APPENDIX D

SURFACE WATER ASSESSMENT

Narrabri to Turrawan Line Upgrade Project

Surface Water Assessment

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1.0 INTRODUCTION

1.1. Background and scope

The Australian Rail Track Corporation Limited (ARTC) is an Australian Government owned statutory corporation that maintains approximately 8,500 kilometres (km) of rail track across five states. In New South Wales (NSW), ARTC is responsible for the Interstate Network (which includes the Sydney Metropolitan Freight Network), Hunter Valley coal rail network, and delivery of the portion of Inland Rail which traverses the state.

ARTC propose to upgrade approximately 35 km of track between Turrawan and Narrabri, which is currently capable of accommodating sub 25 tonne axle load (TAL) and exhibits capability limitations resulting from the presence of steel and timber sleepers, aging rail for most of the line and poor track geometry.

The 'proposal' known as the Narrabri to Turrawan Line Upgrade (N2TLU), will enhance the quality and capability of the 35 km connection between the Hunter Valley Coal Network south of Turrawan and Inland Rail at Narrabri North to provide a consistent service offering between northern NSW, Inland Rail and the port of Newcastle.

The proposal will deliver a corridor capable of an enhanced weight rating of 25 TAL at 80 kilometres per hour (km/h), thereby allowing longer and heavier freight trains travelling from northern NSW to access international ports in Newcastle and Sydney.

Southeast Engineering and Environmental were engaged by Element Environment to undertake a surface water assessment to support the Review of Environmental Factors (REF) for the proposal.

1.2. Proposed works

The proposal comprises upgrades to track on the Main North Line between the Whitehaven Coal Junction at the approximate chainage of 540.3 km and Narrabri North at approximate chainage 575 km (Figure 1.1). The proposal is in the Narrabri local government area (LGA). Works will include:

- replacement of existing steel and timber sleepers with heavy duty concrete sleepers;
- replacement of the existing 47 kilograms per metre (kg/m) or 53 kg/m rail with 60 kg/m rail for 8.1 km between the Whitehaven Coal Balloon Loop Junction (540.38 km) and the northern end of Turrawan passing loop (548.490 km).
- replacement of the existing 47-53 kg/m rail with 60 kg/m rail for 26.7 km in length between 52 points at the northern end of Turrawan passing loop (548.490 km) and the future Inland Rail interface at Narrabri North (575.00 km).
- lifting of the track in some sections by approximately 50-200 millimetres (mm) to accommodate approximately 100 mm of new ballast below the new concrete sleepers;
- sleeper and rail replacement at the Turrawan crossing loop, using recovered steel sleepers and recovered 53 kg rail;
- track formation works at bridge ends (where required); and

- partial level crossing upgrades (including new concrete sleepers, steel crossing panels and partial track lift or lifting of level crossing, where feasible)

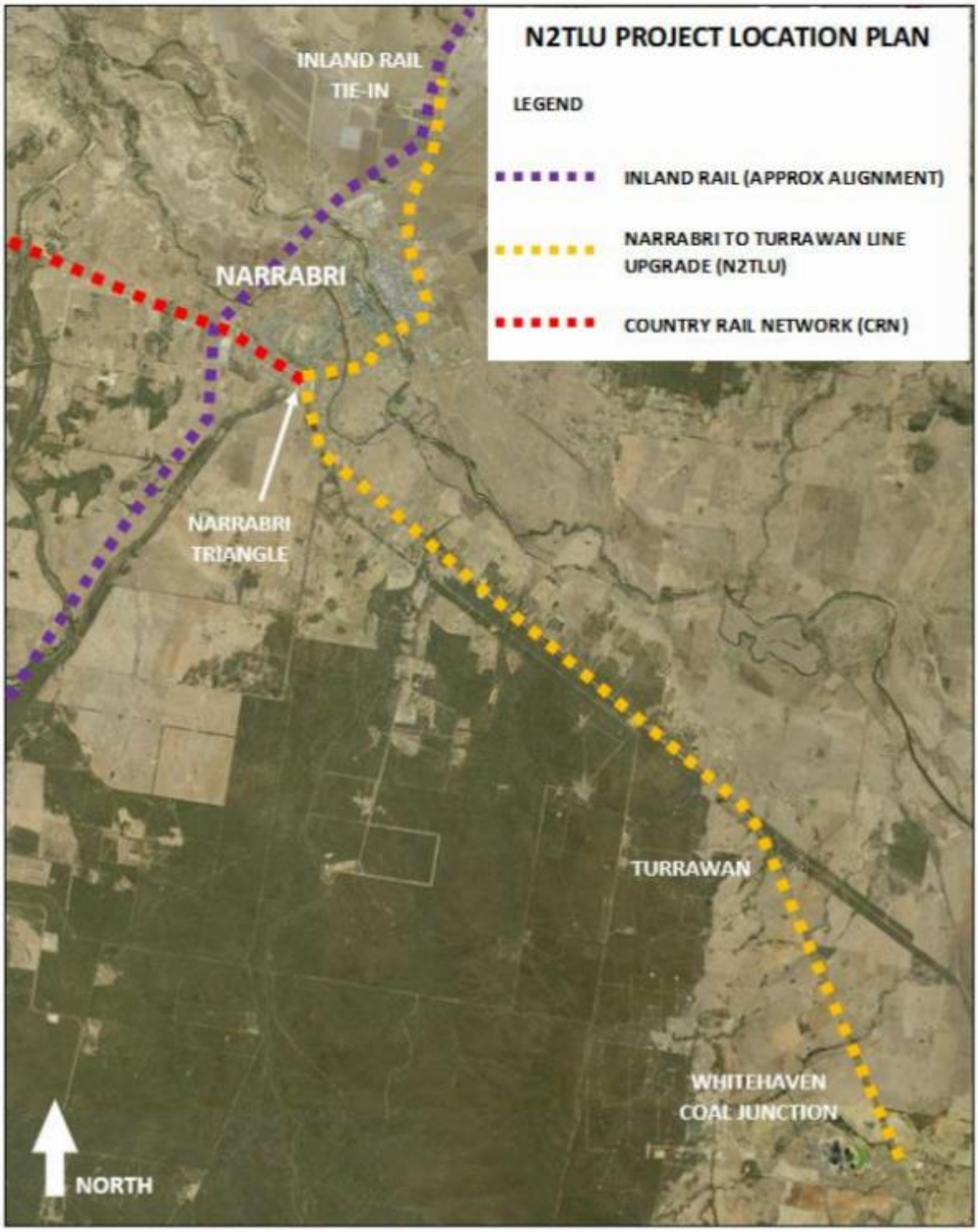


Figure 1.1 Proposal overview

1.3. Construction methodology

1.3.1. Overall project

The construction methodology for the proposal will comprise several activity types that will be completed in overlapping stages as determined by detailed design.

The activity types will generally include:

Site establishment

Prior to the commencement of construction of the proposal, the following general activities will be conducted:

- notify affected landowners and stakeholders in accordance with a community and stakeholder engagement plan;
- if required, conduct preliminary investigations including ground survey, underground and overhead services location, potholing, geotechnical investigations and soil testing.
- completion of Dial Before You Dig (DBYD) plans;
- establish environmental controls including erosion and sediment controls and exclusion fencing for sensitive areas;
- site establishment including setting up temporary site security fencing, traffic and pedestrian management controls, protection of existing services, temporary ancillary facilities, parking and laydown areas within the proposal area;
- delivery of construction equipment and materials (e.g. rail, ballast, pre cast concrete headwalls) to designated ancillary facilities in advance of construction commencement;
- remove vegetation where approved by this REF.

Formation reconditioning

Formation reconditioning will be completed as required at bridge ends, culvert replacements, level crossing reinstatements, sections of poor rail track stability and potentially in sections through Narrabri where a track lift is impractical due to fixed level constraints (level crossings, turnouts, rail platforms, etc.)

The formation reconditioning methodology will broadly comprise:

- cut and remove existing rail in sections using track tools (track saw, oxy-acetylene, rattle guns etc.), excavators, hi-rail excavators and front-end loaders;
- remove existing sleepers using excavators and front-end loaders and stockpile;
- remove ballast and landscaping using excavators;
- excavate existing track formation material to required depth using excavators, dump trucks and front-end loaders. Excavated material to be stockpiled for re-use in backfill or where required waste classification and disposal;
- trim subgrade to profile using excavator, pozitrack or grader;
- install imported structural fill and capping (typically from stockpile) using excavator, pozitrack/ grader and tip trucks/dump trucks, and compact using rollers and plate compactors (as required);
- install new ballast using excavators, front-end loaders, dump trucks, pozitrack/grader and compact with rollers;

- install new concrete sleepers using excavators, front-end loaders and pozitrack;
- install new 60 kg rail or cascaded 53 kg rail as detailed in the design using excavators, front-end loaders and track tools;
- weld rail using combination of free and adjustment welding using welding equipment and trucks, flash-butt welding truck, hi-rail excavators and front-end loaders;
- completion of track horizontal and vertical alignment to design level and ballast profile using ballast trains, hi-rail excavators, hi-rail hydrema's, tampers and regulators; and
- sleeper replacement, where existing steel and timber sleepers will be replaced with heavy duty concrete sleepers using side insertion (i.e. existing rail retained in situ). The existing steel sleepers will be stockpiled for reuse or scrap disposal if damaged. The existing timber sleepers will likely be disposed due to generally poor condition.
- Access to the respective construction sites will be via existing maintenance access roads or using hi-rail equipment. Material stockpiles and laydown areas will be required during construction within the rail corridor.

Ballasting

Ballast will be applied using a dedicated rake of ballast wagons, thereby minimising disturbance to the rail corridor.

Ballast is applied to the crib and shoulders and spread out to ensure adequate quantity of ballast is available to be packed in and under the sleepers that have been replaced.

Water is used to suppress dust generated by the unloading process where applicable.

Rail replacement

The existing rail will be replaced with new 60 kg rail or cascaded 53 kg rail as detailed in the design. The existing rail within the Turrawan crossing loop will also be replaced with recovered 53 kg rail from elsewhere along the proposal alignment.

The existing rail will be classified and either cut up for scrap disposal or stockpiled in 110 m lengths (or similar) for future reuse.

Rail is normally replaced due to its sub-standard cross section, rail weight per metre or its general shape due to excessive side and top wear.

Rail replacement generally involves:

- removal of existing rail fastenings using mechanical equipment operated by skilled labourers;
- removed sections of rail are removed to the side of the track using a 15-20 tonne excavator with a special rail threader attachment (hi-rail);
- replacement rail is then lifted into place by the excavator/rail threader and placed onto sleepers; and
- fastenings are reattached using mechanical equipment, and once rails are in place and fastened the track is then ready for ballasting and tamping.
- Rail will be delivered to site via a rail set and unloaded. The rail will be stored within three metres of the outermost rail to minimise any disturbance to the corridor.

Sleeper replacement

Timber and steel sleepers along the rail line are to be replaced with concrete sleepers. This will also be carried out within the Turrawan crossing loop.

The removal of sleepers generally involves:

- timber sleeper fastenings are extracted by small mechanical machines operated by skilled labourers;
- the sleepers are then extracted using a sleeper grab on a small excavator (hi-rail); and
- concrete sleepers are then inserted as a replacement and fastenings attached to the rail.
- Sleepers will be delivered to site and placed off the ground on timber bracing along the maintenance access tracks, adjacent to the rail track and within the rail envelope.
- Sleeper replacement will be completed using hi-rail excavators and associated hi-rail plant and trailers, minimising disturbance to the rail corridor.
- The side insertion methodology for concrete re-sleepering will broadly comprise:
- pre-lift of track using tamper and regulator;
- removal of excess ballast and landscaping using excavators;
- remove existing sleepers (side removal) using excavators and front-end loaders to stockpile;
- side insert new sleepers using excavators and front-end loaders to distribute new sleepers;
- replace ballast using either hydrema dump trucks, ballast hoppers and shunt engine; and
- interim resurfacing using hi-rail excavator with tamping banks, track tamper and regulator.

Track realignment (vertical and horizontal)

Track geometry is adjusted using an on rail mechanical tamping / lining machine.

Track tamping is a process where ballast is compacted beneath the sleepers to provide support under train loading.

Following tamping, ballast is profiled on the shoulder and crib to ensure standard profiles are installed.

All track resurfacing will be performed by specialised rail bound equipment within the rail envelope, minimising disturbance to the rail corridor.

Welding and adjustment

Following rail replacing, rails are welded into a continuous pattern which eliminates mechanical joints.

The normal process used is an aluminothermic welding process, however flash butt welding may be required and provides an improved quality weld.

