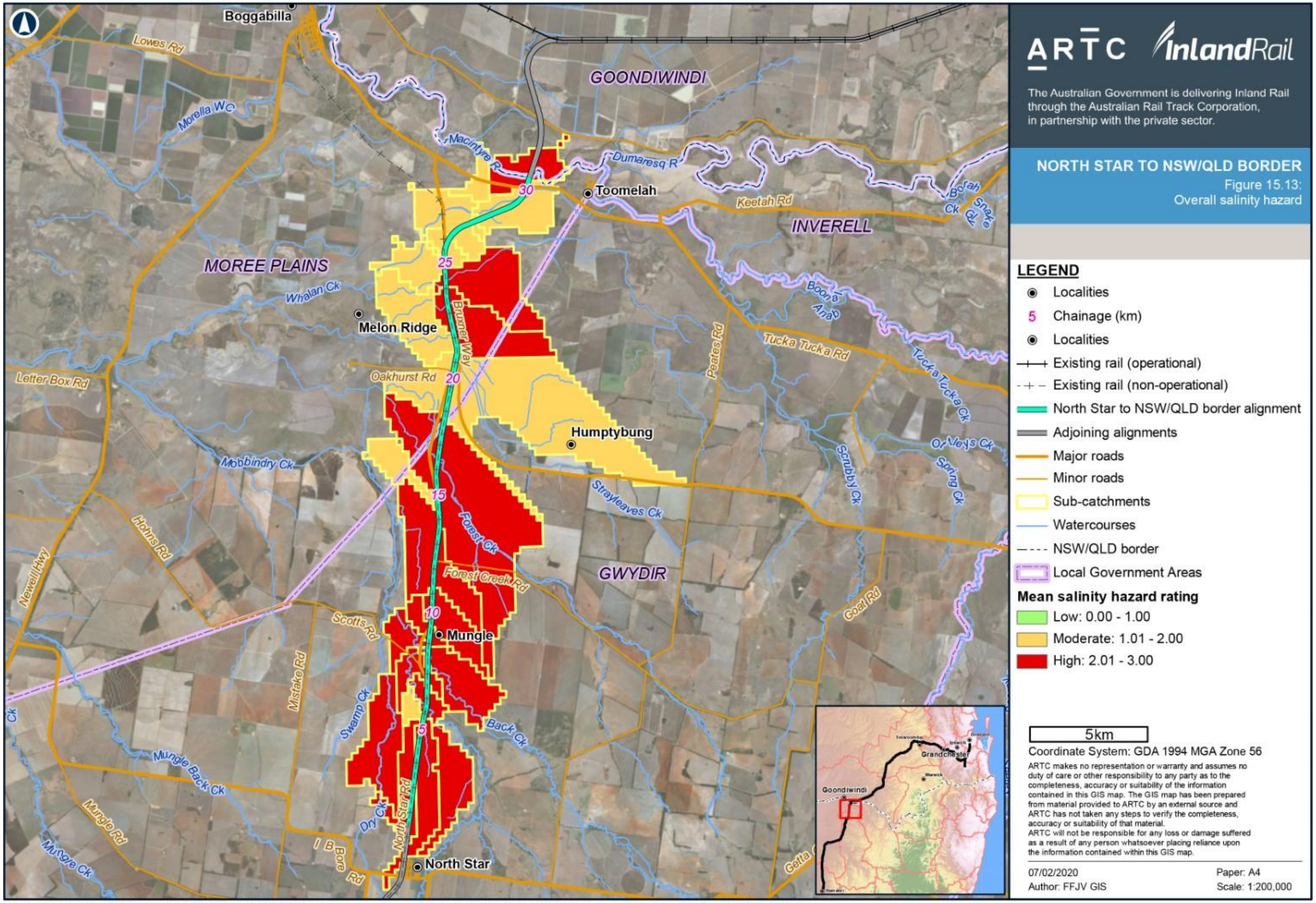
Preventing and managing erosion is important to consider when a change to the land use will occur. Erosion, the transport of sediment and eventual deposition by water, wind or both occurs across virtually all landscapes in Australia, even those on low slopes and is a potential risk for the alignment as the railway requires a stable base to operate safely.

The soil variability in the region is typically a reflection of the dominant presence of erosional and transportation surfaces on the slopes, as opposed to the depositional environments of valleys and floodplains. The transitional zones of these soil environments can increase the complexity and variability of the soil types (Department of the Environment and Energy, 2013).

The erodibility of soil can be associated with two key factors, dispersibility and sodicity of the soil type. As part of the proposal geotechnical investigations, an Emerson Class Test (refer Table 15.6), which measures the dispersive characteristics of a soil when exposed to water, was undertaken (Golder Associates, 2019).

The Emerson Class Test undertaken on the alluvial soils overlying the Quaternary-age alluvium (Qa) and Tertiary-aged sediment (Qs) geology concluded the alluvial soils along the alignment are expected to be slaking, high-to-moderately dispersive, reactive soils. These were classed as Class 2 to 3. The test also classified the soil sampled as being reactive with high plasticity, high shrink–swell index, high fines content and containing high dispersion potential.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: NCW/MEF/GN Z:\GIS\GIS_270_NS2B\Tasks\270-EAP-201909051232_100pc_Land_resources_and_contamination\270-EAP-201909051232_Fig15.13_Overall_Salinity_ARTC_A4L_v3.mxd Date: 7/02/2020 11:44

In addition to dispersibility, soil sodicity is another key indicator of a soil's erodibility. Sodicity of a soil is the presence of a high proportion of sodium ions relative to other cations. An excessive amount of sodium degrades soil properties by weakening the bond between soil particles (Queensland Government, 2016).

Soil sampling investigations for the single location analysed for salts indicated an exchangeable sodium percentage of 17.3 per cent (refer Table 15.4). Soils with an exchangeable sodium percentage of less than 6 per cent are considered non-dispersive, while soils over 6 per cent are considered dispersive. An exchangeable sodium percentage exceeding 15 per cent may completely disperse (Department of Primary Industries and Regional Development, 2019).

The results also identified an availability of exchangeable calcium and magnesium within the soil sampled which, in high percentages, increases a soil's capacity to disperse by reducing its ability to maintain structure.

Erosion risks based on landform type and geology are summarised in Table 15.12.

TABLE 15.12 EROSION RISK

Landform type	Geology	Erosion risk
Erosional surfaces, ridges and plateaux remnants on basalt with steep stony slopes, restricted lower slopes, stony interfluves. Highest elevation is at North Star, at 260 m. This gradually descends from the highlands into the low ridges of the Macintyre River with the point of lowest elevation at 223 m, as the corridor passes over Whalan Creek.	Basaltic Uplands, Kumbarilla Beds	Moderate
Flood plains and river terraces subject to regular overbank flooding, sandy banks and poorly defined levees and cobble plains. Supports grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.	Quaternary alluvium	Moderate

Source: Damara, 2013

Two NSW OEH-published soil profiles were examined along the study area (Blair 2001a, 2001b). One soil profile was tested 50 m south of the road crossing of Back Creek on the western side of the road which identified minor sheet, rill and gully erosion with stable scald erosion. The second profile taken at the railway crossing on the western side of North Star Road revealed minor sheet erosion with stable scald.

In the same study of soil erosion for the physiographic provinces of Australia, mapping found the study area graded as 'poor'. The map assessed soil erosion by wind and water across Australia, drawing on State of the Environment reports from NSW.

Data from the study for soil erosion in NSW in the Central West region, consisting of the study area, revealed 25 per cent of soil monitoring units experienced sheet erosion, followed by 4 per cent gully erosion and 4 per cent for wind erosion.

15.5.4 Soil and water environment

15.5.4.1 Surface water

The proposal site falls within the Border Rivers catchment management area of NSW (MDBA, 2012). This catchment is one of the northern most catchments within the Murray–Darling Basin and is made up of a group of rivers straddling the NSW/QLD border. The rivers of the catchment start at the Great Dividing Range and run westward, gradually merging to become the Barwon River.

Watercourses within the proposal typically consist of gravel and/or sandy bed composite and are not expected to be resistant to scour if exposed to high-velocity waters. The full geomorphic assessment (using the AUSRIVAS assessment methodology) is presented within Appendix S: Aquatic Biodiversity Technical Report. Appendix H: Hydrology and Flooding Technical Report includes assessments of water levels, flow-paths, and flow velocities. A summary of the watercourses in the study area is provided in Table 15.13 and further detail of surface water provided in Chapter 13: Surface Water and Hydrology

TABLE 15.13 WATERCOURSES WITHIN THE PROPOSAL SITE

Watercourse	Description
Macintyre River	The Macintyre River is the major river that begins in the Northern Tablelands between Glen Innes and Guyra. The river is 321 km long and is a tributary of the Barwon River. The proposed rail crossing location is situated between the confluence of the Dumaresq River and Macintyre River and Boggabilla. This is the only permanent waterway within the proposal site. There is a broad, well-vegetated riparian flood plain on both sides of the river. Impacts of human disturbance are high. There is an extensive riparian cover along both banks with an overstory of *Eucalyptus* sp. and *Melaleuca* sp. The banks are 50–100 m wide and have a substantial cover of weedy species. The riverbed includes gravel and sand beds with some mud banks and snags. The river level was low but flowing at the time of the survey and provides high-value fish habitat. Emergent (*Phragmites australis*) macrophytes were along the banks.  Macintyre River downstream of Site 11 (Low flow at time of assessment—August 2018)
Whalan Creek	Whalan Creek is a major creek approximately 60 km long that discharges in a westerly direction into the Macintyre River, downstream of Goondiwindi. Whalan Creek is an anabranch of the Macintyre River and appears to also receive flows from the Macintyre River during over-bank flow events. This creek is ephemeral but larger than other creeks in the area, with a well-defined channel likely to flow seasonally. The creek is approximately 50–70 m wide and runs within a broad agricultural landscape with a mix of grazing and cropping on both banks. The width of the floodplain was undetermined as there were no distinctive features or changes in vegetation to identify the floodplain extent. However, the entire area adjacent to the creek is a floodplain. These sites are highly disturbed/modified with significant impacts to the waterway and the riparian zone. Riparian vegetation cover is highly degraded/modified, with an overstory of *Eucalyptus sp.* and *Acacia sp.* providing sparse cover. There was limited evidence of tree regeneration and shrub/ground cover was low. The bed of the creek is stable and dominated by silt and some sand, and there was limited fish habitat visible at the site. A large pool was visible outside of the assessment reach; however, the creek was otherwise dry at the time of the site inspection.

