REDUCING THE IMPACT OF ROAD CROSSINGS ON AQUATIC HABITAT IN COASTAL WATERWAYS – NORTHERN RIVERS, NSW

REPORT TO THE NEW SOUTH WALES ENVIRONMENTAL TRUST

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Environmental TRUST

Published by NSW Department of Primary Industries

This report should be cited as:

NSW Department of Primary Industries (2006) *Reducing the impact of road crossings on aquatic habitat in coastal waterways – Northern Rivers, NSW.* Report to the New South Wales Environmental Trust. NSW Department of Primary Industries, Wollongbar, NSW.

ISBN 0 7347 1701 6

Cover photo: Two-celled piped causeway over unnamed tributary on Tunnel Road, Stokers Siding (Dunbible Creek Subcatchment).

EXECUTIVE SUMMARY

The highly modified nature of catchments in the Northern Rivers region presents many challenges in the way we protect the environment and manage its natural resources. In particular, setting goals and targets for aquatic habitat conservation in the region requires clear understanding of the extent of aquatic habitat degradation and where we can achieve the best outcomes.

Within lotic systems, native Australian fish have evolved to be reliant on a variety of habitat types to complete their life cycle, thus requiring free movement within rivers and streams and between estuarine and freshwater environments. Unfortunately, riverine connectivity has been severely disrupted within Australia through the installation of numerous instream structures that impede the natural flow regime and act as physical, hydrological, and behavioural barriers to fish movement. Until recently, management of fish passage barriers has centred on the effects of weirs and dams, while little attention has been given to the extent of the impact of poorly designed road crossings.

Waterway crossings can affect the health of aquatic habitat and fish populations in several ways. Structures such as causeways and pipe and box culverts can prevent fish passage due to excessive headloss (> 100 mm), increased flow velocities, and shallow flow depths (< 100 mm) that segregate upstream and downstream populations and habitats. Road crossings are also linked to increased sediment loads from point (unsealed roads) and diffuse sources (adjacent floodplains and slopes). Moreover, some structures can adversely affect fish by altering natural flow patterns, disrupting localised erosion and sedimentation processes, and affecting instream habitat condition.

Although current policy within NSW legislates for the incorporation of fish passage into the design of all new instream structures, a legacy of poorly designed road crossings exists that detrimentally affects fish migration. As a result, the NSW Department of Primary Industries (NSW DPI Fisheries) initiated a comprehensive investigation funded by the NSW Environmental Trust to specifically address the impact of road crossings upon fish passage and stream connectivity in coastal catchments. Detailed environmental assessments were conducted for over 2500 waterway crossings in the Northern Rivers Catchment Management Authority region, with identified barriers prioritised in terms of their impact on aquatic biodiversity, benefits should the structure be remediated, and the ease of structural remediation. Additionally, management recommendations were put forth to remediate the barrier type(s) at each structure. The main findings from the investigation were:

- 1500 bridges were assessed, none of which were barriers to migrating fish species;
- 524 (20%) crossings were identified as obstructions to fish passage, with the majority of barriers being located in the Northern Rivers subregion;
- Pipe culvert crossings were the most common structure inhibiting fish passage in the region (51% of obstructions assessed);
- Causeways (28%) and box culvert (18%) crossings were also commonly found to restrict fish passage;
- Excessive headloss (i.e. > 100 mm) was the most prevalent barrier type recorded at waterway crossings (64%), with a mean headloss of 500 mm being recorded for barrier structures across the region;
- High flow velocities (51%) and shallow flow depth (38%) were frequently observed at crossing barriers. Moreover, multiple barriers types (e.g. headloss, high velocity, and shallow flow depth) were commonly recorded at a single site over the full range of hydrological flows; and
- Grazing (74%) was the primary landuse recorded in the Northern Rivers CMA region, with crossings located in National Parks, State Forest, and rural (non-grazing) settings accounting for less than 25% of barriers identified.

A ranking scheme for waterway crossing sites was developed to determine remediation priorities for the improvement of fish passage in the region. Crossings were ranked as “high”, “medium-high”, “medium”, “medium-low” or “low” priorities, with 63 high priority and 38 medium-high priority structures identified – the majority of which were found within the

Northern Rivers subregion. Remediation recommendations for barriers identified in the report included:

- Maintenance of sites (e.g. removal of sediment and debris blockages, improved floodgate management);
- Modification of structures (e.g. retrofitting low-flow channels, installing fishways);
- Complete replacement of structures (e.g. causeways replaced with bridges); and
- Permanent removal of redundant obsolete structures.

Demonstration sites were developed within each of the subregions of the Northern Rivers for the purpose of illustrating best-practice techniques associated with the design, construction, and remediation of waterway crossings. Through the remediation of these barriers, NSW DPI Fisheries (Conservation and Aquaculture) aimed to increase stream connectivity for native fish, as well as to improve the safety and reliability of the waterway crossings during minor river rises for resident landholders. The primary outcomes of the demonstration site project were:

- Remediation of four road crossing barriers;
- Improved stream connectivity to 17 km of upstream habitat;
- Education of relevant road management authorities concerning the influence of waterway crossings on instream habitat and biota;
- Improved safety and reliability of crossing for local residents at Tunnel Road and Kungala Road following flood inundation;
- Contribution from local councils totalling $214,250 relative to $25,500 provided through the Environmental Trust; and
- Demonstration of best-practice techniques for road crossing remediation during the planning, design, and construction phases of the projects.

The results from this investigation, including management recommendations and remediation case studies, are discussed herein.

ACKNOWLEDGEMENTS

This project was funded through the Environmental Trust Program and undertaken by the Department of Primary Industries (Fisheries Management).

The NSW DPI Aquatic Habitat Rehabilitation Program Team managed the project including research, fieldwork and report preparation. Personnel involved in data collection, data analysis and report writing were: Matthew Gordos, Charlotte Grove, Sarah McGirr, Natalie McCarthy, and Scott Nichols. Peter King assisted with the Mid North Coast subregion road crossing audit for which we are greatly indebted. In addition valuable assistance was provided by regional NSW DPI staff, including Marcus Riches (Senior Fisheries Conservation Manager) and Patrick Dwyer (Conservation Fisheries Manager).

The Northern Rivers Catchment Management Authority (NRCMA), Department of Natural Resources (DNR) and local government councils provided extensive advice and assessment toward the project for which we are grateful. Special thanks go to Peter Boyd, Tony Broderick, Peter Menzies, Peter Corlis, Sharon Cunial, and Stuart Johnson (NRCMA), Paul Busmanis and Malcolm Fox (Ballina Shire Council), Michael King, Bob Fyfe, and Colin Stewart (Byron Shire Council), Graham Kennett, Graham Love, and Frank Winter (Kyogle Shire Council), Charles Mitchell (Lismore City Council), Ray Medhurst and Peter Lowndes (Richmond Valley Council), Bob Messingham and Steve Paff (Tweed Shire Council), Warrick Knight (Bellingen Shire Council), Bret Nelson and Simon Thorn (Coffs Harbour City Council), John Howell, Bob Pavitt, Richard Roper, and Greg Lowcock (Clarence Valley Council), Malcolm Donnelly and Barry Jones (Severn Glen Innes Shire Council), Craig Townsend, Peter O'Shannessy, and Greg Tory (Guyra Shire Council), Tony Larkham (Tenterfield Shire Council), Alan Harvey and Chris Peckham (Armidale-Dumaresq Shire Council), Peter Jenkins (Hastings Council), Tom Vermeulen and Alex Pelser (Kempsey Shire Council), Noel Chapman (Nambucca Shire Council), Robert Bell (Uralla Shire Council), and Steve Roberts (Walcha Shire Council).

TABLE OF CONTENTS

1. INTRODUCTION

The following report outlines the findings collated within the Northern Rivers Catchment Management Authority (NRCMA) region for the project entitled "*Reducing the impact of road crossings on environmental flows, water quality and fish passage*". The project was managed by NSW Department of Primary Industries and funded by the NSW Environmental Trust (Contract No. ET-H08030).

1.1 Project aims and objectives

The primary objective of the project was to inform relevant stakeholders (e.g. local & state Government, Road and Traffic Authority (RTA), NRCMA, and landholders) of the impacts of road crossings on fish passage, water quality, and environmental flows in the Northern Rivers region, and more importantly to provide direction for improved management. The project was developed and managed to deliver the following outcomes:

- Development of a digital database and audit format to record barriers to fish passage;
- Completion of a detailed inventory of road crossing barriers;
- Production of a report to identify the location and prioritisation of road crossings that form barriers to fish passage, including recommendations for the remediation of these barriers; and
- Establishment of three demonstration sites within the NRCMA, with the aim to instruct relevant road management authorities on best-practice techniques for the remediation of fish passage.

1.2 Project Scope and Setting

This project was initiated in December 2003 by DPI (Fisheries, Conservation and Aquaculture) (formerly NSW Fisheries) to address knowledge gaps regarding the impacts of road crossings on fish passage and associated water quality parameters within the (former) twelve coastal Catchment Management Board (CMB) areas of NSW. The study builds upon previous NSW DPI Fisheries (Conservation and Aquaculture) investigations that have assessed fish passage barriers associated with weirs, floodgates, tidal restrictions, and road crossings in coastal NSW (see Williams *et al.* 1996; Pethebridge *et al.* 1998; and Thorncraft and Harris 2000), and is underpinned by recommendations put forth in the NSW Policy & Guidelines for Waterway Crossings (Fairfull and Witheridge 2003).

Subsequent changes in Natural Resource Management within New South Wales have seen the twelve coastal CMB areas merge into five Catchment Management Authorities. The NRCMA incorporates the former Northern Rivers CMB (NR subregion), Upper North Coast CMB (UNC subregion) and Mid North Coast CMB (MNC subregion); with boundaries extending from John River south of Port Macquarie to the Queensland border and including all eastern draining subcatchments. The geographical setting of each zone and the aquatic habitat issues relating to these areas are outlined in Section 2.4. For ease of reporting, road crossings assessed for this project were prioritised within the NRCMA as a whole before being summarised by subregion.

2. BACKGROUND

2.1 Fish passage in NSW

Stream connectivity and habitat diversity are critical components of healthy rivers. Within these systems, native fish have evolved to be reliant on a variety of habitat types to complete their life cycle, thus requiring free movement within rivers and streams and between estuarine and freshwater environments. In southeastern Australia, approximately 70 percent of coastal fish species migrate as part of their lifecycles (Fairfull and Witheridge 2003), including key

species such as Australian bass, sea mullet, short finned and long-finned eels, freshwater mullet and freshwater herring.

Impeding fish passage through the construction of dams, weirs, floodgates and waterway crossings can negatively impact native fish by:

- interrupting spawning or seasonal migrations;
- restricting access to preferred habitat, available food resources and breeding partners;
- reducing genetic flow between populations;
- increasing susceptibility to predation and disease through aggregation below barriers;
- fragmenting previously continuous communities; and
- disrupting downstream movement of adults and impeding larval drift through the creation of still water (lentic) environments.

Many aquatic species have evolved life history strategies in direct response to natural flow regimes (Bunn and Arthington, 2002). For example, fluctuations in water flow and aquatic temperature provide valuable triggers to initiate spawning for certain species such as the golden perch (*Macquaria ambiguae*) and short-finned eel (*Anguilla australis*). Natural flow regimes are also essential in maintaining connectivity between upstream and downstream reaches (longitudinal connectivity) and adjacent riparian and floodplain habitats (lateral connectivity).

Instream structures that span the whole channel (e.g. weirs and causeways) can impede natural flows and act as physical and hydrological barriers to fish movement, thus isolating upstream and downstream habitats (Williams *et al.* 1996; Pethebridge *et al.* 1998; Thorncraft and Harris 2000; and Fairfull and Witheridge 2003). Additionally, levees, floodgates and other off-stream structures (e.g. sediment basins and gross pollutant traps) can disrupt lateral connectivity by isolating seasonal or ephemeral habitats on floodplains and wetlands. For fish that have large-scale migrations in their life cycles, particularly anadromous (marine-to-freshwater) and catadromous (freshwater-to-marine) species, preventing fish passage can cause local extinctions above barriers and reduce population numbers downstream (Thorncraft and Harris 2000).

The cumulative effect of instream barriers has been identified as a key threatening process to the overall health of native fish populations in Australia (Fairfull and Witheridge 2003). As a result, NSW DPI, under sections 218-220 of the Fisheries Management Act 1994 (FM Act), has the responsibility to ensure that the construction of any new road crossing or the modification of an existing structure does not deleteriously impact upon resident fish populations. Fairfull and Witheridge (2003) and NSW Fisheries (2003) provide a comprehensive overview of the legislative and policy requirements that must be observed during the planning, design, and construction of waterway crossings in NSW. These legislative tools, and associated NSW Government policies on fish passage, act to regulate the construction of structures that can impede fish passage. In addition, reinstating connectivity between upstream and downstream habitats and adjacent riparian and floodplain areas through the remediation of fish passage barriers has become an essential part of aquatic habitat management and rehabilitation programs in NSW.

2.2 Waterway crossings as barriers to fish passage

Waterway crossings can act as barriers to fish passage by creating a physical blockage, a hydrological barrier, or by forming artificial conditions that act as behavioural barriers to fish. The impact of road crossings on fish passage will vary depending on a) the design of the structure; b) the nature of flow, debris and sediment movement in the waterway; and c) the swimming capabilities of resident fish.

In general, **bridges** and **arch structures** promote natural, unimpeded stream flow, allowing the free movement of fish underneath the structure during a wide range of hydrological conditions (Fairfull and Witheridge, 2003). However, bridges that are built too low, or whose

piers and footings constrict the channel, can affect hydrological flows and aquatic habitat conditions (e.g. excessive velocity and turbulence; Fig. 2.1A).

Culverts are waterway crossings with round or box-shaped cells, designed to convey flow beneath the roadway (Fig. 2.1B-C). Culverts can result in significant modification to channel bed form and flow conditions due to increased flow velocities, turbulence and reduced flow depth through the structure. Warren and Pardew (1998) observed that fish passage at waterway crossings was inversely related to flow velocity, in addition to culvert structures exhibiting the highest velocities of crossing types assessed. If a piped or box culvert displays excessive headloss (i.e. > 100 mm) across the outlet, the crossing also acts as a physical barrier to migrating fish until structural drownout occurs. High water velocities and excessive headloss (otherwise known as the waterfall effect) are of particular importance to Australian native fish, which are known for their poor swimming performance compared to their northern hempisphere counterparts (Kapitzke and Patterson, 2002). Finally, culverts can further restrict fish movement due to insufficient lighting within culvert cells, and from debris build-up at the opening which physically blocks fish passage.

Low-level crossings such as **causeways** are generally constructed at or near bed-level and are designed to convey water across the road surface as sheet flow (Fig. 2.1D). Although causeways drownout relatively quickly, fish passage is often obstructed due to excessive headloss and shallow flow depth (< 100 mm) across the structure. In some cases, causeways may possess low-flow pipes beneath the roadway that can further restrict fish passage as outlined above for piped culverts. Alternatively, **fords** are formed directly on the

Figure 2.1: Waterway crossing barriers to migrating fish include **A)** bridges, **B)** pipe culverts, **C)** box culverts and **D)** causeway. Barrier types demonstrated in the photos include debris accumulation (**A**), excessive headloss (**B-D**), shallow flow depths (**B-D**), and excessive water velocities (**B** – following minor river rises).

channel bed (i.e. “wet crossing”), which eliminates the waterfall effect observed on the downstream side of causeways. However, ford designs can potentially impede fish passage during low flow periods if the crossing promotes shallow flow depths across the structure.

In tidal reaches, waterway crossings (especially those over drains) commonly incorporate **floodgates** that restrict fish passage between flood events. Floodgates include hinge-flap, winch, sluice, and auto-tidal designs. Between flooding, floodgates are generally maintained in the closed position thus ensuring a complete blockage to fish migration between estuaries and tidal tributaries. Although recorded during the investigation, floodgates have been treated as a separate management issue and thus were not included in the road crossing audit nor prioritisation.

2.3 Further impacts of road crossings

In addition to preventing fish passage, road crossings can also deleteriously affect water quality, flow regimes, and instream channel processes. Unsealed roads have been identified as significant sources of runoff and sedimentation, with the extent to which water quality is affected being a function of the degree of hydrologic connectivity between sediment sources and the stream network (Takken 2004; Farabi 2004). An additional compounding factor is Horton overland flow (Horton 1933), where the compaction of road surface material reduces water absorption capacity which facilitates the channelisation of runoff and its associated sediment load towards waterways. As a result, waterway crossings are a significant sediment delivery pathway where, in the absence of adequate erosion and sedimentation controls (e.g. diversion drainage, vegetated swales or sediment basins), runoff generated from road surfaces is carried directly to streams. Moreover, road maintenance procedures can affect the rate to which sediment is delivered to streams, particularly when sediment spoil from the grading of unsealed roads is left to the side of the road within existing drainage lines.

Increased sediments in the waterway can lead to: elevated turbidity levels (suspended sediments); limited light penetration; excessive sediment deposition; smothering of aquatic habitats (e.g. riffle zones); and increased toxicant loads (see Wood and Armitage, 1997 for a review). The effects of increased sediment input on water quality are further exacerbated in areas of high anthropogenic activity, where toxicants bound to soil particles can readily enter the waterway. Storm water runoff from roads, industrial and urban environments; and runoff from logged forestry land or areas cleared for urban development are also renowned for their adverse effect on water quality.

Road crossings can also impact on waterways by altering natural flow patterns, disrupting localized erosion and sedimentation processes, and affecting instream habitat condition. These impacts are most evident with structures such as raised causeways that produce an upstream weir-pool effect, whereby the structure creates a lentic (still) stream environment that can impede larval drift. The prevalence of such structures can reduce the capacity of eggs and larvae to reach preferred nursery habitat thereby reducing cohort recruitment. Still-water environments also promote sediment accumulation, which in turn increases the potential for algal blooms. Moreover, exotic species such as carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), gambusia (*Gambusia holbrooki*), and redfin perch (*Perca fluviatilis*), that are considered habitat generalists, thrive in such disturbed habitats compared to native fish which are habitat specialists. As a consequence, in flow-modified waterways native fish fauna diversity, abundance, breeding success and ratio to introduced species is reduced compared to less flow-modified streams (Gehrke and Harris, 2001).

Road crossings can also adversely affect terrestrial species. As with fish, land-based animals need to move between habitats to feed, breed, and avoid predation and competition. Riverine corridors are used as natural byways for the movement of many land-based animals including mammals, reptiles and amphibians. Road crossings that are designed without terrestrial passage components effectively isolate upstream and downstream riparian habitats. Crossings with raised and barricaded approaches prevent terrestrial species from following streams over the road surface. Low bridges and culverts without accessible vegetated banks or dry cells prevent land-based animals from moving under road crossings. Lack of riparian

connectivity, including cleared easements adjacent to roadways at road crossings, can also deter animals from venturing across roads to follow waterways.

The following investigation primarily focuses on the impacts of road crossings on stream connectivity in the Northern Rivers region. However, deleterious impacts such as those listed above were also considered in the assessment process.

2.4 Regional Setting and Landuse

The Northern Rivers Catchment Management Authority (NRCMA) area covers nearly 50,000 km^2 and takes in all rivers that flow east into the Pacific Ocean from the Camden Haven River in the south to the Tweed River in the north (Fig. 2.2). The major rivers in the region are the Tweed, Brunswick, Richmond, Clarence, Bellinger, Nambucca, Macleay, and Hastings, with the catchments of these rivers commencing up to 160 km inland in the steep, eastern slopes of the Great Dividing Range.

Currently, over 550,000 people inhabit the Northern Rivers, with key population centres including Port Macquarie, Kempsey, Coffs Harbour, Grafton, Ballina, Lismore, Tweed Heads, and Armidale. However, with population levels increasing at over 2 % per annum, the North Coast of NSW is one of the States' fastest growing regions. As a consequence, natural resources in the region are under mounting strain as managers struggle to maintain sustainable practices in an environment of economic and population growth.

Within the North Coast Region is located six of Australia's World Heritage listed areas (including Dorrigo National Park, Border Ranges National Park, and Lord Howe Island Marine Park), as well as a multitude of smaller parks, nature reserves, rainforest remnants, and State Forests; all of which support rich terrestrial and aquatic ecosystems that are abundant in natural biodiversity. Furthermore, over 90,000 ha of zoned Marine Park extend off the coast, providing protection for a range of aquatic species and marine habitats. For reporting purposes, three geographic subregions have been identified to highlight catchment and sub-catchment issues and priorities: Northern Rivers, Upper North Coast, and Mid North Coast subregion (Fig. 2.2).

Northern Rivers Subregion

The Northern Rivers subregion is located in north-eastern New South Wales and encompasses the catchments of the Tweed, Brunswick and Richmond Rivers. The Tweed Catchment, with an area of 1326 km^2, includes the Tweed River and the subcatchments of the Oxley and Rous River. The Brunswick Catchment is approximately 274 km^2 and includes the coastal waterways of the Brunswick River, Marshalls Creek, Belongil Creek and Tallow Creek. The Richmond Catchment is approximately 7022 km^2 with a large coastal plain extending from Evans Head to Cape Byron, and includes the Wilsons River and North Creek subcatchments. Only a small percentage of waterways in the Northern Rivers subregion are regulated for irrigation and environmental flows, with the reaches downstream of Toonumbar Dam (capacity of 11,000 ML) in the Upper Richmond Catchment being an exception.

The Northern Rivers subregion is characterised by extensive forest networks that incorporate National Parks, State Forests, and numerous Nature Reserves. World Heritage Areas including the Border Ranges National Park, Mt Warning National Park, Nightcap National Park and Cambridge Plateau are of particular environmental significance. In addition, Cape Byron Marine Park is located off the Byron Bay coast where it extends over 22,700 hectares, providing protection for a range of marine habitats and aquatic species.

Land use varies across the region, and includes primary industries such as forestry, sugarcane, dairy, beef, horticulture, and relatively new industries including tea tree, macadamia, and coffee (DLWC, 2003). Additionally, commercial fishing (net hauling, mesh netting, fish trapping, handlining and hand gathering for primarily marine finfish as well as prawns and crustaceans) and aquaculture (principally oysters) are undertaken in the

Fig 2.2: The Northern Rivers CMA region exhibiting 3rd order and above water ways. Divisions shown from north to south are the Northern Rivers, Upper North Coast and Mid North Coast subregions.

estuaries and marine zone. The Northern Rivers subregion incorporates six local government areas (LGAs): Tweed, Byron, Ballina, Lismore, Richmond Valley, and Kyogle.

Upper North Coast Subregion

The Upper North Coast subregion extends from Yamba in the north to Urunga in the south, and includes the catchments of the Clarence River, Bellinger River and Coffs Harbour Waterways. The Clarence Catchment is 22,716 km^2 and comprises the Clarence River (the largest river on the east coast of NSW) and the main subcatchments of the Timbarra, Mann, Guy Fawkes, Nymboida and Orara Rivers. The Corindi, Sandon and Wooli Rivers are small coastal catchments which drain directly into the ocean. The 1119 km^2 Bellinger Catchment includes the Bellinger River to the north and the Kalang River in the south, while the Coffs Harbour Waterways are a series of 13 small coastal catchments near Coffs Harbour from Corindi River to Bundagaree Creek (508 km^2).

Nearly a third of all land in the Upper North Coast falls under National Park estate (e.g. Gibraltar Range, Nymboida, Guy Fawkes, and Dorrigo) or State Forests (e.g. Dalmorton, Chaelundi, and Kangaroo), contributing to the region's extensive forest network that supports high terrestrial and aquatic biodiversity. In addition, the Solitary Islands Marine Park is located off the Coffs Harbour coast and extends over 70,000 hectares, providing protection for a range of marine habitats and aquatic species.