All welding resources will access the construction sites via existing maintenance access roads or using hi-rail equipment and works are restricted to the rail envelope, minimising disturbance to the rail corridor.

Rail grinding

Rail grinding is a process used to re-profile the existing rail head shape to enable an optimum wheel rail interface.

The process is also used to remove surface defects from rail and is performed by specialised rail bound track grinders, with multiple grind stones operated by electric motors.

All rail grinding resources will access the construction sites via existing maintenance access roads or using hi-rail equipment and works are restricted to the rail envelope, minimising disturbance to the rail corridor.

Hi-rail equipment will also have water and firefighting resources on board to minimise any ignition of fires from the welding.

Level crossing upgrades

Level crossings are upgraded using a similar process to track reconditioning, where track geometry is poor due to degraded ballast and formation.

The process involves removing rails and sleepers and excavating to a predetermined depth depending on geotechnical conditions.

New formation and capping is installed, compacted and trimmed. A bottom layer of ballast is laid and compacted. Sleepers and rail are reinstalled and fastened. Top ballast is then added, the track is then resurfaced, and ballast profiled using a mechanical tamper and ballast regulator.

Once the level crossing track has been reconditioned, the road surface is re-applied using a range on different configurations including:

- Asphalt.
- Steel panel top.
- Cast in situ concrete.
- Rubber modular panels.
- Pre cast concrete panels.

Once the road surface at the crossing has been completed, the track is then welded and adjusted to stress free temperature. Level crossing signs and line marking is then installed to complete the process.

There is no requirement to upgrade electrical signalling or alarm systems.

Culvert upgrades

Culverts will be replaced via conventional open excavation or pipe jacking methodology.

Culverts being replaced via open excavation will include the following:

- relocating of any utility infrastructure which may affect the works;
- cutting the track and removing panel;
- excavating the area where pipe / culvert is to be replaced;
- installing new pipe or culvert runs;
- compacting and rebuilding rail embankment;
- installing bottom ballast;
- installing track panel and resurfacing; and
- welding and adjustment of tracks.

Pipe jacking will comprise a less intrusive methodology and include:

- relocating any utility infrastructure which may affect the works;
- installing jacking pits and jacking equipment;
- installing pipes and commence jacking pipes through the rail embankment;
- completing pipe jack installation;
- installing headwalls; and
- certifying tracks.

Bridge works

The reinstatement of bridge ends will include:

- removal of existing track (rail, sleepers, and ballast) to expose the track formation over the specified length;
- excavation to required depth to install new structural layer and capping as required;
- installation of a reinforced pre-cast concrete transition slab at each abutment.
- Re-construction of the track with new ballast, concrete sleepers and new 60 kg rail or cascaded 53kg rail as detailed in the design.

The construction methodology will be as per that of formation reconditioning at the bridge locations.

Demobilisation

Upon completion of construction of the proposal, the following activities will be carried out:

- dispose all redundant waste materials to an approved waste management facility;
- restore all disturbed areas to pre-existing condition or better, or where this is impractical stabilise disturbed surfaces to meet the requirements of Managing Urban Stormwater: Soils and Construction' published by Landcom (commonly, and hereafter, referred to as 'the Blue Book'); and
- demobilise site amenities, remove security fencing and environmental controls.

1.3.2. Section 1 – Whitehaven coal junction to Narrabri Triangle

This section runs from the Whitehaven coal junction to the south of Narrabri (the Narrabri Triangle). Works will predominantly consist of skim reconstruction, rail and sleeper replacement, with formation reconstruction at bridge ends, where required.

1.3.3. Section 2 - Narrabri Triangle to Narrabri North

This section of track runs from approximately Old Turrawan Road on the western side of Narrabri, through the southern and then eastern part of the town, past Narrabri Station and to the north to the Narrabri Saleyards.

Over time, the railway has degraded due to deteriorating sleepers, movement of ballast material and degradation of the subgrade and foundation soils. This has resulted in an uneven track profile. The proposal will remove these profile inconsistencies, reinstate previous levels and, in some areas, increase track levels to achieve a more efficient operation of the railway.

A refinement of the reconstruction approach has been developed as site investigations in this area have proceeded,

Upgrades for this section include three approaches:

1. Formation reconstruction, involving reconstruction of subgrade material to a maximum of 1400 millimetres (mm) deep;
2. Formation skim, involving replacement of a thin layer of material at ground level and track lift of up to 100mm; and
3. Side insertion of new sleepers which involves a track lift of up to 100mm.

In addition to track upgrades, existing culverts will be replaced at the following track markers:

- 564.930 km – two 300 mm concrete pipes to be replaced with a single box culvert (estimated dimensions of 450 mm high by 600 mm wide).
- 565.130 km – one 450 mm concrete pipe to be replaced with single box culvert (estimated dimensions of 450 mm high by 600 mm wide).
- 565.585 km – two 600 mm corrugated pipes to be replaced with twin box culverts, each with estimated dimensions of 600 mm high by 750 mm wide).
- 566.985 km – two 450 mm corrugated pipes to be replaced with twin box culvert, each with estimated dimensions of 450 mm high by 600 mm wide.
- 573.360 km – two 600 mm corrugated pipes to be replaced with twin box culverts, each with estimated dimensions of 600 mm high by 750 mm wide.

1.4. Hydraulic Assessment Methodology

For the purposes of this assessment, sections of track that are to be lifted **and** that are currently inundated in the 1% annual exceedance probability (AEP) flood event are further assessed for potential flood impacts. Sections of the track within the 1% AEP that may be subject to track lift include:

- Chainage 565.99km to 566.9km (Lift A)
- Chainage 567.92km to 568.92km (Lift B) and
- Chainage570.00km to CH571.00km (Lift C).

These sections are solely contained within section 2 – Narrabri Triangle to Narrabri North, as described above. Refer to Figure 1.2 for the location of each lift location.

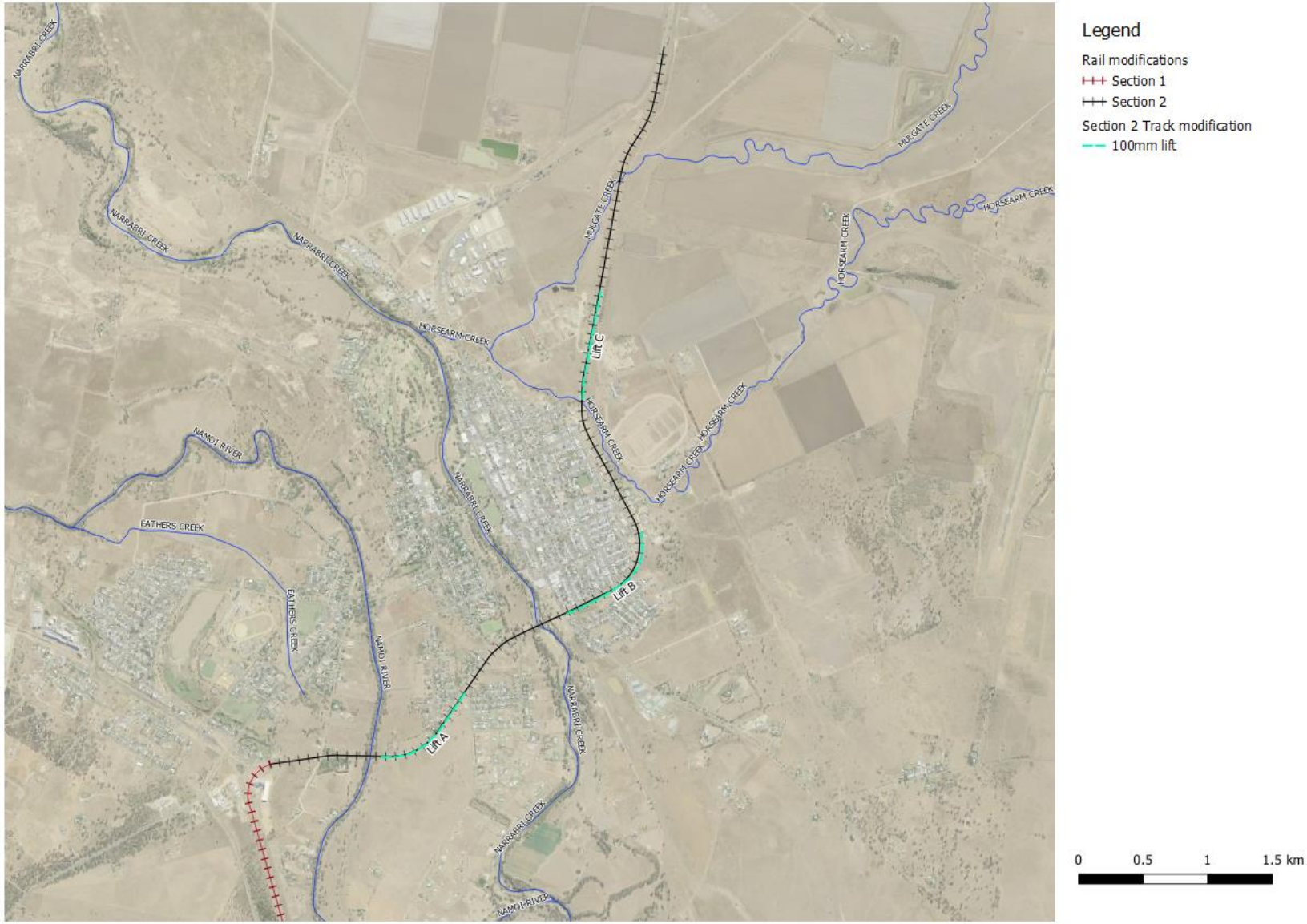


Figure 1.2 Section 2 works location

2.0 EXISTING ENVIRONMENT

2.1. Soils

Native soils over Section 1 of the proposal are a combination of vertosols, sodosols and chromosols associated with the Namoi River floodplain edge and undulating landscape to the west. Soils include clays, black and red earths, as well as solodic soils on the low hillsides and lower slopes, which are likely to be dispersive and have the potential to lose structure when worked in a wet environment.

Through Section 2 of the proposal, soils include vertosols, generally black earths or clay soils associated with the Namoi River floodplain. These soils are generally highly impermeable, have high shrink-swell properties and have the potential to lose structure when worked in a wet environment.

2.2. Hydrologic landscape

2.2.1. Section 1

Between Turrawan and Narrabri, the Namoi River meanders through a floodplain about 3km wide at the southern end, widening as the River approaches Narrabri. The section of railway between Turrawan and Narrabri generally follows the alignment of the Namoi River, between 20 to 30m above the Namoi River at the southern end, and grading closer to the river as the track approaches Narrabri (Figure 2.1).

Jacks Creek (154km^2), Sandy Creek (30km^2), Jones Hollow Creek (6.3km^2) and Pine Creek (32.4km^2), along with a number of smaller catchments drain beneath the railway embankment to the Namoi River floodplain.

2.2.2. Section 2

The Narrabri township sits within the Namoi River floodplain. At this point the Namoi River drains a large catchment to the west of about 25,400 km^2. The Namoi River splits at the southern end of the town into the Narrabri Creek and Namoi River. Narrabri Creek carries the low flows through the town and the Namoi River carries only flood flows (WRM, 2016).