Watercourse	Description
Whalan Creek	 Whalan Creek upstream of Site 7 (Dry at time of assessment—August 2018)
Mobbindry Creek	Mobbindry Creek is a tributary of Whalan Creek and is approximately 55 km long. The headwaters of the creek are southeast of the township of North Star and flow parallel to the North Star Rd in a north-westerly direction and appear to discharge into Whalan Creek near the Newell Highway. The proposed rail crossing location is adjacent to the Boggabilla–Warialda Rd. The creek is ephemeral, with a well-defined channel. The floodplain is broad and undefined adjacent to Mobbindry Creek. The local land use and the broader catchment are highly modified and impacted by agricultural activities (grazing and cropping). The creek is 26–30 m wide. The riparian corridor comprises an overstorey of *Eucalyptus sp.* and Brigalow, with some shrub cover and a good understory cover. The creek-bank vegetation includes a continuous cover of fringing rushes and sedges. The creek bed was stable at the time of assessment and includes silts and some sand. The channel form was varied but dominated by run habitat, with some pools expected to be present during flow. Obstructions to the waterway include the existing rail-and-road crossing, and there were some natural barriers in the form of large snag piles.  Mobbindry Creek downstream of Site 1 (Dry at time of assessment—August 2018)

Watercourse	Description
Back Creek	Back Creek is a tributary of Mobbindry Creek and is approximately 25 km long. There is a well-vegetated riparian zone along both sides of the creek at the crossing location. There was recent evidence of stock presence at the sites investigated. This creek is ephemeral, with a well-defined channel. Riparian vegetation was dominated by *Eucalyptus sp.* and Brigalow, with shrubs present and good understory dominated by native species. The creek is approximately 18–30 m wide. The top of the banks along the creek are covered by *Carex sp*. The creek channel was between 1 m deep and 3 m wide at the time of assessment. The substrate is unconsolidated silt with many snags present in the creek. There was a slight sheen to the water and an anaerobic odour generated from the sediment when disturbed.  Back Creek upstream of Site 5 (Low flow at time of assessment—August 2018)
Forest Creek	Forest Creek is over 20 km long, discharges in a north-westerly direction and appears to discharge into Whalan Creek although the flow path is not clearly defined. The floodplain is broad and poorly defined along the creek. There is a mixed coverage of riparian vegetation dominated by *Casuarina sp.* along the creek. The channel was variable and 31–40 m wide at the sites surveyed, with a broad, shallow (0.2 m) bed dominated by silt and sand and some gravel. The creek bed is vegetated with a mixture of terrestrial species with evidence of aquatic species in some shallow depressions. This creek is ephemeral, with a highly modified waterway and poorly defined channel. An on-stream dam has been constructed and all flows diverted to the dam. Two levees have been constructed that divert overland flow from the creek to the on-stream dam before excess water is able to bypass the dam. Downstream of the dam the existing rail line has formed a barrier to flows. The rail line and levee banks have altered the hydrology of the site between the dam and the rail line that has allowed a stand of *Casuarina sp*. to establish.

Watercourse	Description
Forest Creek	 Forest Creek downstream of Site 16 at the rail crossing (Isolated pool at time of assessment—August 2018)
Unnamed tributary of Mobbindry Creek	The unnamed tributary of Mobbindry Creek is a short drainage line approximately 5 km long. The creek line is highly modified and impacted by agricultural land use. The creek is 9–30 m wide. At the time of assessment it was narrow and shallow (<0.5 m) in parts, with a uniform sand bed. In other reaches it contained highly mobile silt and sand that has a scoured low-flow channel within it. The overstorey riparian zone was non-existent with a highly degraded understorey and ground-cover riparian vegetation. Levees have been constructed along both banks.  Unnamed tributary of Mobbindry Creek downstream of Site 15 (Dry at the time of assessment—August 2018)

Source: EIS Appendix S: Aquatic Biodiversity Technical Report

15.5.4.2 Regional groundwater recharge, discharge and flow

Groundwater flow in the Quaternary alluvium is considered to mimic the topography and is limited to the areas where alluvial units are present, generally in proximity to surface water features. Regional mapping of the water table indicates a general north to northwest flow of groundwater in the shallow alluvial aquifer across the study area (Ransley et al., 2015). Groundwater elevations measured in October 2018 from proposal monitoring wells ranged from 213 to 218 mAHD and are generally consistent with this regional pattern. Cenozoic-aged alluvial aquifers are mapped in association with the current major watercourses (e.g. Macintyre River and Whalan Creek) and antecedent systems that form paleo-valley fill and broad alluvial fan systems within and surrounding the proposal site.

This aquifer is formally known as the NSW Border Rivers—Downstream Keetah Bridge Alluvial Water Source (NSW DPI, 2012). Other areas of mapped alluvium include narrower units within Mobbindry Creek and Whalan Creek. Subdivision of the alluvium into a shallow Narrabri Formation and deeper Gunnedah Formation is often applied to the alluvium in the Border Rivers region.

Local groundwater flow is expected to flow towards the perennial Macintyre River.

The alluvial aquifers are strongly linked to surface water features. This strong hydraulic connection is demonstrated during periods of high rainfall in several monitored bores near the proposal site. Flooding events such as events in January 1996 and July 1998 are clearly observed in monitored bores within the alluvium adjacent to Macintyre River, where groundwater elevations rose up to 1 m (refer to bore hydrographs 41640005-B, GW36684 and GW036693 in Appendix N: Groundwater Technical Report).

Recharge to alluvial units is expected to occur via the following mechanisms:

- Recharge from stream losses from the regulated Dumaresq River and Macintyre River
- Recharge from stream losses during seasonal flow in minor creeks/tributaries (i.e. Mobbindry Creek)
- Direct infiltration from rainfall and irrigation where permeable alluvium units are exposed
- Upward leakage from underlying Surat Basin Strata (CSIRO, 2007).

It is considered that alluvial units may provide a source of recharge to the underlying units where the underlying units are appropriately permeable and vertical gradient is downwards. Seepage from the alluvial aquifer into the underlying stratigraphic units has potential to occur through the base of the Cenozoic alluvium.

Discharge from the alluvial sediments is predominantly throughflow and baseflow to the surface water features. Limited effective storage in the coarse-grained permeable alluvium is likely to result in groundwater level decline during the dry season (where not artificially recharged from the regulated Dumaresq River and Macintyre River). Quaternary alluvium within the ephemeral creek systems (i.e. Mobbindry Creek and Forrest Creek) will not contain permanent groundwater as recharge to the alluvium seeps downwards into the underlaying sedimentary units or downgradient because of low effective storage.

The impacts of proposal activities on groundwater salinity is further detailed in Chapter 14: Groundwater.

15.5.4.3 Existing flood regime

Flooding in the study area occurs through two mechanisms, or a combination of both (refer Appendix H: Hydrology and Flooding Technical Report), that is:

- Regional flood events caused by high flows in the Macintyre River, Dumaresq and/or Macintyre Brook systems, and/or
- Local catchment events due to rainfall over the local area.

The hydrologic and hydraulic investigation undertaken as part of the surface water and hydrology assessment to inform and assess the potential impacts of the reference design on the existing flood regime, concluded that:

- As a result of the developed case, there are no impacts greater than 10 mm predicted on habitable dwellings on the floodplain including at the Toomelah Community
- Increases in peak water levels at identified non-habitable dwellings are predicted to be less than 39 mm
- Tucka Tucka Road and Bruxner Way are non-trafficable in the Existing Case 1 per cent AEP event. Both roads are not predicted to be non-trafficable for any longer than currently occurs due to the Developed Case
- No significant changes to peak flood flow distributions are predicted as a result of the Developed Case
- Under the representative concentration pathway 8.5 climate change scenario, 1 per cent AEP event peak flood levels are predicted to increase by 0.4 m with no overtopping of the rail formation

- There is little change to the predicted impacts on sensitive receptors as a result of varying the applied culvert blockage allowance between 0 per cent and 50 per cent.

Further details regarding flood regimes and hydrology is provided in Chapter 13: Surface Water and Hydrology.

15.5.5 Agricultural activities

Biophysical Strategic Agricultural Land is defined by the Department of Planning and Environment (2013) as land with high-quality soil and water resources capable of sustaining high levels of productivity. These lands intrinsically have the best quality landforms, soil and water resources that are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain quality.

Biophysical Strategic Agricultural Land mapping revealed three areas of Biophysical Strategic Agricultural Land in the study area (refer Figure 15.14). These include:

- An approximate 40,990 m^2 area east of Mobbindry Creek and west of Mungle
- An area of approximately 770,863 m^2 east of Melon Ridge past Oakhurst Road
- An approximate 193,138 m^2 area at the Macintyre River between NSW and Queensland.

A Bioregional Assessment (2013) was conducted by the Department of the Environment and Energy of the Gwydir subregion, which forms part of the Northern Inland Catchments bioregion. This assessment found the subregion to have moderately fertile soils over most of its land surface with an overwhelming amount consisting of vertosols. The strong agricultural capability of vertosols appeal to irrigated cropping of cotton, wheat, sorghum and rice, because the soil type can be worked under a narrow range of moisture conditions as well as the ability to withstand frequent cultivation. An assessment of NSW soil health, commenced in 2008, categorised the soil condition of the Gwydir subregion as generally 'good'. However, there was a small loss of soil condition relative to reference conditions for a range of soil indictors and a low likelihood of change in the future through current land use (DoEE, 2013; NSW Government, 2010).

Chapter 22: Land Use and Property provides further details on the land and soil capability assessment scheme developed by the NSW OEH in 2012, which provides greater guidance on the physical capability of land to support varying agricultural land uses.