Land use varies across the region and includes primary industries such as dairy and beef cattle grazing on the plateau; grazing, cropping and horticulture on the midlands and

tablelands; sugar cane and grazing on the coastal floodplains; banana plantations and forestry along the small coastal streams; and commercial fishing (primarily fin fish and crustaceans) and aquaculture (primarily oysters) in the estuaries and marine zone (DLWC 2003). The Clarence estuary includes a general estuary fishery and an estuary prawn trawl fishery, and is valued as the most important wild catch fishery in the state.

The Upper North Coast subregion incorporates eight LGAs: Kyogle, Tenterfield, Clarence Valley, Glen Innes, Guyra, Coffs Harbour, Bellingen, and parts of Nambucca.

Mid North Coast Subregion

The Mid North Coast subregion extends from Nambucca Heads in the north to Taree in the south, and includes the catchments of the Nambucca, Macleay, Hastings and Camden Haven Rivers. The Nambucca River discharges north of Macksville at Nambucca Heads and is one of the smaller north coast systems with a catchment area encompassing 1427 km^2 which includes the primary tributaries of Taylors Arm, Jasper Creek and Warrell Creek. The Macleay Catchment is a large coastal system (11435 km^2) extending from the Northern Tablelands in the west to the floodplains near Kempsey and South West Rocks where it discharges into the ocean. Significant waterways in the catchment include the Macleay River, Chandler River, Belmore River, Kinchela Creek, Collombatti Creek, Hickeys Creek and Parrabel Creek. The Hastings Catchment, which includes the major waterways of the Wilson River, Maria River, Pappinbarra River, Forbes River, and Ellenborough River, extends from the tablelands to the coast where it discharges at Port Macquarie. Finally, the Camden Haven Catchment includes the waterways of Watson Taylors Lake, Queens Lake, the Camden Haven River, Stewarts River, Deep Creek, and Upsalls Creek. These preceding two catchments are collectively known as the Hastings Camden Haven Catchment with a combined catchment area of 4484 square kilometres.

Land use varies across the region with approximately 60% of the area being rural land, 22% registered as National Parks and Wildlife Service estate, 11% as State Forest, 7% as Crown Land, and less than 1% as urban (DLWC, 2003).

Primary industries in the region include beef, lamb, and wool production in the Northern Tablelands; forestry and horticulture in the hills; dairy, grazing, sugarcane and horticulture on the floodplains; and commercial fishing (primarily based on wide range of finfish species, as well as prawns and other crustaceans) and aquaculture (an extensive Sydney rock oyster producing area) in the estuaries and marine zone.

The Mid North Coast subregion incorporates six LGAs: Nambucca, Kempsey, Hastings, Walcha, Armidale-Dumaresq, and Uralla.

2.5 Aquatic Biodiversity in the Northern Rivers Region

The aquatic habitat in the NRCMA area comprises freshwater, estuarine, and marine environments. From montane streams to lowland floodplain wetlands and coastal lagoons, the extensive range of aquatic habitats supports a diverse assemblage of fish species including the threatened Eastern freshwater cod (*Maccullochella ikei*) and Oxleyan pygmy perch (*Nannoperca oxleyana*) (Appendix C). The Northern Rivers also includes key estuarine species of conservation concern such as the threatened grey nurse shark (*Carcharias Taurus*), green sawfish (*Pristis zijsron*), and vulnerable black cod (*Epinephelus daemelii*). Moreover, the region supports an array of aquatic macroinvertebrates including insects, prawns, crayfish, and freshwater mussels. Over 100 species of frogs are found in the region (including the threatened Green and golden bell frog – *Litoria aurea*, Booroolong frog – *Litoria booroolongensis*, Giant barred frog – *Mixophes iterates*, and Red-crowned toadlet – *Pseudophryne australis*), as well as three chelonians (Eastern snake-necked turtle- *Chelodina longicollis*, Saw-shelled turtle – *Elseya latisternum*, and Macquarii turtle – *Emydura macquarii*). In addition, platypus (*Ornithorhynchus anatinus*) and water rats (*Hydromys chrysogaster*) – both mammals specialised for freshwater aquatic habitats – are found in North Coast waterways.

All these aquatic species are dependent on healthy streams and access to diverse habitats for their survival. Freshwater fish habitat in the Northern Rivers encompasses swamps, floodplains, wetlands, streams and major rivers. These broad habitat types provide niche habitats such as deep pools and shallow riffles, gravel beds, boulders, snags (large woody debris), aquatic vegetation, riparian vegetation and riparian overhangs and bank undercuts.

Healthy freshwater habitats in the Northern Rivers region are essential for conserving aquatic biodiversity. Of the 204 subcatchments identified in the North Coast Stressed Rivers Assessment (DLWC, 1999a&1999b), 33 were defined as *High Conservation Value* (HCV) including Cudgen Lake and Mooball Creek in the Tweed catchment; Belongil Creek, Lower Marshalls Creek and Simpsons Creek in the Brunswick catchment; 11 subcatchments of the Richmond system; Clarence River subcatchments including the Boyd, Nymboida, Sandon and Mann Rivers; Coastal Nambucca; Lower Deep Creek; Toorumbee Creek; Coastal Hastings; Ellenborough River; and Forbes River. However, more than 50% of the subcatchments assessed in the region were identified as having *high environmental stress*, including 22 of the HCV subcatchments.

Wetlands, both fresh and saltwater, provide specialised habitat for fish and aquatic invertebrates, as well as other fauna such as waterbirds, frogs and reptiles. Land-based pressures including urban development, stormwater runoff, grazing pressure and introduced pest species, can deleteriously impact wetlands. As a result, key wetland complexes in the NRCMA have been listed as SEPP 14 wetlands to minimise the impact of such pressures. SEPP 14 listings in the three subregions include (Northern Rivers) Cudgen Lake in the Tweed catchment; (Upper North Coast) the dunal wetland system of Bundjalung National Park, estuarine wetlands (seagrasses, mangroves and alluvial islands) in the Clarence River estuary and The Broadwater, Everlasting Swamp on the Clarence floodplain, freshwater lake habitats in Yuraygir National Park; (Mid North Coast) Limeburners Creek Nature Reserve, and Swan Pool-Belmore Swamp in the Lower Macleay Catchment. Additionally, higher altitude swamps and lagoons such as Round Mountain Swamp (near Ebor) and the RAMSAR-listed Little Llangothlin Lagoon provide niche habitat for a range of aquatic species, as well as for several threatened species of birds, amphibians, and plants.

Aquatic habitat rehabilitation, in particular reinstating stream connectivity, is essential for maintaining aquatic biodiversity and protecting the integrity of rivers, lakes and wetlands in coastal NSW. This particular project was designed to identify locations where the greatest environmental gains could be made when undertaking such remediation works.

2.6 Road Transport Infrastructure in Northern Rivers

Road transport infrastructure in the Northern Rivers region includes several major roads such as the Pacific Highway, Bruxner Highway, Summerland Way, Waterfall Way, Gwydir Highway, New England Highway, and Oxley Highway. However, a large percentage of roads in the region are Council-owned country roads, small private roads, and tracks through State Forest and National Park estates. Overlaying the road network on the stream channels highlights how the transport infrastructure dissects the catchments in the area (Appendix D).

Using the road crossing GIS database, each road/stream intersection point has been marked to identify the number of waterway crossings in the region. The data layers used in the GIS system can identify the state of the roads (i.e. sealed or unsealed), structure ownership, structure type, and how large the waterway is at the crossing point. Appendix D illustrates road crossing points in the Northern Rivers that lie on major waterways (bridges have not been included on the map). Only a fraction of these culverts and causeways actually represent obstructions to fish passage. The density and configuration of the regional road network can however impact on streams in other ways including: localised changes to stream flows; fragmenting and isolating otherwise continuous forest, floodplain and riparian habitat; prohibiting terrestrial passage along the river; and by providing a source of sediment and pollutants (over half the crossing points on the map in Appendix D are located on unsealed roads).

3. PROJECT METHODS

3.1 Compilation of road crossing data

A detailed audit was undertaken of waterway crossings identified in the NRCMA region by the following means:

- Assessment of GIS drainage and road network data layers for the NRCMA, as well as visual assessment of topographic maps (1:25,000) for the region. Sites where roads traversed 3rd order and above waterways were flagged;
- LGA datasets that included asset registries and work maintenance schedules;
- Road crossing obstructions identified in previous fish passage investigations (Williams et al. 1996, and Thorncraft and Harris 2000);
- Consultation with regional staff from the Department of Natural Resources (DNR) and NSW DPI Fisheries Habitat Protection Unit;
- Public knowledge regarding private road crossings.

Fieldwork in the region was conducted from April 2004 – October 2005. A GIS based digital assessment proforma (Freestone V1.2) was developed for ArcPad (V.6.03) and uploaded onto a handheld IPAQ hx4700 PDA to ensure that data gathering was consistent and transferable for the prioritisation process across all subregions and CMAs (see Appendix A). The proforma was completed for each road crossing assessed in the study, with location details (Haicom HI-303E GPS; GDA 94) and digital photographs taken. Utilisation of ArcPad provided a spatial record of all road crossings assessed, which facilitates the incorporation of additional barriers into the database as they are identified. Integration of data into a GIS framework also provided information on broad-scale regional trends in relation to the road and stream networks in the Northern Rivers CMA region.

Data recorded in the field included structure type and description, ancillary uses of the crossing (e.g. bed control); road type (sealed vs. unsealed); whether the structure was a barrier to fish passage, and if so what type; aquatic and riparian habitat condition; channel morphology (e.g. width and depth); and surrounding land use (Appendix A). Following the field-based audit, a detailed desktop investigation was conducted on identified barriers to determine location information (e.g. section of the catchment), structural details (e.g. ownership, number of barriers downstream, available upstream habitat), and further environmental considerations (ranges of threatened and protected species and wildlife reserves – Marine Parks, SEPP wetlands) (Appendix A). All data recorded in the road crossing audit was downloaded into the Department of Primary Industries Fish Habitat Database prior to comparative analysis to determine regional remediation priorities.

3.2 Road crossing prioritisation

A waterway crossing prioritisation (WCP) scheme was developed to assist in ranking road crossing barriers requiring remediation in the NRCMA (Appendix B). This scheme was developed to determine regional priorities by ranking sites based on the following categories: a) stream habitat value; b) structural impact; c) environmental criteria; and d) modification criteria.

An initial prioritisation was conducted based upon stream habitat and structural impact criteria, which were viewed as the primary variables affecting fish passage. Stream habitat criteria was based upon habitat class, location of the barrier in the catchment, number of downstream obstructions, and the amount of upstream habitat (i.e. stream length in km) fish were restricted from accessing. NSW DPI Fisheries (Conservation and Aquaculture) applies a 'Class' system to assign aquatic habitat values to waterways (Fairfull and Witheridge 2003). Table 3.1 outlines the characteristics of each waterway class that was used in the WCP scheme to determine the stream habitat value of road crossing sites in the Northern Rivers

Table 3.1. NSW DPI Fisheries Classification of Fish Habitat in NSW Waterways	
Classification	**Characteristics of Waterway Type**
Class 1 Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek); habitat of a threatened fish species or 'critical habitat'.
Class 2 Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 3 Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
Class 4 Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events (eg dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

region, with Class 1 systems receiving a high ranking while Class 4 reaches recorded a null score. Location of the barrier in the catchment (e.g. tidal vs. upper) was determined by geomorphological and hydrological characteristics of the system, as well as from stream order. Barriers located within the tidal or lower reaches of the catchment with few-to-no obstructions downstream were ranked higher than crossings positioned in the upper headwaters. Moreover, a higher weighting was placed on crossings that, if remediated, would provide access for migrating fish to longer sections of unimpeded upstream habitat.

Structural impact criteria assessed whether the crossing was a physical, hydrological, or behavioural barrier to migrating fish. Headloss over a structure, otherwise known as the "waterfall effect', was measured under low-flow conditions, with larger values representing a greater fish passage barrier. Additional physical barriers included excessive slope (> 1:20) and presence of debris, with each of these barriers being recorded as presence (true) vs. absence (false). Crossings were assessed to be debris barriers based upon the conditions at the time of the assessment rather than upon the potential of the structure to accumulate debris. It should be noted that most pipe and box culvert designs offer the potential for debris accumulation; however, the extent of such crossings as debris barriers is dependent upon recent hydrological events as well as maintenance programs by local councils and concerned citizens. As a result, debris barriers received a low structural impact ranking due to the ephemeral nature of the obstruction. Hydrological barriers were determined as displaying excessive water velocity or insufficient flow depth (< 100 mm) and assessed over the full range of hydrological flows till the structure drowned out. Finally, crossings displaying inadequate lighting through the culvert cell may act as a behavioural barrier to certain species of fish including bony herring (*Nematolosa erebi* - this species occurs in inland waterways of NSW and coastal draining rivers of QLD).

Following the initial prioritisation, a secondary prioritisation incorporating environmental and structural modification criteria was conducted to further delineate crossing rankings. Environmental criteria incorporated low-flow channel width, aquatic and riparian habitat condition (i.e. good, fair, and poor), point sediment impacts (sealed vs. unsealed roads), threatened species habitat, and surrounding land use. Within the known ranges of species of conservation concern, priority rankings were determined by the quality of the surrounding aquatic habitat as classified by habitat class (Class 1-2: high ranking; Class 3: low ranking; Class 4: no ranking). Surrounding land use also influenced barrier rankings with, for example, crossings located within nature reserves (e.g. National and Marine Parks) receiving a higher score compared to structures located adjacent to cleared land used for grazing.

Modification criteria assessed structural use and the ease of remediating the fish passage barrier. Occasionally, structures were recorded during the road crossing audit that were no longer used by vehicle traffic. These obsolete crossings were given a higher priority score given the ease associated with removing the structure regarding cost and timescales. Similarly, crossings that require maintenance to remove debris or remediate a blockage were

weighted more given the lower costs and reduced timescales compared to structures that require the insertion of a box culvert or bridge. Finally, structures that displayed an ancillary purpose (e.g. bed control structure, pumping pool) were given a lower priority scale given the increased challenges (e.g. costs, compensation, and time) associated with remediating fish passage.

The WCP was applied to all road crossings identified as fish passage obstructions in the CMA region. Results are presented in Sections 4 – 7, illustrating subregion priorities and LGA trends, as well as overall CMA results. Additionally, recommendations are provided on how structures could be modified to allow for effective fish passage. Structure owners (in particular local Councils and State Government agencies) will be provided with a list of priority structures and modification recommendations for consideration in future works programs.

4. RESULTS & DISCUSSION

A comprehensive data set for all road crossing barriers assessed in this investigation is summarised in Appendix I, including details of the waterway, catchment, LGA, road name, barrier type, structure type, and recommendations for remediation. The discussion below focuses on trends within the data and the top priority sites for remediation within the Northern Rivers and its associated subregions.

4.1 Road Crossing Audit

In total, 2543 road crossings were assessed in the Northern Rivers CMA region, of which approximately 20% (524) were found to be barriers to fish passage (Table 4.1). The majority of road crossing barriers were recorded in the Northern Rivers subregion, which encompasses the Tweed, Brunswick, and Richmond catchments. Partitioning of barriers amongst Northern Rivers catchments shows that over half of the obstructions were located in the Richmond catchment (Table 4.2), which includes the Byron (50 barriers), Ballina (31), Lismore (54), and Kyogle (25) LGAs. Nearly a third of road crossing barriers in the Northern Rivers subregion were logged in the Tweed Catchment (88), which is incorporated in the Tweed Shire LGA, while the remaining barriers (53) were found in the Brunswick Catchment located in the Byron Shire LGA. The Tweed and Brunswick Catchments recorded two of the highest totals for road crossing barriers, despite having a catchment area of only 1326 km^2 and 274 km^2 respectively.

In addition to having the smallest catchment area of the three subregions investigated (Table 4.1), the scale of the problem in the Northern Rivers subregion is further exacerbated by the concentration of road crossing barriers in four local government areas (i.e. Tweed, Byron, Ballina, and Lismore) that account for only half of the catchment area in the subregion. Few obstructions were recorded within the Kyogle LGA (25 barriers; 1,920 km^2), while no road crossing barriers were found in the Richmond Valley LGA (2,420 km^2) due to the prolific use of bridges as waterway crossings in these Shires. The high number of barriers recorded in the Northern Rivers is attributed to the elevated population density of the subregion and ensuing road infrastructure required to support the populace compared to the Upper and Mid North Coast. Additionally, large tracts of land (up to 30 %) in the Upper and Mid North Coast

Table 4.1. Waterway crossing assessments by subregion in the Northern Rivers CMA region.

Subregion	Catchment Area (km^2)	Population Density (per km^2)	Catchment Stream Length (km)*	Crossings Assessed	Barriers Identified
Northern Rivers	8,622	24.8	5,152	965	302
Upper North Coast	24,343	8.2	11,848	864	127
Mid North Coast	17,346	8.1	5,319	714	95
			TOTAL	**2543**	**524**

* determined for 4th order streams and above

reside within National Parks or State Forests compared to smaller allotments (< 15 %) within the Northern Rivers. Finally, the amount of stream length relative to catchment area is considerably greater within the Northern Rivers subregion, and is attributed to higher annual rainfall totals and the presence of perennial flowing systems compared to the numerous low order, ephemeral flowing reaches in the Upper and Mid North Coast.

The majority of barriers (90%) recorded in the Upper North Coast subregion were located in the Clarence Catchment (Table 4.2), which is bounded by the Clarence Valley (38), Guyra (13), Tenterfield (29), and Glen Innes Severn LGAs (24). The Clarence River is the largest system on the east coast of NSW, with the river's catchment (22,716 km^2) accounting for the majority of land mass in the Upper North Coast subregion. In addition to the Clarence Catchment, the road crossing audit also identified 8 structures (6%) as barriers inhibiting fish migration in the Coffs Harbour Waterways (508 km^2), which includes a series of 13 small coastal catchments near Coffs Harbour from Corindi River to Bundagaree Creek. Despite having a catchment area of 1119 km^2, only 5 road crossing barriers were recorded within the Bellinger Catchment, which encompasses the Bellinger River to the north and the Kalang River to the south.

In total, 712 road crossings were assessed in the Mid North Coast, of which 13% (95) were identified as barriers to fish passage (Table 4.1). Separation of barriers within the Mid North Coast catchments shows that nearly two-thirds of road crossing obstructions were located in the Macleay Catchment (Table 4.2), which includes Armidale (24 barriers), Kempsey (15), Walcha (11), Uralla (9), and Guyra (1) LGAs. The Macleay Catchment is the second largest system in the Northern Rivers CMA (Table 4.2), extending from the Northern Tablelands in the west near Armidale to the floodplains around Kempsey and South West Rocks where it discharges into the ocean. In addition to the Macleay, nearly a third of barriers in the Mid North Coast were recorded in the Hastings Catchment (4484 km^2), which is predominantly incorporated in the Hastings LGA (23). The remaining barriers (9) were found in the Nambucca Catchment (1427 km^2), a small coastal system situated in the Nambucca Shire LGA.

Table 4.2: Summary of Road Crossing Barriers to Fish Passage in the Northern Rivers CMA region

Catchments	Catchment Area (km^2)	Pipe Culvert	Box Culvert	Causeway	Ford	Weir	Road Xing barriers
Northern Rivers							
Tweed	1326	57	14	16	0	1	88
Brunswick	274	22	30	1	0	0	53
Richmond	7022	109	22	27	1	2	161
	Subtotal	**188**	**66**	**44**	**1**	**3**	**302**
Upper North Coast							
Clarence	22716	28	19	65	1	1	114
Coffs Waterways	508	5	0	1	1	1	8
Bellinger	1119	4	1	0	0	0	5
	Subtotal	**37**	**20**	**66**	**2**	**2**	**127**
Mid North Coast							
Nambucca	1427	5	0	3	0	1	9
Macleay	11435	28	4	23	5	0	60
Hastings	4484	8	6	10	2	0	26
	Subtotal	**41**	**10**	**36**	**7**	**1**	**95**
	TOTAL	**266**	**96**	**146**	**10**	**6**	**524**

4.2 Barrier Types

Structural barrier types recorded in the Northern Rivers CMA region included pipe and box culverts, causeways, weirs, and fords; with Table 4.2 providing a summary of sites identified based on structural type and subregion (also see Appendices F-H). Pipe culverts were the most common barrier identified, comprising over half of road crossing obstructions assessed in the Northern Rivers CMA region. The remaining barriers recorded were primarily comprised of poorly designed causeways (28%) and box culverts (18%), with only the occasional weir and ford being identified (~ 3%). Trends were recorded within each subregion regarding structural barrier types, with pipe culverts being more prevalent within the Northern Rivers compared to causeways within the Upper North Coast (Table 4.2). The relatively low number of causeways in the Northern Rivers subregion (14%) may be attributed to the perennial flowing nature of waterways in the area that would potentially hinder vehicle access resulting in the preference of crossing where water flows through rather than over the structure.

Road crossing designs in the Northern Rivers region act as physical and hydrological barriers to migrating fish, resulting in the isolation of upstream and downstream habitats to native species. Physical barriers include excessive headloss (> 100 mm) and debris accumulation, while hydrological impediments to migrating fish consist of high velocities and shallow flow depth. Moreover, the design of road crossings can inhibit fish passage due to behavioural trends of certain species. Native fish such as bony herring (*Nematalosa erebi*) avoid darkened environments during the day, and thus will avoid passing through crossings with cells that display reduced light levels. Additionally, depending upon the design of the crossing, multiple barrier types (e.g. headloss, high velocity, and shallow flow depth) can occur at a single site over the full range of hydrological flows.

Regardless of subregion, excessive headloss was the most prevalent obstruction to migrating fish in the Northern Rivers CMA, being recorded at 64% of sites assessed as road crossing barriers (Table 4.3). Headloss recorded at crossings across the CMA region ranged from 100 – 3000 mm, with a mean headloss of 500 mm being recorded. Road crossing barriers exhibiting excessive headloss included pipe and box culverts displaying raised invert surfaces on the downstream side of the crossing relative to the stream bed, as well as weir-type causeways (Fig. 4.1; Table 4.4).

High flow velocity barriers were noted for over half of the road crossing barriers in the CMA region (269 sites; Table 4.3), with the Northern Rivers subregion accounting for the majority of such barriers due to the prevalence of culvert crossings. Road crossings that incorporate narrow pipes and small box cells relative to the natural channel width display excessive linear flow velocities following minor river rises (Fig. 4.1A). Given that the timing of migration for most fish species in NSW coincides with increased hydrological flows, velocity barriers generally prohibit fish passage in the upstream direction until structural drownout occurs.

Shallow flow depths (< 100 mm) were identified at 38% (201 sites) of fish passage barriers highlighted in the Northern Rivers CMA region. Causeways and culverts may restrict adult fish movement due to insufficient flow depth over or through the structure during periods of low flow (Fig. 4.1; Table 4.4). Causeways in particular are designed to convey water across the road surface in a laminar sheet flow (Fig. 4.1B).

Table 4.3: Summary of fish passage barrier types in the Northern Rivers CMA region

Subregion	Physical Barrier		Hydrological Barrier	
	Headloss	Debris	Velocity	Flow Depth
Northern Rivers	193	16	173	110
Upper North Coast	88	15	56	55
Mid North Coast	57	8	40	36
TOTAL	**338**	**39**	**269**	**201**

A) Crossing over Emigrant Creek off Friday Hut Rd

B) Chilcotts Road crossing over the Rous River

C) Wardell Road crossing over Duck Creek

D) Crossing over Yellow Creek on a private road

Fig. 4.1: **A)** Piped crossing in Ballina Shire exhibiting the waterfall effect and excessive water velocities; **B)** Chilcotts Road causeway demonstrating a severe headloss resulting in a waterfall effect; **C)** Box culvert crossing exhibiting head loss and shallow flow depths through the structure; **D)** Piped crossing in Ballina Shire displaying a combination of excessive water velocity, low flow depth, and debris accumulation on the upstream side.