Mulgate and Horsearm Creeks enter the eastern part of the town and collect rainfall from a combined catchment of about 201 km^2. These Creeks meet the railway along the eastern and northeastern corner of Narrabri (Figure 2.2)

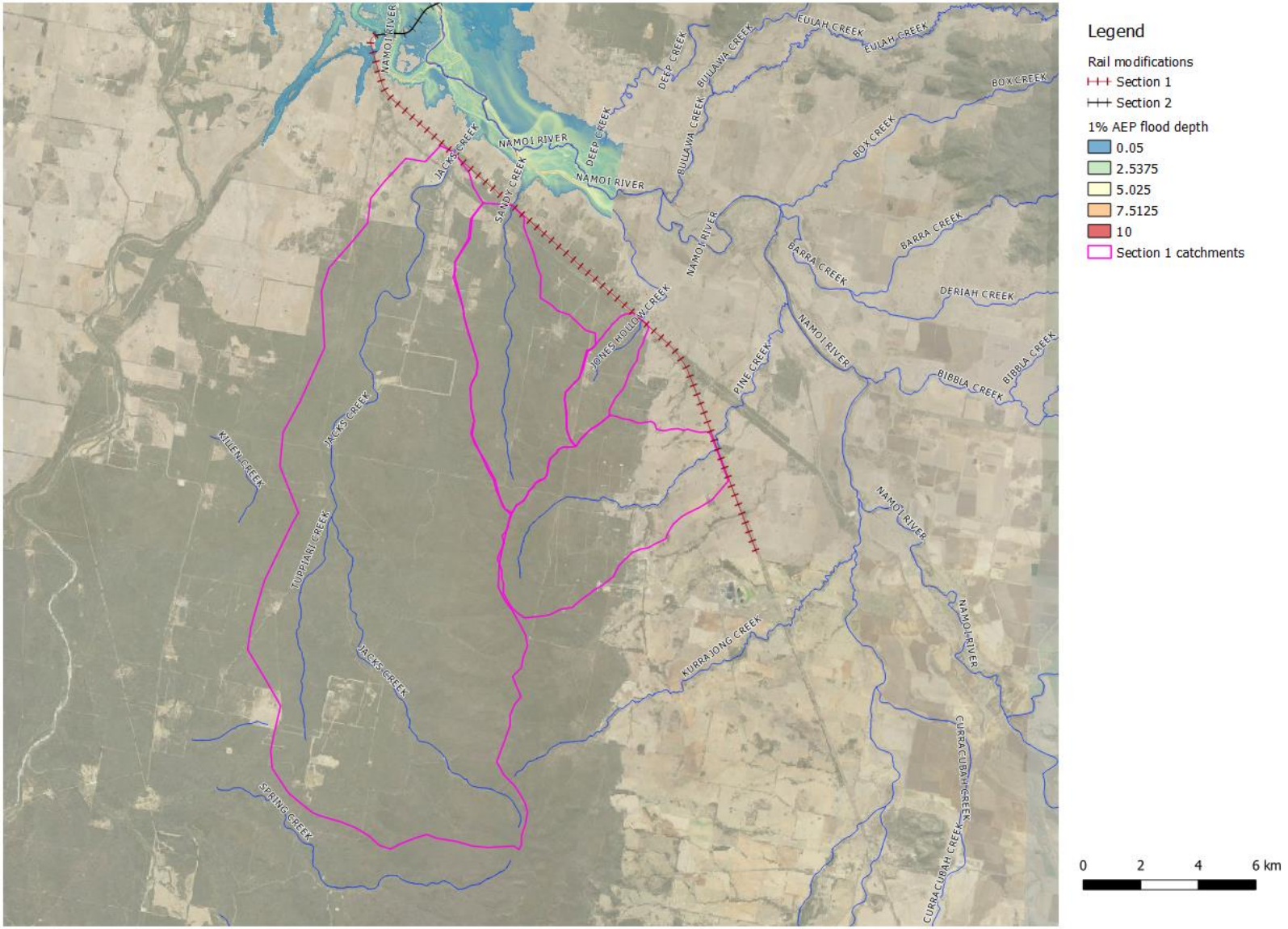


Figure 2.1 Section 1 context

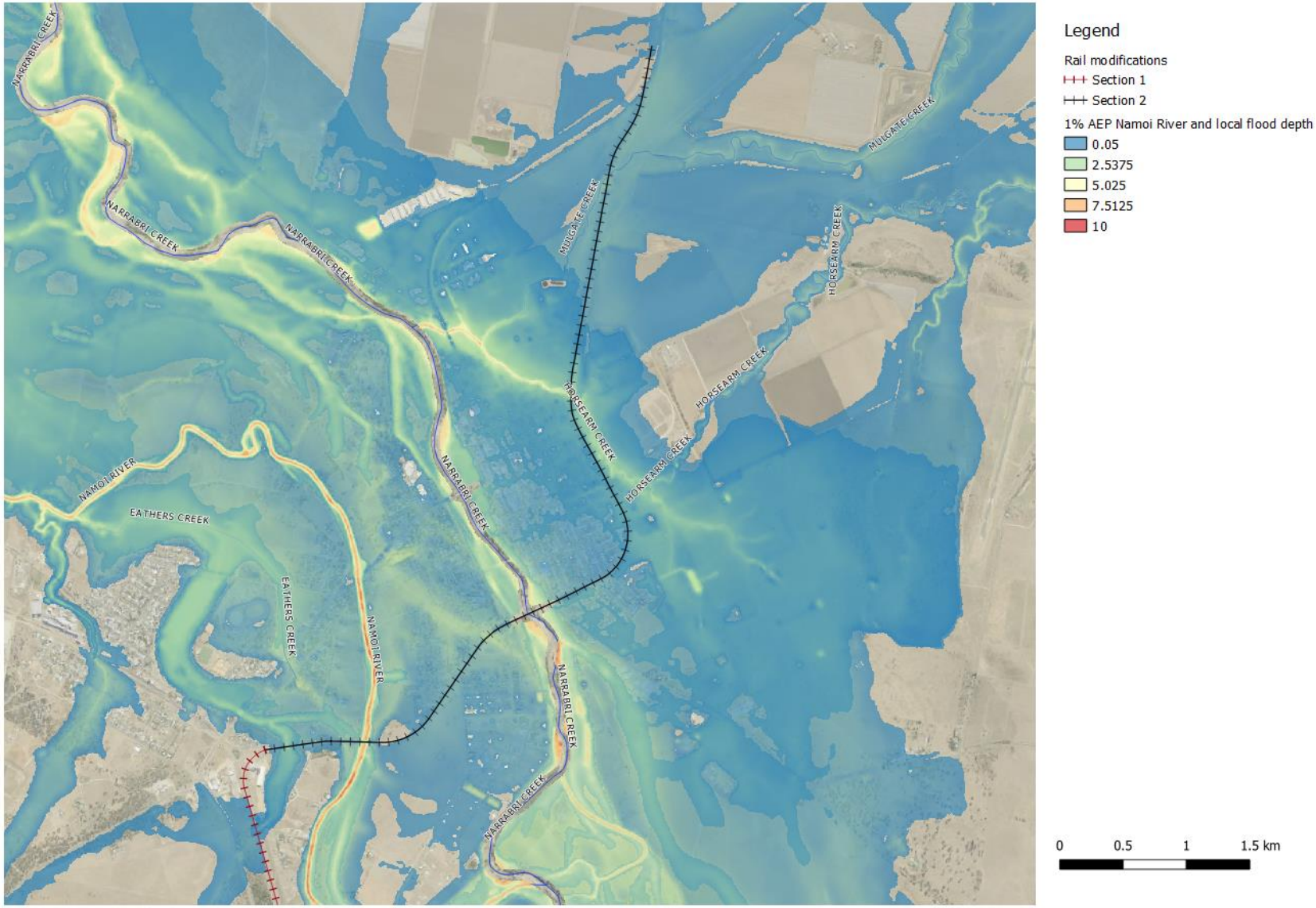


Figure 2.2 Section 2 context

2.3. Flood behaviour

The *Narrabri Flood Study* (WRM, 2016) was completed in December 2016. This study addresses causes of flooding in Narrabri, including **regional flooding** associated with flows from the Namoi River, and **local flooding** associated with tributaries (Mulgate Creek and Horsearm Creek) on the eastern side of the town. The flood study extends from about 10km upstream of the centre of Narrabri, which is approximately chainage 554.5km of the rail line, to Narrabri itself, incorporating the surrounding land to the east and west, and continuing approximately 10km past the confluence of Narrabri Creek and the Namoi River (Figure 2.3).

Much of the Narrabri township is flood impacted from both regional flooding and local flooding from Mulgate and Horsearm creeks.

For Section 1, there is no interaction with the railway embankment in this area for the 1% AEP or smaller events, apart from bridges and culverts where flows pass from catchments to the west. The regional probable maximum flood (PMF) event would overtop the railway embankment at the northern end close to the Narrabri Triangle.

For Section 2, elevations through the township where the railway is located range from about 214m Australian Height Datum (AHD) just to the east of the Narrabri Triangle, rising to cross the Namoi River, then lowering again to about 214.4m AHD, raising to cross the Narrabri Creek, then lowering to 213.3m AHD at the railway station, with a low point at 212.8m AHD around Horesearm Creek and then rising again gradually to the connection with Inland Rail.

The threshold for overtopping of the railway embankment is around the 5% AEP (20 year annual recurrence interval (ARI) events) for the local flooding event, which occurs in the area around the Narrabri cemetery. The threshold for overtopping of the railway for the regional event is between the 5% and 2% (20 year and 50 year ARI events), which occurs around the Narrabri Station area.

The track is currently overtopped in the 1% AEP event in a number of locations in both the local and regional events (refer to Figure 2.4) including:

- To the east of the Namoi River Crossing, including the area around the McKenzie Street level crossing; and
- To the east of Narrabri Creek from approximately Fitzroy Street, through the station area and north past the Doctors Creek level crossing and towards the Narrabri Cemetery.

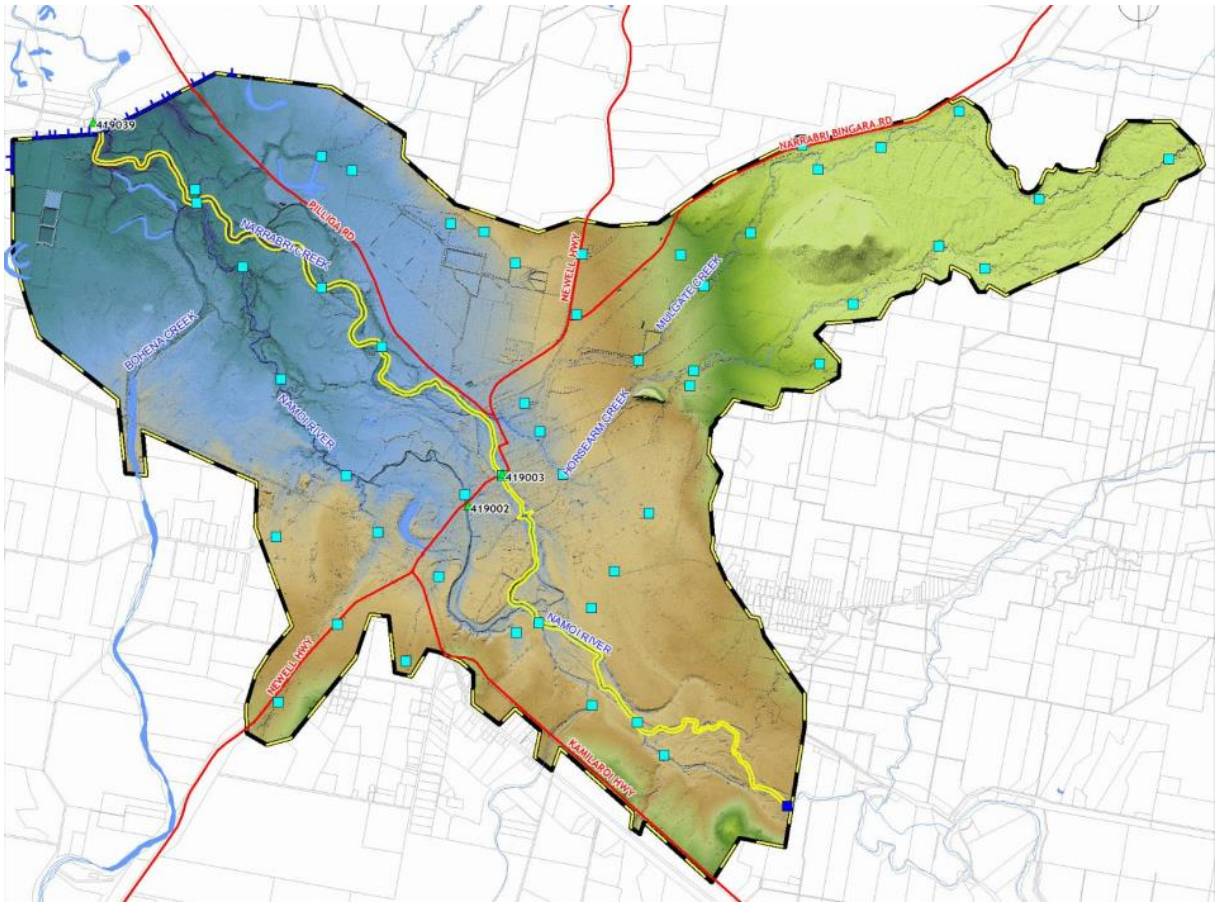


Figure 2.3 Hydraulic model extents (extracted from Narrabri Flood Study (WRM, 2016).