15.5.6 Contaminated land

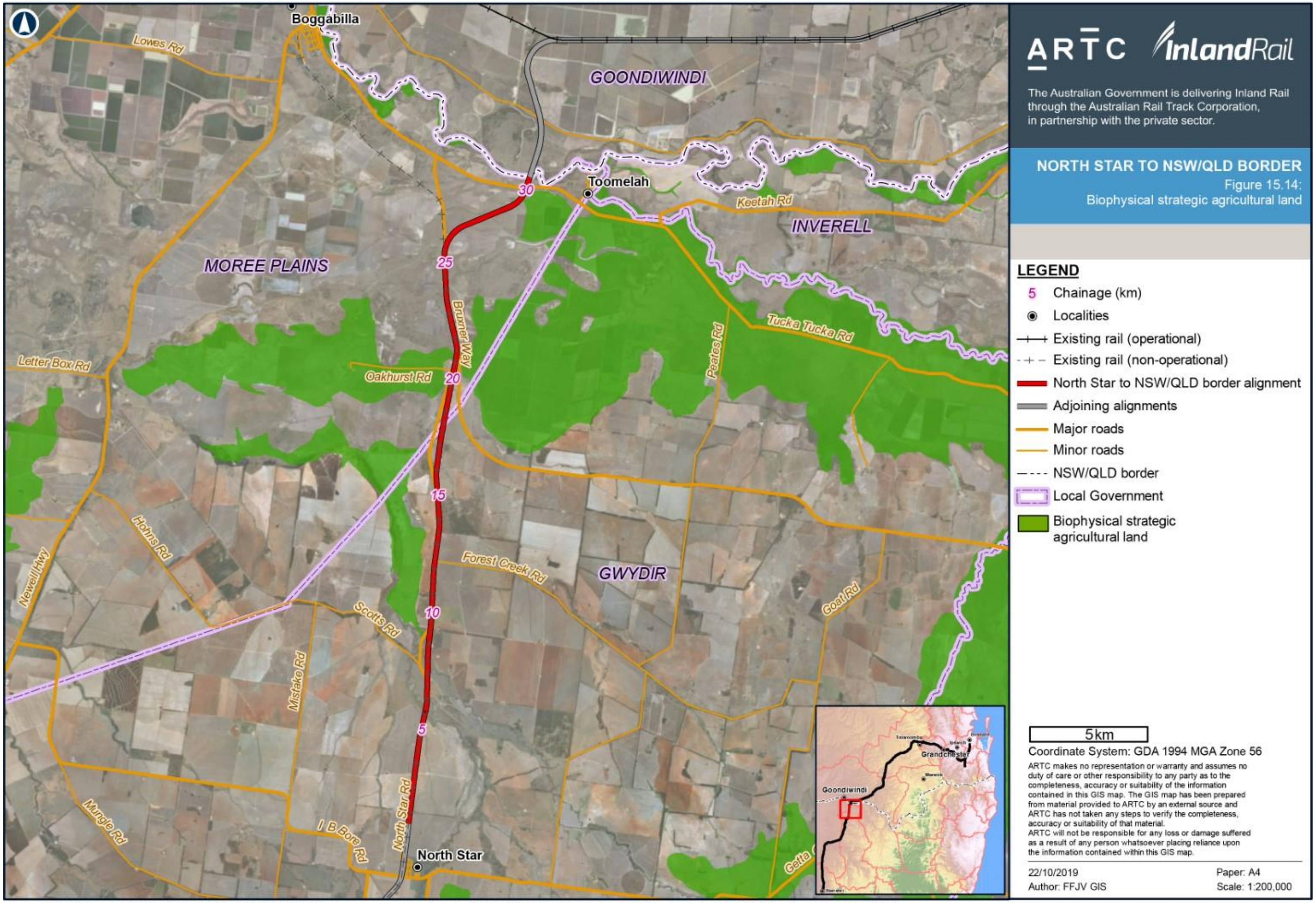
An assessment of contaminated land within the land resources study area was undertaken using a contaminated land risk assessment based on a contaminant (source)-pathway-receptor methodology, that is:

- Contaminant (source): a substance present in or on land, water or site at above-background concentrations that presents, or has the potential to present, a risk to human health, the environment or any environmental value.
- Pathway: the route by which the source is brought into contact with the receptor. This can include the transport of contamination via water (surface and groundwater), aeolian deposition, vapours, excavation and deposition.
- Receptor: humans, other living organisms, physical systems and built structures that could be affected by the source. A receptor will be affected only if a pathway from the source to the receptor is present. Groundwater and surface water systems can be considered as receptors as their quality is regulated by statutory bodies, as well as being pathways for contaminant migration to other receptors.

The source-pathway-receptor relationship allows an assessment of potential environmental risk to be determined, based on the nature of the source, the degree of exposure of a receptor to a source and the sensitivity of the receptor.

The fundamental concept of risk assessment is that an exposure pathway linking the source of contamination and the exposed population (humans or the environment) must be present for a risk to exist (NEPC, 2013).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: NCW/MEF/GN Z:\GIS\GIS_270_NS2B\Tasks\270-EAP-201909051232_100pc_Land_resources_and_contamination\270-EAP-201909051232_Fig15.14_Biophysical_Strategic_Agricultural_Land_ARTC_A4L_v2.mxd Date: 22/10/2019 15:40

Identification of potential sources of contamination within the study area were assessed through site inspections (including walkover) of the study area, undertaken as part of the geotechnical investigations, assessment of bore logs and a desktop assessment which included any additional areas within a 1 km buffer that may pose a potential risk to the proposal.

The desktop assessment identified potential sources of contamination within the study area through:

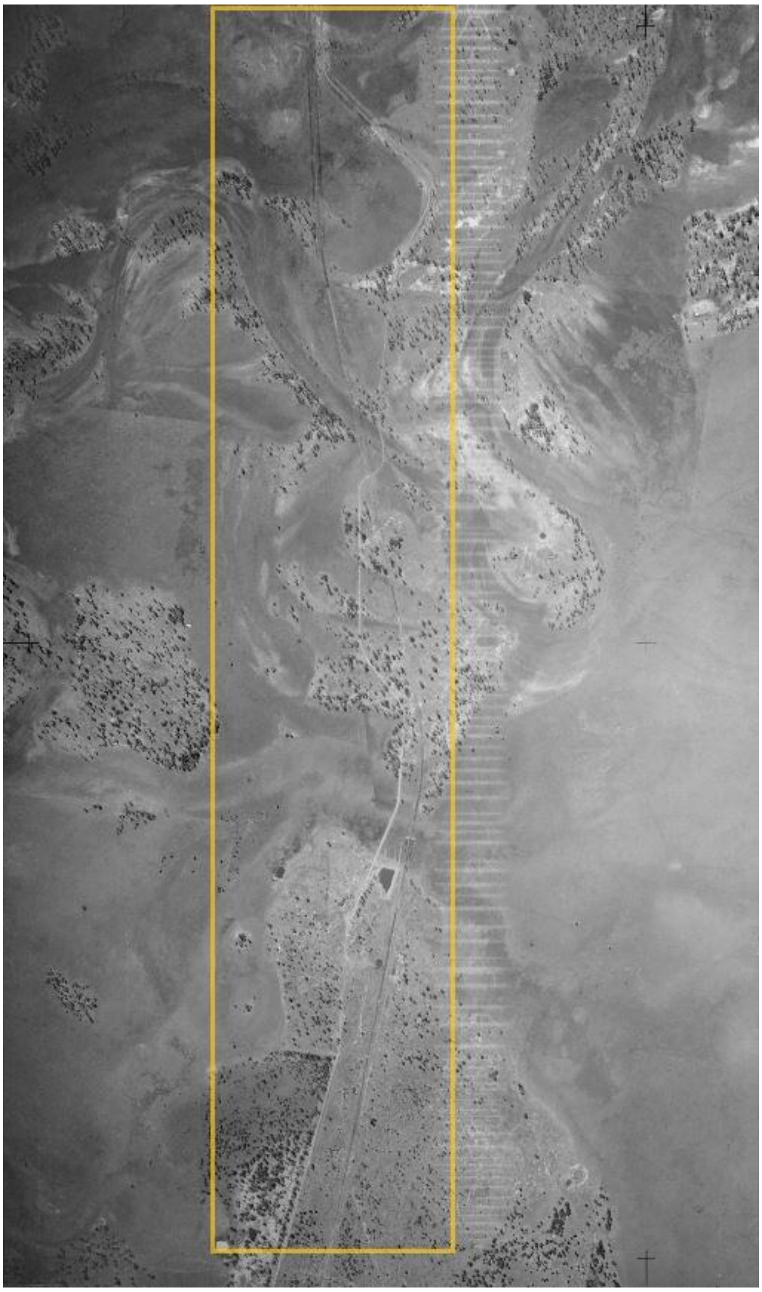
- A search of NSW EPA (2018b) contaminated sites record
- The Department of Primary Industries (2018) cattle dip site locator
- The *ARTC Contaminated Land Register* for potentially contaminated sites
- An assessment of historical aerial imagery from areas of interest (e.g. potentially contaminated sites, infrastructure, environmentally significant areas etc.)
- A search of the Department of Defence (2017) online mapping for UXOs
- A search of the NSW Department of Environment and Planning (2019) current and historic mineral exploration titles.

Potential sources of contamination identified from the assessment are detailed in Section 15.5.6.2.

15.5.6.1 Historical aerial imagery

An assessment of historical aerial imagery from areas of interest (e.g. potentially contaminated sites, infrastructure, environmentally significant areas etc.) was undertaken to explore current potential sources, as well as historical sources of contamination within the study area (refer Table 15.14).

TABLE 15.14 HISTORICAL AERIAL PHOTOGRAPHS

Study area	Details
	Year: 1949 Direction: Aerial Details: Aerial image displays the existing non-operational Boggabilla rail corridor traversing the landscape between North Star and the Macintyre River. It is evident from the aerial image that grazing pastures are the dominant land use in the region. Cleared patches exist east and west of the rail corridor due to land clearing, with eroding soils identifiable through smudge-like patterns on the aerial image to the north. Several private dams also exist near the rail corridor. Source: Queensland Department of Natural Resources and Water (2009).