Following flood pulses, the build-up of debris around the upstream openings of culverts can further restrict fish passage (Table 4.4). However, the permanence of this barrier type is dependent upon maintenance programs carried out by local councils and private landholders. Debris accumulation resulting in the complete blockage of a crossing's cells was recorded at 7 % of barriers in the region.

Excessive headloss and shallow flow depth were commonly recorded together at culvert and causeway structures during low-flow conditions. Remediation of headloss barriers caused by crossing inverts that are set above bed level requires drownout of the structure, which at some sites only occurs 1-2 times per year. Although shallow flow barriers are quickly overcome in times of minor river rises, a majority of culvert and causeway structures also

Table 4.4: Summary of road crossing barriers to fish passage in the Northern Rivers CMA region

Fish Passage Barrier	Pipe Culvert	Box Culvert	Causeway	Ford	Weir	Total
Headloss	152	70	105	5	6	**338**
Velocity	202	26	41	0	0	**269**
Flow Depth	82	48	64	7	0	**201**
Debris	23	4	12	0	0	**39**

display narrow cell dimensions that constrict the flow of water and result in increased velocities following flood pulses. Consequently, culvert and causeway waterway crossings that act as barriers to native fish often inhibit migration during the majority of flow regimes until the structure is overtopped.

Potentially more valuable is the assessment of structures that were not barriers to migrating fish (Table 4.5). Bridges were the predominant waterway crossing identified in the Northern Rivers CMA region, however no barriers were recorded for this structural type. NSW DPI Fisheries (Conservation and Aquaculture) promotes bridges as the preferred design for waterway crossings given their limited disturbance to flow regimes and surrounding aquatic habitat.

Nearly 30 % of crossings assessed in the audit were culvert structures, yet unlike bridges over half of pipe culvert crossings investigated were determined to be barriers to fish passage as a result of excessive headloss, high flow velocities, shallow flow depth, debris accumulation, or a combination of these factors (Table 4.4 & 4.5). As a result, pipe culvert designs are supported only for Class 3 or 4 waterways (i.e. upper level tributary displaying intermittent flow and unlikely to support fish populations) where the invert of the cells is set below bed level and the diameter of the pipes can adequately support bank-full flow.

Compared to pipe culverts, only 35 % of box culverts were identified as inhibiting fish migration in the Northern Rivers CMA region (Table 4.5). The majority of box culvert barriers were attributed to excessive headloss and shallow flow depths resulting from structural inverts set above downstream bed level (Table 4.4). Provisions put forth in the Fisheries Management Act (1994) now require that all box culverts be set at or below bed level, preferably with a central low-flow channel design that pools water during low-flow conditions to limit shallow flow depths through the structure.

Relatively few causeways were noted in the waterway crossing audit (< 7 %); however, nearly all such structures were recorded as barriers to migrating fish primarily due to excessive headloss and shallow flow depth (Table 4.4 & 4.5). Consequently, NSW DPI Fisheries (Conservation and Aquaculture) only supports the insertion of causeways where the waterway is characterised as Class 4 habitat. Conversely, only 16 % of fords crossings were noted to impinge upon migrating fish species. Given that flow depths across a ford are likely to be similar to natural stream conditions, NSW DPI Fisheries (Conservation and Aquaculture) supports the design for Class 2 – 4 waterways. However, the prevalence of ford crossings is limited due to the "wet" nature of the crossing, with most Councils now preferring elevated structures that promote vehicle traffic over a greater hydrological flow range.

4.3 Further effects of road crossings

Out of the 2543 road crossings assessed in the Northern Rivers CMA region, over 50 % (1297) were located on unsealed roads. The potential for degraded water quality at these sites is elevated due to increased surface runoff levels which can result in highly turbid conditions, limited light penetration, greater sedimentation resulting in the smothering of

Table 4.5: Summary of road crossings assessed in the Northern Rivers CMA region

Crossing Type	Crossings Assessed	Barriers Identified	Barrier Occurrence (%)
Bridge	1530	0	0.0
Pipe Culvert	486	268	55.1
Box Culvert	265	94	35.5
Causeway	176	145	82.4
Ford	82	13	15.9
Weir	4	4	100.0
TOTAL	**2543**	**524**	

aquatic habitats, and an increase in the contribution of toxicants bound to sediment particles into the watercourse.

Water quality impacts from surface runoff, erosion, and sedimentation are further exacerbated at sites located within areas of extensive anthropogenic activities including agricultural land, urban and industrial environments, and logged forestry tracts. Stock grazing was the predominant land use recorded in the Northern Rivers CMA region, accounting for 70 % (Northern Rivers subregion) to 90 % (Upper North Coast subregion) of sites assessed. Riparian fencing at such sites was limited, with livestock often having free access to the waterway. Alternatively, urban road crossings in the subregions accounted for less than 5 % of the road crossing barriers identified in the investigation.

Crossings located in National Parks, State Forest, and rural (non-grazing) settings accounted for less than 25% of barriers identified in the Northern Rivers CMA region. The 14 road crossing barriers identified in the regions' State Forests and National Parks are of particular interest. When compared to other sites, the aquatic habitat in State Forests and particularly National Parks is often in excellent condition and supports a diverse assemblage of fish species. Agreements have recently been reached between NSW DPI and other State Government Departments with respect to the provision of fish passage when constructing new road crossings in protected reserves and forest plantations.

4.4 Remediation priorities in the Northern Rivers CMA Region

A primary component of this project aimed to develop a method of ranking road crossing barriers to determine priority structures for remediation (Appendix B). The ranking scheme takes into account a variety of factors, including the quality and condition of the existing aquatic habitat, the potential impact of the structure on fish passage, and remediation possibilities (such as ancillary uses of the crossing and potential costs).

The WCP scheme was applied to all 524 road crossing barriers identified in the Northern Rivers CMA region to determine a ranking list for potential remediation within the area. In total, 101 sites (19 %) were designated as high and medium-high remediation priorities, 146 crossings (28%) were allocated as medium to medium-low remediation priorities, and 277 structures (53%) were determined to be low remediation priorities (Table 4.6; Appendix F-H). Table 4.7 lists the Top 40 sites for remediation in the Northern Rivers CMA while Appendix I provides the rankings for all barriers assessed.

Following final prioritisation of barriers within each subregion, it was observed that a higher proportion of sites within the Northern Rivers subregion were ranked as "medium" and "medium-low" remediation priorities in comparison to the Upper and Mid North Coast subregions. This outcome is likely attributed to the smaller catchment size of the subregion in conjunction with a higher population density which has resulted in an increased road infrastructure network. Although a large percentage of barriers in the Northern Rivers subregion were noted on perennial flowing streams displaying excellent aquatic and riparian condition (unlike in the other two subregions), the ranking of such crossing barriers was diminished due to the increased number of obstructions downstream and the reduced length

Table 4.6: Road Crossing barrier remediation priorities in the Northern Rivers CMA region

Subregion	High	Medium-High	Medium	Medium-Low	Low
Northern Rivers	39 (12.9)	23 (7.6)	39 (12.9)	58 (19.2)	143 (47.4)
Upper North Coast	8 (6.3)	7 (5.5)	11 (8.7)	15 (11.8)	86 (67.7)
Mid North Coast	16 (16.8)	8 (8.4)	8 (8.4)	15 (15.8)	48 (50.5)
Total	**63**	**38**	**58**	**88**	**277**

* number in parenthesis represents percentage of barriers within each subregion

of habitat available upstream.

Of the high and medium-high priority sites identified within this study, approximately 20 % were determined to be obsolete structures, with several additional sites being fish passage obstructions due to debris accumulation (sediment build up, or plant material including large woody debris). These sites could therefore be remediated relatively easily and cost effectively within a short time frame. In contrast, 84 priority structures were identified that require reasonably large scale works (and thus a significant financial contribution) to remediate fish passage. Such recommendations include the installation of a fishway, construction of bridges, installation of box culverts with low flow cells, and increasing the number of cells on structures of greater than 10m wide. In general, remediation actions that require maintenance works or structural removal will be far less expensive than on-ground works requiring complete replacement of the road crossing structure. Additionally, the installation of highly-engineered structures such as fishways may be far more expensive than installing a replacement road crossing structure (such as a prefabricated culvert or Doolan deck bridge).

The on-ground works recommendations made in this report are based on initial site assessments. Feasibility studies must be conducted to assess whether alternative options are available. As outlined previously, site priorities were chosen through a rapid assessment technique and therefore provided a snap-shot of environmental conditions at each site. Detailed environmental assessments and cost-benefit analyses need to be conducted before sites are selected for remediation and on-ground works are pursued. As a way forward, road managers (Councils and the Catchment Management Authority), with assistance from state government agencies (including the Department of Primary Industries), should identify areas where funding may be available for future works and where environmental, social, and economic benefits are maximised.

Concerning the comparison of rankings among the Northern Rivers CMA subregions, natural resource managers should note that the prioritisation process provides only a general guideline upon which informed decisions can be based pertaining to fish passage obstructions. However, caution is warranted in directly comparing barrier ranking scores and remediation priorities among subregions due to fundamental differences in hydrology and channel geomorphology. Benefits gained from remediating a crossing barrier in the Mid North Coast versus a similarly ranked crossing in the Northern Rivers will vary between subregions, with realised outcomes to native fish populations being dependent upon site-specific conditions.

Table 4.7: Priority road crossings for remediation in the Northern Rivers CMA region.

Rank	Crossing ID	Waterway & Catchment	Road Name	Barrier Type & Remediation Recommendation
1	Kemp - 10	Dungay Creek, Macleay	Dungay Creek Rd, Kempsey	Pipe culvert with headloss and excessive flow velocities. Replace with box culvert with low flow cells.
1	Lism - 17	Terania Creek, Richmond	Izzes Road, The Channon	Pipe culvert with headloss, excessive flow velocities and low flow depth. No longer in use – removal.
3	Lism - 39	Coopers Creek, Richmond	Eureka Road, Rosebank	Box culvert with head loss and low flow depth. Replace with bridge.
4	Coff - 01	Orara River, Clarence	Casuarina Lane, Karangi	Box culvert displaying high flow velocity and headloss. Stabilisation works and fishway installation required.
4	Namb - 13	Deep Creek, Nambucca	Sullivans Road, Valla	Obsolete log sill causeway with excessive headloss. Remove.
6	Hast – 11	Thone River, Hastings	Barabaroo Baroo Road, Wauchope	Box culverts with shallow flow depths and headloss. Replace with box culvert with low flow channel.
6	Hast - 28	Forbes River, Hastings	Forbes River Rd, Ellenborough	Ford crossing created by deposition of large rocks and boulders. Remove.

6	Tent - 23	Timbarra River, Clarence	off Upper Rocky River Rd, Tenterfield	Obsolete causeway displaying headloss and shallow flow depths. Remove.
9	Ball – 28	Skinners Creek, Richmond	Old Tooheys Mill Rd	Causeways displaying excessive headloss and velocity, Replace with Bridge
9	Namb – 16	Taylors Arm, Nambucca	Private Road, Upper Taylors Arm	Causeway with excessive headloss. Remove
11	Byro - 119	Wilsons River, Richmond	Goonengerry Rd, Mullumbimby	Historic obsolete rock causeway displaying excessive headloss. Remove.
11	Kemp – 24	Parrabell Creek, Macleay	Dowling Falls Raod, Kempsey	Pipe culverts with velocity and shallow flow barrier. Replace with box culverts with low flow cell.
11	Twee – 67	Rous River, Tweed	Numinbah Road, Murwillumbah	Remains of log sill from former causeway crossing with headloss. Remove
11	Twee - 68	Crystal Creek, TweeD	Off Numinbah Road, Murwillumbah	Causeway structure displaying excessive water velocity and headloss. Replace with box culvert with low-flow channel.
11	Twee – 73	Rous River, Tweed	Off Numinbah Road, Murwillumbah	Pipe culvert with large headloss and excessive water velocity. Replace with bridge.
16	Byro – 41	Brunswick River	Private Road, Mullumbimby	Pipe Culvert with excessive velocity, shallow flow depth and headloss. Replace with bridge.
17	Clar – 03	Micalo Channel, Clarence	Yamba Road	Causeway causing blockage of water flow. Replace with Bridge.
17	Hast - 14	Wilson River, Hastings	Clarefield Dungay Ck Rd, Telegraph Point	Remains of an obsolete causeway, causing blockage & excessive water velocity. Remove
17	Twee - 02	Oxley River, Tweed	Old Lismore Road, Murwillumbah	Box culvert with headloss and insufficient flow depth. Replace with box culvert with low flow cell.
20	Twee – 100	Oxley River, Tweed	Private Rd off Tyalgum Rd, Murwillumbah	Obsolete causeway displaying excessive headloss and velocity. Remove.
20	Twee – 72	Rous River, Tweed	Chilcotts Road, Murwillumbah	Causeway displaying excessive headloss. Replace with box culvert with LF channel.
22	Byro - 115	Byron Creek, Richmond	Off Bangalow Rd, Bangalow	Pipe culvert with excessive velocity and debris accumulation. Replace with bridge.
22	Kemp – 02	Warbo Brook, Macleay	Fifes Creek Road, Kempsey	Pipe culvert displaying excessive headloss and flow velocities. Replace with box culvert with low flow cell.
24	Ball – 11	Emigrant Creek, Richmond	Friday Hut Road, Ballina	Piped culvert displaying excessive headloss and water velocity. Replace with box culvert with low-flow channel.
24	Seve - 38	Mann River, Clarence	off Red Range Road, Glen Innes	Obsolete causeway displaying excessive headloss, high flow velocity and low flow depths. Remove.
26	Clar - 59	Ewingar Creek, Clarence	Ewingar Road, Ewingar	Box culvert with head loss and insufficient flow depths. Replace with a bridge.
26	Lism – 16	Tuntable Creek, Richmond	Paterson Road, Lismore	Piped culvert with excessive water flow. Replace with box culvert with LF channel.
28	Clar - 61	Deep Creek, Clarence	Deep Creek Road	Causeway with headloss and high flow velocities. Replace with bridge.
28	Lism - 18	Terania Creek, Richmond	Terania Creek Road, The Channon	Pipe culvert with headloss, excessive flow velocities and low flow depth. No longer in use – removal.
30	Twee – 88	Byrrill Creek, Tweed	Off Byrrill Creek Road, Murwillumbah	Pipe culvert displaying excessive headloss and water velocity. Replace with box culvert with low flow pipe.
30	Byro – 42	Brunswick R., Brunswick	Johnson Lane, Mullumbimby	Pipe culvert displaying excessive headloss. Replace with bridge or box culvert with LF channel.
30	Lism – 53	Tuntable Creek Richmond	Off Tuntable Ck Rd, Lismore	Pipe culvert results in high velocities and shallow flow depths. Replace with box culvert with LF channel.
33	Twee – 89	Byrrill Creek, Tweed	Off Byrrill Creek Road, Murwillumbah	Ford crossing displaying shallow flow depths. Replace with box culvert with LF channel.
34	Guyr - 03	Oban River, Clarence	Kookabrookra Road, Guyra	Causeway creates head loss and low flow depths. Replace with box culvert with low flow cell.

34	Byro – 113	Brunswick R., Brunswick	Off Main Arm Road, Mullumbimby	Obsolete crossing displaying excessive headloss and high flow velocities. Remove.
34	Byro – 44	Brunswick R., Brunswick	Durrumbul Road, Mullumbimby	Box culvert displaying excessive headloss. Replace with a bridge or box culvert with LF channel
37	Seve – 27	Timbarra River, Clarence	Leamons Road, Glen Innes	Causeway displaying excessive headloss and shallow flow depths. Replace with box culvert with LF channel.
37	Twee – 24	Dunbible Creek, Tweed	Stokers Road, Murwillumbah	Obsolete log sill resulting in excessive headloss. Remove.
39	Armi – 13	Chandler River, Macleay	Fassifern Road, Armidale	Pipe culvert that favors high water velocities and shallow flow depths. Replace with box culvert with LF channel.
40	Byro - 87	Coopers Creek, Richmond	Tickles Road, Repentance Creek	Pipe culvert with high water velocity and insufficient flow depth. Replace with bridge structure.

4.5 Steps in stream rehabilitation projects

This study provides baseline data for pursuing stream connectivity rehabilitation in the Northern Rivers CMA region. The following summary illustrates how this report can inform and lead to on-ground stream rehabilitation works. For this purpose, a *12 Step Stream Rehabilitation Process*, taken from the Manual for Rehabilitating Australian Streams (Rutherfurd *et al.*, 2001), has been adopted here to outline the main stages of undertaking on-ground fish passage projects.

The Rutherfurd stream rehabilitation process includes the following steps:	
1. Visions and goals	7. Setting measurable objectives
2. Gain support	8. Feasibility
3. Assess stream condition	9. Detailed design
4. Identify problems and assets	10. Evaluation
5. Priorities	11. Implementation
6. Strategies	12. Maintenance and evaluation

Steps 1 – 5 Visions and goals, gaining support, assessing stream condition, identify problems and assets, priorities:

This report has provided information to successfully complete steps 1 to 5 in the process of rehabilitating fish passage barriers by achieving the following:

- Establishment of a vision for reinstating stream connectivity and improving fish passage in coastal waterways of NSW;
- Providing a source document for stakeholders outlining major findings and providing management recommendations for regional groups and local government; Promotion of the report findings will offer an opportunity to gain broad regional and local support for future initiatives;
- Identifying specific road crossings that are obstructions to fish passage across the Northern Rivers region;
- Establishing and implementing a method of prioritising fish passage obstructions at the regional and subregion/catchment scale.

Steps 6 to 12 in the stream rehabilitation process need to be undertaken by relevant stakeholders (private landholders, Councils, state government and the CMA) with the aim of achieving on-ground outcomes. The following is a summary of how those steps can be achieved for road crossing remediation in coastal NSW.

Step 6 – 8 Strategies, setting measurable objectives, and feasibility:

Strategies for rehabilitation, in this instance options for remediating road crossings, need to be set out within an overall rehabilitation plan that involves outlining specific project objectives. In this investigation, rapid assessments were conducted for waterway crossings to provide a 'snap shot' view of environmental conditions at a site. Due to the sheer number of structures in the Northern Rivers region, detailed assessments of each structure were not feasible. For the purposes of informing future planning, the application of a rapid assessment technique (the fieldwork methodology and desktop prioritisation outlined above) was a simple and effective way of highlighting the extent of the problem and determining broad regional priorities. It is understood however, that many environmental, social, cultural and economic considerations need to be reviewed before undertaking on-ground works recommended within this report. Additional pertinent considerations include:

- Location of other instream structures (e.g. weirs and dams) and natural barriers within the waterway that were overlooked during the initial assessment;
- Existence of sensitive habitats in the vicinity of proposed works;
- Impact of structure removal/modification on channel bed and bank stability;
- Presence of Acid Sulfate Soils;
- Impacts of mobilising sediment stored behind the crossing;
- Impacts on water quality (e.g. from contaminated sediments) and water chemistry (e.g. at tidal barriers) upon upstream and downstream habitats;
- Additional uses for the structure (e.g. pumping pool, bed-control structure, floodgate);
- Benefactors and stakeholders – identifying support and opposition; and
- Estimated costs of various remediation options.

The above factors must be considered well before detailed designs for remediating a fish passage barrier should be considered.

Step 9 – Detailed design:

Design guidelines in relation to undertaking 'fish friendly' road crossing projects can be found in:

- *Why do fish need to cross the road? Fish passage requirements for waterway crossings.* (Fairfull & Witheridge, 2003); and
- *Fish passage requirements for waterway crossings – Engineering Guidelines*. (Witheridge, 2002).

Fairfull and Witheridge (2003) provides a comprehensive overview of the best way to plan, design and construct waterway crossings to minimise impacts on fish passage and aquatic habitats. NSW DPI Fisheries (Conservation and Aquaculture) requires that these national guidelines be followed by anyone intending to design and construct a waterway crossing in NSW. For engineers, Witheridge (2002) also provides a comprehensive and useful engineering guide to the design and construction of 'fish and fauna friendly' waterway crossings. Both documents were developed with the input of a national steering committee of experts in the field of road design, construction and fish passage.

Table 4.8 is adapted from Fairfull and Witheridge (2003) and provides a summary of preferred waterway crossing designs depending on waterway CLASS (see Table 3.1 for characteristics of different waterway classes).

In contrast to road crossing designs, DPI does not use a generic classification system to stipulate remediation designs for highly-engineered structures such as fishways. Rather, decisions are based on the specifics of the biology and hydrology of the waterway and the conservation value of the site to determine the most appropriate course of action. Design advice is provided on a case-by-case basis.

Table 4.8: NSW DPI Fisheries preferred waterway crossing types in relation to waterway class.		
Waterway Classification	**Minimum Recommended Crossing Type**	**Additional Design Information**
CLASS 1 Major fish habitat	Bridge, arch structure or tunnel	Bridges are preferred to arch structures.
CLASS 2 Moderate fish habitat	Bridge, arch structure, culvert [1] or ford	Bridges are preferred to arch structures, culverts and fords (in order of preference). [1] High priority given to the 'High Flow Design' (Fairfull and Witheridge, 2003).
CLASS 3 Minimal fish habitat	Culvert [2] or ford	[2] Minimum culvert design using the 'Low Flow Design' procedures; however, 'High Flow Design' and 'Medium Flow Design' should be given priority where affordable.
CLASS 4 Unlikely fish habitat	Culvert [3],causeway or ford	Culverts and fords are preferred to causeways. [3] Fish friendly waterway crossing designs possibly unwarranted. Fish passage requirements should be confirmed with NSW DPI Fisheries (Conservation and Aquaculture).

Step 10 – 12: **Evaluation, implementation, monitoring and maintenance:**

Steps 10 to 12 are common steps in any project management process and include establishing an evaluation procedure, implementing the plan and assessing the success of the project. These stages include developing a timeline, allocating responsibilities, finalising funding, conducting on-ground works and organising an evaluation schedule.

For road crossing remediation works, establishing a working group (comprising representatives from relevant government agencies and other associated parties) to ratify a remediation works plan is an effective way of ensuring that the plan meets project objectives.

Permit and works approvals requirements in relation to road crossing construction, modification and maintenance in NSW can be found in:

- *Policy and Guidelines for Fish-Friendly Waterway Crossings* (NSW Fisheries, 2003); and
- *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries, 1999).

The financing of on-ground rehabilitation works can be achieved through several avenues of cost-sharing between stakeholders and value-adding to existing programs/projects. Funding opportunities include State and Federal environmental grants for aquatic habitat rehabilitation projects. The Department of Primary Industries can assist road managers, structure owners and community groups interested in applying for funding related to stream connectivity and fish passage projects in NSW.

The following section outlines the implementation of these steps 6 to 12 by discussing the results and lessons learned from the remediation of four road crossing barriers in the Northern Rivers CMA region.

5. ROAD CROSSING DEMONSTRATION SITES

5.1 Demonstration Site Selection and Remediation

Demonstration sites were developed within each of the subregions of the North Coast for the purpose of illustrating best-practice techniques associated with the design, construction, and remediation of waterway crossings. Through the remediation of these barriers, NSW DPI Fisheries (Conservation and Aquaculture) aimed to improve stream connectivity for native fish, as well as to improve the safety and reliability of the waterway crossings during minor river rises for resident landholders.