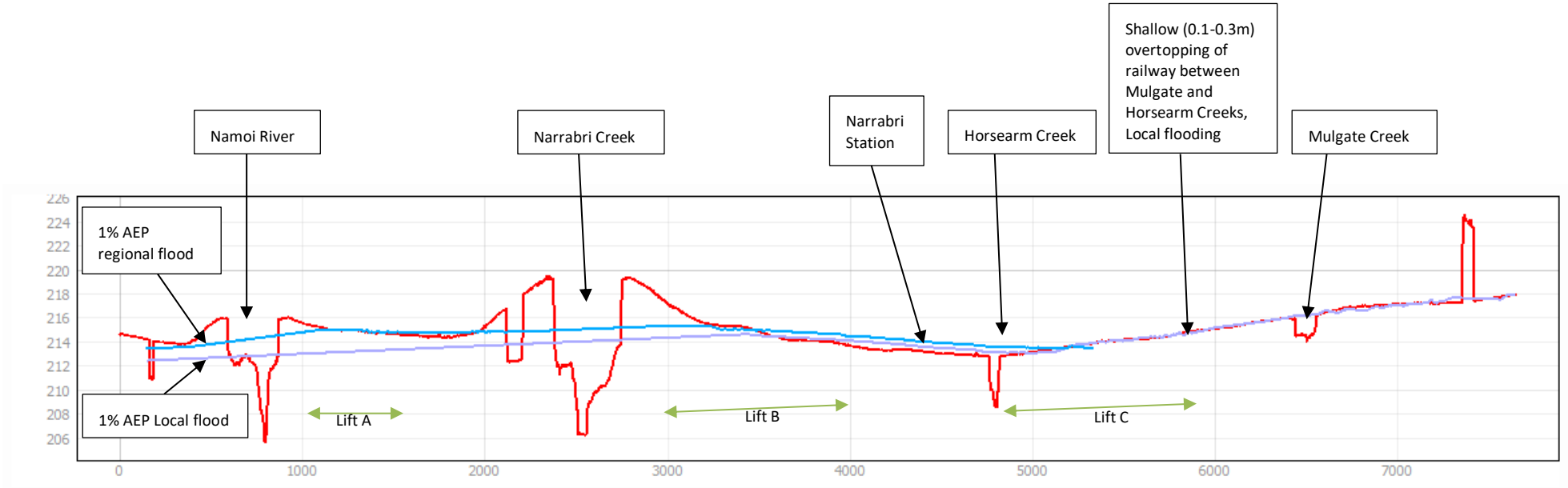


Figure 2.4 1% AEP flood levels along section 2 upgrade alignment (approximate surface levels in red)

3.0 RELEVANT LEGISLATION AND GUIDELINES

3.1. Water Management Act 2000

The NSW *Water Management Act 2000* (WM Act) regulates the management of water by granting licences, approvals for taking and using water, and trading groundwater and surface water. The WM Act applies to those areas where a water sharing plan (WSP) has commenced. Alternatively, if a WSP has not yet commenced, the *NSW Water Act 1912* (Water Act) applies. The WM Act is progressively replacing the Water Act as relevant WSPs are introduced across the State.

Water sharing plans have commenced for most of NSW. Licensing of monitoring bores continues under the Water Act until a regulation for aquifer interference gives a mechanism to approve these activities. Licensing of reinjection into groundwater systems is also still currently managed under the Water Act.

The proposal falls within the following water sharing plans:

- NSW Murray Darling Basin Porous Rock Groundwater Sources 2011 (Gunnedah-Oxley Basin Groundwater Source).
- NSW Great Artesian Basin Groundwater Sources 2008 (Southern Recharge Groundwater Source).
- Upper and Lower Namoi Groundwater Sources 2003 (Upper Zone 5, Namoi Valley (Gin's Leap to Narrabri) Groundwater Source and Lower Namoi Groundwater Source).

The provisions of the WM Act therefore apply to the proposal.

Approval is required prior to undertaking works in, on or under waterfront land under the WM Act. Waterfront land is defined as land within 40 m of both sides of a river, lake or estuary, including the bed itself, and works requiring approval include construction, vegetation removal, deposition of material or any other works that may affect the water flow within the watercourse.

Under section 91E, a person must not carry out a controlled activity in, on or under waterfront land otherwise than in accordance with a controlled activity approval. A controlled activity includes:

- the erection of a building or the carrying out of a work;
- the removal of material or vegetation from land;
- the deposition of material on land, whether by way of landfill operations or otherwise; and
- the carrying out of any other activity that affects the quantity or flow of water in a water source.

The proposal may constitute a controlled activity under the WM Act. However, pursuant to clause 37, schedule 4 of the Water Management (General) Regulation 2018, ARTC is permitted to undertake rail infrastructure works on waterfront land without the need to obtain a controlled activity approval, provided the activity does not cause any change to the course of a river, and the activity is not likely to significantly affect the environment.

Despite exemption from the requirements of section 91E, the proposed work activities should be carried out in accordance with the relevant guidelines for controlled activities published by the former NSW Office of Water.

Section 91C of the WM Act makes it an offence to construct or use a drainage work without a drainage works approval.

Section 91D of the WM Act also makes it an offence to construct or use a flood work without a flood work approval. The proposal will involve raising the rail line within flood prone areas. Despite this, ARTC are exempt from the requirement for a flood work approval pursuant to section 47 of the Water Management (General) Regulation 2018.

Activities that intercept aquifers require approval under section 91F of the WM Act. Previous consultation with the Natural Resources Access Regulator has indicated that an aquifer interference approval is generally only required if more than three megalitres would be extracted per annum from excavations such as trenches. The extraction of less than three megalitres per annum is an exemption under the Water Management (General) Regulation 2018, providing the water extracted is not for consumption and ARTC keep a record of the quantity of water taken under the exemption and provide a record to the Minister at the end of the water year.

The proposal requires excavation during construction and may require the associated dewatering of perched groundwater that may infiltrate into excavations. Despite this, it is anticipated that dewatering quantities are not expected to be significant and would not exceed the three megalitre threshold thereby requiring an aquifer interference approval under the WM Act. ARTC will monitor the requirement for excavation dewatering and if it is determined that there is potential for the three megalitre limit to be reached, an aquifer interference approval (in the form of a water access licence and water supply works approval) will be obtained.

Alternatively, if ARTC propose to utilise all groundwater extracted for use in construction of railway infrastructure facilities (e.g. for the purposes of dust suppression), in accordance with clause 3, schedule 4 of the Water Management (General) Regulation 2018, ARTC as a designated transport authority are exempt from the need to obtain an access licence.

3.2. Narrabri Local Environmental Plan (LEP) 2012

The Narrabri LEP 2012 incorporates flood planning provisions. These provide Council with guidance on how to assess and interpret a development's floodplain impact. The previous clause has recently been repealed and updated to the following:

Flood Planning

1. The objectives of this clause are as follows—
    a) to minimise the flood risk to life and property associated with the use of land,
    b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,
    c) to avoid adverse or cumulative impacts on flood behaviour and the environment,
    d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

2. Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development -
   a) is compatible with the flood function and behaviour on the land, and
   b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and
   c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and
   d) incorporates appropriate measures to manage risk to life in the event of a flood, and
   e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation

3.3. NSW Floodplain Development Manual

The NSW Floodplain Development Manual 2005, incorporates the NSW Government's Flood Prone Land Policy. The document provides guidance on how to assess flood risk and plan for floodplain risk management. Of relevance in this case is both section 3.0 of the manual, which outlines responsibilities for Council and proponents, as well as Appendix L which covers hydraulic and hazard categorization and Appendix M which outlines metrics for assessment of flood impacts.

3.4. Flood Impact and Risk Assessment – Flood Risk Management Guide LU01

The guideline provides an assessment framework for developments or planning proposals that need to consider flooding. The guideline outlines how the assessment should be undertaken, the flood related criteria to be included and how flood plain risk impacts should be considered in the approval process. This surface water assessment generally follows the framework of this guideline.

3.5. Narrabri Council, Controlled Works on a floodplain Policy

Although no longer known as 'controlled works' as that section of the Water Act 1912 No.44 has been repealed, Council have the above policy to assist with management of the Namoi Floodplain to ensure Council assets are protected from proposed works in a floodplain. This aspect of floodplain management is now addressed through the WM Act and proposed modifications to the floodplain, generally outside of urban areas, require a *flood work approval*. As mentioned above, ARTC are exempt from requiring a *flood work approval.*

Nevertheless, Council's policy represents a benchmark of acceptable impact that is useful from the perspective of assessing the proposal.

The policy states that Council will object to works on the floodplain that:

- Detrimentally affect the ability of Council to drain water away from its roads and other assets.

- Encroach within 5m of the shared boundary with Council and thus affect Council's and the applicant's ability to maintain the existing natural surface levels on the shared boundary.
- Cause predicted flow depths across Council's Assets in the Design Flood Event (Designated Flood) to increase by more than 50mm, when compared to flow depths without the Controlled Works, and thus will not increase the time Council's asset is submerged.
- Cause predicted velocities across Council's Assets in the Design Flood Event (designated flood) to increase by more than 50% (or to a maximum value 0.5m/sec), when compared to flow depths without the Controlled Works, and thus will not increase the potential for damage to occur to Council's Asset.

3.6. Narrabri shire flood emergency sub plan

The NSW State Emergency Service (SES) have prepared a flood emergency sub plan for Narrabri. This plan identifies four evacuation centres for the town, namely:

- The Crossing Theatre in Tibbereena Street.
- Narrabri RSL Club, 7 Maitland Street.
- Narrabri Public School in Barwan Street.
- Narrabri West Public School in Cooma Road.

All of these locations are inundated to some degree in a 1% AEP event apart from Narrabri West Public School.

Ugoa Street is specifically identified as an evacuation route that is susceptible to flooding for the Narrabri Motel and Caravan Park and the Highway Tourist Village. It is mentioned to let the community know its flood liability to assist with evacuation planning. No other specific evacuation routes are identified in the sub-plan.

4.0 SURFACE WATER IMPACTS

4.1. Hydraulic impacts - Section 1

Section 1 of the proposal is located above the 1% AEP flood level for the Namoi River. There are a number of watercourse crossings over Jacks Creek (154km^2), Sandy Creek (30km^2), Jones Hollow Creek (6.3km^2) and Pine Creek (32.4km^2). There are no proposed changes at these major crossings, and the rail embankment is well above the watercourses in this area.

As the railway is above the 1% AEP flood levels, rail lifts will not have any hydraulic impact on Namoi River flood flows.

Any hydraulic impacts for the Section 1 upgrade area will be associated with any minor culvert upgrades. Adverse impacts will be temporary, only occurring during construction, and as post upgrade capacities will be retained or increased no long term hydraulic impact is expected.

4.2. Hydraulic impacts - Section 2

The proposed lift areas are solely contained within Section 2 are all either fully or partially located within sections of the track that are currently overtopped in the 5% AEP event or larger flooding events. This creates afflux on the upstream side of the embankment associated with the increased spillover height and/or energy losses associated with diversion of flows.

The impact of these changes has been estimated by modelling the existing conditions and comparing the flood surface levels. Modelling was undertaken by WRM using the model prepared for the Narrabri Council's Narrabri Flood Study.

There is a small section of approximately 100m (Chainage 569.14km to 569.34km) adjacent to the Narrabri rail platform that will be raised between 62 to 159mm that has not been included in this flood assessment as the track is immediately adjacent to the railway platform, which is approximately 1.1m above the existing track level. The platform is essentially acting as an extension to the railway embankment and overrides any changes to track level in this area from the perspective of flood impact.

The final rail level adjustments are yet to be finalised as subgrade testing and design refinement is ongoing, The lift extents used in this assessment therefore, represent a 'worst case' scenario, and it is likely that significant portions of these lifts will be less than 100mm.

4.2.1. Hydraulic model methodology

The existing MIKE hydraulic model used in the Narrabri Flood Study (WRM, 2016), and ongoing Floodplain Risk Management Plan. The model used for the flood study uses 1m Digital Elevation Model (DEM) surface information sourced from LIDAR survey, although sufficient for broadscale flood planning, the accuracy is not sufficient along a linear structure such as a rail embankment. As such, the railway embankment surface was adjusted to incorporate surveyed rail levels along the rail embankment through Narrabri. This provides a more accurate estimation of current conditions.

The updated existing model was then adjusted upwards at the three proposed main lift areas by 100mm to represent a 'worst case' model of proposed changes along the rail alignment.

Replacement of existing culverts have not been incorporated into the hydraulic model as the culvert upgrades are predominantly similar in opening area and are relatively small culverts unlikely to have any influence on flood flows.

4.2.2. Assessment criteria

As outlined in Appendix M of the *NSW Floodplain Development Manual* (DIPNR, 2005), the most accurate assessment of the change to flood risk associated with modifications to the floodplain is to assess both the number of properties impacted pre and post the modification in terms of frequency and depth of flooding. This is usually assessed for additional lots flooded and for flooding above habitable floor levels, or commercial or industrial use floor levels.

There are a range of quantitative limits for the determination of an acceptable and unacceptable flood impact from a development in terms of afflux or other parameters outlined in legislation or other guidelines.