Study area	Details
	Year: 1956 Direction: Aerial Details: The aerial image shows the study area, from west of Humptybung towards the Macintyre River, during the 1956 Macintyre River floods. Areas of cleared land and potential grazing pastures feature throughout the landscape, as well as several waterways, many ephemerals, crossing the existing non-operational Boggabilla rail corridor. Potential cropping land is present to the northeast, where the new rail corridor is proposed to be established, towards the Macintyre River. A small house and sheds can be identified south of Whalan Creek, beside the rail corridor to the west. No significant change in the landscape of the rail corridor can be observed. Source: Queensland Environment and Resource Management (2010)

Study area	Details
	Year: 1981 Direction: Aerial Details: The aerial image shows the study area, from west of Humptybung towards the Macintyre River. Cropping land features north of Humptybung as well as to the east of the rail corridor. Waterways evident from the 1952 aerial have dried out in places and created large bodies of standing water other areas. No significant change in the landscape of the rail corridor can be observed. Source: Queensland Department of Natural Resources and Mines (2014a)

Study area	Details
	Year: 1989 Direction: Aerial Details: The aerial image shows the study area, from west of Humptybung towards Whalan Creek. A distinct divide between potential cropping land and grazing land is evident in the aerial image. Areas to the west of the rail corridor feature grassed areas/grazing land, while areas to the east of the rail corridor can be identified as cultivated cropping land. Soil erosion is also evident in the northern portion of the image. Several natural dams have also been created on properties alongside the rail corridor for agricultural purposes. No significant change in the landscape of the rail corridor has been observed. Source: Queensland Department of Natural Resources and Mines (2014b)

Study area	Details
	Year: 1997 Direction: Aerial Details: The aerial image shows the study area, from west of Humptybung towards the Macintyre River. Former grazing land to the west of the rail corridor has now become cultivated cropping land. Several houses and sheds have been constructed, as well as small dams emerging within the landscape. No significant change in the landscape of the rail corridor has been observed. Source: Queensland Department of Natural Resources and Mines (2014c)

Study area	Details
	Year: 2003 Direction: Aerial Details: The aerial image shows the study area, from west of Humptybung towards the Macintyre River. Cultivated land/cropping has become the dominant land use in the area. Erosion can also be identified in areas predominantly to the east of the rail corridor. No significant change in the landscape of the rail corridor can be observed. Source: Queensland Department of Natural Resources and Mines (2003)

Study area	Details
	Year: 2018 Direction: Aerial Details: The aerial image shows the study area, from North Star to the Macintyre River. The landscape is dominated by agricultural land. Cultivated cropping land features heavily between North Star and north of Humptybung, while grazing land features towards the western side of the rail corridor, towards Melon Ridge. Small creeks and ephemeral waterways intersect the rail corridor, while private dams feature throughout the landscape. No significant change in the landscape of the rail corridor can be observed. Source: Queensland Government (2018)

15.5.6.2 Potential sources

Based on the land uses within the study area and the findings of a desktop assessment and field investigations, potential sources of contamination within the study area are considered to include:

- Agricultural activities: hydrocarbons (fuel and oil storage and use), pesticides and herbicides, asbestos and lead paint, arsenic (livestock dips or spray races), landfilling
- Housing/sheds: hydrocarbons (fuel and oil storage and use), pesticides and herbicides, lead paint, asbestos
- Landfilling, waste disposal: hazardous materials, hydrocarbons, metals/metalloids, phenols, polychlorinated biphenyls, phthalates, volatiles and pesticides and herbicides
- Existing rail corridor: metals, asbestos, hydrocarbons, pesticides/herbicides
- Roads: metals and hydrocarbons
- Unknown fill material in the rail corridor: asbestos, metals/metalloids, hydrocarbons.

During the geotechnical site investigation, no visual contamination was identified, and no anthropogenic material was observed (Golder Associates, 2019). A targeted contaminated land investigation will be undertaken following completion of detailed design, where the proposal (disturbance footprint) intersects areas of potentially contaminated soils and presents a risk to human health and the environment exist, with management measures required.

Unexploded ordnance

A search of the Department of Defence (2017) online mapping for unexploded ordnance identified no records of related material in the study area. It recommended 'All land usage and development, within these areas, should continue without further UXO investigation or remediation' (DoD, 2017).

State environmental records

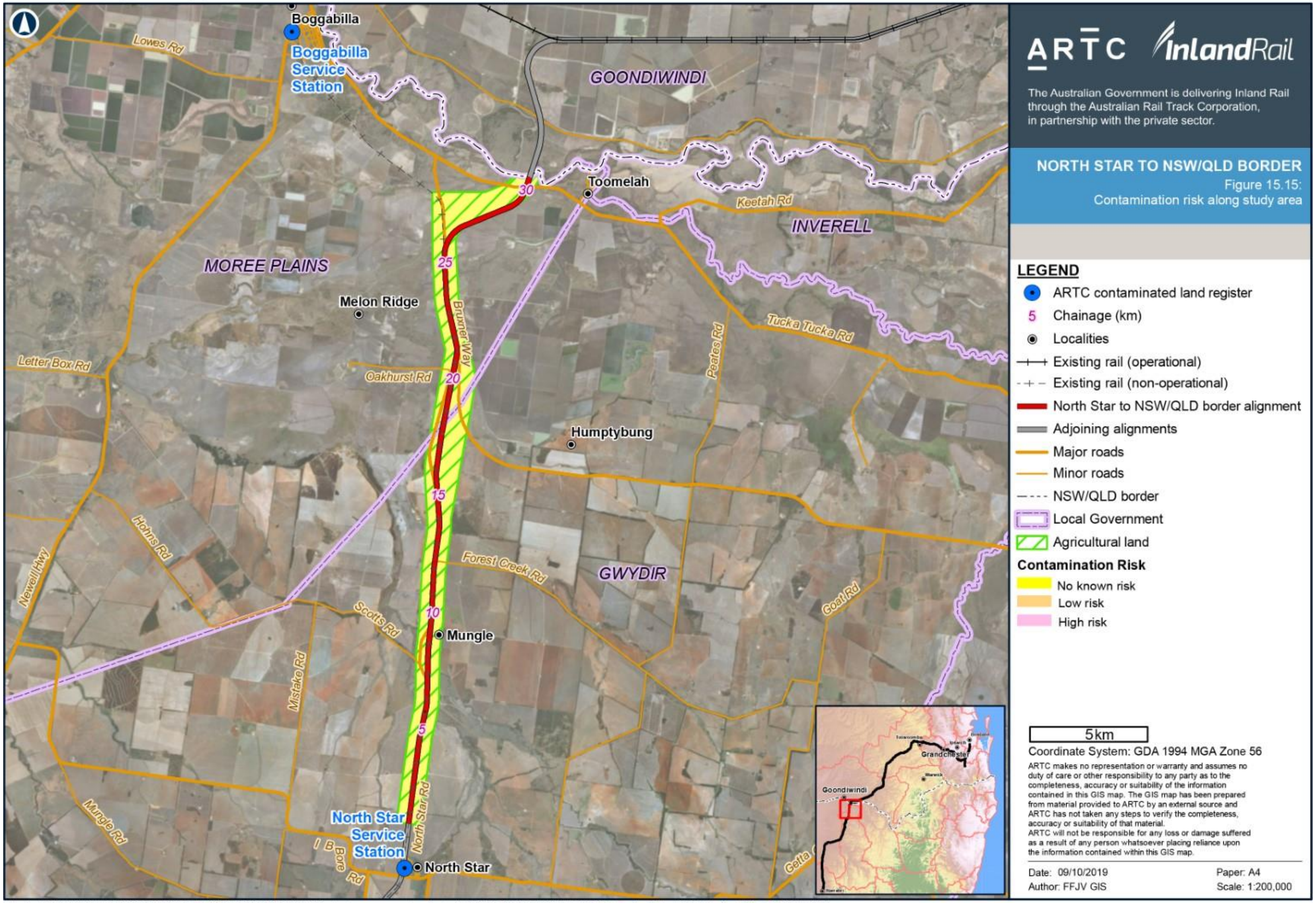
A search of the NSW EPA (2018b) contaminated sites records as well as the Department of Primary Industries (2018) cattle dip site locator for the suburbs within the study area confirmed no recorded sites.

A search of the Department of Planning, Industry and Environment (DPIE) (2019) current and historic mining titles within the study area identified no current or historical mining titles, and two historical exploration permits by Sedimentary Uranium NL, between 1970 and 1971, and Triako Resources Limited between 2006 and 2007.

ARTC contaminated land register

A search of the ARTC Contaminated Land Register identified no potentially contaminated sites within the study area. However two service station sites, a Caltex Service Station and Mobil (Ellonette Lease) Service Station, near the study area were identified (2 km and 9 km respectively from the study area). Figure 15.15 illustrates the two sites identified on the ARTC Contaminated Land Register, as well as providing a contamination risk rating. The 'low' contamination risk rating for the study area was obtained after a qualitative assessment of potential sources of contamination existing within the study area and immediate surrounds, such as roads, railway and agricultural activities. Potential risk of roads, railway and agricultural activities for the study area are detailed in Table 15.15.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: NCW/MEF/GN Z:\GIS\GIS_270_NS2B\Tasks\270-EAP-201909051232_100pc_Land_resources_and_contamination\270-EAP-201909051232_Fig15.15_Contamination_Risks_ARTC_A4L_v2.mxd Date: 22/10/2019 16:02

15.5.6.3 Contamination risk summary

Table 15.15 and Figure 15.15 provide a summary of the areas considered to be potential sources of contamination within the study area. For the potential impacts to present a risk there must be the following:

- A source of contamination
- An exposure pathway for the contamination to reach a sensitive receptor
- Environmental values (receptor) that may be affected by this exposure.

Should one or more of these above components be unavailable (i.e. a source, pathway or receptor), then the risk of exposure to an environmental value is likely to be either minimal or non-existent. Where activities pose potential risks, based on the desktop study, these activities and risks have been advanced through to impact assessment. Should further information be obtained to indicate a potential risk is present for any of the activities, further assessment will be required if mitigation measures presented do not adequately address potential risk.