Initial investigations to identify possible sites included consultation with regional NSW DPI Fisheries (Conservation and Aquaculture) staff, regional staff from the Department of Natural Resources (DNR), and local government asset managers. Preliminary desktop and field investigations commenced for potential sites to assess the priority of short-listed crossings, during which the owners of the structures were contacted to determine stakeholder interest as well as to discuss design options, site rehabilitation, works permitting, and funding assistance. Following favourable responses, design options were costed with contract agreements being established between NSW DPI Fisheries (Conservation and Aquaculture) and the structure owner(s).

Two demonstration sites were selected for remediation in the Northern Rivers subregion: Tunnel Road at Stokers Siding in the Tweed Shire (medium priority), and Wilsons Creek Road near Mullumbimby in the Byron Shire (medium priority). The crossing on Tunnel Road was a council owned piped causeway over an unnamed tributary of Dunbible Creek that restricted fish passage at low-flow conditions due to excessive headloss and shallow flow depth through the structure. Additionally, water velocity through the pipes following minor river rises further restricted migrating fish till the structure drowned out. Remediation of the crossing involved the removal of the existing structure and the insertion of a single span, recycled bridge at a cost of $160,000. Realised benefits included improved access for native fish species to 1.0 km of upstream habitat, reinstatement of a natural creek channel bed, and improved safety and reliability of the crossing for 95 local residents in the Tweed Shire.

The crossing located adjacent to Wilsons Creek Road was an obsolete three-celled causeway over the Wilsons River. The causeway presented itself as an efficient and low cost remediation opportunity that, if removed, would build upon the success of a previous road crossing remediation projection that was carried out immediately downstream as part of the NSW Environmental Trust funded project – “Habitat Rehabilitation of the Endangered Freshwater Cod (*Maccullochella ikei*) in the Richmond Catchment”. The instream portion of the causeway was removed over a five hour period at a cost of $1,500, resulting in improved stream connectivity to 4 km of upstream habitat for native fish species including the endangered Eastern freshwater cod (*Maccullochella ikei*).

A third demonstration site was selected in the Upper North Coast subregion: Kungala Road near Grafton in the Clarence Valley Shire. The council owned crossing on Kungala Road incorporated a single piped crossing that was blocked with sediment, thus effectively forming a weir that prevented the movement of water and instream fauna beneath the road. The existing crossing was removed using an excavator, after which a single-celled box culvert incorporating a low flow channel was installed. Total construction time was less than one week at a cost of $64,000. Benefits associated with remediation included increased access for native fish to 1.7 km of upstream habitat, as well as improved safety and reliability of the crossing for local residents following flooding.

The final demonstration site was located within the Mid North Coast subregion: Guyra Road in the Guyra Shire. The crossing was an obsolete causeway located on the Gara River that had been superseded by a nearby bridge. During low-flow conditions the crossing restricted fish access to 10 km of upstream habitat due to excessive headloss and shallow flow depths. The instream portion of the causeway was removed over a two-day period at a cost of $9,750, resulting in improved stream connectivity to 10 km of upstream habitat for native fish species such as mountain galaxias (*Galaxius olidus*) and long-finned eels (*Anguilla reinhardtii*).

Detailed case study reports are presented below which outline the description and setting of the crossing barrier, proposed remediation actions, construction activities undertaken, projected and final costs, and realised benefits associated with the project.

5.2 Demonstration Site Outcomes

The primary outcome of the demonstration site project was the remediation of four road waterway barriers. In total, stream connectivity was improved to 17 km of upstream habitat, with Appendix C highlighting fish species in the Northern Rivers region that have potentially

benefited from the project. An additional environmental outcome stemming from the project was the education of relevant road management authorities concerning the influence of waterway crossings upon instream habitat and biota. Moreover, social benefits resulting from the project centred on the improved safety and reliability of the modified crossings on Tunnel Road and Kungala Road relative to flood inundation. Through the Environmental Trust, NSW DPI Fisheries (Conservation and Aquaculture) provided $25,500 towards the on-ground works, with contributions from local councils totalling $214,250.

Best-practice techniques for road crossing remediation were demonstrated throughout the planning, design, construction, and remediation of road crossings during this project. Surveying raised awareness within local councils of required standards (e.g. upstream and downstream longitudinal and cross-sectional bed level surveys) to assess the impacts of proposed works upon fish passage, channel geomorphology, and hydrology. Additionally, Councils also became accustomed to permitting requirements associated with works involving dredging, reclamation, and fish passage (Part 7 FM Act), disturbance to riparian corridors, and occupation of Crown Land (Department of Lands).

Throughout the construction phase, effective sediment/erosion controls was implemented to minimise the environmental impacts of the projects. For larger waterways, sediment control consisted of a floating silt boom placed 5 – 10 m downstream of the works site, while hay bales wrapped in geotextile fabric were the preferred option on lower order creeks. Additionally, pool-to-riffle ratios remained unaltered during the course of the project, with predicted changes to channel morphology and stream hydrology viewed as beneficial in the long term. Following the completion of on-ground works, revegetation occurred at two of the sites to aid in bank stabilisation and riparian connectivity.

5.3 Demonstration Site Considerations

Local councils generally address road crossing upgrades if the structure is in disrepair, or if there are safety / liability concerns regarding the waterway crossing during river rises. If a crossing was functional and safe, NSW DPI Fisheries (Conservation and Aquaculture) found it difficult to sway councils towards remediating the structure based upon environmental grounds unless the majority of the project costs were met externally. NSW DPI Fisheries (Conservation and Aquaculture) also noted that Councils in some cases appeared to overstate the costs of the project, possibly to price themselves out of the proposed environmental works.

Given the high costs associated with road crossing remediation (up to $250,000), current funding arrangements ($10,000) were inadequate to alter a council's viewpoint regarding whether a project was initiated or not. Therefore, projects were funded more on an opportunistic basis when they appeared on Council work schedules (e.g. Tunnel Road), rather than through targeted funding of priority barriers. NSW DPI Fisheries (Conservation and Aquaculture) suggests that if priority fish passage barriers are to be addressed in the future, a minimum funding of $30,000 - $50,000 is available to contribute to the project.

Similar difficulties were also experienced when NSW DPI Fisheries (Conservation and Aquaculture) attempted to address private waterway crossings. Assuming the structure was functional and safe, private landholders had little incentive to shoulder the high costs associated with crossing upgrades. Unlike Councils though, when a privately owned structure required repair, landholders were generally unwilling to consider bridge or box culvert designs due to the costs, and instead favoured the cheaper piped culvert structures. Only when permits were refused were alternative designs considered.

Initially, the preferred design by Councils when upgrading a crossing has been the multi-celled box culvert unless the structure was to traverse a major waterway. This preference is attributed to the view that box culverts are less expensive compared to bridges or arched structures. However, comparison of project costs between all demonstration sites undertaken in NSW shows that box culverts were roughly the same or only marginally cheaper than prefabricated bridges such as Doolan Decks. Councils generally underestimate the difficulty

of working instream to construct a stable concrete base slab at or below the natural bed level of the waterway, resulting in a drawn out construction period and higher costs. Alternatively, prefabricated modular units such as the Doolan Deck Bridge require minimal on-ground and instream work (especially if the structure is a sing span), which achieves cost savings of 40 – 60 %.

Although best-practice guidelines followed by Councils today stipulate that superseded structures are to be removed, numerous relic structures exist from a period when such guidelines were not commonplace. Compared to other remediation options, removal of obsolete structures is relatively inexpensive (< $10,000) and quick (< 2 days). During the road crossing audit, a total of 31 obsolete road crossings were recorded, with nearly half of the structures occurring within the Northern Rivers subregion. Given the high ranking of these structures in the waterway crossing prioritisation scheme, the relatively low cost and short timescale associated with remediation, and the fact that removal of the crossing will permanently eliminate the barrier; obsolete crossings should be among the first targeted for future demonstration sites. However, most Councils consider their removal as having no direct capital benefit, and thus are reluctant to provide a significant contribution to such projects. Additionally, adjacent property owners need to be consulted to determine whether the crossings are required for cattle or heavy vehicle access. NSW DPI Fisheries (Conservation and Aquaculture) will continue to approach local councils and relevant stakeholders for the purpose of achieving improved environmental outcomes through productive working relationships.

CASE STUDY 1: TUNNEL ROAD, UNNAMED TRIBUTARY, STOKERS SIDING

The causeway structure, from the right bank.

Downstream view of the piped crossing,

Description and setting

Tunnel Road causeway crosses an unnamed tributary of Dunbible Creek in the Tweed Shire local government area near Stokers Siding. The crossing initially consisted of a downstream capped log sill. However, at a later date a second concrete culvert structure was constructed on top of the causeway to raise the height of the crossing and provide improved access across the creek. The crossing measured 23 metres in length and 3.5 metres wide and possessed two high-set pipes that conveyed water through the structure. The invert of the crossing was 300 mm above bed level resulting in excessive headloss and shallow flow depths through the structure during low-flow conditions. Fish passage was further impeded by increased flow velocities through the pipes following minor river rises until the structure drowned out. Additionally due to the narrow pipe width, debris often accumulated on the upstream side of the structure producing a physical barrier to migrating fish.

The crossing was ranked as a medium remediation priority within the Northern Rivers subregion due to the following factors:

- The crossings is located on an ephemeral flowing, unnamed tributary of Dunbible Creek;
- Dunbible Creek supports a diverse range of native fish species including the fork-tailed catfish (*Arius graeffei*), Australian bass (*Macquaria novemaculeata*), and Australian smelt (*Retropinna semoni*) (Appendix C);
- Riparian and instream habitat condition upstream of the crossing range from fair to good;
- Stream connectivity below the crossing is considered good, with few barriers being present;
- Remediation of the crossing would open up approximately 1 km of upstream waterway.

Proposed remediation actions

The crossing is owned by Tweed Shire Council and provides the primary access way for 95 landholders. Council approached DPI (Fisheries, Conservation and Aquaculture) concerning the upgrade of the crossing due to traffic safety concerns stemming from the narrow width (i.e. single lane) and dilapidated nature of the crossing.

Designs initially produced by Tweed Shire Council proposed a three-celled box culvert with a central low-flow channel; however, this design was later changed to a single span concrete bridge using recycled materials from a previous structure. Creek bed level surveys were conducted to determine the likely impact of removing the causeway on channel stability and hydrology.

Remediation works

Designs and permits for the crossing were approved by DPI (Fisheries, Conservation and Aquaculture) in mid August 2005, with construction commencing shortly thereafter. Prior to the start of on-ground works, instream sediment control consisting of a floating silt boom was installed across the full width of the downstream channel. In order to maintain vehicle access during construction, a temporary timber bridge road crossing was erected immediately upstream of the existing structure.

The causeway barrier was removed over a two-day period using an excavator fitted with a rock-hammer (**Plate a – c**). Following removal of the causeway, difficulties were encountered in maintaining a dry working environment to install the bridge abutments. The work procedure was therefore amended to insert precast concrete boxes at each end of the bridge, within which abutment work could be contained (**Plate d**). This modification negated the need to insert multiple coffer dams to control stream flow and water level during construction. The abutment boxes were subsequently filled with concrete, with raker walls being added prior to the installation of the bridge deck. Road approaches 20 m either side of the crossing were then sealed via bitumen, with rock scour protection inserted around the structure to limit erosion and sedimentation into the waterway (**Plate e**). Construction was completed in 10 weeks (**Plate f**), with revegetation of disturbed banks to occur in the following weeks.

a)

b)

c)

d)

e)

f)

Project Costs:

Tunnel Road, Stokers Siding	
	Final Cost
Site establishment and supervision	2,200
Erosion and sediment control	8,000
Causeway removal	12,500
Bridge installation	109,000
Adjacent roadworks	27,500
Signage	800
TOTAL	**$160,000**

The projected cost for removing the causeway barrier and inserting a single-span concrete bridge at Tunnel Road was estimated at $80,000. However, due to complications associated with working in and around water, the final cost for the project was $160,000. DPI (Fisheries, Conservation and Aquaculture) agreed to provide a financial contribution totalling $10,000 to the proposed works through the Environmental Trust funded project (Contract No. ET-H08025). The following is the financial breakdown of the contribution provided to Tweed Shire Council:

- $ 500 Erosion and sediment control
- $ 1,500 Site establishment
- $ 1,000 Disposal of tippage waste
- $ 2,000 Removal of causeway barrier
- $ 3,000 Installation of bridge crossing
- $ 1,000 Revegetation of banks with native vegetation
- $ 1,000 Promotional signage and project awareness

Benefits associated with remediation

The primary outcomes of the Tunnel Road project were:

- Improved stream connectivity for native fish species (**Plate g-h**; Appendix C);
- Reinstatement of a natural creek channel bed that will facilitate sediment movement;
- Improved safety and reliability of the crossing for 95 local residents (22 properties) in the Tweed Shire; and
- Reduced sediment input due to the sealing of bridge approaches.
- Revegetation of adjacent riparian zone with native species.

g)

h)

Case Study 2: Obsolete causeway at Wilsons Creek Road, Mullumbimby:

View across the low lying causeway.

Three celled causeway, view from downstream side.

Description and setting

The construction of Pioneer Bridge and the associated realignment of Wilsons Creek Road diverted traffic away from the historical route that traversed the Wilsons River using a low-lying, three-celled causeway. The obsolete crossing, which measured 14 metres in length (bank to bank) and 7 metres wide, consisted of a downstream log sill that was concrete capped. As a result, the crossing obstructed fish passage due to excessive water velocities flowing through the narrow piped culverts.

The crossing was ranked as a medium remediation priority within the Northern River subregion region due to the following:

- The Wilsons River is a perennial flowing, mid order tributary of the Richmond River that supports a diverse range of native fish;
- The upper reaches of the Wilsons River are within the known historical range of the endangered Eastern freshwater cod (*Maccullochella ikei*). In the recent past, Eastern freshwater cod were stocked within the vicinity of the crossing; however, it is unknown whether the current population is self-sustaining;
- Riparian and instream condition within the upper reaches of the Wilsons River is considered excellent;
- Stream connectivity is fragmented downstream of the crossing due to the presence of numerous barriers including Lavertys Gap Weir; and
- Along with the remediation of the next downstream road crossing, removal of the obsolete crossing near Pioneer Bridge improves access for migrating fish to 4 km of upstream habitat.

Proposed remediation actions

Given that the obsolete causeway near Pioneer Bridge was located on Council road reserve, DPI (Fisheries, Conservation and Aquaculture) initially approached Byron Shire Council regarding the removal of the structure. Council indicated that finances were not available to proceed with the works, whereupon DPI (Fisheries, Conservation and Aquaculture) permitted a private contractor to remove the crossing.

Landholders adjacent to the crossing were contacted to ascertain perceptions towards the structure, with unanimous support being garnered for its removal. Additionally, Byron Shire Council judged that the works constituted ecological restoration, which negated the need to lodge a Development Application under Council regulations. Changes in channel geomorphology associated with the removal of the causeway and subsequent mobilisation of sediment were viewed as a minimal; however, upstream water height was predicted to drop by 20 - 30 cm.

a)

b)

c)

d)

e)

f)

Remediation works

Access to the site was gained via a Council road reserve. Prior to the start of on-ground works, a floating silt boom was installed downstream of the causeway to limit the impacts of sedimentation. Using an excavator, the instream portion of the causeway was removed over a five hour period starting from the right bank (when looking downstream) and working back towards the left bank (**Plate a – d**). Dredged material was removed to the Council tip, with the dump fees waived by Byron Shire Council.

Project costs

Obsolete Causeway at Williams Bridge; Mullumbimby		
		Final Cost
Erosion and sediment control		100
Site establishment		100
Removal of obsolete crossing		900
Tippage Disposal & site cleaup		400
	TOTAL	**$ 1,500**

The total cost of removing the obsolete causeway near Pioneer Bridge on Wilsons Creek Road was $1,500. DPI (Fisheries, Conservation and Aquaculture) provided a financial contribution totalling $1,000 towards the works, with the remaining $500 being waived by Byron Shire Council for waste tippage.

Benefits associated with remediation

The primary outcome associated with the removal of the obsolete crossing at Pioneer Bridge was the reinstatement of unimpeded fish passage and sediment movement past the structure (**Plates e-h**). In conjunction with the removal of another crossing barrier immediately downstream, native fish, including the Eastern freshwater cod (*Maccullochella ikei*), now have improved access to over 4 km of upstream habitat within the Wilsons River.

g)

h)

CASE STUDY 3: KUNGALA ROAD, GRAFTON:

Unsealed Kungala Road at waterway crossing site.

Heavily silted pipe culvert, downstream view.

Description and setting

The pipe culverts at Kungala Road cross an unnamed tributary of Dundoo Creek, a tributary of the Orara River in the Clarence Valley Shire local government area. The crossing consisted of an 8.3 m by 0.35 m pipe that was blocked with sediment, thus effectively forming a weir preventing the movement of water and instream fauna beneath the road.

Prioritisation of road crossing barriers in the Upper North Coast subregion highlighted the crossing on Kungala Road as a medium priority due to the following factors:

- Dundoo Creek is a perennial flowing tributary of the Orara River within the middle reaches of the Clarence Catchment;
- Riparian and instream condition within Dundoo Creek and surrounding subcatchments is considered fair to good;
- Stream connectivity is considered good beneath the crossing, with few barriers to migrating fish; and
- The crossing restricts fish access to 1.7 km of upstream habitat throughout the year except during flooding when the structure drowns out.

Proposed remediation actions

The crossing is owned by Clarence Valley Shire Council and is used by upwards of 250 vehicles per day. Due to the inability of water to pass beneath the crossing, Clarence Valley Shire Council approached DPI (Fisheries, Conservation and Aquaculture) with a proposal to remove the existing pipe culvert and replace with a large box culvert that contained a low-flow channel. Bed level surveys were consulted to determine the invert of the middle cell to ensure that water maintained a depth of 300 mm through the structure.

Remediation works

Designs and permits for the crossing were approved by DPI (Fisheries, Conservation and Aquaculture) in June 2004, with construction commencing shortly thereafter. Prior to the start of on-ground works, instream sediment control consisting of a hay bales wrapped in geotextile fabric were installed across the full width of the downstream channel to prevent the downstream movement of mobilised sediment. However, on-ground works were conducted during a period of prolonged drought, during which no water was flowing or pooling beneath the structure.

a)

b)

c)

d)

e)

f)

An excavator was used to remove the piped crossing to a level below the natural bed of the tributary (**Plates a & b**), which enabled a low flow channel to be constructed at a predetermined level based upon longitudinal surveys of the surrounding reach (**Plates c & d**). Pre-cast box culverts which incorporated the low flow channel were placed within the channel created and set in concrete (**Plates e & f).** Rock protection was inserted on the downstream side of the crossing, with the approach roads sealed 50m on either side of the crossing to reduce sediment input from the road surface. Total construction time was less than one week.

Project costs

Kungala Road, Grafton		
	Projected Cost	**Final Cost**
Survey & Design	1,000	1,000
Sediment erosion control	1,500	1,000
Site Establishment	500	500
Roadworks	37,190	36,200
Box Culvert	24,500	24,500
Signage		800
TOTAL	**$64,690**	**$64,000**

Initial project costs were estimated at $64,690 by Clarence Valley Council; however, the final costs came to $64,000. DPI (Fisheries, Conservation and Aquaculture) agreed to provide a financial contribution totalling $8,000 to the proposed works through the Environmental Trust funded project. The following is the financial breakdown of the contribution provided to Clarence Valley Council:

- $ 1,000 Erosion and sediment control
- $ 2,000 Sealing a minimum of 50 m either side of the crossing
- $ 4,000 Structural and instream works
- $ 1,000 Promotional signage and project awareness

Benefits associated with remediation

The primary outcomes of the Kungala Road project were:

- Improved stream connectivity for native fish species (**Plate g-h**; Appendix C);
- Reinstatement of a natural flow regime to the unnamed tributary along with reduced sediment inputs associated with the sealing of road approaches; and
- Improved safety and reliability of the crossing for approximately 250 vehicles which traverse the crossing daily.

g)

h)

CASE STUDY 4: OBSOLETE CAUSEWAY ON GUYRA ROAD, GUYRA:

Obsolete causeway within Council road reserve.

Downstream side of crossing exhibiting headloss.

Description and setting

An obsolete crossing located on the Gara River in the Guyra Shire local government area was selected as a demonstration site for road crossing remediation. The crossing, which measured 30 metres in length (from bank to bank) and 8.0 metres wide, consisted of a downstream log sill that was concrete capped with a single pipe culvert which was completely blocked with sediment. Fish passage was obstructed due to excessive headloss (400 mm) and shallow flow depths during low-flow conditions. However, the structure quickly drowned out during moderate river rises.

The crossing was ranked as a medium remediation priority within the Mid North Coast subregion due to the following factors:

- The Gara River is an upper catchment tributary of the Macleay River that supports a diverse range of native fish;
- The crossing is obsolete and serves no apparent purpose,
- Stream connectivity is fragmented downstream and upstream of the crossing due to the presence of several barriers including Malpas Dam;
- Instream habitat condition is considered fair to good within the vicinity of the crossing; however riparian condition is considered poor; and
- Along with the removal of the obsolete causeway on Wards Mistake Road, remediation of fish passage at Guyra Road opens up approximately 23.4 km of unimpeded stream length.

Proposed remediation actions

The crossing was located within a road reserve was owned by Guyra Shire Council. DPI (Fisheries, Conservation and Aquaculture) approached Council to determine the possibility of removing the crossing at Guyra Road and a second obsolete causeway located on the Gara River approximately 2 km upstream. Although unwilling to make a significant financial contribution to the project, Guyra Shire Council agreed to assist in the removal of both crossings to improve stream connectivity. Landholder consultation was not required for either crossing as Council owned the adjacent land.

a)

b)

c)

d)

Remediation works

Access to the site was obtained via the existing road approaches (**Plate b**). Prior to the start of on-ground works, hay bales wrapped in geotextile fabric were installed instream to prevent the downstream migration of mobilised sediment. However, on-ground works were conducted in March 2005 during which the surrounding region was experiencing an extreme drought. Over this period, the Gara River stopped flowing (**Plate c**), possibly due to the retention of water in Guyra's water supply reservoir located approximately 8 km upstream of Guyra Road. Using an excavator, the instream portion of the culvert was removed over a two day period starting from the left bank and working back towards the right bank (when looking downstream)(**Plate c – d**). Dredged material was disposed off-site at the Council tip.

Project costs

The total cost of removing the obsolete causeway on Wards Mistake Road was $9,750. DPI (Fisheries, Conservation and Aquaculture) provided a financial contribution totalling $6,500 towards the removal of the crossing through the Natural Heritage Trust funded project UNCRH803. The following is the financial breakdown of the contribution provided towards the project:

- $ 250 Erosion and sediment control
- $ 500 Site establishment
- $ 5,000 Removal of obsolete crossing
- $ 250 Site cleanup
- $ 500 Promotional signage and project awareness

Obsolete Causeway on Wards Mistake Road; Guyra	
	Final Cost
Erosion and sediment control	250
Site establishment	1000
Removal of obsolete crossing	6000
Tippage Disposal	1200
Site cleanup	500
Signage	800
TOTAL	**$ 9,750**

Benefits associated with remediation

The primary outcomes associated with the removal of the obsolete crossing on Guyra Road were the remediation of fish passage and the reinstatement of unimpeded sediment movement at the site. In conjunction with the removal of the obsolete causeway on Wards Mistake Road, native fish including mountain galaxias (*Galaxias olidus*) and long-finned eel (*Anguilla reinhardtii*) now have improved access to over 10 km of upstream habitat within the Gara River (**Plate e-f**).

e)

f)

6. REFERENCES

Allen G.R., Midgley, S.H. & Allen M. (2002) *Field guide to the freshwater fishes of Australia*. Western Australian Museum, Perth.