Narrabri Council provides a limit for impacts on Council infrastructure, of an increase in flood depth of 50mm in the 1% AEP event based on Council's *Policy for Controlled Works on a floodplain*. This limit has been applied for this assessment.

In lieu of other specific limits, the *Narromine to Narrabri Inland Rail Flooding and Hydrology Impact Assessment* (N2N)(ARTC, 2020) proposed a range of quantitative design objectives in conjunction with the Department of Planning, Industry and Environment for the assessment of the new Inland Rail line to the west of Narrabri Township.

For the purposes of this assessment, a modified and simplified version of the Inland Rail (N2N) Quantitative Design Limits (QDLs) has been selected to assist in estimating the potential impacts of the proposal. These are listed in Table 4.1. Surveyed floor levels, collected as part of the Narrabri Flood Study and ongoing Floodplain Risk Management Plan have been used determine flood impacts on habitable floor levels.

It is noted however, that the proposal differs from N2N in that it involves the maintenance and upgrade of an existing rail line that currently impacts flood flows. There are limited options to design out potential flood impacts, noting the corridor is fixed as are the established drainage points. It is also likely the current rail levels within the rail corridor have altered over time from various previous maintenance and operational activities.

Table 4.1 Assumed QDLs

Parameter	Location	Design objective
Afflux (5%, 2% and 1% AEP)	Habitable floors Sensitive infrastructure: • Emergency hospitals • Flood evacuation routes • Electricity sub stations • Water treatment plants	10mm (for residences already inundated)
	Council infrastructure	50mm
	Other land	200mm
Velocity (5%, 2% and 1% AEP)	Increase in velocity in residential or built areas	0.05 metres per second (m/s)
Hazard (1% AEP)	All land	No change in flood hazard from Low to High as defined in Appendix L, *NSW Floodplain Development Manual* (DIPNR, 2005),

4.2.3. Hydraulic impacts

Regional flooding

The 5% AEP event is below all of the lift areas. As such, there is no impact on this flood event, or smaller events.

Lift A has the largest impact on flood flows primarily as there is only shallow overtopping of the railway embankment at the modelled 1% AEP, so any change in rail height has a relatively large change on flood behaviour. In the 2% AEP and 1% AEP event, flood levels in the residential area along McKenzie Street (opposite the level crossing) experience increases of about 40mm and 55mm respectively, with the remaining residential land between McKenzie Street and Guest Street experiencing an increase of between 10 to 40mm, reducing towards Guest Street. The existing 1% AEP flood depths in this area are between 700 to 1100mm.

Lift B creates a small impact (20mm increase in the 2% AEP event) on a single lot on Fitzroy Street to the east of the railway line.

Lift C creates a 10 to 20mm increase in the 1% and 2% AEP event for residential land on Bailey Street, where flood depths are between 700 to 1000mm.

The total number of properties impacted in the 1% AEP event is 16 houses with the majority adjacent to the Lift A area (Table 4.2). The maximum change in flood level above existing habitable floor levels is 55mm in the 1% AEP event and 49mm in the 2% AEP event.

There are no areas where the increase in flood levels for any event exceeds 200mm. There are no residential or built areas where the increase in flood velocity exceeds 0.05m/s.

Approximately 2.3ha changes from Low Hazard to High hazard, the majority of which is located within rural land. There are small isolated changes in residential areas and small areas over existing roads to the area upstream of Lift A around Taylor Street and McKenzie Street.

Appendix A contains mapping showing the changes in flood height for a range of flood events as well showing areas affected based on the flood impact criteria.

Local Flooding

Lift A has no impact in all local flooding events modelled as no overtopping occurs up to and including the PMF event.

Lift B creates a small impact (20mm increase) on a single house on Fitzroy Street to the east of the railway line.

The area where Lift C is occurring generates relatively substantial changes in flood behaviour when this section is raised, as current overtopping flows in this area are relatively shallow. The change in level results in increased flow depths upstream of the Lift C area as well as increased depths in some downstream areas as flows that previously overtopped and flowed to the sale yard area are diverted to Horsearm Creek.

Residential areas around Bailey Street experience up to an 80mm increase on existing 180-200mm flood depths in a 5% AEP event, and a 50mm increase in larger events (2% and 1% AEP). There is in excess of 50mm of increase over part of Cemetery Road, the Narrabri Cemetery and part of Stoney Creek Road.

Residential areas alongside Horsearm Creek and in the area between Loyd to Denhurst Streets receive flood increases of between 10 to 35mm in the 5%, 2% and 1% AEP events, with the largest impact in the 5% AEP event.

The maximum change in flood level above existing habitable floor levels is between 48 to 52mm for the 5%, 2% and 1% AEP event, all occurring on Bailey Street.

The number of properties impacted in the 1% AEP event is 50 houses with the majority downstream of the railway crossing over Horsearm Creek (refer to Table 4.2).

There are no areas where the increase in flood levels for any event exceeds 200mm. There are no residential or built areas where the increase in flood velocity exceeds 0.05m/s.

Approximately 4.4ha changes from Low Hazard to High hazard, the majority of which is located within rural land. There are small isolated changes in residential areas and small areas over existing roads to the area around Kaputar Street and Reid Street.

Appendix A contains mapping showing the changes in flood height and velocity for a range of flood events.

Table 4.2 Impact summary

Criteria	**Regional Flood**			**Local Flood**		
	5% AEP event	2% AEP event	1% AEP event	5% AEP event	2% AEP event	1% AEP event
Habitable floors Afflux >10mm	0	32 (max increase 49mm)	16 (max increase 55mm)	5 (max increase 52mm)	47 (max increase 48mm)	50 (max increase 51mm)
Sensitive infrastructure: • Emergency hospitals • Flood evacuation routes • Electricity sub stations • Water treatment plants Afflux >10mm	0	0	0	0	0	0
Impact on Council infrastructure Afflux >50mm	No impact	No impact	• 266m of McKenzie Street • 30m of Taylor Street • 41m of Cunningham Close	No impact	• 412m of Old Cemetery Road • Narrabri Cemetery • 77m of Stoney Creek Road	• 730m of Old Cemetery Road • Narrabri Cemetery • 220m of Stoney Creek Road
Other land Afflux >200mm	No impact	No impact	No impact	No impact	No impact	No impact
Increase in velocity in residential or built areas >0.05m/s	No impact	No impact	No impact	No impact	No impact	No impact
Hazard	N/A	N/A	Low to High for 2.2ha	N/A	N/A	Low to High for 4.4ha

4.2.4. Cumulative impacts

The Inland Rail - Narromine to Narrabri (N2N) project is a proposed new rail corridor between Narromine and Narrabri, currently under assessment by the NSW Government. At Narrabri, the rail corridor is proposed around the northern and western side of the Narrabri township (Figure 4.1)

Hydraulic and hydrologic assessment of this new rail corridor has been completed as part of the environmental impact assessment to support the State significant Infrastructure proposal.

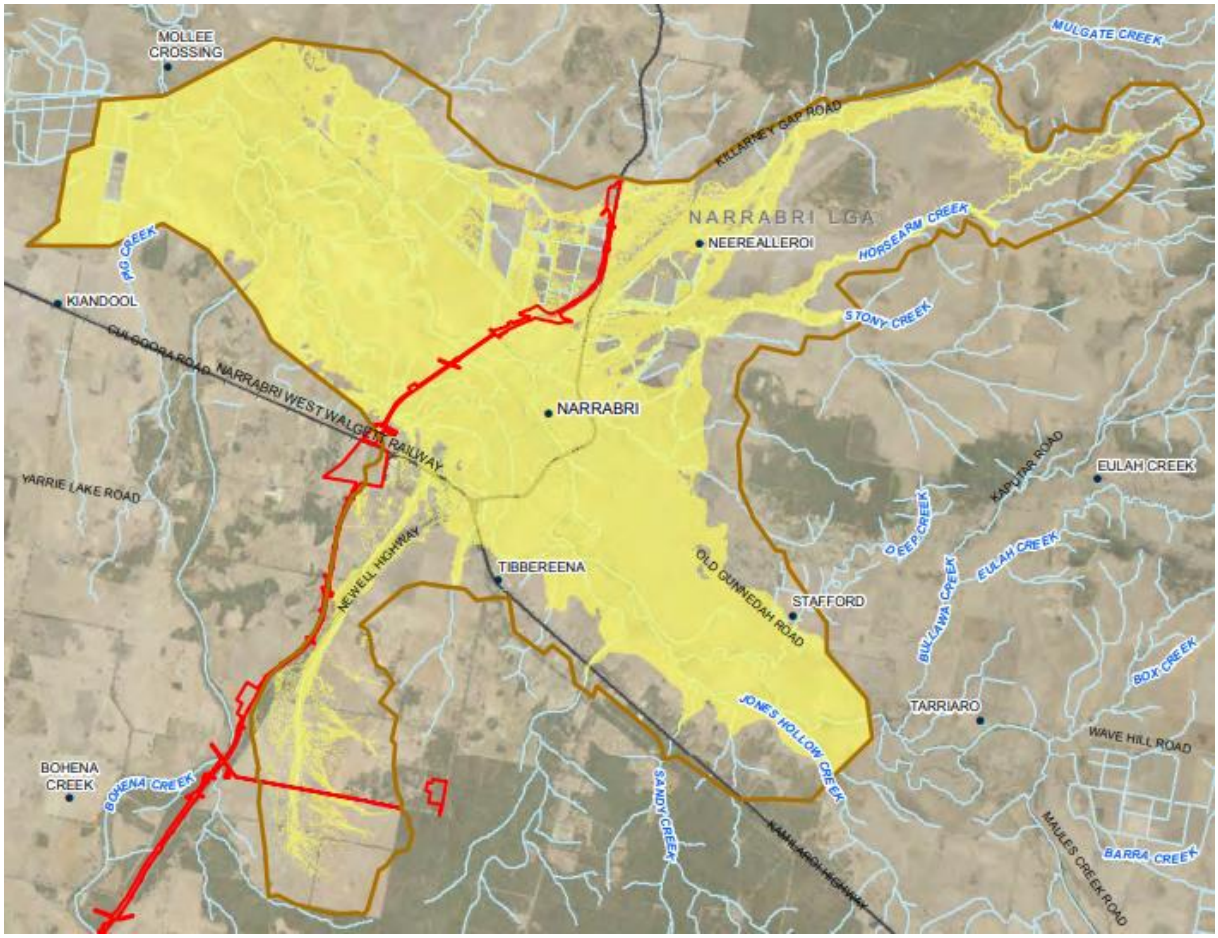


Figure 4.1 Inland Rail - Narromine to Narrabri, Narrabri section in red, extract from EIS- (N2N)(ARTC, 2020))

A review of detailed hydraulic assessment results for the Inland Rail – Narromine to Narrabri project shows the increase in flood levels greater than 10mm around Narrabri is confined to the area downstream of the junction between Horsearm Creek and Narrabri Creek (Figure 4.2), outside of that area impacts are between + or – 10mm.

There is significant distance between the modelled impact areas for each project, as such cumulative impacts between the two projects are not likely.