TABLE 15.15 POTENTIAL EXISTING SOURCES AND IDENTIFIED CONTAMINATION RISKS

Activity	Location	Potential contaminants	Potential risk (based on desktop study)
Within study area			
Agricultural land	North Star to Macintyre River	Hydrocarbons (fuel and oil storage and use)	Unlikely, due to distance from agricultural buildings.
		Pesticides and herbicides	Potential because of proximity to cropping land.
		Asbestos and lead paint	Unlikely, due to distance from agricultural buildings.
		Livestock dips or spray races arsenic, dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyldichloroethane (DDD)	Unlikely—historical aerials did not identify presence of livestock dips or spray races (historic or current).
		Landfilling (agricultural)	Unlikely—historical aerials did not identify presence of landfills (historic or current).
Housing/ sheds	North Star to Macintyre River	Hydrocarbons (fuel and oil storage and use), pesticides and herbicides, lead paint and asbestos	Unlikely to impact study area due to distance from houses/sheds.
Landfilling	North Star to Macintyre River	Hazardous materials, hydrocarbons, metals/metalloids, phenols, polychlorinated biphenyls, phthalates, volatiles and pesticides and herbicides	Unlikely—historical aerials did not identify presence of landfills (historic or current).
Proposal permanent rail corridor	North Star to Macintyre River	Metals, asbestos, hydrocarbons, pesticides/herbicides	Potential.
Roads	Bruxner Way, North Star Road, Tucka Tucka Road, Forest Creek Road	Metals, hydrocarbons, pesticides/herbicides	Potential.
Unknown Fill Material	Existing rail corridor	Asbestos, metals/metalloids, hydrocarbons	Unlikely—anthropogenic materials not observed during geotechnical investigation.
Adjacent study area (ARTC Contaminated Land Registered)			
Caltex Service Station	Edward Street, North Star (2 km south of study area)	Metals and hydrocarbons	Unlikely to impact study area due to distance from service station.

Activity	Location	Potential contaminants	Potential risk (based on desktop study)
Mobil (Ellonette Lease)	Newell Highway, Boggabilla (9 km west/north west of study area)	Metals and hydrocarbons	Unlikely to impact study area due to distance from Mobil.

15.5.7 Borrow pits

Ten borrow pits with the potential to provide general and/or structural fill have been identified with a maximum amount of extracted material during construction estimated to be 1,500,000 m³. Borrow pit location IDs, corresponding soil types and potential qualitative contamination, soil erosion and salinity risk are detailed in Table 15.16.

Further details regarding borrow pits are provided in Chapter 7: Construction of the Proposal.

TABLE 15.16 SOIL CLASSIFICATION AND POTENTIAL QUALITATIVE RISK OF BORROW PITS

			Potential risks (qualitative assessment)		
Borrow pit ID	Soil type	Surrounding land uses	Contamination risk*	Soil erosion risk	Salinity risk
4	Chromosols	Existing borrow pit, cropping pasture	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
5	Vertosols	Existing borrow pit, scattered vegetation, cropping pastures	Low	Low—soil type is rich in clay and has high plasticity. Difficult to cultivate. Known shrink–swell phenomena (cracks when dry and expands when wet). Typically low sodicity	Low—High water-holding capacity. Typically low salinity
7, 7B	Chromosols	Existing borrow pit, scattered vegetation, cropping pastures, house.	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
8	Vertosols	Existing borrow pit, cropping pasture, shed	Low	Low—soil type is rich in clay and has high plasticity. Difficult to cultivate. Known shrink–swell phenomena (cracks when dry and expands when wet). Typically low sodicity	Low—High water-holding capacity. Typically low salinity
9	Chromosols	Existing borrow pit, dense vegetation, cropping pastures	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
11	Chromosols	Existing borrow pit, dense vegetation, suspected residential rubbish disposal, housing	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
13, 14	Vertosols	Existing borrow pit, cropping pastures, scattered vegetation	Low	Low—soil type is rich in clay and has high plasticity. Difficult to cultivate. Known shrink–swell phenomena (cracks when dry and expands when wet). Typically low sodicity	Low—High water-holding capacity. Typically low salinity

			Potential risks (qualitative assessment)		
Borrow pit ID	Soil type	Surrounding land uses	Contamination risk*	Soil erosion risk	Salinity risk
25	Chromosols	Existing borrow pit, cropping pastures, vegetation, house	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
26	Chromosols	Existing borrow pit, vegetation, cropping pastures	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity
2	Chromosols	Existing borrow pit, cropping pastures, scattered vegetation	Low	Medium—soil type known to be susceptible to structural decline	Low—Found in well-drained sites, moderate water-holding capacity

Table notes:
Contamination risk rating:
* Low - No infrastructure at site or immediate surroundings or contamination risks

Source: Agriculture Victoria (2017)

15.6 Potential impacts

Several potential impacts to land resources have been identified, after an assessment of aspects related to the proposal in Section 15.4. A description of the proposal is available in Chapter 6: The Proposal and Chapter 7: Construction of the Proposal.

15.6.1 Permanent change to landform and topography

Landform and topography are valuable for their ability to retain and move water within a soil catchment system. Proposal activities have the potential to permanently change the landform and topography of each catchment the proposal traverses, through increased erosion and landslip associated with specific landscapes. Proposal activities may also alter localised contours within the landscape.

Changes to landform and topography may cause secondary impacts to surface water, such as changes to flow patterns and infiltration. Groundwater and flow direction can also be impacted, particularly in flood plain areas where railway infrastructure can significantly impede floodwaters and potentially redirect waters to sensitive receptors.

Impacts to surface water are detailed in Chapter 13: Surface Water and Hydrology, while impacts to groundwater are detailed in Chapter 14: Groundwater.

As a result, the design, construction, operation and decommissioning of a major rail route within various catchments will require careful planning to minimise impacts to the landform and topography.

15.6.2 Loss of soil resources

Designating land classified as biophysical strategic agricultural land to infrastructure will result in the loss of natural soil resources and affect farming activities. Poor land management practice decisions can also cause loss of ground cover, leading to erosion from wind or water and increased dust levels and declining regional soil fertility over time.

Proposal activities that aren't managed properly can also lead to dust, compaction, contamination via foreign material, nutrient loss, soil leaching, secondary salinisation of good quality soil and soil inversion. Additionally, mixing subsoils and surface soils can potentially impact on natural soil processes and productivity and introduce contaminants into soil horizons.

Within the study area, limited biophysical strategic agricultural land exist within the footprint (refer Chapter 22: Land Use and Property). As a result, the impact to soil resources is also expected to be limited. Furthermore, the proposal has undertaken to minimise loss of soil resources through minimisation of impact to fertile soils where possible.

15.6.3 Acid sulfate soils

An assessment of ASS and acid rock undertaken during the desktop study and field investigations concluded a low probability of encountering ASS and acid rock.

Proposal activities may, however, encounter unexpected ASS during construction. Soil disturbance may expose potentially unknown ASS to oxygen, creating damaging level of sulfuric acid with the potential to corrode infrastructure built from concrete, steel as well as other material.

Potential ASS are also located, under general conditions, below the water table. ASS also have the potential to degrade or destroy ecosystems. This is because under acidic conditions, metals such as iron and aluminium, along with trace heavy metals including arsenic, become increasingly mobile and allow infiltration into soil (Hicks et al., 1999).

Unexpected encounters of acid rock have the potential to cause acid rock drainage when sulfide minerals are exposed to air and water. This process is accelerated through excavation activities, which increase rock exposure to air, water, and microorganisms. The resulting drainage may be neutral to acidic with dissolved heavy metals and significant sulfate levels.

15.6.4 Degradation of soil resources through invasive flora and fauna

During the construction, operation and decommissioning phases of the proposal, introduction of weed-seed material through human actions may present a potential risk to land resources, through soil degradation. Weed species have the potential to adversely impact soil, influencing critical factors such as soil stability and fertility. Weeds are known to increase the rate of erosion in soil through inadequate soil protection, alter the soil's physical structure, and change soil nutrient status (Weidenhamer & Callaway, 2010).

The proposal may also encounter potential impacts from feral animals burrowing or tunnelling in soil, causing soil degradation. Erosion of the soil, as well as adverse impacts to groundwater flow and/or infiltration of rainfall may result from invasive fauna activity. Introduced invasive fauna species were identified within the subject land, including the:

- Feral cat (*Felis catus*)
- Pig (*Sus scrofa*)
- European rabbit (*Oryctolagus cuniculus*)
- European fox (*Vulpes vulpes*)
- European hare (*Lepus europaeus*)
- Dog (*Canis lupus*)
- Camel (*Camelus dromedarius*)
- Rock dove (*Columbia livia*)
- Common myna (*Sturnus tristis*)
- Common starling (*Sturnus vulgaris*).

Further detail is provided in Chapter 11: Biodiversity.

15.6.5 Salinity hazard

Proposal activities have the potential to cause secondary salinisation, which is salting caused by human activities, through processes such as the removal of vegetation, altering waterways and general land use changes. Secondary salinisation can cause water-table salting, irrigation water salting and erosion scalding (Department of Environment and Resource Management, 2011).

Geological features and past patterns of weathering result in some landforms having more potential to express salinity. This occurs because of restrictions to groundwater flow that may cause the water table to rise to near the soil surface, resulting in a discharge area with evaporative salts. Further details on potential landforms identified within the proposal study area with a risk for salinity formation are in Table 15.17.

TABLE 15.17 LANDFORMS WITH SALINITY FORMATION RISK IDENTIFIED DURING DESKTOP SALINITY HAZARD ASSESSMENT

Feature	Information contributing to salinity investigations	Potential impact	Rating
▸ Landform feature identification ▸ Geology ▸ Waters	Potential expression area: Basalt over sandstone interface	Potential to have a more permeable basalt layer contacting with a less permeable sandstone geology underneath. This landform type can cause a restriction to downward water movement with seepages occurring at the interface area.	Low
	Potential expression area: Confluence of streams	Potential for the junction of a minor steam with a major stream to have a reduction in flow velocity and resultant deposition of suspended particles and salts.	Low
	Potential expression area: Catena form	Potential to have a change in hydraulic gradient similar to a barrier in water movement. Salting arising from infiltration of water into the soil and lateral movement through the weathered parent horizon or through more permeable soil.	Moderate
▸ Soil properties	Potential expression area: Soil salt store	Potential for soluble salts to be sitting within the soil profile.	Low
	Potential expression area: Artificial restriction(roads)	Potential to have a reduction in water transmission, enough to cause salting upslope of the road.	High
▸ Known salinity expressions	Known salinity expressions	Active or stable sites along the alignment.	Low
▸ Overall salinity hazard	Total PEAs	Potential for various methods of salt build up and transportation.	Moderate to High

Through the construction phase of the corridor, the focus must be on avoidance of known salinity expressions, particularly where there are geological interfaces of basalt sitting over sandstone or where there are shallow groundwaters.