Bunn, S. & Arthington, A. (2002) *Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity.* Environmental Management (30) 4: 492-507

Cotterell, E (1998) *Fish Passage in Streams – Fisheries guidelines for design of stream crossings*. Fish Habitat Guideline FHG001, Queensland Department of Primary Industries, Brisbane.

Fairfull, S. and Witheridge, G. (2003) *Why do fish need to cross the road? Fish passage requirements for waterway crossings.* NSW Fisheries, Cronulla, 16pp.

Farabi, H., James, R., & McCormack, R.J. (2004) Mitigating the effects of forests roads on water quality by managing hydrological connections. *Proceedings of the 4th Australian Stream Management Conference*. October 2004, Tasmania.

Gehrke, P.C. & Harris, J.H. (2001). *Regional-scale Effects of Flow Regulation on Lowland Riverine Fish Communities in New South Wales, Australia*. Regul. Rivers: Res. Mgmt. **17**: 369-391

Horton, R.E., (1933). *The role of infiltration in the hydrologic cycle*. EOS, American Geophysicists Union Transactions, **14**, 446-460.

Kapitzke, R. & Patterson, J. (2002). *Developing and testing culvert fishways: Featuring the prototype culvert fishway on University Creek, Townsville, north Queensland* at http://www.eng.jcu.edu.au/research/trem/website_culvert_fishway.pdf.

McDowall, R.M (1996) *Freshwater fishes of south-eastern Australia*. Reed Books, Sydney.

NSW Department of Land and Water Conservation (1999a) *Stressed Rivers Assessment Report: North Coast Region - Nambucca, Macleay and Hastings, Camden Haven Catchments*. DLWC, Sydney

NSW Department of Land and Water Conservation (1999b) *Stressed Rivers Assessment Report: Region North Coast – Tweed, Brunswick and Richmond Catchments*. DLWC, Sydney.

NSW Department of Land and Water Conservation (2003) *Integrated Catchment Management Plan for the Mid North Coast Catchment 2002*. Mid North Coast Catchment Management Board. NSW DLWC, February 2003.

NSW Fisheries (1999) *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation*. NSW Fisheries, Cronulla, NSW.

NSW Fisheries (2003) *Policy and Guidelines for fish friendly waterway crossings*. Fishnote Series NSWF1181, NSW Fisheries, Cronulla NSW.

Petheridge, R., Lugg, A., & Harris, J. (1998) *Obstructions to Fish Passage in New South Wales South Coast Streams*. Final Report Series 4, Cooperative Research Centre for Freshwater Ecology, NSW Fisheries, Cronulla, NSW.

Rutherfurd, I.D., Jerie, K., and Marsh, N. (2001) *A Rehabilitation Manual for Australian Streams*. Cooperative Research Centre for Catchment Hydrology. Land & Water Australia.

Takken, I., Croke, J., Mockler, S., Hairsine, P., & Lane, P. (2004) Delivery of sediment from forest roads to streams: A function of hydrologic connectivity. *Proceedings of the 4th Australian Stream Management Converence*. October 2004, Tasmania.

Thorncraft, G. and Harris, J.H. (2000) *Fish passage and fishways in NSW: A Status Report.* Cooperative Research Centre for Freshwater Ecology Technical Report 1/2000.

Warren Jr, M. & Pardew, M. (1998) *Road crossings as barriers to small-stream fish movement.* Transactions of the American Fisheries Society. 127:637-644

Williams, R.J., Watford, F.A. & M.A. Taylor (1996) *A Summary of Aspects of FRDC Project 94/041 "Restoration of Estuarine Fisheries Habitat" Relevant to Tidal Obstructions in New South Wales Estuaries.* NSW Fisheries Research Institute, Cronulla, NSW, 109pp.

Witheridge, G. (2002) *Fish passage requirements for waterway crossings – Engineering Guidelines.* Catchment and Creeks Pty Ltd, Brisbane.

Wood, P.L. & Armitage, P.D. (1997) *Biological effects of fine sediment in the lotic environment*. Env. Mgmt. **21** (2): 203-217

WWF Australia. (2005) *Duck creek Crossing Removal Case Study*. WWF Australia, Sydney.

Yearsley G.K., Last P.R. & Ward R.D. (2001) *Australian Seafood Handbook – Domestic Species*. CSIRO Marine Research and Fisheries Research & Development Corporation, Aust.

7. APPENDICES

Appendix A: Coastal Waterway Crossings Desktop & Field Assessment

ASSESSOR: _____ DATE: dd/mm/yy
CROSSING ID: _____ CLASS (select one): 1 2 3 4
GPS (or Grid reference and map name and number): Lat_____ Long_____
IMAGE FILE NUMBERS: _____

---

1. LOCATION INFORMATION

Surrounding Land Uses (please select one)**:**

Grazing Cropping Urban Rural Industrial State Forest National Park

---

2. STRUCTURE DETAILS

2a Road Type (please select one): Sealed Unsealed

2b Obsolete (please select one): Yes No

2c Ancillary purposes (select one): Bed-control Erosion Control Flood Mitigation Irrigation Regulation Stock Watering Water Supply

2d Structure Type (please circle):

- **Bridge** - single or multiple span or arched structure raised above channel bed.
- **Box Culvert** - pipe or box shaped cell to convey water underneath roadway.
- **Pipe Culvert** - cylindrical-celled culvert.
- **Weir –**in-stream structure designed to back water upstream.
- **Causeway** - low-level crossing designed to convey water over road; may have low-flow pipe.
- **Ford** – low level crossing formed directly on the channel bed in a shallow section of a watercourse.
- **Floodgate** - gated levee to regulate flow between floodplain and stream channel.

2e. Structure Description:

No. of cells or pipes _____ Cell Width _____m
Height (from downstream bed-level to structure crest) _____m Width (bank to bank) _____m
Breadth (upstream to downstream) _____m
Construction material (select one): Concrete Timber Steel Rock Gravel Sand/Fines

---

3. ENVIRONMENTAL CONSIDERATIONS

Fish Passage

3a Does the structure potentially block fish passage: Yes No
If yes, what type of blockage (select one or more)**:**
Head loss: est. (mm) _____ **Slope:** est. grade: _____
Velocity **Debris** **Low flow depth though structure** **Light**
Blockage **Other** _____

3b Is there flow over/through the structure: Through Over Both

3c Does water pool upstream of the structure**:** Yes No

- If yes, what is the average depth of pool _____m and length of the pool _____m

3d Bank height _____m; channel width _____m; low-flow channel width _____m & depth ____m

3e Habitat features (substrate type, pools, riffles, gravel bed, boulders, macrophytes, snags, undercuts, riparian overhangs etc)

3f Condition of aquatic habitat: good fair poor
3g Condition of riparian zone: good fair poor

4. WATERWAY NAME _____

5. ROAD NAME _____

6. COMMENTS (channelised, erosion, siltation, reduced water quality, riparian & aquatic pests etc)

7. RECOMMENDATIONS (select one): Box Culvert with Low Flow Channel Bridge Fishway
Floodgate Management Maintenance Remove

COASTAL WATERWAY CROSSINGS – DESKTOP ASSESSMENT FORM

ASSESSOR: _____ DATE: _____ CROSSING ID: _____
CATCHMENT: _____ WATERWAY: _____
STREAM CLASS: _____ LGA_____ SUBREGION_____

1. LOCATION INFORMATION

1a Location: Nearest Town: _____ Road Name: _____

1b Section of Catchment (please circle)**:** Upper Middle Lower Tidal

2. STRUCTURE DETAILS

2a Structure ownership (please circle)**:** Federal State Local Government Private Landholder

2b Distance to next potential barrier: Upstream _____km Downstream _____km

2c How many barriers downstream: (please circle): None 1 2 3 4 5 or more

2d Owner of the next potential barrier (please circle)**:**
Upstream: Federal State Local Government Private Landholder
Downstream: Federal State Local Government Private Landholder

2e If the structure blocks fish passage, how much habitat upstream would become available if the structure was modified to allow for fish passage _____km

3. ENVIRONMENTAL CONSIDERATIONS

3a Threatened and protected coastal aquatic species present (please circle)**:**
Olive perchlet Eastern freshwater cod Purple spotted gudgeon Oxleyan pygmy perch
Macquarie perch Black cod Australian grayling Estuary cod

3b Other key aquatic species present: _____
_____

NB: Use *Fishfiles* or *Freshwater Fish Research Database*. Include recreational and commercial fish species and key species such as platypus, turtles and water birds (if identified in the field).

3c Environmental status: _____
_____

NB: Include terrestrial threatened species, critical habitat, conservation rating (HCV etc) and protected area status (e.g. MPAs, SEPP and significant wetlands, reserves, NPs and wilderness listings) if known.

Appendix B: Fish Passage Barrier Prioritisation Scheme for the Northern Rivers CMA Region, NSW

INITIAL PRIORITISATION							
A) STREAM HABITAT VALUE CRITERIA							**SCORE**
Primary aquatic habitat rating							
Habitat Class		1	2	3	4		
Location in the system		Tidal	Lower	Middle	Upper		
Downstream obstructions		0	1-2	3 - 5	> 5		
Upstream habitat – stream length opened up (>/= 3rd order)		> 20 km	10 – 20 km	5 - 10 km	1 - 5 km	< 1 km	
B) STRUCTURE IMPACT CRITERIA							
Environmental effect rating							
Physical barrier	Headloss	> 1000 mm	500 - 1000 mm	250 – 500 mm	100 - 250 mm		
	Slope	"True"					
	Debris	"True"					
	Blockage	"True"					
Hydrological barrier	Velocity	"True"					
	Flow depth	"True"					
Behavioural barrier	Light penetration	"True"					
						SUBTOTAL	

SECONDARY PRIORITISATION					
C) ENVIRONMENTAL CRITERIA					
Secondary aquatic habitat rating					
Low-flow channel width	> 15 m	10 – 15 m	5 - 10 m	< 5 m	
Instream habitat condition	Good		Fair		
Riparian condition	Good		Fair		
Point Sediment Impacts	Unsealed		Sealed		
Threatened species	"True" Class 1-2 (within range, likely habitat)		"True" Class 3 (within range, unlikely habitat)		
Landuse / Environmental Status	National Park = 1	State Forest = 2	Rural = 3		
D) MODIFICATION CRITERIA					
Structure use and remediation cost rating					
Obsolete Crossing	"True"				
Ease of Remediation	Maintenance	Box Culvert Low Flow Channel	Bridge		
Ancillary uses	Flood mitigation = 1	Bed Control = 2	Pump pool, Irrigation = 3		
				SUBTOTAL	
				TOTAL	

Appendix C: Freshwater and Estuarine Fish in the North Coast NSW

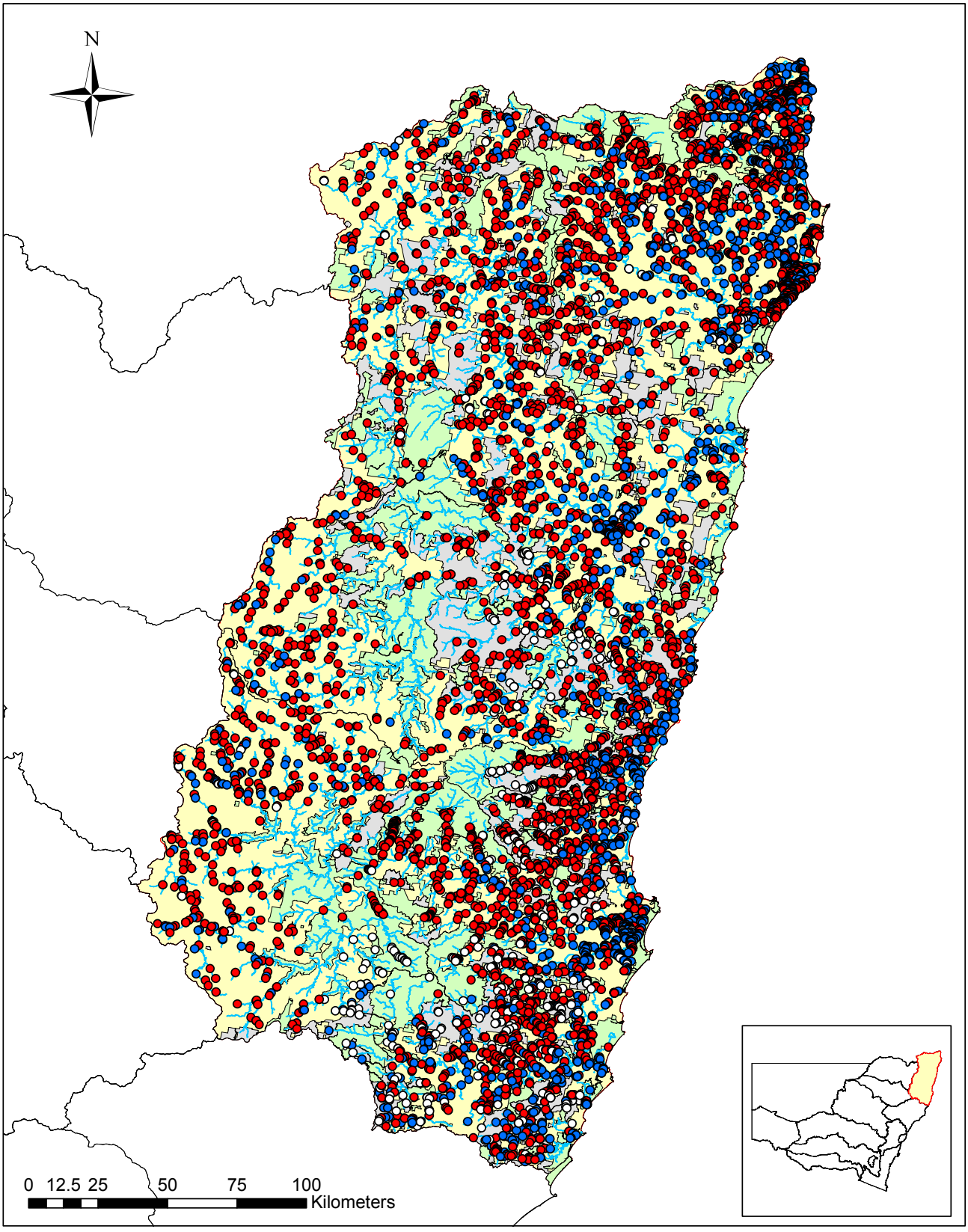
Scientific Name	Common Names	Status	Migration[1] and habitat
Acanthopagrus australis	Yellowfin bream Silver bream	Common	Amphidromous; coastal marine; estuaries and inshore reefs
Afurcagobius tamarensis	Tamar River goby	Common	Estuaries, coastal lakes and lower freshwater river reaches
Ambassis agassizii	Olive perchlet	Threatened species - Endangered western population	Local migration; freshwater streams, ponds and swamps
Ambassis marianus	Estuary perchlet Glass perchlet	Common	Local migration; brackish mangrove estuaries and tidal creeks
Amniataba percoides	Banded grunter	Exotic; Noxious listing, NSW	Freshwater habitats
Anguillia australis	Short-finned eel	Common	Catadromous; coastal rivers & wetlands
Anguilla reinhardtii	Long-finned eel Marbled eel	Common	Catadromous; coastal rivers
Annoya bifrenatus	Bridled goby	Common	Estuaries and marine waters
Arius graeffei	Freshwater fork-tailed catfish	Common	Anadromous; northern coastal rivers
Arrhamphus sclerolepis	Snub-nosed garfish	Common	coastal bays and brackish estuaries
Atherinosoma microstoma	Smallmouthed hardyhead	Common	Unknown migration pattern; coastal estuarine and fresh waters
Butis butis	Bony-snouted gudgeon	Reasonably abundant in range	Brackish waters and coastal rivers
Carassius auratus	Goldfish	Exotic	Widespread in lowland rivers
Chanos chanos	Milkfish	Common	Marine and warm water, shallow estuaries and rivers
Craterocephalus marjoriae	Marjorie's hardyhead	Uncertain	Unknown migration pattern; found in abundance in fresh waters of the Clarence & Mary Rivers – few elsewhere.
Cyprinus carpio	Common carp	Exotic; Noxious listing	Still gentle flowing rivers in inland NSW and some catchments along the coast.
Epinephelus coioides	Estuary cod Rock cod	Protected	Marine – found mainly in reefy inshore waters and estuaries
Gambusia holbrooki	Gambusia	Exotic Noxious listing	Widespread in coastal and inland NSW
Galaxias maculatus	Common jollytail	Common	Catadromous; coastal streams, lakes and lagoons – salt and fresh water environs
Galaxias olidus	Mountain galaxias	Common	Local migration; moderate and high elevations in coastal and inland rivers.
Gerres subfasciatus	Silver biddy	Common	Marine estuaries and bays, brackish coastal rivers and lakes.
Glossamia aprion	Mouth almighty	Abundant within its range	Local migration; northern freshwater streams, ponds and reservoirs
Gobiomorphus australis	Striped gudgeon	Common	Amphidromous; coastal streams generally at lower elevations.
Gobiomorphus coxii	Cox's gudgeon	Common	Potamodromous; coastal rivers from the Richmond River south.
Gobiopterus semivestitus	Glass goby	Uncertain	Estuarine

[1] Migration patterns of freshwater fish include: *Potamodromous* – fish that migrate wholly within fresh water; *Anadromous* – fish that spend most of their life in the sea and migrate to fresh water to breed; *Catadromous* - fish that spend most of their life in fresh water and migrate to the sea to breed; *Amphidromous* - fish that migrate between sea and fresh water, but not for the purpose of breeding.

Hypseleotris compressa	Empire gudgeon	Common throughout its range	Unknown migration; lower reaches of coastal rivers.
Hypseleotris galii	Firetailed gudgeon	Common	Potamodromous; freshwater reaches of coastal streams.
Hypseleotris klunzingeri	Western carp gudgeon	Common	Unknown migration; inland and north coast streams
Leiopotherapon unicolor	Spangled perch	Common	Potamodromous; warm fresh waters in inland and north coast streams, backwaters and dams.
Liza argentea	Flat-tail mullet	Common	Estuaries and sea beaches
Maccullochella ikei	Eastern freshwater cod	Threatened Species – Endangered	Unknown migration; restricted to the Clarence and Richmond catchments
Macquaria colonorum	Estuary perch	Uncertain	Amphidromous; estuarine areas in coastal rivers and lakes
Macquaria novemaculeata	Australian bass	Uncertain	Catadromous; Coastal rivers up to 600m altitude.
Megalops cyprinoides	Oxeye herring	Abundant throughout its range	Amphidromous; tropical waters, estuaries and northern coastal fresh waters
Melanotaenia duboulayi	Duboulay's rainbowfish	Relatively common throughout its range	Local migration; coastal waterways from Macleay River north into QLD
Mogurnda adspersa	Purple-spotted gudgeon	Threatened Species listing - Endangered western population	Local migration; inland NSW and coastal streams of northern NSW and QLD
Mugil cephalus	Striped mullet Sea mullet	Common	Amphidromous; lower reaches and estuaries of coastal catchments
Myxus elongatus	Sand mullet	Common	Amphidromous as juveniles; estuaries and brackish waters in lower river reaches
Myxus petardi	Freshwater mullet	Common	Catadromous; freshwater reaches of coastal rivers north of Georges River into QLD
Nannoperca oxleyana	Oxleyan pygmy perch	Threatened Species – Endangered	Local migration; some northern streams and swampy areas.
Notesthes robusta	Bullrout	Limited abundance but not threatened	Catadromous; tidal estuaries and fresh waters
Oncorhynchus mykiss	Rainbow trout	Exotic	Local migration; montane regions along the Great Dividing Range
Philypnodon grandiceps	Flathead gudgeon	Common	Unknown migration; inland and coastal waters especially lakes and dams
Philypnodon sp.1	Dwarf flathead gudgeon	Common	Unknown migration; coastal and inland streams
Platycephalus fuscus	Dusky flathead	Common	Amphidromous; marine and estuarine waters
Potamalosa richmondia	Freshwater herring	Not common but not considered under threat	Catadromous; estuaries and coastal fresh water rivers
Pseudomugil signifer	Southern blue-eye	Common	Amphidromous; eastern draining catchments
Redigobius macrostoma	Largemouth goby	Common	Amphidromous; estuaries, coastal rivers and some freshwater streams
Retropinna semoni	Australian smelt	Common	Potamodromous; Inland and coastal freshwater
Rhadinocentrus ornatus	Softspined rainbowfish	Patchy localised distribution	Local migration; northern coastal streams
Tandanus tandanus	Freshwater catfish	Common	Local migration; lakes and slow-flowing rivers
Valamugil georgii	Fantail mullet	Common	Amphidromous as juveniles; marine and estuarine waters

Sources: Thorncraft & Harris (2000), McDowall (1996), Allen *et al.* (2002) and Yearsley *et al.* (2001).