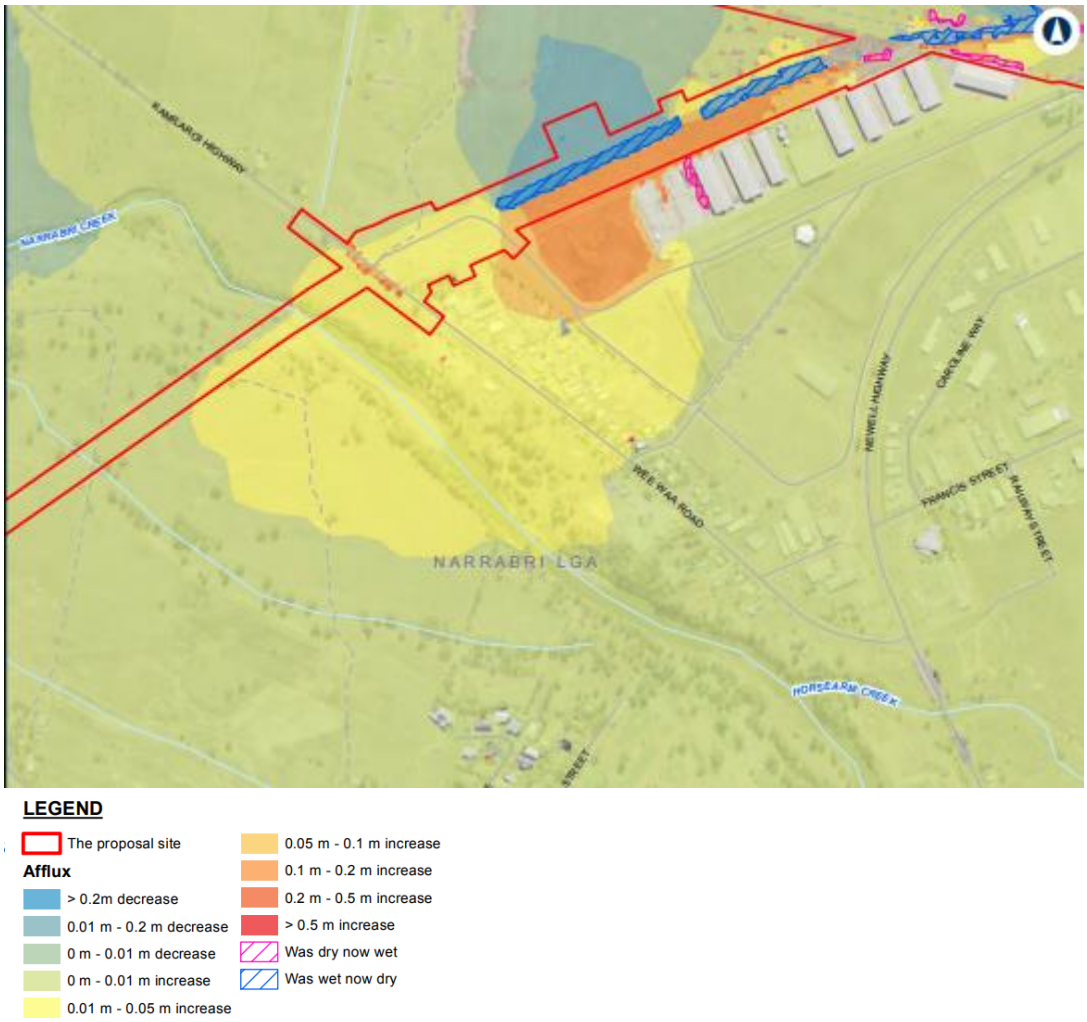


Figure 4.2 Change in 1% AEP peak flood level, extracted from Inland Rail- Narromine to Narrabri EIS (N2N)(ARTC, 2020))

4.3. Construction phase impacts

4.3.1. Hydraulic impacts

Potential hydraulic impacts during construction are associated with placement of materials (stockpiles) and/or machinery within flow paths or watercourses which may then cause local diversion of flows. Given the floodplain size, it is not feasible to exclude stockpiles or machinery from flood impacted areas during construction, however, materials should be kept beyond drainage lines and identified watercourses, and should be limited in length and height in these areas. Where feasible from a construction perspective, materials should be kept outside of flood impacted areas.

4.3.2. Erosion and sediment transport.

Potential water quality impacts are likely associated with track formation earthworks, culvert upgrades (where required) and machinery access and stockpile areas associated with these upgrades.

Erosion and transport of sediment off-site is possible, particularly during periods of prolonged wet weather, and where earthworks are being undertaken within, or in close proximity to overland flow paths and waterways.

Management of erosion and sediment transport during and immediately post construction can be managed using standard sediment and erosion controls as outlined in *Managing Urban Stormwater: soils and construction - vol 1 (*Landcom, 2004).

It is unlikely that sediment basins will be necessary as estimated soil losses within works areas would be below the recommended threshold of for the construction of a sediment basin of 150m^3/y (Landcom, 2004). Given the railway vertical alignment and slope, exposed areas would have to exceed approximately 5 hectares before formal sediment basins would be required.

An Erosion and Sediment Control Plan, or Soil and Water Management Plan should be prepared for the proposal, in particular, addressing areas where track formation earthworks are required. Issues to consider include:

- Soil types and potential for dispersion and loss of structure;
- Proximity to overland flow paths and watercourses;
- Locations of stockpile areas; and
- Machinery access points.

4.3.3. Chemicals, oils, grease and petroleum hydrocarbon spills from construction machinery

There is the potential for spills associated with machinery and hydrocarbon storage, and for these materials to make their way to receiving waters particularly where works areas are located in close proximity to overland flow paths and watercourses.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1. Construction phase

5.1.1. Flood impact management

During construction of culvert replacements, or works within the floodplain or low drainage points, the contractor should be aware of the flood risk in these locations. The CEMP should clearly outline flood depths at these construction locations where available.

The CEMP should include procedures for managing construction in the event of heavy rain, and flood situations. This shall include:

- Identification of stockpile and storage areas outside of drainage lines and watercourse areas
- Consideration of the flood risk of temporary diversions from stockpiles or other temporary structures on adjoining land
- Flood depth and associated flood risk at construction locations
- Warning systems (BOM will provide flood warnings for the Namoi River in Narrabri).
- Triggers for changes to construction practice, site preparation and machinery and personal evacuation.
- Plans for machinery and personnel evacuation

5.1.2. Water quality management

An Erosion and Sediment Control Plan, or Soil and Water Management Plan should be prepared for the proposal, in particular, addressing areas where track formation earthworks are required. Issues to consider include:

- Soil types and potential for dispersion and loss of structure;
- Proximity to overland flow paths and watercourses;
- Locations of stockpile areas; and
- Machinery access points.

Chemical and hydrocarbon storage and spill management shall be incorporated into the Construction Environmental Management Plan for the proposal.

5.2. Operational phase

5.2.1. Flood impact management

5.2.1.1. Section 1

Works on the railway in Section 1 are above the 1% AEP flood level and will have no hydraulic impact. Culvert replacements at drainage low points will have minor temporary hydraulic impacts during culvert replacement. The capacity of any culvert replacement should equal or improve on existing hydraulic capacity considering both opening area and roughness. Culvert inverts should be maintained, or lowered.

5.2.1.2. Section 2

The existing flood behaviour over the Narrabri Township means that small changes in surface levels over the floodplain, particularly for linear structures such as rail embankments that traverse the floodplain, will have an impact on water movement and flood levels.

In this case, the upgrade of the railway will alter rail levels and in areas require slight raising to allow for subgrade improvements, additional ballast and new concrete sleepers.

Conservative allowances of 100mm of track raising within the 1% AEP flood area have been modelled to predict worst case impacts from the proposed works

There are limited mitigation measures available to offset the impact of raising the railway due to the existing extent of flood impact in the floodplain and the nature of the proposal, within an existing rail corridor with established drainage infrastructure.

Narrabri Council are currently preparing a floodplain risk management plan. The plan will include an option to provide flood protection to the southern and eastern parts of the town, the same areas where the rail upgrades are proposed. This flood protection option would mitigate the potential impacts as outlined in this assessment as upstream diversions and increased channel capacity are proposed. There is still significant consultation and planning required for this option to be adopted by Council, then implemented, and this is unlikely within the next 12 months.

The proposal would continue to be refined during detailed design to not worsen flood characteristics, where practicable. This will include further subgrade investigations during detailed design of the proposal, to limit the need for raising track levels within the 1% AEP flood extents.

Further flood modelling will be undertaken during detailed design to confirm compliance with QDLs outlined in this assessment. Where it is not practicable or feasible to satisfy the QDLs and non-compliance with the QDLs would change the flood hazard category to residential land (as defined in Appendix L of the NSW Government Floodplain Development Manual 2005), flood mitigation measures shall be developed in consultation with the affected property, structure and infrastructure owners, the SES, and the Narrabri Council.

A flood verification report shall also be prepared by an appropriately qualified person within an agreed number of months of commencement of construction. The flood verification report shall detail the final design of the proposal and the results of the revised modelling. The flood verification report must confirm any increase to the flood hazard category to residential land as a result of non-compliance with the QDLs and, where required, outline the mitigation measures to be implemented to reduce future impacts of flooding, including timing and responsibilities for implementation.

REFERENCES

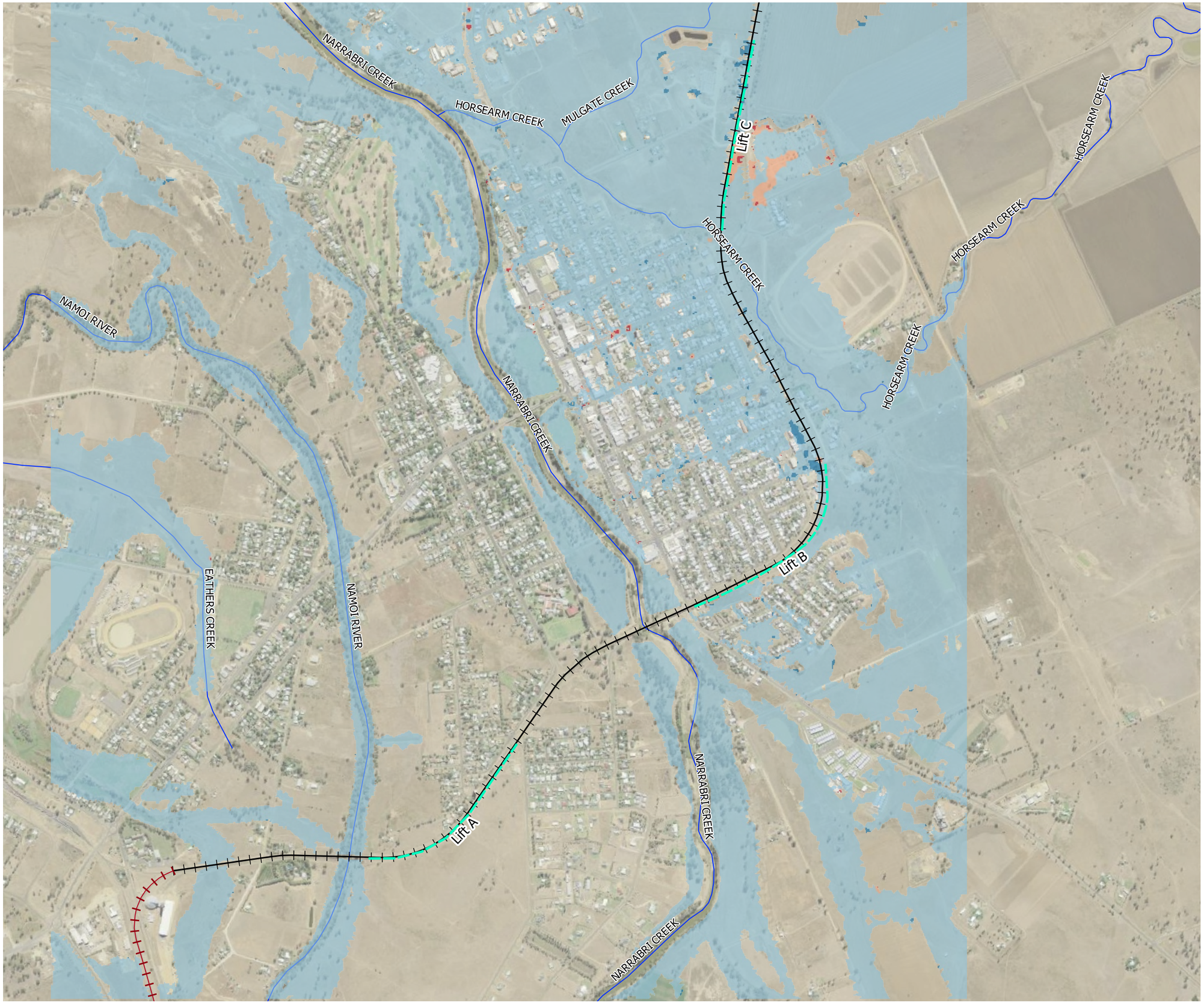
ARTC, (2020) *Narromine to Narrabri Inland Rail Flooding and Hydrology Impact Assessment*