In operation, salinity will occur in two ways:

- Ponding of water behind the railway culvert, which can increase the recharge of local groundwater that can be managed properly through surface drainage engineered solutions
- In areas of shallow groundwater, railways can increase the pressure of the local groundwater leading to rising water table.

Salinity also presents a risk to infrastructure in saline areas through corrosion (Searle et al., 2007). Several naturally occurring, as well as man-made assets, within the study area, or adjacent, could potentially be affected by salinity including forested areas, pastures, farm dams, roads, railways and buildings.

Identified landforms (refer Table 15.17) pertaining a moderate to high risk of salinity formation were considered at risk from proposal activities. The residual risk of proposal activities to salinity hazard is presented in Section 15.8.

15.6.6 Disturbance of existing contaminated land

Proposed activities have the potential to disturb existing contaminated land resources during each of the phases of proposal development: construction, operation and decommissioning. The disturbance of contaminated soil or groundwater during proposal activities have the potential to contaminate previously unaffected soil or groundwater and affect human health through ingestion as well as dermal contact with contaminants.

On a review of existing contaminated land in Section 15.5.6 and identifying potential sources of contamination within the study area as well as their relative risk in Section 15.5.6.3, Table 15.18 links the identified potential sources, pathways and receptors derived from existing contaminated land, which may be further exacerbated through proposal activities.

TABLE 15.18 POTENTIAL EXISTING CONTAMINATED LAND SOURCE, PATHWAY AND RECEPTOR LINKAGES

Potential source	Contaminants	Potential pathway	Potential receptor/s
Existing potential contamination			
Agricultural land	Pesticides and herbicides	Direct contact Dispersion of soil and dust from wind and water Surface water runoff	Human health: - Ingestion, inhalation, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users. Ecological: - Terrestrial—direct contact and consumption (including bioaccumulation) - Aquatic ecosystems—direct contact and consumption (including bioaccumulation).
Proposal permanent rail corridor	Metals, asbestos, hydrocarbons, pesticides/ herbicides	Direct contact Dispersion of soil and dust from wind and water Surface water runoff	Human health: - Ingestion, inhalation, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users. Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption (including bioaccumulation).
Roads	Metals, hydrocarbons, pesticides/ herbicides	Direct contact Dispersion of soil and dust from wind and water Surface water runoff	Human health: - Ingestion, inhalation, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users. Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption (including bioaccumulation).

Many of the potential sources identified in Table 15.18 are not located in and/or do not impede on the disturbance footprint. As a result they are unlikely to be a potential source of contamination during proposal activities. The residual risk of proposal activities to existing contaminated land is presented in Section 15.8.

15.6.7 Creation of contaminated land

The following proposal activities during the construction and operational phases of the proposal have the potential to contaminate land resources through:

- Transport or movement of existing contaminated soil/groundwater leading to migration of contaminants to previously uncontaminated soil/groundwater and affecting human health through contact with contaminants
- Leaks or spills leading to migration of contaminants through surface water/soil/groundwater or exposure to human health risks through ingestion/dermal contact to contaminants from:
  - Permanent/mobile fuel/chemical storage
  - Waste storage areas/facilities (including storage tanks, sewage).

Table 15.19 provides further information on identified potential sources, pathways and receptor linkages resulting from proposal activities during the construction and operational phases of the proposal. Figure 15.16 outlines a strategy to identify, document and manage contaminated sites encountered during proposal activities.

TABLE 15.19 POTENTIAL CREATION OF CONTAMINATED LAND SOURCE, PATHWAY AND RECEPTOR LINKAGES

Potential source	Contaminants	Potential pathway	Potential receptor/s
Construction			
Hydrocarbon leaks and/or spills	Hydrocarbons	- Direct contact	Human health: - Ingestion, inhalation, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users. Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption.
		- Overland flow/runoff to surface water bodies - Migration to groundwater	Human health: - Ingestion, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts). Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption.
Leaks and or spills from waste storage areas/facilities (including storage tanks, sewage)	Biological waste (sewage), other wastes	- Direct contact	Human health: - Ingestion, inhalation, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users. Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption.
		- Overland flow/runoff to surface water bodies - Migration to groundwater	Human health: - Ingestion, dermal contact - Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts). Ecological: - Terrestrial—direct contact and consumption - Aquatic ecosystems—direct contact and consumption.

Potential source	Contaminants	Potential pathway	Potential receptor/s
Operation			
Hydrocarbon leaks and/or spills	Metals and hydrocarbons	▸ Direct contact	Human health: ▸ Ingestion, inhalation, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users. Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption.
		▸ Overland flow/runoff to surface water bodies ▸ Migration to groundwater	Human health: ▸ Ingestion, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts). Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption.

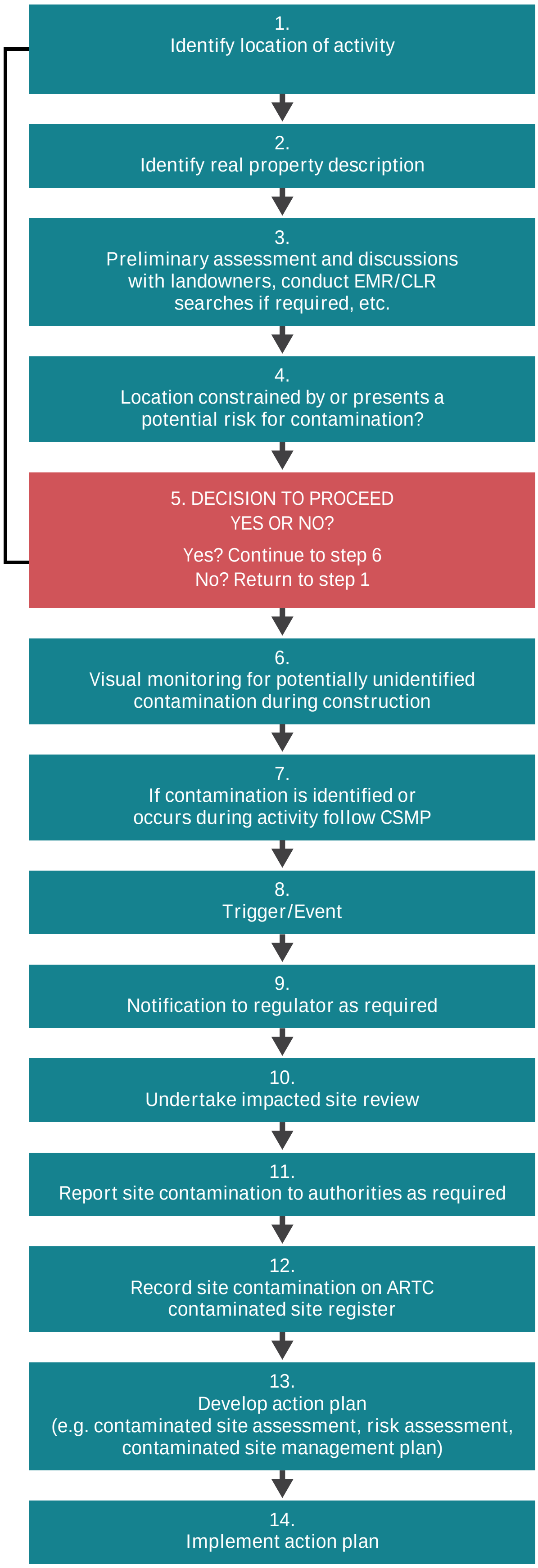


FIGURE 15.16 CONTAMINATED SITE MANAGEMENT PLAN (CSMP) STRATEGY

On conclusion of the desktop assessment, most soil existing in the rail corridor may be suitable for re-use without treatment. However, some materials may require treatment or management prior to re-use and will be subject to assessment by a suitably qualified person. It will also be subject to sampling and laboratory analysis, where it will be screened against applicable health and ecological guidance values/screening criteria.

Chapter 24: Hazard and Risk further details contamination that may arise as a result of proposal activities and provides an assessment of impacts as well as mitigation measures.

15.7 Mitigation measures

This section outlines both the land resources and contamination mitigation measures included as part of the proposal design, and the mitigation measures that are planned to manage predicted environmental impacts. The impacts are initially assessed with consideration of the design mitigation measures and then reassessed to determine residual risk after the inclusion of the proposed mitigation measures.

15.7.1 Design considerations

The mitigation measures and controls presented in Table 15.20 have been factored into the design of the proposal. These design considerations are proposed to minimise the environmental impacts of the proposal and help to lower the initial risk rating for each potential impact.

TABLE 15.20 INITIAL MITIGATIONS OF RELEVANCE TO LAND RESOURCES AND CONTAMINATION

Aspect	Initial mitigations
Land resources and contamination	▸ The proposal follows the existing non-operational Boggabilla rail corridor for approximately 25 km. The design has been developed to use the existing rail corridor protection and minimise impacts to land resources and contamination to the greatest extent possible. ▸ The rail corridor is generally 40 m wide and designed to minimise disturbance to existing land resources and contamination. ▸ Cut-and-fill balance and minimisation of transport requirements for import/disposal of spoil has been considered.

15.7.2 Mitigation measures

In order to manage risks during construction, a number of mitigation measures have been proposed for implementation in future phases of delivery, as presented in Table 15.21. These suggested mitigation measures have been identified to address proposal-specific issues and opportunities and address legislative requirements, accepted government plans, policy and practice.

Table 15.21 identifies the relevant proposal phase, the aspect to be managed, and the proposed mitigation measure, which is then factored into the assessment of residual risk in Table 15.22.