Appendix D: Road Crossings on Major Waterways in the Northern Rivers CMA, NSW



Land Tenure

- State Forests
- National Parks
- Other

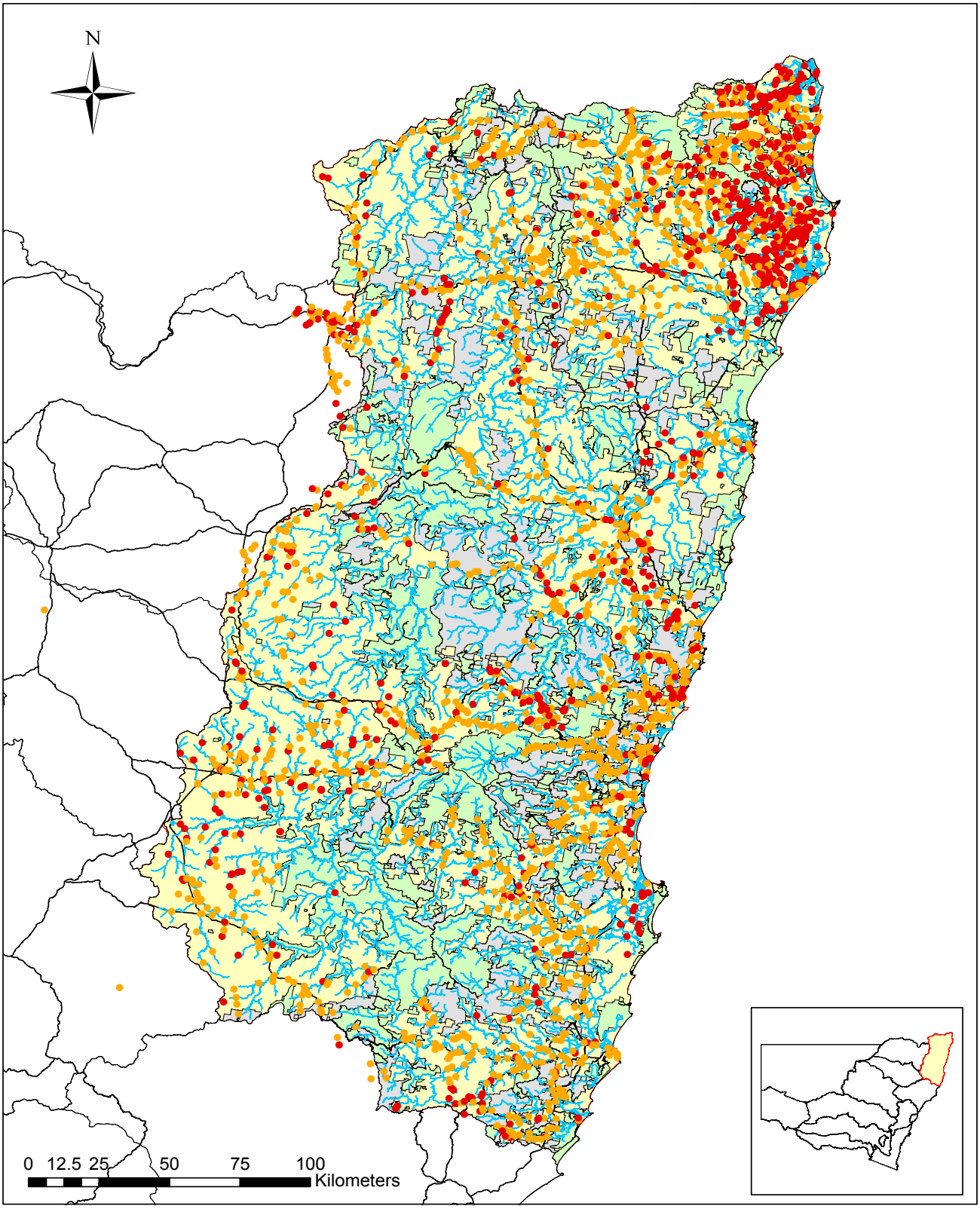
Surface Type

- Unsealed
- Sealed
- Unknown

- Waterways 4th order and above
- Northern Rivers Catchments

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Appendix E: All Road Crossings Assessed in the Northern Rivers CMA



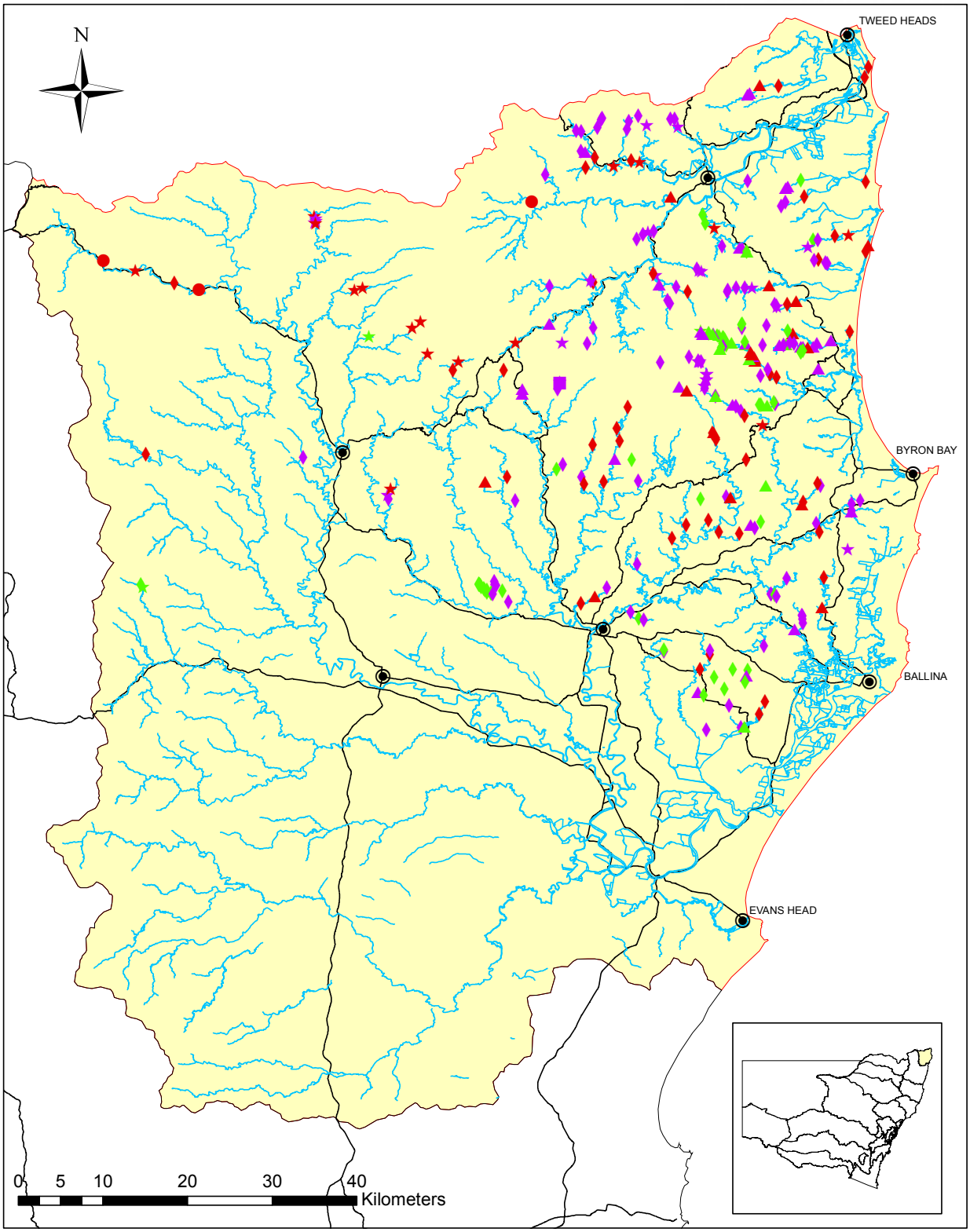
Land Tenure
- State Forests
- National Parks
- Other

Fish Passage Barrier
- Yes
- No

- Waterways 4th order and above
- Highways and major roads
- Northern Rivers Catchments

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Appendix F: Location of Road Crossing Barriers in the Northern Rivers Subregion



Structure Type

- Pipe Culvert
- Box Culvert
- Causeway
- Ford
- Weir

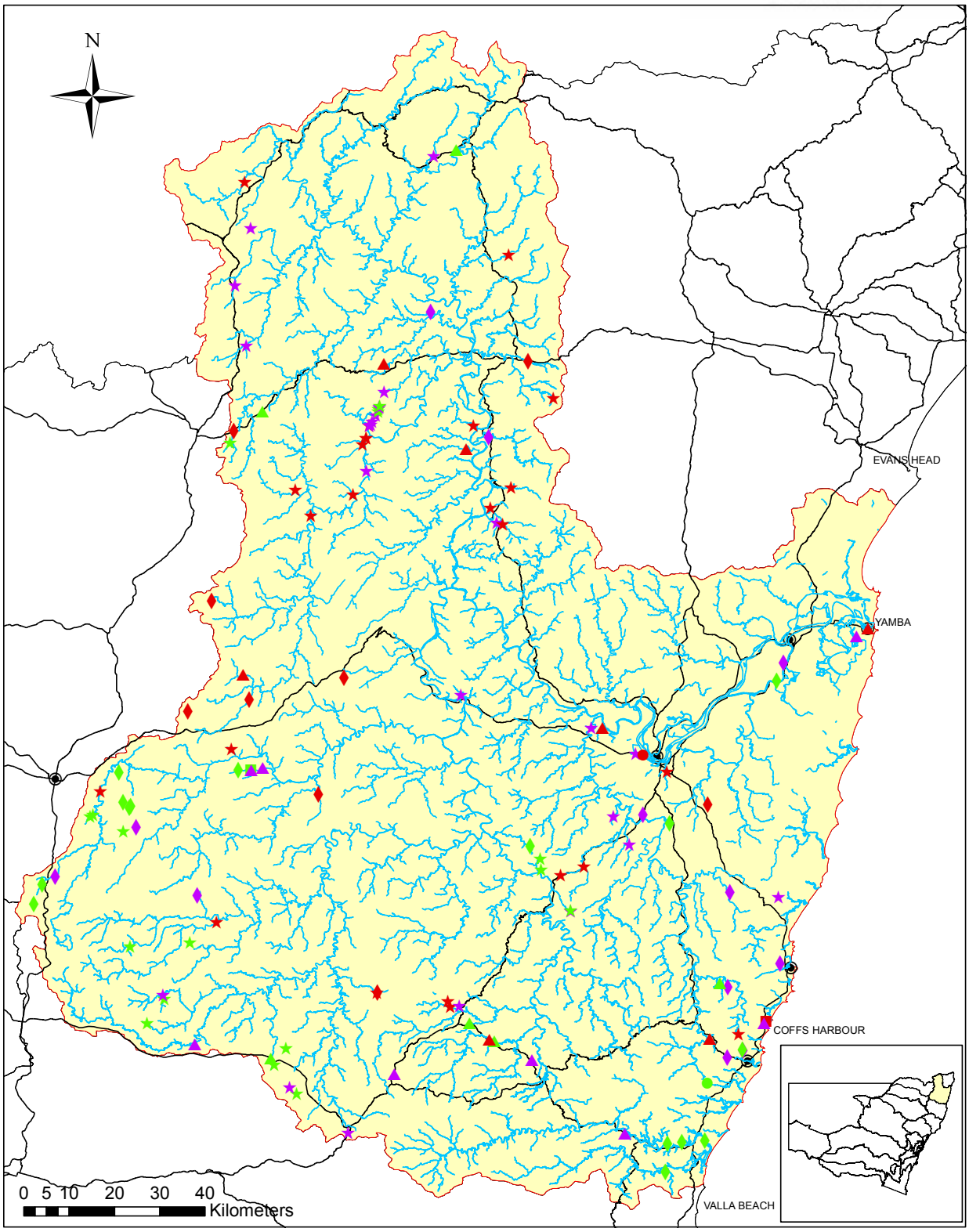
Priority Rank

High | Medium | Low

- Waterways 4th order and above
- Highways and major roads
- Northern Rivers Catchments

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Appendix G: Location of Road Crossing Barriers in the Upper North Coast Subregion



Structure Type

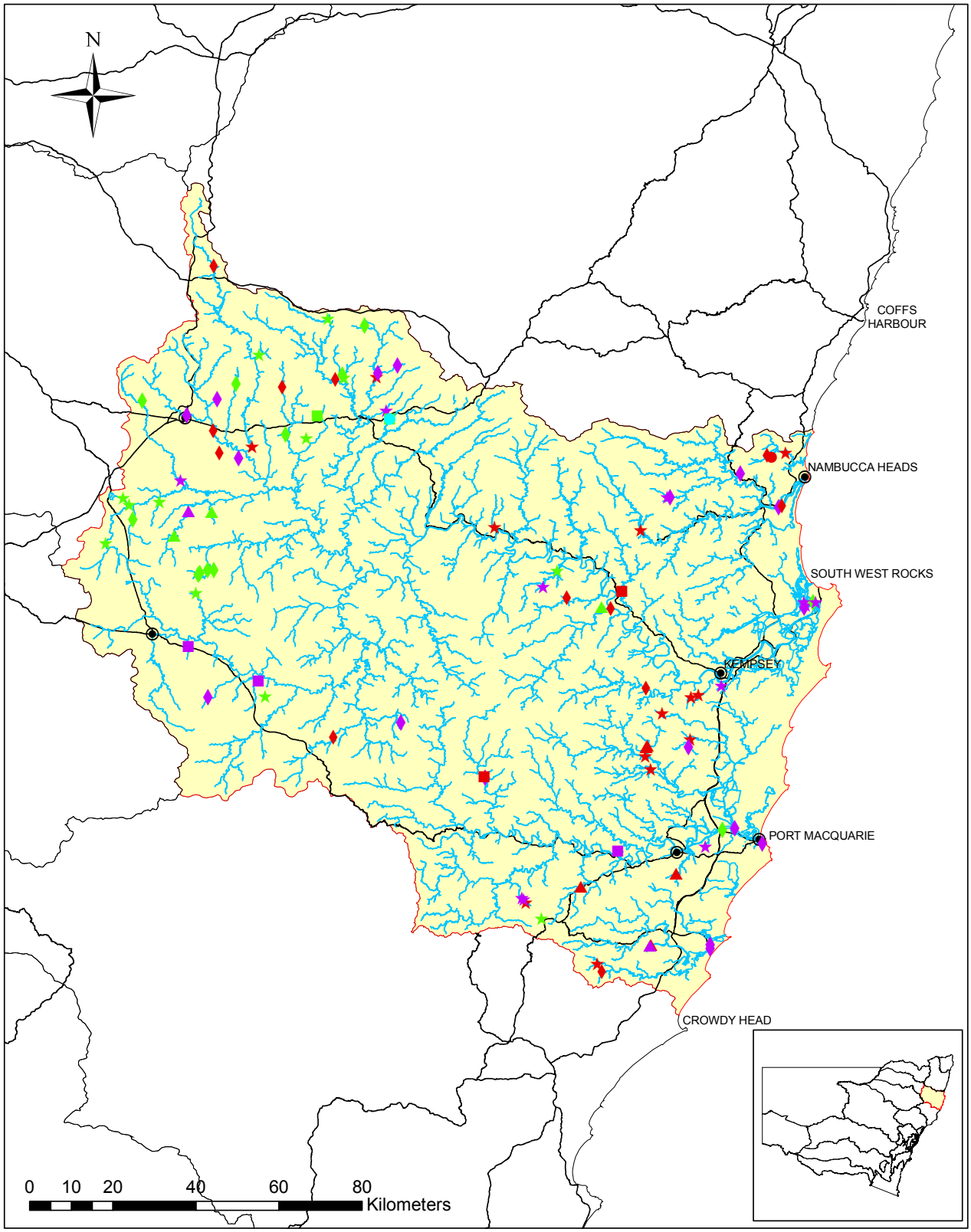
- Causeway
- Box Culvert
- Ford
- Weir
- Pipe Culvert

Priority Rank

High | Medium | Low

- Waterways 4th order and above
- Highways and major roads
- Upper North Coast Catchments

Appendix H: Location of Road Crossing Barriers in the Mid North Coast Subregion



Structure Type

- Pipe Culvert
- Causeway
- Box Culvert
- Ford
- Weir

Priority Rank

High Medium Low

- Waterways 4th order and above
- Highways and major roads
- Mid North Coast Catchments

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Appendix I: Detailed Summary of Road Crossing Barriers in the Northern Rivers CMA

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Ball - 28	Richmond	Skinners Creek	Tooheys Mill Road	-28.7533000	153.4772000	1	Pipe Culvert	V, LF	Box Culvert LF	H	9
Northern Rivers	Ball - 11	Richmond	Emigrant Creek	Friday Hut Road	-28.7844000	153.5149000	1	Box Culvert	V	Box Culvert LF	H	25
Northern Rivers	Ball - 20	Richmond	Emigrant Creek	Off Friday Hut Road	-28.7529037	153.5170530	1	Pipe Culvert	HL, V	Box Culvert LF	H	47
Northern Rivers	Ball - 41	Richmond	Houghlahans Creek	Houghlahans Creek Road	-28.8061383	153.4920583	2	Pipe Culvert	LF, V	Remove	H	55
Northern Rivers	Ball - 30	Richmond	Yellow Creek	Private Road	-28.8985833	153.4478767	2	Pipe Culvert	WD, V, LF	Box Culvert LF	M	102
Northern Rivers	Ball - 14	Richmond	Houglahans Creek	Houglahans Creek Road	-28.7972000	153.4940000	2	Pipe Culvert	HL, V, LF	Box Culvert LF	M	142
Northern Rivers	Ball - 07	Richmond	Houglahans Creek	Houglahans Creek Road	-28.8009000	153.4946000	2	Pipe Culvert	V, LF	Box Culvert LF	M-L	160
Northern Rivers	Ball - 08	Richmond	Yellow Creek	Marom Creek Road	-28.9113000	153.4320000	2	Box Culvert	LF	Box Culvert LF	M-L	178
Northern Rivers	Ball - 15	Richmond	Yellow Creek	Bartlett Lane	-28.8853850	153.4539967	2	Pipe Culvert	HL, WD, V	Box Culvert LF	M-L	178
Northern Rivers	Ball - 29	Richmond	Houglahans Creek	Houglahans Creek Road	-28.7925000	153.4936000	2	Pipe Culvert	V, LF	Box Culvert LF	M-L	212
Northern Rivers	Ball - 05	Richmond	Youngmans Creek	Rous Lynwood Road	-28.8750323	153.3825975	2	Box Culvert	HL	Bridge	M-L	229
Northern Rivers	Ball - 38	Richmond	Yellow Creek	Behs Lane	-28.8729540	153.4548518	2	Pipe Culvert	HL	Box Culvert LF	M-L	229
Northern Rivers	Ball - 42	Richmond	Unnamed waterway	Off Houghlahans Road	-28.7705900	153.4606483	3	Pipe Culvert	HL, V	Box Culvert LF	L	248
Northern Rivers	Ball - 22	Richmond	Marom Creek	Lindendale Road	-28.8351000	153.3954000	2	Pipe Culvert	V, LF	Box Culvert LF	L	270
Northern Rivers	Ball - 12	Richmond	Branch Creek	Hawards Road	-28.8258000	153.4530000	3	Pipe Culvert	V, LF	Box Culvert LF	L	291
Northern Rivers	Ball - 09	Richmond	Emigrant Creek	Watsons Lane	-28.7223000	153.5419000	2	Causeway	HL, LF	Box Culvert LF	L	291
Northern Rivers	Ball - 10	Richmond	Gum Creek	Dalwood Road	-28.8891454	153.4158901	2	Pipe Culvert	V	Box Culvert LF	L	291
Northern Rivers	Ball - 39	Richmond	Unnamed waterway	Dalwood Road	-28.8782891	153.3887494	3	Pipe Culvert	HL, WD	Box Culvert LF	L	291
Northern Rivers	Ball - 40	Richmond	Unnamed watercourse	Marom Creek Road	-28.9144000	153.3916000	3	Pipe Culvert	V, LF	Box Culvert LF	L	325
Northern Rivers	Ball - 17	Richmond	Unnamed waterway	Off Houghlahans Road	-28.7729400	153.4661867	2	Pipe Culvert	HL, V	Box Culvert LF	L	325
Northern Rivers	Ball - 26	Richmond	Unnamed Waterway	Eltham Road	-28.8078933	153.4855117	3	Box Culvert	HL	Box Culvert LF	L	363
Northern Rivers	Ball - 21	Richmond	Unnamed waterway	Off Houghlahans Road	-28.7704037	153.4613608	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Ball - 24	Richmond	Unnamed Waterway	Off Houghlahans Road	-28.7710833	153.4646883	3	Pipe Culvert	HL, LF	Box Culvert LF	L	363
Northern Rivers	Ball - 25	Richmond	Duck Creek	Wardell Road	-28.8573003	153.4345267	2	Box Culvert	HL	Bridge	L	363
Northern Rivers	Ball - 34	Richmond	Duck Creek	Grays Lane	-28.8636332	153.4328983	2	Pipe Culvert	V, LF	Box Culvert LF	L	363
Northern Rivers	Ball - 35	Richmond	unnamed Waterway	Lindendale Road	-28.8301596	153.3958060	3	Pipe Culvert	V	Box Culvert LF	L	433
Northern Rivers	Ball - 31	Richmond	Gum Creek	Rous Road	-28.8714135	153.4108239	3	Pipe Culvert	HD, WD, LF	Box Culvert LF	L	450
Northern Rivers	Ball - 36	Richmond	Maguires Creek	Whites Lane	-28.8506056	153.4198708	3	Pipe Culvert	HL	Box Culvert LF	L	486
Northern Rivers	Ball - 33	Richmond	Unnamed waterway	Wardell Road	-28.8511484	153.4357933	3	Pipe Culvert	LF	Box Culvert LF	L	514
HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris												

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Ball - 32	Richmond	Youngmans Creek	Ellis Road	-28.8591097	153.3999676	3	Pipe Culvert	V	Box Culvert LF	L	514
Northern Rivers	Ball - 37	Richmond	Wilsons River	Goonengerry Road	-28.5902148	153.4517860	1	Causeway	HL	Remove	H	11
Northern Rivers	Byro - 119	Brunswick	Brunswick River	Private Road	-28.5394000	153.4664000	1	Pipe Culvert	HL, V, LF	Bridge	H	16
Northern Rivers	Byro - 41	Richmond	Byron Creek	Slatterys Lane	-28.7039471	153.5122095	1	Pipe Culvert	WD, V	Bridge	H	22
Northern Rivers	Byro - 115	Brunswick	Brunswick River	Johnson Lane	-28.5366000	153.4596000	1	Pipe Culvert	HL, V	Bridge	H	32
Northern Rivers	Byro - 42	Brunswick	Brunswick River	Durrumbul Road	-28.5122450	153.4388617	1	Box Culvert	HL, WD, V	Remove	H	36
Northern Rivers	Byro - 113	Brunswick	Brunswick River	Durrumbul Road	-28.5220000	153.4436000	1	Box Culvert	HL, V	Bridge	H	36
Northern Rivers	Byro - 44	Richmond	Coopers Creek	Tickles Road	-28.6053411	153.4019349	1	Pipe Culvert	V, LF	Bridge	H	45
Northern Rivers	Byro - 87	Brunswick	Brunswick River	Durrumbul Road	-28.5155083	153.4400767	1	Box Culvert	HL, V	Remove	H	47
Northern Rivers	Byro - 112	Brunswick	Brunswick River	Durrumbul Road	-28.5195000	153.4433000	1	Box Culvert	HL, V	Box Culvert LF	H	53
Northern Rivers	Byro - 45	Richmond	Whian Creek	Whian Creek Road	-28.6733550	153.4308650	2	Causeway	HL, V	Box Culvert LF	H	55
Northern Rivers	Byro - 118	Brunswick	Brunswick River	Durrumbul Road	-28.5181000	153.4426000	1	Box Culvert	HL,	Box Culvert LF	H	55
Northern Rivers	Byro - 46	Richmond	Bennys Creek	Beacom Road	-28.7039000	153.4051000	2	Pipe Culvert	HL	Box Culvert LF	H	60
Northern Rivers	Byro - 40	Richmond	Oppossum Creek	Friday Hut Road	-28.6751000	153.4934000	2	Box Culvert	HL, V	Box Culvert LF	M-H	70
Northern Rivers	Byro - 54	Richmond	Wilsons River	Lilly Pilly Road	-28.5803200	153.4324383	1	Pipe Culvert	V, LF	Box Culvert LF	M-H	70
Northern Rivers	Byro - 47	Brunswick	Brunswick River	Durrumbul Road	-28.5172000	153.4412000	1	Box Culvert	LF	Remove	M-H	77
Northern Rivers	Byro - 90	Richmond	Byrangery Creek	Federal Road	-28.6272497	153.4341514	2	Pipe Culvert	HL, V	Box Culvert LF	M-H	77
Northern Rivers	Byro - 92	Richmond	Opossum Creek	Off Friday Hut Road	-28.6726579	153.4947295	2	Pipe Culvert	HL, V	Box Culvert LF	M-H	77
Northern Rivers	Byro - 04	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5458000	153.3905000	1	Pipe Culvert	HL, V, LF	Box Culvert LF	M-H	84
Northern Rivers	Byro - 05	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5458000	153.3906000	1	Pipe Culvert	HL, V, LF	Box Culvert LF	M-H	84
Northern Rivers	Byro - 02	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5509000	153.3902000	1	Pipe Culvert	HL, V, LF	Box Culvert LF	M-H	91
Northern Rivers	Byro - 109	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5051333	153.4740817	2	Pipe Culvert	HL, V, LF	Box Culvert LF	M-H	91
Northern Rivers	Byro - 15	Brunswick	Marshalls Creek	The Pocket Road	-28.5005000	153.5245000	2	Box Culvert	LF	Box Culvert LF	M-H	91
Northern Rivers	Byro - 35	Richmond	Coopers Creek	Wanganui Road	-28.5536000	153.3708000	2	Box Culvert	HL, V, LF	Box Culvert LF	M-H	91
Northern Rivers	Byro - 107	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5035950	153.4849200	2	Pipe Culvert	HL, V	Bridge	M	102
Northern Rivers	Byro - 89	Richmond	Coopers Creek	Private Road	-28.5980766	153.3994516	1	Box Culvert	V	Bridge	M	102
Northern Rivers	Byro - 08	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5357000	153.3919000	1	Causeway	HL, LF	Box Culvert LF	M	112
Northern Rivers	Byro - 31	Richmond	Wilsons Creek	Blackbean Road	-28.5754000	153.4286000	1	Pipe Culvert	V	Box Culvert LF	M	112
Northern Rivers	Byro - 103	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5077100	153.4994933	2	Box Culvert	HL, V	Remove	M	125
Northern Rivers	Byro - 100	Brunswick	Lacks Creek	Off The Middle Pocket Rd	-28.4926533	153.4835500	2	Box Culvert	HL, WD, LF	Box Culvert LF	M	142
Northern Rivers	Byro - 110	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5051417	153.4692700	2	Box Culvert	HL, LF	Box Culvert LF	M	142
Northern Rivers	Byro - 120	Brunswick	Mullumbimby Creek	Yankee Creek Road	-28.5499936	153.4486972	2	Box Culvert	HL	Box Culvert LF	M	142