DIPNR (2005) *NSW Floodplain Development Manual*

Landcom (2004), *Managing Urban stormwater: soils and construction - vol 1*

WRM, (2016), *Narrabri Flood Study, Narrabri Shire Council*

APPENDIX A



1% AEP Regional flood velocity impact

Legend

Railway Modifications

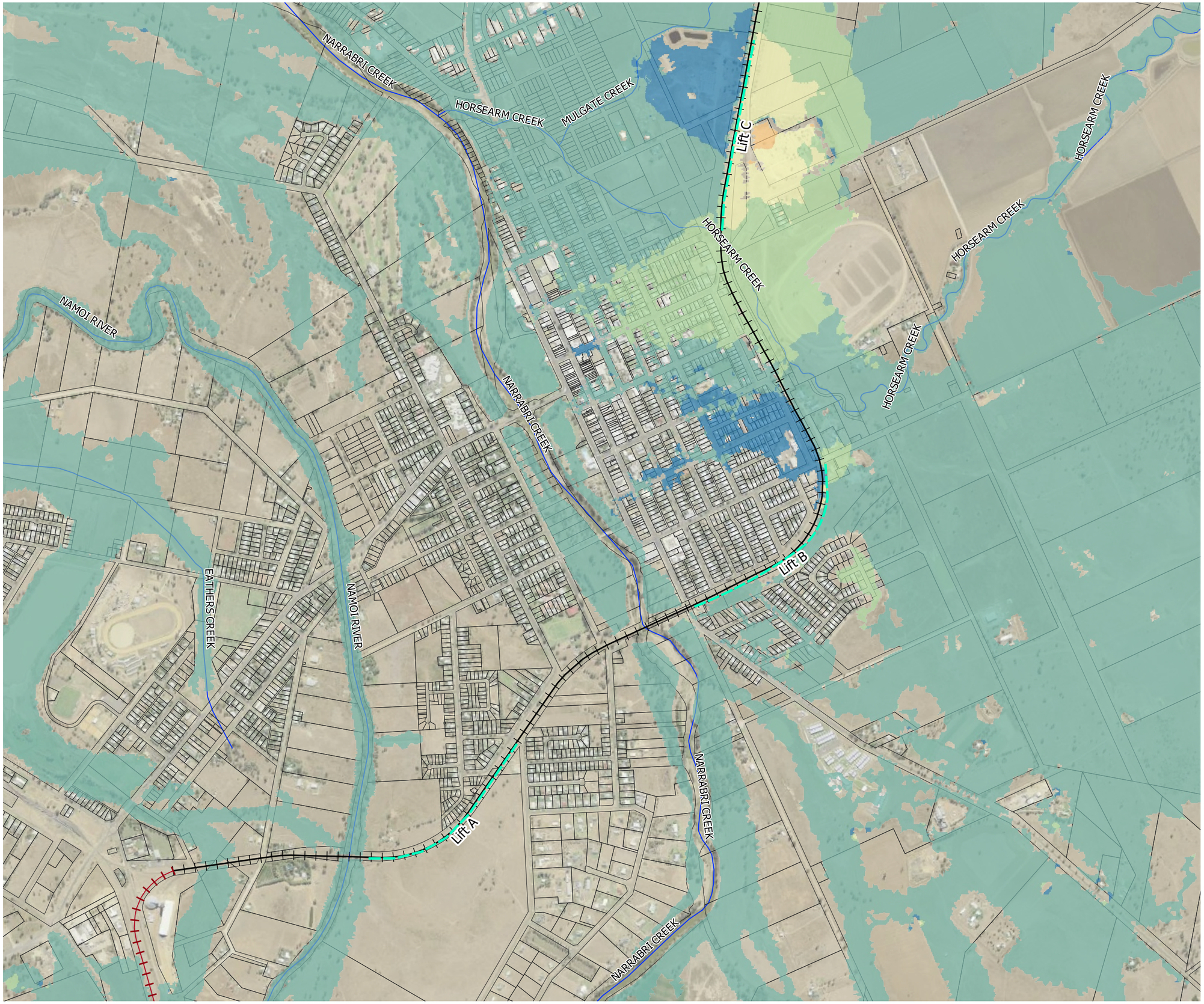
- Section 1
- Section 2

Velcocity change (m/s)

- <= -.05
- -.05 - 0
- 0 - .05
- .05 - .1
- > .1

0 500 1000 m

southeast
engineering+environmental



1% AEP Local flood impact

Legend

Railway Modifications

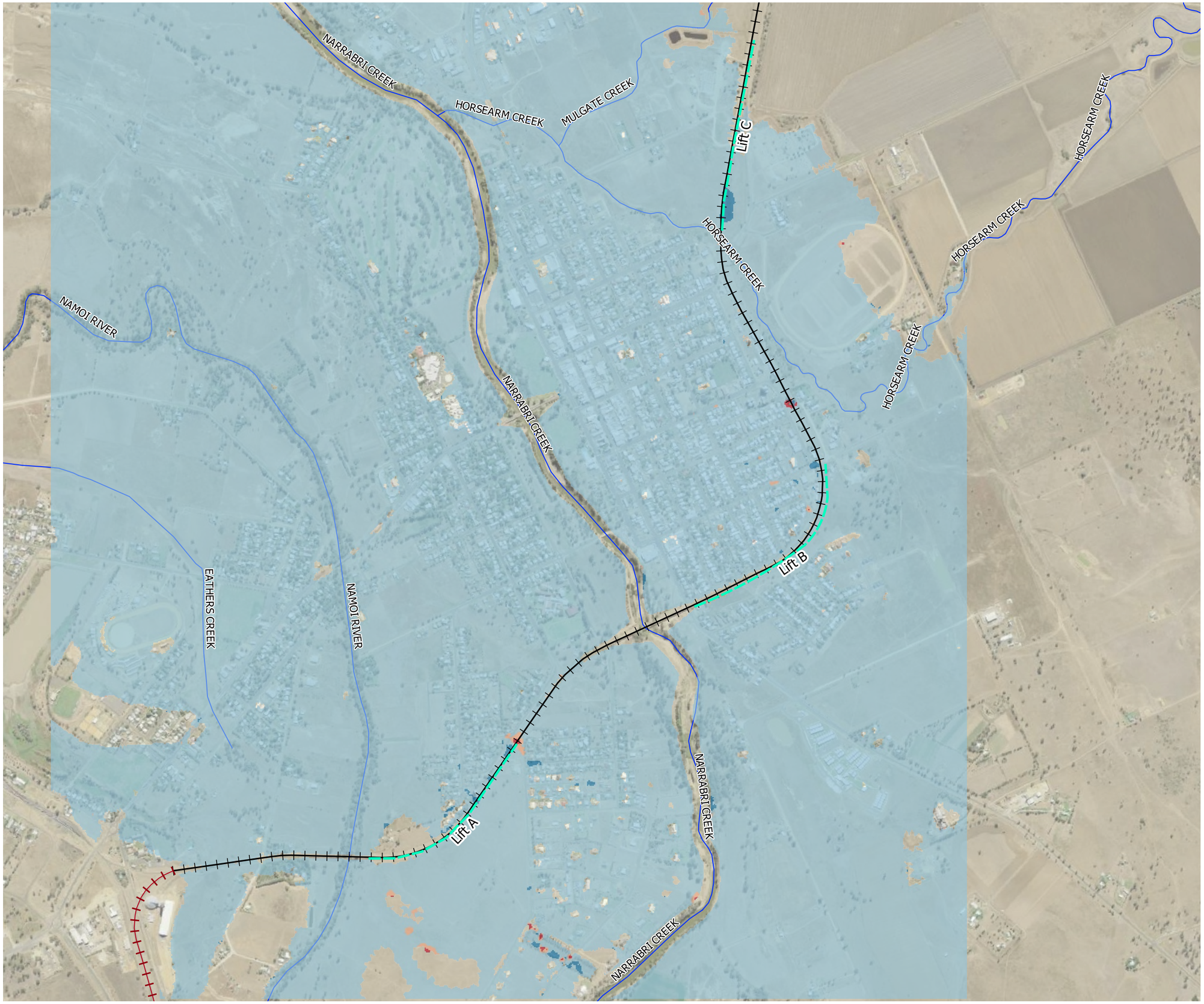
- Section 1
- Section 2

1% AEP Flood Depth Difference (m)

- <= -.01
- -.01 - .01
- .01 - .05
- .05 - .1
- .1 - .5
- > .5

0 500 1000 m

southeast
engineering+environmental



1% AEP Regional flood velocity impact

Legend

Railway Modifications

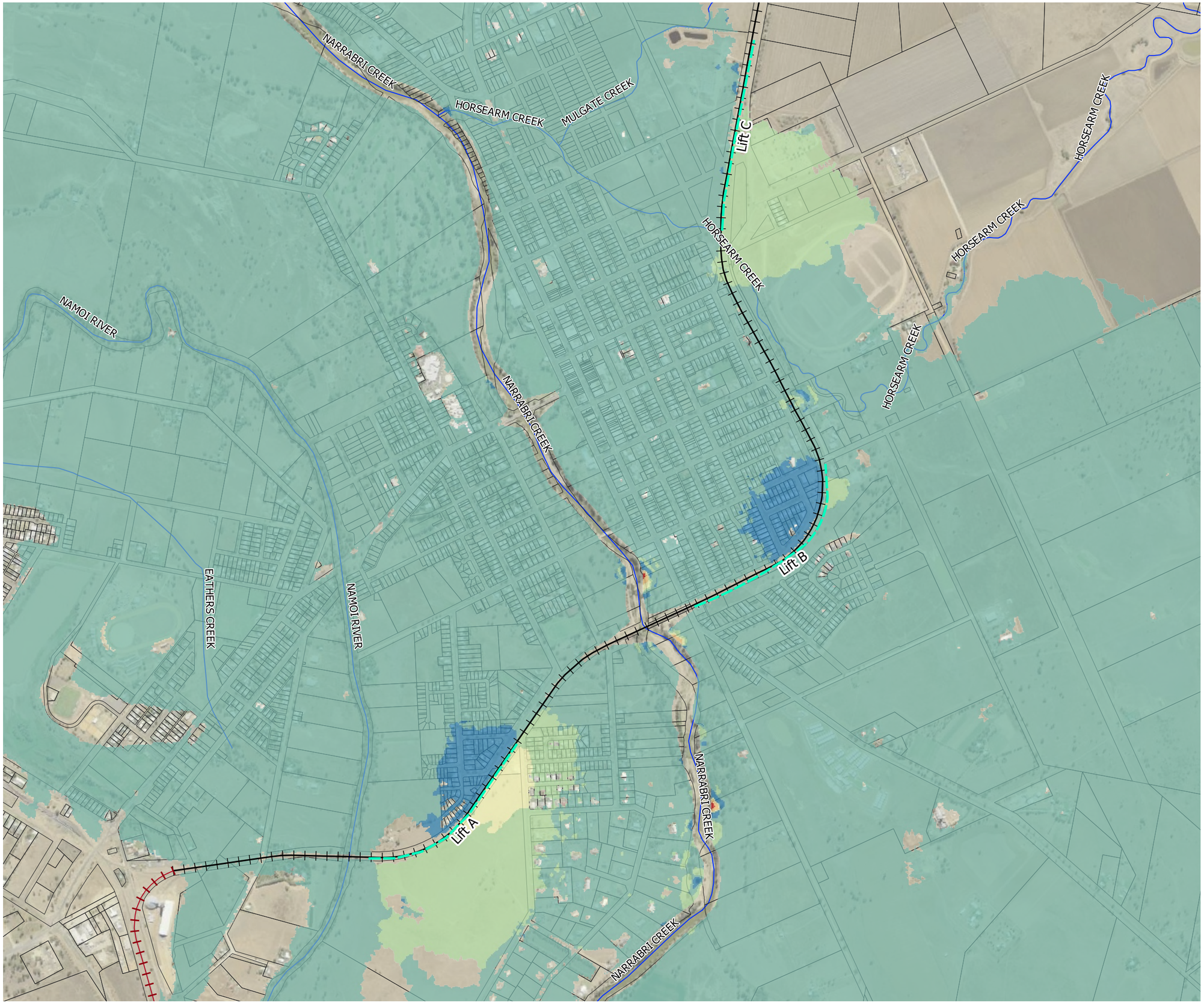
- Section 1
- Section 2

Velcocity change (m/s)