Chapter 27: Environmental Management Plan provides further context and the framework for implementation of these proposed mitigation measures.

TABLE 15.21 LAND RESOURCES AND CONTAMINATION MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measures

Detailed design	Erosion and sediment control	▸ Proposal clearing extents are limited to that required to construct and operate the works and clearing is scheduled to minimise the exposure time of unprotected earth.
		▸ An Erosion and Sediment Control Plan will be created. The Erosion and Sediment Control Plan will include temporary and permanent measures implemented across phases of the proposal that are appropriate to the site conditions, contain an erosion risk assessment, relevant environmental receptors, climatic zone and seasonal factors. It will also establish and specify the monitoring and performance objectives for handover on completion of construction. Furthermore, the plan will detail the following procedures and protocols relevant to potential impacts of land resources and contamination:
		  ▸ Soil/land conservation objectives for the proposal
		  ▸ Temporary/permanent erosion and sediment control measures
		  ▸ Workplace health and safety requirements relating to management of contamination and unexploded ordnance risk
		  ▸ Management of problem soils (e.g. ASS, erosive, dispersive, reactive, acidic, sodic, alkaline soils)
		  ▸ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material
		  ▸ Vehicle, machinery and imported fill hygiene protocols and documentation.

	Materials handling and storage	▸ A hazardous substances and dangerous goods risk management strategy will be developed to manage the potential for risks.

	Rehabilitation	▸ Prepare a Rehabilitation and Reinstatement Plan to guide the approach to rehabilitation following the completion of construction. The plan should include and clearly specify:
		  ▸ Location of areas subject to rehabilitation and/or reinstatement/stabilisation
		  ▸ Details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas, consistent with the agreed objectives.

	Land and soil	▸ Minimise risks through appropriate geotechnical design where reactive or problem soils are present or suspected. ▸ Cut-and-fill balance and minimisation of transport requirements for import/disposal of spoil are considered as part of the design process. ▸ Soil conditions across the study area are appropriately characterised at a suitable scale in accordance with the Environmental Management Plan prior to construction to inform design and environmental management measures. This includes identification of potential/actual ASS, reactive soils, erosive soils, dispersive soils, saline soils, acidic soils, alkaline soils and contaminated soils. ▸ A contaminated land investigation of the NS2B rail corridor will be undertaken by a suitably qualified person in accordance with requirements of NEPM (NEPC, 2013) and the methodology captured within the CEMP.

Delivery phase	Aspect	Proposed mitigation measures
Pre-construction/ Construction	Materials handling and storage, hazardous waste	A CEMP will be developed as part of the proposal. The CEMP will detail the following procedures and protocols relevant to potential impacts of land resources and contamination: ▸ A response plan to deal with accidental spills and leaks. The supervisor or person in charge of the work activity must be notified immediately. The matter will be recorded on the reportable environmental incident checklist or the emergency management procedure. ▸ All bunding, hydrocarbon and chemical storage areas are routinely checked, and their integrity and functionality maintained in a good condition, so they continue to function in an effective manner. ▸ Operator must ensure appropriate controls are in place to prevent environmental Incidents including leaks/spills from refuelling activities and locomotive operations and to protect the environment if incidents occur. ▸ Spill kits will be available at all work fronts and laydown areas in the event of a spill or leak. ▸ Chemical and dangerous goods storage areas will be stored and located in accordance with relevant Australian Standards. ▸ Identification of contaminated, hazardous or potentially contaminated material onsite (i.e. soil, ballast) will be subject to a risk assessment. ▸ Appropriate register and records of chemicals, hydrocarbons and hazardous substances and materials on-site will be maintained up-to-date as required by the CEMP. Where appropriate, this should include a relevant risk assessment prior to the substance coming to, and being used onsite, plus a Safety Data Sheet Register. ▸ Operators must not transport hazardous substances or dangerous goods if they know, or ought reasonably to know, that a special provision applies to the transport of the goods and the transport of the goods does not comply with the special provision. Operators must notify their employee of the storage, handling or transport of hazardous substances or dangerous goods. ▸ Refuelling to occur 50 m from a defined watercourse, overland flow path or other sensitive environment receivers where practical.
	Contamination	▸ Personnel involved in ground-disturbing works must be familiar with the unexpected finds protocol/procedure and are trained in the identification of potential contaminated soil/material and relevant controls. ▸ The re-use or retention of contaminated or potentially contaminated material onsite (i.e. soil, ballast) will be subject to a risk assessment and/or occur as per the relevant components of the CEMP.
	Erosion and sediment control, rehabilitation	▸ Appropriate erosion and sediment control measures are to be implemented for each phase or elements of the construction works, in accordance with the Construction Erosion and Sediment Control Plan. ▸ Reinstatement, stabilisation and rehabilitation of temporarily disturbed areas (such as laydown, site offices and temporary access tracks) will be undertaken progressively, consistent with a Reinstatement and Rehabilitation Plan.
	Hazardous waste	A contaminated and hazardous material survey will be undertaken prior to demolition of structures. If asbestos or other hazardous materials are identified, removal will be undertaken in accordance with relevant state guidelines and the CEMP.
	Unexploded ordnance	Identification of unexploded ordnance will be subject to a risk assessment. Where a risk of encountering known or possible unexploded ordnance is identified, assessment and identification of management options will be carried out by a suitably qualified person.
Operation	Land and soil Contamination	Ongoing management and maintenance of the corridor to be accordance with existing environmental management system and corridor management procedures.

15.8 Impact assessment

Potential impacts to land resources and contamination associated with the proposal in the construction, operation and decommissioning phases are outlined in Table 15.22. These impacts have been subjected to a risk assessment as per the methodology detailed in Chapter 10: Assessment Methodology.

The initial risk assessment is undertaken on the assumption that the design considerations (or initial mitigations) have been incorporated into the proposal design (refer Table 15.20).

Proposed mitigation measures, including those listed in relevant subplans, were then applied as appropriate to the phase of the proposal to reduce the level of potential impact.

The residual risk level of the potential impacts was then reassessed. The initial risk levels were compared to the residual risk levels in order to assess the effectiveness of the mitigation measures.

TABLE 15.22 IMPACT ASSESSMENT FOR POTENTIAL IMPACTS ASSOCIATED WITH LAND RESOURCES

			Initial risk[1]			Residual risk[2]		
Aspect	Potential Impact	Phase	Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Land and soil	Change to landform and topography: ▸ Erosion ▸ Loss of natural contours ▸ Landslip	Construction	Likely	Moderate	High	Likely	Minor	Medium
		Operation	Possible	Minor	Low	Possible	Minor	Low
Erosion and sediment control, land and soil	Loss of soil resources: ▸ Loss of biophysical strategic agricultural land within proposal footprint ▸ Decline in soil fertility ▸ Loss of groundcover ▸ Soil inversion	Construction	Likely	Minor	Medium	Possible	Minor	Low
		Operation	Possible	Minor	Low	Possible	Minor	Low
Land and soil	Disturbance of: ▸ Existing ASS ▸ Potential ASS ▸ Acid rock	Construction	Unlikely	Moderate	Low	Unlikely	Minor	Low
		Operation	Unlikely	Moderate	Low	Unlikely	Minor	Low
Erosion and sediment control	Disturbance of soil resources through invasive flora and fauna: ▸ Invasion ▸ Re-use of soil ▸ Erosion ▸ Disturb native species ▸ Alter soil properties or groundwater flow ▸ Infiltration	Construction	Likely	Minor	Medium	Likely	Not significant	Low
		Operation	Likely	Minor	Medium	Likely	Not significant	Low
Land and soil	Salinity hazard ▸ Catena form ▸ Artificial restrictions (roads)	Construction	Possible	Moderate	Medium	Possible	Minor	Low
		Operation	Possible	Minor	Low	Possible	Minor	Low

Aspect	Potential Impact	Phase	Initial risk[1]			Residual risk[2]		
			Likelihood	Consequence	Risk	Likelihood	Consequence	Risk
Contamination, land and soil	Disturbance of existing contaminated land: ▸ EMR listed properties ▸ Agricultural land ▸ Existing rail ▸ Roads	Construction	Possible	Minor	Low	Unlikely	Minor	Low
		Operation	Possible	Minor	Low	Unlikely	Minor	Low
Material handling and storage	Creation of contaminated land: ▸ Leaks or spills ▸ Permanent and mobile fuel and chemical storage ▸ Waste storage areas and facilities ▸ proposal infrastructure	Construction	Possible	Moderate	Medium	Possible	Minor	Low
		Operation	Possible	Minor	Low	Possible	Minor	Low

Table notes:

1. Includes implementation of initial mitigations specified in Table 15.20.
2. Assessment of residual risk once the land mitigations and controls identified in Table 15.21 have been applied.

15.9 Cumulative impact assessment

The cumulative impacts of multiple projects in the vicinity of the study area may contribute to impacts to water quality if not managed appropriately. Based on the assessment of the land resources in the study area, the risk of the proposal is relatively low. However, the major potential impacts identified as a result of the study area are common to all projects throughout the region and are therefore cumulative.

Several projects have been identified within the cumulative impact study area and are highlighted in Table 15.23. Each of these projects are either currently underway or are going through the EIS process.

Land resources presents an overview of the environmental values associated with geology, topography and soils of the proposal site. The proposal site is characterised by gently undulating topography. The underlying surficial geology of the proposal site primarily consists of Quaternary sand and Quaternary alluvium units, while the bedrock geology is composed of sandstone, siltstone, mudstone and conglomerate. Several soil types occur in the proposal site with vertosols being the dominant soil type along the proposal site and these, exhibit strong agricultural capability that appeal to irrigated cultivation of various crops. Based on the land uses that are known to occur within the proposal site, a search of the NSW EPA (2018) contaminated site records as well as the Department of Primary Industries (2018) cattle dip site-locator for the suburbs where the proposal site is located confirmed no recorded sites.

The potential for loss of soil resources particularly through erosion associated with the proposal was identified as a potential impact and is considered as a risk during construction and decommissioning works. Implementing standard erosions and sedimentation control measures and any additional environmental management plans for the proposal is expected to be able to mitigate this. The risk of the proposal generating land contamination through leaks and spills is considered low, because measures to avoid and minimise leaks and spills will be part of environmental management plan. These potential impacts were assessed, and the proposal would be unlikely to generate impacts at scale that would interact with other projects.