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Byro - 57	Richmond	Wilsons River	Off Wilsons Creek Road	-28.5706433	153.4232683	1	Pipe Culvert	V	Box Culvert LF	M	142
Northern Rivers	Byro - 88	Richmond	Snows Gully	Upper Coopers Creek Rd	-28.5988819	153.3980357	2	Pipe Culvert	HL, V, LF	Box Culvert LF	M	142
Northern Rivers	Byro - 09	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5358000	153.3919000	1	Causeway	HL	Box Culvert LF	M-L	160
Northern Rivers	Byro - 111	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5053417	153.4518200	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	160
Northern Rivers	Byro - 58	Richmond	Wilsons River	Off Wilsons Creek Road	-28.5686917	153.4192967	1	Box Culvert	V	Box Culvert LF	M-L	160
Northern Rivers	Byro - 06	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5418000	153.3915000	1	Causeway	HL	Box Culvert LF	M-L	178
Northern Rivers	Byro - 07	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5417000	153.3916000	1	Causeway	HL	Box Culvert LF	M-L	178
Northern Rivers	Byro - 123	Brunswick	Mullumbimby Creek	Mullumbimby Creek Road	-28.5496100	153.4308117	2	Pipe Culvert	LF, V	Box Culvert LF	M-L	178
Northern Rivers	Byro - 98	Richmond	Little Bennys Creek	Beacoms Road	-28.7056445	153.4269929	2	Pipe Culvert	V	Box Culvert LF	M-L	178
Northern Rivers	Byro - 03	Richmond	Upper Wilsons Creek	Upper Wilsons Creek Rd	-28.5483000	153.3895000	1	Causeway	HL	Box Culvert LF	M-L	199
Northern Rivers	Byro - 34	Richmond	Coopers Creek	Huonbrook Road	-28.5493000	153.3627000	2	Box Culvert	HL	Box Culvert LF	M-L	199
Northern Rivers	Byro - 94	Richmond	Opossum Creek	Off Fowlers Lane	-28.6527005	153.5101394	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	199
Northern Rivers	Byro - 102	Brunswick	Lacks Creek	Off Middle Pocket Road	-28.4842150	153.4558483	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	212
Northern Rivers	Byro - 108	Brunswick	Marshalls Creek	Off The Pocket Road	-28.5026900	153.4804517	2	Pipe Culvert	V	Box Culvert LF	M-L	212
Northern Rivers	Byro - 122	Brunswick	Mullumbimby Creek	Mullumbimby Creek Road	-28.5490533	153.4296250	2	Box Culvert	HL	Box Culvert LF	M-L	229
Northern Rivers	Byro - 19	Brunswick	Marshalls Creek	The Pocket Road	-28.5070000	153.4924000	2	Box Culvert	HL, LF	Maintenance	M-L	229
Northern Rivers	Byro - 32	Richmond	Coopers Creek	Huonbrook Road	-28.5237000	153.3428000	3	Pipe Culvert	HL, V	Box Culvert LF	M-L	229
Northern Rivers	Byro - 36	Richmond	Byron creek	Coopers Shoot Road	-28.6819000	153.5463000	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	229
Northern Rivers	Byro - 60	Richmond	Unnamed Waterway	Off Wilsons Creek Road	-28.5597600	153.4013267	3	Pipe Culvert	HL	Remove	M-L	229
Northern Rivers	Byro - 116	Brunswick	Maori Creek	Off Coopers Lane	-28.5373458	153.4494759	2	Pipe Culvert	HL	Box Culvert LF	L	248
Northern Rivers	Byro - 18	Brunswick	Marshalls Creek	The Pocket Road	-28.5069000	153.4944000	2	Box Culvert	HL	Maintenance	L	248
Northern Rivers	Byro - 50	Brunswick	Blindmouth Creek	Main Arm Road	-28.5043000	153.4333000	2	Box Culvert	LF	Box Culvert LF	L	248
Northern Rivers	Byro - 51	Brunswick	Blindmouth Creek	The Pocket Road	-28.5035000	153.4334000	2	Box Culvert	HL, LF	Box Culvert LF	L	248
Northern Rivers	Byro - 99	Brunswick	Marshalls Creek	Moffatts Road	-28.5067950	153.5054967	2	Box Culvert	LF	Box Culvert LF	L	248
Northern Rivers	Byro - 121	Brunswick	Mullumbimby Creek	Mullumbimby Creek Road	-28.5530183	153.4366800	2	Box Culvert	HL	Box Culvert LF	L	270
Northern Rivers	Byro - 16	Brunswick	Marshalls Creek	The Pocket Road	-28.5030000	153.5094000	2	Box Culvert	HL	Box Culvert LF	L	270
Northern Rivers	Byro - 21	Brunswick	Unnamed watercourse	Coolamon Scenic Drive	-28.5307000	153.5111000	3	Box Culvert	HL, LF	Box Culvert LF	L	270
Northern Rivers	Byro - 63	Richmond	Wilsons River	Upper Wilsons Creek Rd	-28.5226617	153.3846281	2	Causeway	HL	Box Culvert LF	L	270
Northern Rivers	Byro - 64	Richmond	Unnamed waterway	Upper Wilsons Creek Rd	-28.5227717	153.3834133	3	Causeway	HL	Box Culvert LF	L	270
Northern Rivers	Byro - 62	Richmond	Wilsons River	Upper Wilsons Creek Rd	-28.5232617	153.3859733	2	Pipe Culvert	V	Box Culvert LF	L	291
Northern Rivers	Byro - 65	Richmond	Wilsons River	Upper Wilsons Creek Rd	-28.5225467	153.3830817	2	Causeway	LF	Box Culvert LF	L	291
Northern Rivers	Byro - 66	Richmond	Wilsons River	Upper Wilsons Creek Rd	-28.5180433	153.3732567	2	Pipe Culvert	V	Box Culvert LF	L	291

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Byro - 67	Richmond	Wilsons River	Upper Wilsons Creek Rd	-28.5218183	153.3829383	2	Pipe Culvert	V	Box Culvert LF	L	291
Northern Rivers	Byro - 74	Brunswick	Brunswick River	Main Arm Road	-28.4930981	153.3989092	3	Box Culvert	HL, V	Box Culvert LF	L	291
Northern Rivers	Byro - 80	Brunswick	Unnamed Waterway	Blindmouth Road	-28.4865300	153.4296091	3	Pipe Culvert	HL, V	Box Culvert LF	L	291
Northern Rivers	Byro - 95	Richmond	Bennys Creek	Springvale Road	-28.7001038	153.4431445	2	Pipe Culvert	HL, LF	Bridge	L	291
Northern Rivers	Byro - 37	Richmond	Unnamed waterway	Private Road	153.5463854	-28.6824277	3	Box Culvert	HL, V	Box Culvert LF	L	325
Northern Rivers	Byro - 114	Richmond	Tinderbox Creek	Off Bangalow Road	-28.6704724	153.5554529	2	Pipe Culvert	HL, V	Box Culvert LF	L	352
Northern Rivers	Byro - 86	Brunswick	Stony Creek	Palmwoods Road	-28.5092304	153.4060624	3	Box Culvert	HL	Box Culvert LF	L	352
Northern Rivers	Byro - 10	Richmond	Maori Creek	Sewage Treatment Works	-28.6950000	153.5089000	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Byro - 27	Richmond	Yankee Creek	Yankee Creek Road	-28.5682000	153.4651000	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Byro - 38	Richmond	Tinterbox Creek	Tinterbox Road	-28.6739000	153.5463000	2	Pipe Culvert	V	Box Culvert LF	L	363
Northern Rivers	Byro - 52	Brunswick	Blindmouth Creek	Blindmouth Creek Road	-28.5017000	153.4326000	2	Pipe Culvert	V	Box Culvert LF	L	363
Northern Rivers	Byro - 78	Brunswick	Brunswick River	Main Arm Road	-28.4898851	153.3855711	3	Causeway	HL	Remove	L	363
Northern Rivers	Byro - 84	Brunswick	Stony Creek	Palmwoods Road	-28.5073435	153.4094741	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Byro - 85	Brunswick	Stony Creek	Palmwoods Road	-28.5079247	153.4074205	3	Pipe Culvert	HL	Box Culvert LF	L	363
Northern Rivers	Byro - 43	Brunswick	Unnamed watercourse	Private Rd Off Main Arm	-28.5309000	153.4572000	3	Pipe Culvert	HL, V	Box Culvert LF	L	392
Northern Rivers	Byro - 68	Brunswick	Stony Creek	Main Arm Road	-28.5025976	153.4183185	3	Box Culvert	HL, V	Box Culvert LF	L	392
Northern Rivers	Byro - 77	Brunswick	Brunswick River	Main Arm Road	-28.4933355	153.3878168	3	Box Culvert	HL	Box Culvert LF	L	392
Northern Rivers	Byro - 79	Brunswick	Brunswick River	Main Arm Road	-28.4909277	153.3858955	3	Box Culvert	HL	Box Culvert LF	L	392
Northern Rivers	Byro - 93	Richmond	Sleepy Creek	Fowlers Lane	-28.6545214	153.5132837	2	Pipe Culvert	V	Box Culvert LF	L	392
Northern Rivers	Byro - 97	Richmond	Little Bennys Creek	Eureka Road	-28.6963032	153.4386696	2	Box Culvert	LF	Bridge	L	392
Northern Rivers	Byro - 105	Brunswick	Unnamed waterway	Walkers Lane	-28.5129200	153.4925867	3	Pipe Culvert	HL, V	Box Culvert LF	L	419
Northern Rivers	Byro - 48	Brunswick	Unnamed watercourse	Settlement Road	-28.5201000	153.4374000	3	Box Culvert	HL, LF	Box Culvert LF	L	419
Northern Rivers	Byro - 70	Brunswick	Brunswick River	Main Arm Road	-28.4955049	153.4090925	3	Box Culvert	HL, V	Box Culvert LF	L	419
Northern Rivers	Byro - 71	Brunswick	Brunswick River	Main Arm Road	-28.4944109	153.4050994	3	Box Culvert	HL	Box Culvert LF	L	419
Northern Rivers	Byro - 101	Brunswick	Unnamed Waterway	The Middle Pocket Road	-28.4900583	153.4785517	3	Pipe Culvert	HL, V	Box Culvert LF	L	433
Northern Rivers	Byro - 104	Brunswick	Unnamed waterway	Walkers Lane	-28.5110183	153.4943167	3	Pipe Culvert	HL, V	Box Culvert LF	L	433
Northern Rivers	Byro - 106	Brunswick	Unnamed waterway	Walkers Lane	-28.5128500	153.4924800	3	Pipe Culvert	HL	Box Culvert LF	L	450
Northern Rivers	Byro - 56	Richmond	Unnamed waterway	Yankee Creek Road	-28.5666900	153.4637333	3	Pipe Culvert	LF	Box Culvert LF	L	450
Northern Rivers	Byro - 61	Richmond	Unnamed watercourse	Wilsons Creek Road	-28.5596283	153.4015383	3	Box Culvert	LF	Box Culvert LF	L	450
Northern Rivers	Byro - 81	Brunswick	Blindmouth Creek	Blindmouth Road	-28.4836849	153.4290838	3	Pipe Culvert	V, LF	Box Culvert LF	L	450
Northern Rivers	Byro - 82	Brunswick	Unnamed Waterway	off Blindmouth Road	-28.4828094	153.4300906	4	Pipe Culvert	HL	Box Culvert LF	L	450
Northern Rivers	Byro - 83	Brunswick	Stony Creek	Palmwoods Road	-28.5056145	153.4128445	3	Pipe Culvert	HL, V	Box Culvert LF	L	450

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Byro - 96	Richmond	Bennys Creek	Goremans Road	-28.6938581	153.4497839	3	Pipe Culvert	V	Box Culvert LF	L	450
Northern Rivers	Byro - 20	Brunswick	Unnamed watercourse	The Pocket Road	-28.5045000	153.4766000	3	Box Culvert	HL, LF	Box Culvert LF	L	472
Northern Rivers	Byro - 69	Brunswick	Brunswick River	Main Arm Road	-28.4975652	153.4112622	3	Box Culvert	HL, V	Box Culvert LF	L	472
Northern Rivers	Byro - 29	Richmond	Yankee Creek	Alidenes Road	-28.5689000	153.4497000	4	Pipe Culvert	V, LF	Box Culvert LF	L	486
Northern Rivers	Byro - 72	Brunswick	Brunswick River	Main Arm Road	-28.4964621	153.4099312	3	Box Culvert	HL, WD	Box Culvert LF	L	486
Northern Rivers	Byro - 76	Brunswick	Coolamon Creek	Main Arm Road	-28.4930160	153.3942780	3	Pipe Culvert	HL	Box Culvert LF	L	486
Northern Rivers	Byro - 91	Richmond	Stony Creek	Federal Road	-28.6550724	153.4549748	3	Box Culvert	HL	Box Culvert LF	L	486
Northern Rivers	Byro - 73	Brunswick	Brunswick River	Main Arm Road	-28.4936724	153.4032578	3	Box Culvert	HL	Box Culvert LF	L	501
Northern Rivers	Byro - 30	Richmond	Yankee Creek	Alidenes Road	-28.5698000	153.4564000	3	Box Culvert	LF	Box Culvert LF	L	504
Northern Rivers	Byro - 75	Brunswick	Brunswick River	Main Arm Road	-28.4934810	153.3982710	3	Box Culvert	LF	Box Culvert LF	L	504
Northern Rivers	Byro - 28	Richmond	Yankee Creek	Alidenes Road	-28.5687000	153.4479000	4	Pipe Culvert	HL	Box Culvert	L	512
Northern Rivers	Kyog - 11	Richmond	Richmond River	off Summerland Way	-28.4260054	152.7839575	1	Causeway	HL, LF	Box Culvert LF	H	47
Northern Rivers	Kyog - 12	Richmond	Richmond River	Off Summerland Way	-28.4465102	152.8516509	1	Weir	HL	Remove	H	55
Northern Rivers	Kyog - 09	Richmond	Richmond River	Off Summerland Way	-28.4150306	152.7497419	1	Weir	HL	Bridge	M-H	64
Northern Rivers	Kyog - 14	Richmond	Leycester Creek	Barnes Road	-28.5318942	153.1219098	2	Pipe Culvert	HL	Remove	M-H	70
Northern Rivers	Kyog - 06	Richmond	Gradys Creek	Gradys Creek Road	-28.3758100	152.9755117	2	Causeway	HL, LF	Box Culvert LF	M	102
Northern Rivers	Kyog - 10	Richmond	Richmond River	Off Summerland Way	-28.4393781	152.8252745	1	Pipe Culvert	V	Box Culvert LF	M	102
Northern Rivers	Kyog - 20	Richmond	Warrazambil Creek	Off Warrazambil Creek Rd	-28.4463075	153.0170364	2	Causeway	HL, LF	Bridge	M	102
Northern Rivers	Kyog - 19	Richmond	Warrazambil Creek	Off Warrazambil Creek Rd	-28.4442467	153.0258700	2	Causeway	HL, V	Box Culvert LF	M	112
Northern Rivers	Kyog - 02	Richmond	Gradys Creek	Gradys Creek Road	-28.3680417	152.9742400	2	Causeway	HL, LF	Box Culvert LF	M	122
Northern Rivers	Kyog - 16	Richmond	Fawcetts Creek	Off Green Pigeon Road	-28.4868664	153.0784352	2	Causeway	HL, LF	Bridge	M	125
Northern Rivers	Kyog - 22	Richmond	Iron Pot Creek	Iron Pot Creek Road	-28.6208783	152.7953050	2	Pipe Culvert	HL	Box Culvert LF	M	125
Northern Rivers	Kyog - 15	Richmond	Horseshoe Creek	Horseshoe Creek Road	-28.5143460	153.0947956	2	Causeway	HL, LF	Bridge	M	142
Northern Rivers	Kyog - 03	Richmond	Gradys Creek	Gradys Creek Road	-28.3707033	152.9759067	2	Causeway	HL	Box Culvert LF	M-L	178
Northern Rivers	Kyog - 25	Richmond	Boorabee Creek	Boorabee Creek Road	-28.6584167	153.0556467	2	Causeway	WD, V	Bridge	M-L	199
Northern Rivers	Kyog - 04	Richmond	Gradys Creek	Gradys Creek Road	-28.3727533	152.9760917	2	Causeway	LF	Box Culvert LF	M-L	229
Northern Rivers	Kyog - 05	Richmond	Gradys Creek	Gradys Creek Road	-28.3748517	152.9745283	2	Causeway	LF	Box Culvert LF	M-L	229
Northern Rivers	Kyog - 33	Richmond	Richmond River	Private Road	-28.3833051	152.7138662	2	Weir	HL	Bridge	M-L	229
Northern Rivers	Kyog - 17	Richmond	Fawcetts Creek	Off Green Pigeon Road	-28.4805750	153.0871033	2	Causeway	V	Bridge	L	248
Northern Rivers	Kyog - 23	Richmond	Boorabee Creek	Borrabee Creek Road	-28.6687650	153.0534283	2	Pipe Culvert	HL	Bridge	L	248
Northern Rivers	Kyog - 28	Clarence	Tabulam Rivulet	Old Lawrence Road	-28.9785083	152.7274600	3	Causeway	HL, V	Box Culvert LF	L	291
Northern Rivers	Kyog - 24	Richmond	Boorabee Creek	Boorabee Creek Road	-28.6650468	153.0522052	2	Causeway	V	Bridge	L	352

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Kyog - 21	Richmond	Horse Station Creek	Old Cob O'Corn Road	-28.6248667	152.9624617	3	Pipe Culvert	WD, V	Bridge	L	363
Northern Rivers	Kyog - 18	Richmond	Taylors Creek	Taylors Creek Road	-28.4959072	153.0327420	3	Causeway	HL, LF	Bridge	L	450
Northern Rivers	Kyog - 27	Richmond	Theresa Creek	Theresa Creek Road	-28.7601204	152.7899200	3	Pipe Culvert	HL, V	Box Culvert LF	L	450
Northern Rivers	Kyog - 26	Richmond	Theresa Creek	Theresa Creek Road	-28.7626274	152.7917238	3	Causeway	V	Box Culvert LF	L	472
Northern Rivers	Lism - 17	Richmond	Terania Creek	Izzard Road	-28.6509000	153.2825000	1	Pipe Culvert	HL, V, LF	Box Culvert LF	H	1
Northern Rivers	Lism - 39	Richmond	Coopers Creek	Eureka Road	-28.6671000	153.4173000	1	Box Culvert	HL, LF	Bridge	H	3
Northern Rivers	Lism - 16	Richmond	Tuntable Creek	Paterson Road	-28.6536000	153.2616000	1	Pipe Culvert	V	Box Culvert LF	H	27
Northern Rivers	Lism - 18	Richmond	Terania Creek	Terania Creek Road	-28.6073000	153.2997000	1	Pipe Culvert	HL, V, LF	Remove	H	29
Northern Rivers	Lism - 53	Richmond	Tuntable Creek	Off Tuntable Creek Road	-28.6113085	153.2707155	1	Pipe Culvert	V	Box Culvert LF	H	32
Northern Rivers	Lism - 19	Richmond	Terania Creek	Terania Creek Road	-28.5942000	153.2965000	1	Pipe Culvert	HL, V	Remove	H	45
Northern Rivers	Lism - 12	Richmond	Tuntable Creek	Tuntable Creek Road	-28.6456000	153.2588000	1	Pipe Culvert	HL	Box Culvert LF	M-H	70
Northern Rivers	Lism - 02	Richmond	Terania Creek	Ross Street	-28.6267000	153.2940000	1	Box Culvert	V	Box Culvert LF	M-H	84
Northern Rivers	Lism - 20	Richmond	Dans Creek	Grayden Road	-28.7109000	153.3554000	2	Pipe Culvert	WD, V	Box Culvert LF	M	102
Northern Rivers	Lism - 04	Richmond	Booerie Creek	Booerie Creek Road	-28.7799476	153.2579774	2	Pipe Culvert	WD	Maintenance	M	112
Northern Rivers	Lism - 46	Richmond	Johnston Creek	Mackie Road	-28.6915000	153.3939000	2	Pipe Culvert	HL, V, LF	Box Culvert LF	M	122
Northern Rivers	Lism - 03	Richmond	Marom Creek	Boundary Road	-28.8502000	153.3851000	2	Pipe Culvert	V, LF	Box Culvert LF	M	125
Northern Rivers	Lism - 47	Richmond	Booerie Creek	Hewitt Road	-28.7731651	153.2731758	2	Box Culvert	V, LF	Box Culvert LF	M-L	160
Northern Rivers	Lism - 14	Richmond	Bishops Creek	Bishops Creek Road	-28.6319000	153.2390000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	M-L	178
Northern Rivers	Lism - 43	Richmond	Terania Creek	Terania Creek Road	-28.5714000	153.3079000	2	Pipe Culvert	V	Box Culvert LF	M-L	178
Northern Rivers	Lism - 57	Richmond	Jiggi Creek	Jacobson Road	-28.6456400	153.1794817	2	Pipe Culvert	V	Box Culvert LF	M-L	178
Northern Rivers	Lism - 58	Richmond	Georgica Creek	McLennan Road	-28.6510140	153.1561470	2	Box Culvert	LF	Box Culvert LF	M-L	178
Northern Rivers	Lism - 44	Richmond	Yankey Creek	Strong Road	-28.6971000	153.3702650	3	Pipe Culvert	HL, LF	Box Culvert LF	M-L	212
Northern Rivers	Lism - 37	Richmond	Topsy Creek	Leeson Road	-28.6501000	153.3193000	3	Pipe Culvert	HL, V	Box Culvert LF	M-L	229
Northern Rivers	Lism - 40	Richmond	Unnamed watercourse	Ross Road	-28.7390000	153.3182000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	248
Northern Rivers	Lism - 73	Richmond	Lagoon Creek	Off Bangalow Road	-28.7889832	153.3109244	3	Pipe Culvert	V	Box Culvert LF	L	248
Northern Rivers	Lism - 10	Richmond	Unnamed watercourse	Bice Road	-28.7569000	153.1660000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	270
Northern Rivers	Lism - 38	Richmond	Turkey Creek	Eureka Road	-28.6666000	153.4131000	3	Pipe Culvert	HL, V	Box Culvert LF	L	270
Northern Rivers	Lism - 49	Richmond	Goolmangar Creek	Private Rd off Crofton Rd	-28.5516018	153.2333519	2	Pipe Culvert	HL, WD	Box Culvert LF	L	270
Northern Rivers	Lism - 50	Richmond	Goolmangar Creek	Crofton Road	-28.5454147	153.2355961	2	Ford	HL	Bridge	L	270
Northern Rivers	Lism - 54	Richmond	Calico Creek	Blue Knob Road	-28.5567183	153.1958883	2	Box Culvert	LF	Bridge	L	270
Northern Rivers	Lism - 01	Richmond	Unnamed watercourse	Davis Road	-28.6708000	153.1883000	3	Pipe Culvert	V, LF	Box Culvert LF	L	291
Northern Rivers	Lism - 09	Richmond	Unnamed watercourse	Bice Road	-28.7599000	153.1663000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	291