- <= -.05
- -.05 - 0
- 0 - .05
- .05 - .1
- > .1

0 500 1000 m

southeast
engineering+environmental



1% AEP Regional flood impact

Legend

Railway Modifications

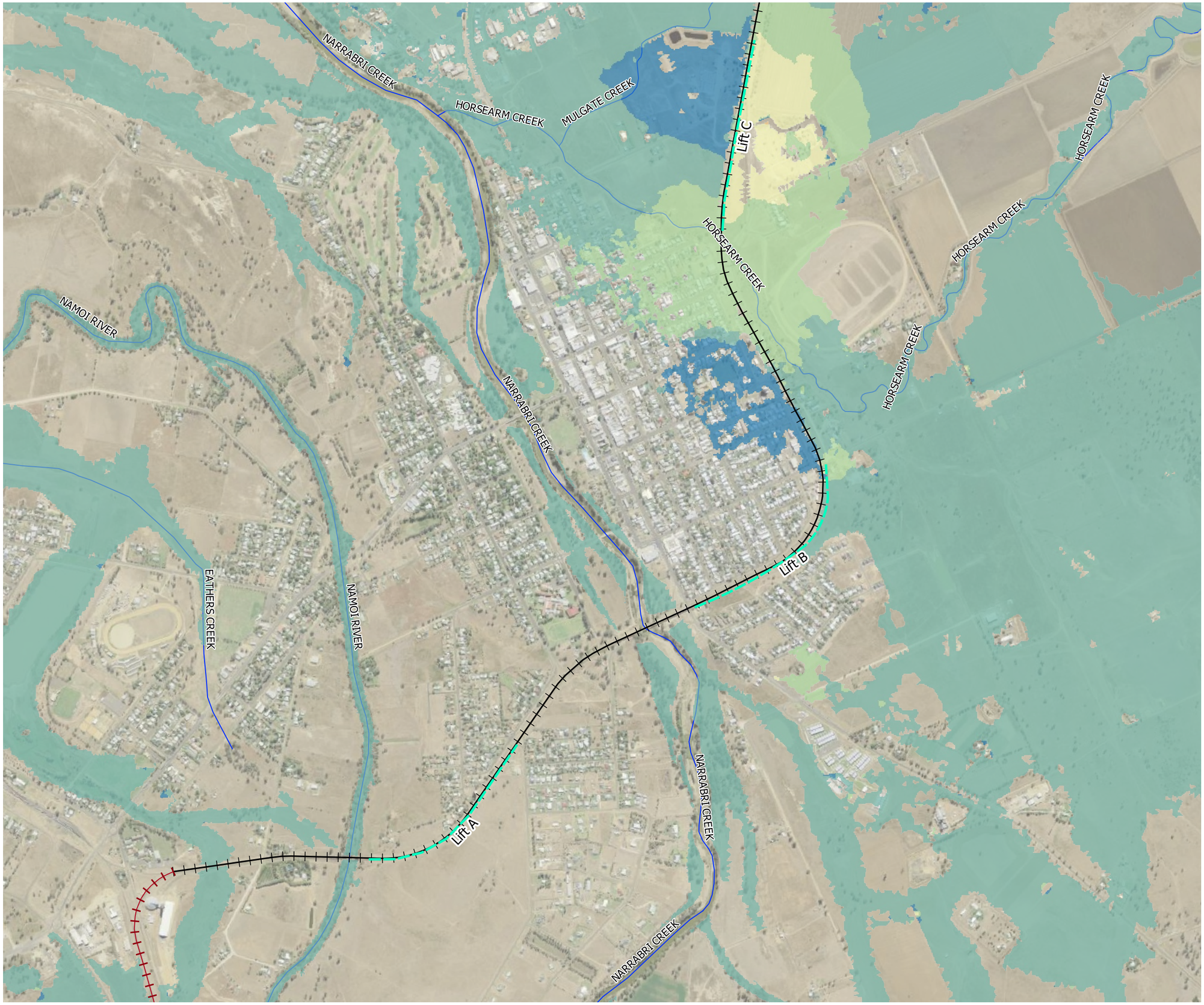
- Section 1
- Section 2

1% AEP Flood Depth Difference (m)

- <= -.01
- -.01 - .01
- .01 - .05
- .05 - .1
- .1 - .5
- > .5

0 500 1000 m

southeast
engineering+environmental



2% AEP Local flood impact

Legend

Railway Modifications

- Section 1
- Section 2

2% AEP Flood Depth Difference (m)

- <= -.01
- -.01 - .01
- .01 - .05
- .05 - .1
- .1 - .5
- > .5

0 500 1000 m

southeast
engineering+environmental

2% AEP Regional flood impact

Legend

Railway Modifications

- Section 1
- Section 2

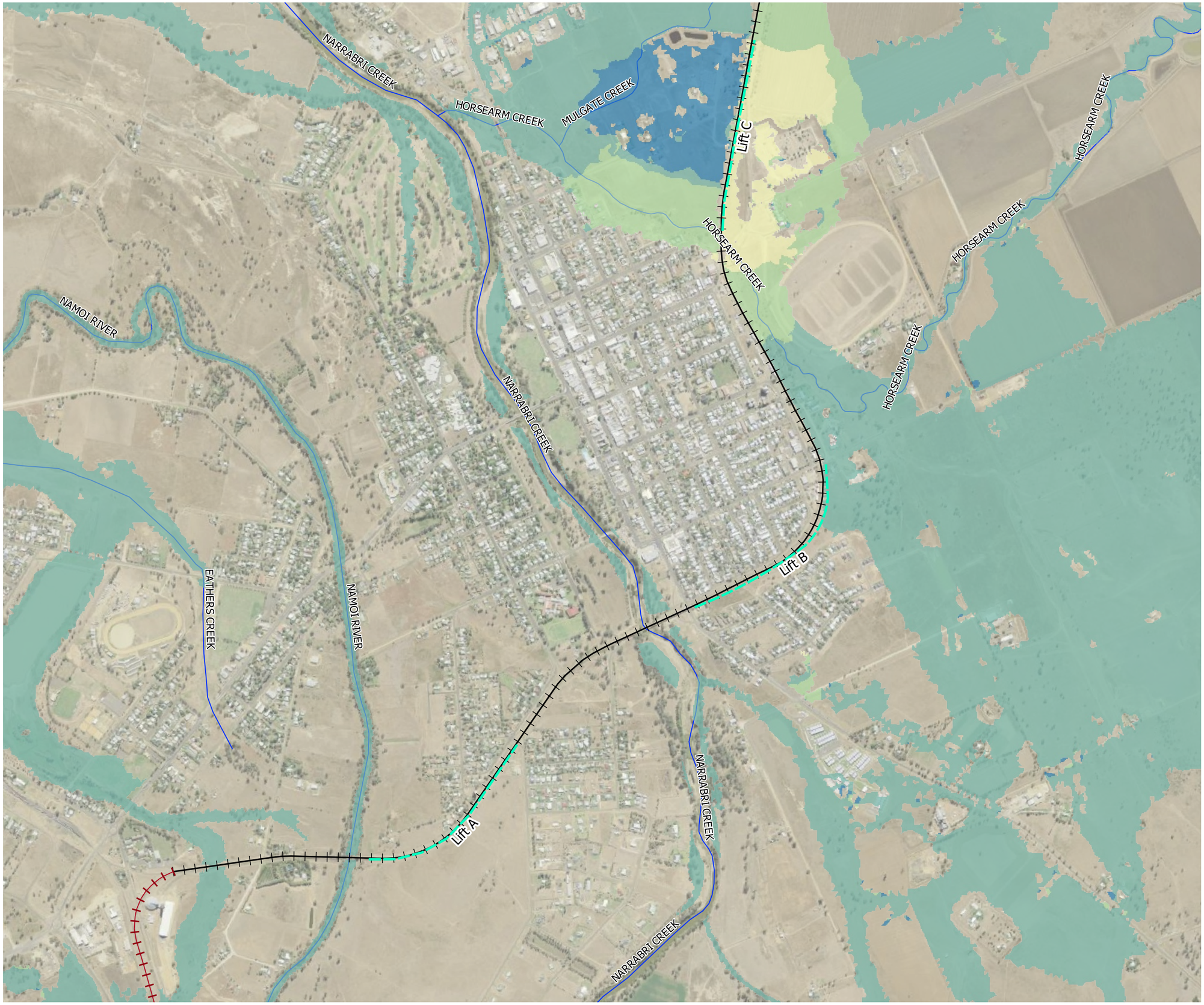
2% AEP Flood Depth Difference (m)

- <= -.01
- -.01 - .01
- .01 - .05
- .05 - .1
- .1 - .5
- > .5

0 500 1000 m

NARRABRI CREEK
HORSEARM CREEK
MULGATE CREEK
Lift C
HORSEARM CREEK
HORSEARM CREEK
HORSEARM CREEK
NAMOI RIVER
NARRABRI CREEK
Lift B
EATHERS CREEK
NAMOI RIVER
Lift A
NARRABRI CREEK
NARRABRI CREEK

southeast
engineering+environmental



5% AEP Local flood impact

Legend

Railway Modifications

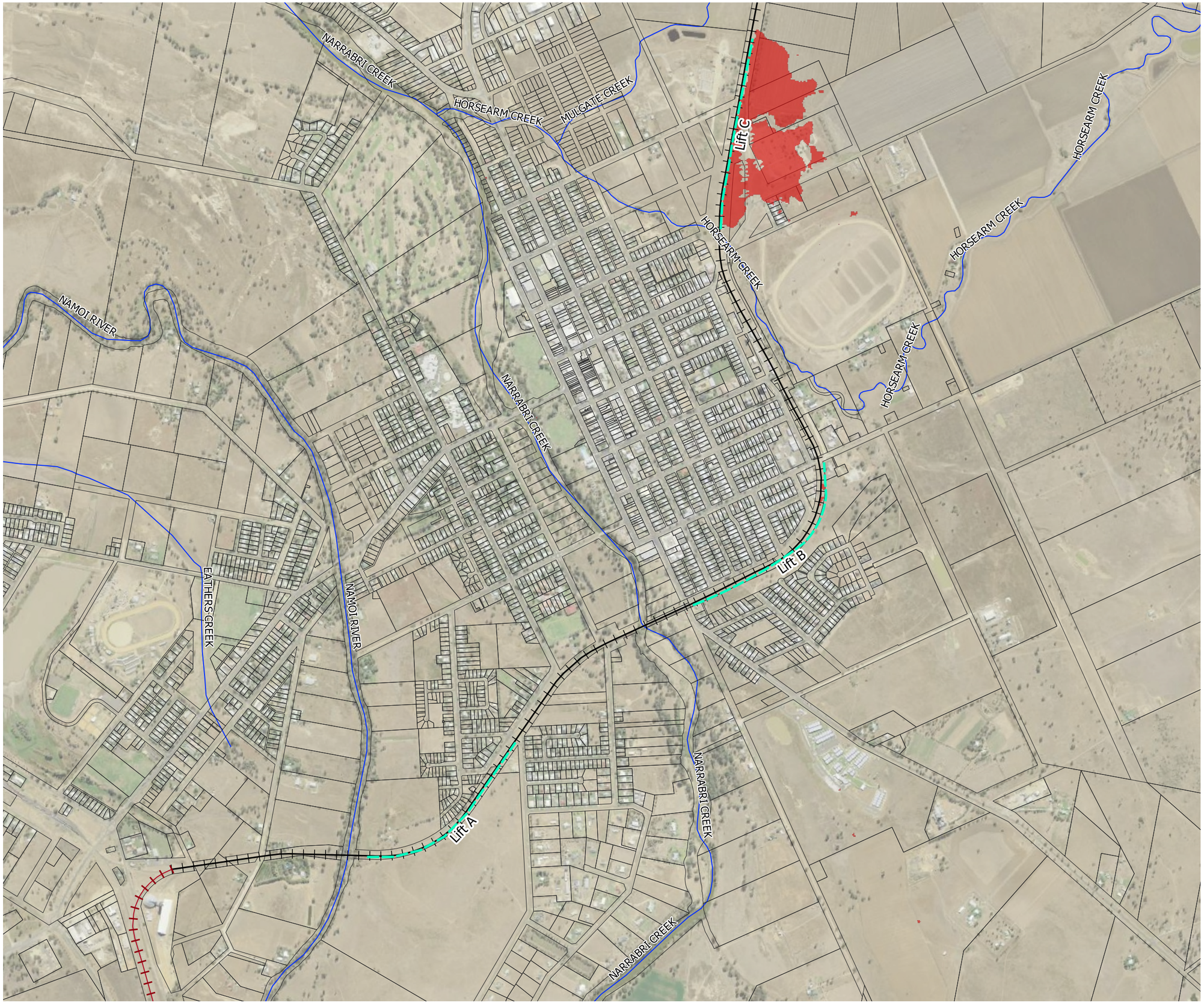
- Section 1
- Section 2

5% AEP Flood Depth Difference (m)

- <= -.01
- -.01 - .01
- .01 - .05
- .05 - .1
- .1 - .5
- > .5

0 500 1000 m

southeast
engineering+environmental



1% AEP Local flood impact on Council Infrastructure

Legend

Railway Modifications

- Section 1
- Section 2

>50mm increase in local 1% AEP flood

0 500 1000 m

southeast
engineering+environmental

1% AEP Local flood impact on Council Infrastructure

Legend

Railway Modifications

Section 1

Section 2

>50mm increase in regional 1% AEP flood

0 500 1000 m

NARRABRI CREEK
HORSEARM CREEK
MULGATE CREEK
Lift C
HORSEARM CREEK
HORSEARM CREEK
HORSEARM CREEK
HORSEARM CREEK
NAMOI RIVER
NARRABRI CREEK
EATHERS CREEK
NAMOI RIVER
Lift B
Lift A
NARRABRI CREEK
NARRABRI CREEK

southeast
engineering+environmental