TABLE 15.23 PROJECTS INCLUDING IN THE CUMULATIVE IMPACT ASSESSMENT

Project and proponent	Location	Description	EIS status	Construction dates	Construction jobs	Operation years	Operation jobs	Selection criteria	Relationship to the proposal
Border to Gowrie—Inland Rail (ARTC)	NSW/QLD Border to Gowrie	Approximately 146 km of new dual gauge track and 78 km of upgraded track from the NSW/QLD border, near Yelarbon, to Gowrie Junction, north west of Toowoomba in Queensland	Project referred to Commonwealth Minister for the Environment and Energy	2021 to 2025	1,600	–	TBA	b)	Potential overlap on construction commencement for Border to Gowrie and finalisation of North Star to Border
Narrabri to North Star—Inland Rail (ARTC)	Narrabri (NSW) to the village of North Star in NSW	An upgrade to approximately 188 km of track within the existing rail corridor and construction of approximately 1.6 km of new rail corridor	Proponent reviewing submissions	Mid-2018 to 2020	TBA	–	TBA	b)	Potential overlap of finalisation of Narrabri to North Star and commencement of North Star to Border construction
Moree Solar Farm	10 km south of Moree, off the Newell Highway in Northern NSW	Construction of a 56 MWac/70.1 MWdc single axis tracking solar PV facility. Construction works currently involve the installation of the framing system which consists of the BladePiles and the NexTracker tracking systems, the JA Solar photovoltaic modules, the DC and AC wiring of the electrical equipment, the 22/66kV on-site substation and the 66kV transmission line	Approved by the NSW Major Projects Office on 17 July 2011	2018 to 2022	1,050	–	10 - 12	c)	Potential increase of traffic on the Newell Highway. Construction of Moree Solar Farm is scheduled around the peak visitation to Moree in autumn

Project and proponent	Location	Description	EIS status	Construction dates	Construction jobs	Operation years	Operation jobs	Selection criteria	Relationship to the proposal
Newell Highway Moree Town Centre Bypass	Moree	Construction of a 4.4 km two-lane bypass of the Moree town centre	Approved by the NSW Major Projects Office on 20 July 2004. Latest modification 8 approved 7 July 2010	–	–	–	–	c)	Potential increase of traffic on the Newell Highway
Bindaree Beef Abattoir—Rendering Plant and Bio-digester Plant	Bindaree Beef Abattoir, Inverell	The proposed project involves the installation of a wastewater treatment system (bio-digester) and new render plant facility to reduce odour and carbon emissions at its existing abattoir site. The bio-digester generates a bio-gas from waste and wastewater that would then be re-used at the site	Approved by the NSW Major Projects Office on 10 December 2014	12 months construction Start date unknown	60	–	–	c)	Potential conflict or demand for construction resources if projects overlap. Increase of traffic volumes on the Gwydir and Newell Highway
Queensland—Hunter Gas Pipeline	Wallumbilla to Newcastle	420 km gas pipeline from the Narrabri Gas Project to Newcastle via Gunnedah, Quirindi, Scone, Muswellbrook, Singleton and Maitland	Project determined under Part 3A—now transitioned to SSI	From approval, approximately eight months of construction	600	–	150	c)	If construction occurs at the same time, there is potential for increase in traffic using similar routes and demand for construction resources and personnel
White Rock Solar Farm	20 kilometres southwest of Glen Innes, 40 km east of Inverell NSW	Establishment of a 20 MW solar farm and associated infrastructure	Approved by the NSW Major Projects Office 14 June 2016	Construction forecast to take six months.	50	25	TBA	c)	Potential increase in road traffic on the Gwydir Highway and the Newell Highway

Project and proponent	Location	Description	EIS status	Construction dates	Construction jobs	Operation years	Operation jobs	Selection criteria	Relationship to the proposal
White Rock Wind Farm	20 kilometres southwest of Glen Innes, 40 km east of Inverell NSW	Stage 2 of White Rock Wind Farm upgrades will consist of up to 48 turbines, producing up to 202 MW of clean renewable electricity	Approved by Major Projects Office on 10 July 2012	Late 2018	100	30	20	c)	Potential increase in road traffic on the Gwydir Highway and the Newell Highway
Sundown Solar Farm	South of Gwydir Hwy, 30 km east of Inverell (NSW)	The project consists of a large-scale solar photovoltaic generation facility, including battery storage and associated infrastructure, with an estimated maximum capacity of up to 600 MW, enough to power over 250,000 homes	SEARs issued by Major Projects Office	2019 to 2023	–	–	–	c)	Potential increase in road traffic on the Gwydir Highway and the Newell Highway
Bonshaw Solar Farm	Bruxner Highway, 16 km south of Bonshaw and 66 km north of Inverell (NSW)	GAIA Australia is proposing to develop a large scale solar photovoltaic generation facility and associated infrastructure with a capacity of 500 MW	SEARs issued by Major Projects Office	Mid 2019 to 2021	–	25	–	c)	Potential increase of traffic on the Bruxner Highway. North Star to Border alignment crossed the Bruxner Highway. Deconfliction at construction times may be required
Sapphire Solar Farm	Project in the Kings Plains, Wellingrove and Sapphire areas, approximately 28 km east of Inverell and 18 km west of Glen Innes	A c 200 MW hybrid solar and battery power facility	Approved by the NSW Major Projects Office on 16 August 2018	2019 to 2020	200	25	150	c)	Potential increase of traffic on the Gwydir and Newell Highway

Project and proponent	Location	Description	EIS status	Construction dates	Construction jobs	Operation years	Operation jobs	Selection criteria	Relationship to the proposal
Sapphire Wind Farm	Project in the Kings Plains, Wellingrove and Sapphire areas, approximately 28 km east of Inverell and 18 km west of Glen Innes	Construction of a 238 to 425 MW capacity wind farm (between 125 and 159 turbines)	Approved by the NSW Major Projects Office on 26 June 2013	TBA	–	–	–	c)	Potential increase of traffic on the Gwydir and Newell Highway

The combined potential of these projects may further increase the land that is potentially affected by cumulative impacts. The projects across the region may have different land use and tenure impacts to the Project but may include:

- Soil conditions not appropriately characterised
- Disturbance of existing contaminated land
- Leaks or spills leading to migration of contaminants
- Change to landform and topography
- Salinity and sodicity development
- Increase to erosion leading to increased total dissolved solids in run off
- Increase to weed migration.

Further information on the assessment of cumulative impacts is provided in Chapter 26: Cumulative Impacts.

TABLE 15.24 CUMULATIVE IMPACT ASSESSMENT NORTH STAR TO BORDER

Cumulative impact	Aspect	Relevant factor	Sum of Relevant Factors	Impact significance	Comments
Soil conditions in the proposed area are not appropriately characterised to inform what the railway corridor will impact, how it will be impacted and when it will be impacted. This includes the identification of reactive soils, erosive soils, dispersive soils, saline and sodic soils, contaminated land	Probability of the impact	2	6	Low	Will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	2			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			
Leaks or spills leading to migration of contaminants through surface water/soil/groundwater or increased human health risk through ingestion/dermal contact to contaminants from: a) Permanent/mobile fuel/chemical storage b) Waste storage areas/facilities c) Proposal infrastructure	Probability of the impact	1	4	Low	Will be managed by a Contaminated Land Management Plan. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	1			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			
Loss of soil resources	Probability of the impact	2	7	Medium	Mitigation measures likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required, where appropriate managed under the CEMP and EMP following construction
	Duration of the impact	2			
	Magnitude/intensity of the impact	2			
	Sensitivity of the receiving environment	1			
Acid sulfate soils, including the potential to disturb ASS	Probability of the impact	1	4	Low	ASS has not been identified within the Project study area. Any potential impacts will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	1			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			

Cumulative impact	Aspect	Relevant factor	Sum of Relevant Factors	Impact significance	Comments
Change to landform and topography	Probability of the impact	2	7	Moderate	Mitigation measures are likely to be needed and will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be park of the general project monitoring
	Duration of the impact	3			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			
Salinity and sodicity development	Probability of the impact	2	6	Low	Will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	2			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			
Erosion	Probability of the impact	2	7	Moderate	Will be managed by an Erosion and Sediment Control Plan. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	2			
	Magnitude/intensity of the impact	2			
	Sensitivity of the receiving environment	1			
Weed management	Probability of the impact	2	7	Moderate	Will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	2			
	Magnitude/intensity of the impact	2			
	Sensitivity of the receiving environment	1			
Feral animal management	Probability of the impact	1	4	Low	Will be managed by a CEMP and EMP. Specific approval conditions are unlikely to be necessary. Monitoring to be part of the general project monitoring
	Duration of the impact	1			
	Magnitude/intensity of the impact	1			
	Sensitivity of the receiving environment	1			

15.10 Conclusions

This chapter has been prepared to evaluate potential impacts of the proposal on land resources and contamination, while meeting the requirements of the SEARs. The chapter has identified existing conditions of the study area in accordance with industry standard methodology and relevant legislation. Through an assessment of existing conditions, proposal impacts with the potential to adversely impact land resources were identified. Various proposal activities at different stages of the proposal can impact land resources via:

- Permanently changing landform and/or topography
- Causing the loss of soil resources on farming and other economically valuable land
- Exposing potential ASS and acid rock to oxygen during excavation and earthworks
- Degrading soil resources through an introduction of invasive flora and fauna altering physical and chemical properties of soil
- Exacerbating existing soil salinity and sodicity or creating new impacts
- Disturbing existing contaminated land
- Contributing to creation of contaminated land.

Most potential impacts to land resources and contamination through proposal activities were found to have low residual risk on implementation of initial mitigation measures. Additional mitigation measures implemented during the detailed design to decommissioning phases also support the low residual risk ranking. Change to landform and topography during the construction phase of the proposal was the only residual medium risk.

The mitigation measures detailed in Section 15.7 are intended to sufficiently manage all identified potential impacts from the proposal.