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Lism - 51	Richmond	Goolmangar Creek	Crofton Road	-28.5445367	153.2357592	2	Causeway	HL	Bridge	L	291
Northern Rivers	Lism - 08	Richmond	Unnamed watercourse	Bice Road	-28.7613000	153.1679000	3	Pipe Culvert	HL, V	Box Culvert LF	L	325
Northern Rivers	Lism - 33	Richmond	Unnamed watercourse	Yeager Road	-28.7705000	153.1645000	3	Pipe Culvert	HL, V	Box Culvert LF	L	325
Northern Rivers	Lism - 55	Richmond	Calico Creek	Blue Knob Road	-28.5524667	153.1959147	2	Box Culvert	WD, LF	Bridge	L	325
Northern Rivers	Lism - 07	Richmond	Unnamed watercourse	Bice Road	-28.7671000	153.1746000	3	Pipe Culvert	LF	Maintenance	L	352
Northern Rivers	Lism - 32	Richmond	Unnamed watercourse	Yeager Road	-28.7691000	153.1628000	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Lism - 34	Richmond	Unnamed watercourse	Yeager Road	-28.7782000	153.1810000	3	Pipe Culvert	V	Bridge	L	363
Northern Rivers	Lism - 35	Richmond	Booerie creek	Bentley Road	-28.7638000	153.2860000	3	Pipe Culvert	HL, V, LF	Maintenance	L	363
Northern Rivers	Lism - 75	Richmond	Lagoon Creek	Lagoon Grass Road	-28.7979849	153.3251733	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Northern Rivers	Lism - 26	Richmond	Unnamed watercourse	Yeager Road	-28.7626000	153.1520000	3	Pipe Culvert	HL, V	Box Culvert LF	L	392
Northern Rivers	Lism - 29	Richmond	Unnamed watercourse	Yeager Road	-28.7659000	153.1583000	3	Pipe Culvert	HL, V	Box Culvert LF	L	392
Northern Rivers	Lism - 22	Richmond	Unnamed watercourse	Yeager Road	-28.7599000	153.1493000	3	Pipe Culvert	V, LF	Maintenance	L	419
Northern Rivers	Lism - 30	Richmond	Unnamed watercourse	Yeager Road	-28.7689000	153.1583000	3	Pipe Culvert	V, LF	Box Culvert LF	L	419
Northern Rivers	Lism - 31	Richmond	Unnamed watercourse	Yeager Road	-28.7690000	153.1628000	3	Pipe Culvert	V, LF	Box Culvert LF	L	419
Northern Rivers	Lism - 27	Richmond	Unnamed watercourse	Yeager Road	-28.7645000	153.1548000	3	Pipe Culvert	V, LF	Box Culvert LF	L	450
Northern Rivers	Lism - 28	Richmond	Unnamed watercourse	Yeager Road	-28.7660000	153.1560000	3	Pipe Culvert	V, LF	Maintenance	L	450
Northern Rivers	Lism - 71	Richmond	Unnamed Waterway	Taylors Road	-28.8314262	153.3467718	3	Pipe Culvert	HL, LF	Box Culvert LF	L	450
Northern Rivers	Lism - 45	Richmond	Yankey Creek	Lychee Drive	-28.6688657	153.3854250	3	Pipe Culvert	WD, V	Box Culvert LF	L	472
Northern Rivers	Lism - 72	Richmond	Unnamed waterway	Taylors Road	-28.8296168	153.3465909	3	Pipe Culvert	HL, LF	Box Culvert LF	L	472
Northern Rivers	Lism - 15	Richmond	Bishops Creek	Bishops Creek Road	-28.6371000	153.2323000	3	Pipe Culvert	V	Box Culvert LF	L	486
Northern Rivers	Lism - 21	Richmond	Unnamed watercourse	Yeager Road	-28.7597000	153.1493000	3	Pipe Culvert	V	Box Culvert LF	L	486
Northern Rivers	Lism - 23	Richmond	Unnamed watercourse	Yeager Road	-28.7601000	153.1501000	3	Pipe Culvert	V	Maintenance	L	486
Northern Rivers	Lism - 24	Richmond	Unnamed watercourse	Yeager Road	-28.7605000	153.1506000	3	Pipe Culvert	V	Box Culvert LF	L	486
Northern Rivers	Lism - 25	Richmond	Unnamed watercourse	Yeager Road	-28.7612000	153.1511000	3	Pipe Culvert	HL	Box Culvert LF	L	486
Northern Rivers	Lism - 74	Richmond	Lagoon Creek	Haywood Lane	-28.7960850	153.3198809	3	Pipe Culvert	V	Box Culvert LF	L	486
Northern Rivers	Lism - 36	Richmond	Branch Creek	Whian Whian Road	-28.6272000	153.3121000	3	Pipe Culvert	V	Box Culvert LF	L	504
Northern Rivers	Twee - 67	Tweed	Rous River	Numinbah Road	-28.3107107	153.3204307	1	Causeway	HL	Remove	H	11
Northern Rivers	Twee - 68	Tweed	Crystal Creek	Off Numinbah Road	-28.3090581	153.3118064	1	Pipe Culvert	HL, V	Bridge	H	11
Northern Rivers	Twee - 73	Tweed	Rous River	Off Numinbah Road	-28.3055266	153.2730248	1	Pipe Culvert	HL, V	Bridge	H	11
Northern Rivers	Twee - 02	Tweed	Oxley River	Old Lismore Road	-28.3476000	153.3540000	1	Box Culvert	HL, LF	Box Culvert LF	H	17
Northern Rivers	Twee 100	Tweed	Oxley River	Private Rd off Tyalgum Rd	-28.3506183	153.2646600	1	Pipe Culvert	HL, V	Remove	H	20
Northern Rivers	Twee - 72	Tweed	Rous River	Chilcotts Road	-28.3146468	153.2931868	1	Causeway	HL	Bridge	H	20

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Twee 101	Tweed	Terranora Inlet	Island Drive	-28.1841726	153.5457576	1	Bridge	HL	Remove Apron	H	22
Northern Rivers	Twee - 88	Tweed	Byrrill Creek	Off Byrrill Creek Road	-28.4384625	153.2712489	1	Pipe Culvert	V	Box Culvert LF	H	29
Northern Rivers	Twee - 89	Tweed	Byrrill Creek	Off Byrrill Creek Road	-28.4367075	153.2684019	1	Causeway	LF	Box Culvert LF	H	32
Northern Rivers	Twee - 50	Tweed	Unnamed waterway	Off Cudgera Creek Road	-28.3875369	153.5430680	2	Causeway	WD, LF	Remove	H	36
Northern Rivers	Twee - 24	Tweed	Dunbible Creek	Stokers Road	-28.3805450	153.3999867	2	Causeway	HL	Remove	H	39
Northern Rivers	Twee - 25	Tweed	Crabbes Creek	Crabbes Creek Road	-28.4584248	153.4875124	2	Box Culvert	HL, LF	Box Culvert LF	H	41
Northern Rivers	Twee - 05	Tweed	Rowlands Creek	off Rowlands Creek Road	-28.4286840	153.3353183	2	Pipe Culvert	HL, V, LF	Bridge	H	47
Northern Rivers	Twee - 30	Tweed	Burringbar Creek	Greenvale Court	-28.4417631	153.4586142	2	Box Culvert	HL	Box Culvert LF	H	53
Northern Rivers	Twee - 12	Tweed	Bilambil Creek	Urliup Road	-28.2289000	153.4486000	2	Box Culvert	HL, V	Box Culvert LF	H	55
Northern Rivers	Twee - 42	Tweed	Smiths Creek	Talyewan Avenue	-28.4242447	153.3818532	2	Pipe Culvert	V, LF	Box Culvert LF	M-H	64
Northern Rivers	Twee - 54	Tweed	Reserve Creek	Woodfords Road	-28.3470552	153.4958293	2	Pipe Culvert	V, LF	Box Culvert LF	M-H	64
Northern Rivers	Twee - 51	Tweed	Cudgera Creek	Cudgera Creek Road	-28.3886269	153.5284708	2	Pipe Culvert	V	Box Culvert LF	M-H	77
Northern Rivers	Twee - 26	Tweed	Crabbes Creek	Crabbes Creek Road	-28.4621411	153.4779440	2	Pipe Culvert	HL, V	Box Culvert LF	M-H	84
Northern Rivers	Twee - 43	Tweed	Chowan Creek	Off Chowan Creek Road	-28.4485011	153.3720108	2	Pipe Culvert	HL, V	Box Culvert LF	M-H	84
Northern Rivers	Twee - 69	Tweed	Crystal Creek	Off Upper Crystal Ck Rd	-28.2755893	153.3074632	2	Pipe Culvert	HL, V	Bridge	M-H	84
Northern Rivers	Twee - 83	Tweed	Oxley River	Carraboi Terrace	-28.3523175	153.2059628	1	Weir	HL	Bridge	M-H	84
Northern Rivers	Twee - 48	Tweed	Sheens Creek	Sleepy Hollow Road	-28.4140036	153.5109211	2	Pipe Culvert	HL, V, LF	Box Culvert LF	M-H	91
Northern Rivers	Twee - 27	Tweed	Crabbes Creek	Off Crabbes Creek Road	-28.4643241	153.4665192	2	Causeway	HL, LF	Box Culvert LF	M	112
Northern Rivers	Twee - 95	Tweed	Tweed River	O'Mearas Road	-28.5022476	153.1883302	2	Causeway	HL, LF	Bridge	M	112
Northern Rivers	Twee - 06	Tweed	Rowlands Creek	Rowlands Creek Road	-28.4410442	153.3418189	2	Box Culvert	HL	Box Culvert LF	M	125
Northern Rivers	Twee - 35	Tweed	Unnamed watercourse	Upper Burringbar Road	-28.4439865	153.4402600	2	Causeway	LHL	Remove	M	125
Northern Rivers	Twee - 44	Tweed	Chowan Creek	Off Chowan Creek Road	-28.4431802	153.3597796	2	Pipe Culvert	HL, V	Box Culvert LF	M	125
Northern Rivers	Twee - 45	Tweed	Rowlands Creek	Rowlands Creek Road	-28.4304653	153.3374249	2	Causeway	HL, B, LF	Remove	M	125
Northern Rivers	Twee - 63	Tweed	Dungay Creek	Off Dungay Creek Road	-28.2725473	153.3611883	2	Causeway	HL	Box Culvert LF	M	125
Northern Rivers	Twee - 74	Tweed	Couchy Creek	Couchy Creek Road	-28.2740888	153.2757803	2	Pipe Culvert	V, LF	Box Culvert LF	M	125
Northern Rivers	Twee - 81	Tweed	Jacksons Creek	Aston Road	-28.3163944	153.2632672	2	Pipe Culvert	HL, V	Box Culvert LF	M	125
Northern Rivers	Twee - 19	Tweed	Unnamed watercourse	Fingal Head Road	-28.2095000	153.5642000	3	Pipe Culvert	V, LF	Box Culvert LF	M	142
Northern Rivers	Twee - 47	Tweed	Sheens Creek	Sleepy Hollow Road	-28.4171610	153.5187218	2	Pipe Culvert	HL	Box Culvert LF	M	142
Northern Rivers	Twee - 64	Tweed	Dungay Creek	Dungay Creek Road	-28.2644314	153.3534995	2	Pipe Culvert	HL, V	Box Culvert LF	M	142
Northern Rivers	Twee - 91	Tweed	Cabbage Tree Creek	Byrrill Creek Road	-28.4422550	153.2247519	2	Pipe Culvert	V, LF	Box Culvert LF	M	142
Northern Rivers	Twee - 92	Tweed	Perch Creek	Midginbil Road	-28.4866263	153.2712098	2	Pipe Culvert	HL, V	Bridge	M	142
Northern Rivers	Twee - 99	Tweed	Tyalgum Creek	Stoddards Road	-28.3485717	153.1644747	2	Box Culvert	HL	Box Culvert LF	M	142

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Twee - 03	Tweed	Rowlands Creek	Rowlands Creek Road	-28.4579233	153.3504612	2	Pipe Culvert	V	Box Culvert LF	M-L	160
Northern Rivers	Twee - 04	Tweed	Rowlands Creek	Rowlands Creek Road	-28.4607524	153.3527228	2	Pipe Culvert	V, LF	Box Culvert LF	M-L	160
Northern Rivers	Twee - 32	Tweed	Burringbar Creek	Off Upper Burringbar Rd	-28.4442935	153.4235230	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	160
Northern Rivers	Twee - 46	Tweed	Sheens Creek	Sleepy Hollow Road	-28.4179039	153.5203933	2	Pipe Culvert	V	Box Culvert LF	M-L	160
Northern Rivers	Twee - 53	Tweed	Cudgera Creek	Off Cudgera Creek Road	-28.4001517	153.4999858	2	Causeway	HL	Box Culvert LF	M-L	160
Northern Rivers	Twee - 86	Tweed	Korrumbyn Creek	Mount Warning Road	-28.3875053	153.3241615	2	Pipe Culvert	HL, V, LF	Bridge	M-L	160
Northern Rivers	Twee - 31	Tweed	Burringbar Creek	Off Burringbar Road	-28.4444981	153.4325566	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	178
Northern Rivers	Twee - 40	Tweed	Unnamed Waterway	Palmwoods Road	-28.4268816	153.3863901	2	Causeway	B	Remove	M-L	178
Northern Rivers	Twee - 49	Tweed	Sheens Creek	Sleepy Hollow Road	-28.4151644	153.5062778	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	178
Northern Rivers	Twee - 71	Tweed	Crystal Creek	Upper Crystal Creek Road	-28.2613800	153.3191548	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	178
Northern Rivers	Twee - 94	Tweed	Kunghur Creek	Kunghur Creek Road	-28.5022814	153.2381705	2	Causeway	HL, LF	Remove	M-L	178
Northern Rivers	Twee - 14	Tweed	Bilambil Creek	Urliup Road	-28.2370000	153.4376000	2	Box Culvert	HL, LF	Box Culvert LF	M-L	199
Northern Rivers	Twee - 28	Tweed	Crabbes Creek	Crabbes Creek Road	-28.4632278	153.4661730	2	Pipe Culvert	HL, LF	Box Culvert LF	M-L	199
Northern Rivers	Twee - 29	Tweed	Crabbes Creek	Crabbes Creek Road	-28.4620160	153.4645574	2	Pipe Culvert	V, LF	Box Culvert LF	M-L	199
Northern Rivers	Twee - 41	Tweed	Smiths Creek	Off Smiths Creek Road	-28.4253088	153.3833043	2	Causeway	HL, LF	Box Culvert LF	M-L	199
Northern Rivers	Twee - 78	Tweed	Numinbah Creek	Numinbah Road	-28.2768452	153.2532929	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	199
Northern Rivers	Twee - 18	Tweed	Unnamed watercourse	Clothiers Creek Road	-28.3309000	153.5613000	3	Pipe Culvert	HL, V	Box Culvert LF	M-L	212
Northern Rivers	Twee - 76	Tweed	Couchy Creek	Couchy Creek Road	-28.2658234	153.2797625	2	Pipe Culvert	V	Bridge	M-L	212
Northern Rivers	Twee - 97	Tweed	Oxley River	Davis Road	-28.3471508	153.1749462	2	Pipe Culvert	V	Box Culvert LF	M-L	212
Northern Rivers	Twee - 70	Tweed	Crystal Creek	Upper Crystal Creek Road	-28.2668367	153.3095519	2	Pipe Culvert	HL, V	Bridge	M-L	229
Northern Rivers	Twee - 79	Tweed	Hopkins Creek	Off Hopkins Creek Road	-28.2988008	153.2579486	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	229
Northern Rivers	Twee - 82	Tweed	Hidden Creek	Youngs Road	-28.3233878	153.2205658	2	Pipe Culvert	V	Box Culvert LF	M-L	229
Northern Rivers	Twee - 84	Tweed	Korrumbyn Creek	Mount Warning Road	-28.3843187	153.3353783	2	Pipe Culvert	V	Box Culvert LF	M-L	229
Northern Rivers	Twee - 34	Tweed	Fosters Gully	Upper Burringbar Road	-28.4468808	153.4147964	3	Pipe Culvert	HL	Box Culvert LF	L	248
Northern Rivers	Twee - 56	Tweed	Reserve Creek	Off Palmvale Road	-28.3570605	153.4714076	3	Pipe Culvert	HL, LF	Box Culvert LF	L	248
Northern Rivers	Twee - 75	Tweed	Couchy Creek	Couchy Creek Road	-28.2633277	153.2810018	2	Pipe Culvert	V	Box Culvert LF	L	248
Northern Rivers	Twee - 80	Tweed	Hopkins Creek	Hopkins Creek Road	-28.2995048	153.2627121	2	Box Culvert	HL, LF	Box Culvert LF	L	248
Northern Rivers	Twee - 85	Tweed	Korrumbyn Creek	Off Mount Warning Road	-28.3841820	153.3294975	2	Causeway	HL	Bridge	L	248
Northern Rivers	Twee - 90	Tweed	Unnamed watercourse	Off Byrrill Creek Road	-28.4362892	153.2686693	3	Pipe Culvert	HL, V	Box Culvert LF	L	248
Northern Rivers	Twee - 15	Tweed	Bilambil Creek	Urliup Road	-28.2387000	153.4354000	2	Box Culvert	LF	Box Culvert LF	L	270
Northern Rivers	Twee - 16	Tweed	Bilambil Creek	Urliup Road	-28.2292000	153.4686000	3	Pipe Culvert	V, LF	Box Culvert LF	L	270
Northern Rivers	Twee - 38	Tweed	Dunbible Creek	Nolands Road	-28.4060102	153.4348808	2	Box Culvert	HL, LF	Box Culvert LF	L	270

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Northern Rivers	Twee - 77	Tweed	Pat Smiths Creek	Numinbah Road	-28.2778129	153.2585186	2	Pipe Culvert	V	Bridge	L	270
Northern Rivers	Twee - 93	Tweed	Perch Creek	Midgimbil Road	-28.5040144	153.2648414	2	Pipe Culvert	HL	Bridge	L	270
Northern Rivers	Twee - 98	Tweed	Tyalgum Creek	Butlers Road	-28.3518784	153.1748257	2	Pipe Culvert	V	Box Culvert LF	L	270
Northern Rivers	Twee - 33	Tweed	Fosters Gully	Jowetts Road	-28.4481963	153.4140947	3	Pipe Culvert	HL, V	Box Culvert LF	L	291
Northern Rivers	Twee - 52	Tweed	Cudgera Creek	Off Cudgera Creek Road	-28.3931884	153.5104455	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	291
Northern Rivers	Twee - 08	Tweed	Unnamed watercourse	Tunnel Road	-28.4002000	153.4084000	3	Pipe Culvert	HL, V	Box Culvert LF	L	325
Northern Rivers	Twee - 36	Tweed	Dunbible Creek	Nolands Road	-28.4016250	153.4271628	2	Box Culvert	LF	Box Culvert LF	L	325
Northern Rivers	Twee - 37	Tweed	Dunbible Creek	Nolands Road	-28.4018443	153.4300132	2	Box Culvert	HL	Box Culvert LF	L	325
Northern Rivers	Twee - 60	Tweed	Unnamed waterway	Clothiers Creek Road	-28.3298063	153.4924614	3	Pipe Culvert	HL	Box Culvert LF	L	325
Northern Rivers	Twee - 61	Tweed	Kings Gully	Stokers Road	-28.3759722	153.3905683	3	Pipe Culvert	LF	Box Culvert LF	L	325
Northern Rivers	Twee - 59	Tweed	Clothiers Creek	Kestrel Place	-28.3359986	153.4786346	3	Box Culvert	HL	Box Culvert LF	L	363
Northern Rivers	Twee - 62	Tweed	Unnamed waterway	Stokers Road	-28.3664970	153.3878537	3	Pipe Culvert	HL	Box Culvert LF	L	363
Northern Rivers	Twee - 66	Tweed	Nobbys Creek	Pigeonberry Road	-28.2713026	153.3279770	3	Causeway	LF	Box Culvert LF	L	363
Northern Rivers	Twee - 87	Tweed	Korrumbyn Creek	Mount Warning Road	-28.3921853	153.3174642	2	Pipe Culvert	V	Box Culvert LF	L	363
Northern Rivers	Twee - 55	Tweed	Reserve Creek	Off Palmvale Road	-28.3531219	153.4758187	2	Pipe Culvert	V	Box Culvert LF	L	392
Northern Rivers	Twee - 57	Tweed	Condong Creek	Off Wulffs Lane	-28.3304884	153.4358381	3	Pipe Culvert	WD	Maintenance	L	392
Northern Rivers	Twee - 58	Tweed	Clothiers Creek	Condor Place	-28.3376493	153.4760800	3	Box Culvert	HL	Box Culvert LF	L	392
Northern Rivers	Twee - 65	Tweed	Dungay Creek	Dungay Creek Road	-28.2648585	153.3578423	2	Pipe Culvert	V	Box Culvert LF	L	392
Northern Rivers	Twee - 39	Tweed	Dunbible Creek	Nolands Road	-28.4054875	153.4345607	2	Pipe Culvert	HL	Box Culvert LF	L	472
Upper North Coast	Bell - 02	Bellinger	Unnamed watercourse	Yellow Rock Road	-30.4534000	153.0290000	3	Pipe Culvert	HL	Box Culvert LF	L	291
Upper North Coast	Bell - 22	Clarence	Double Creek	Tyringham Road	-30.2522917	152.6001733	3	Box Culvert	HL, LF	Box Culvert LF	L	363
Upper North Coast	Bell - 07	Bellinger	Unnamed watercourse	Martells Road	-30.5150000	152.9503000	4	Pipe Culvert	LF	Maintenance	L	419
Upper North Coast	Bell - 20	Clarence	Little Plain Creek	Tyringham Road	-30.2944360	152.6849588	3	Box Culvert	HL, LF	Box Culvert LF	L	419
Upper North Coast	Bell - 21	Clarence	Log Creek	Tyringham Road	-30.2565068	152.6101863	3	Box Culvert	HL, LF	Box Culvert LF	L	419
Upper North Coast	Bell - 24	Bellinger	Roses Creek	Waterfall Way	-30.4395133	152.8700717	3	Box Culvert	LF	Box Culvert LF	L	433
Upper North Coast	Clar - 03	Clarence	Micalo Channel	Yamba Road	-29.4304000	153.3088000	1	Causeway	B	Bridge	H	17
Upper North Coast	Clar - 59	Clarence	Ewingar Creek	Ewingar Road	-29.0795200	152.5544983	2	Box Culvert	HL, LF	Bridge	H	27
Upper North Coast	Clar - 61	Clarence	Deep Creek	Deep Creek Road	-29.1566550	152.6433700	2	Causeway	HL, V	Bridge	H	29
Upper North Coast	Clar - 50	Clarence	Alipou Creek	Fernance Road	-29.7204800	152.9534217	2	Causeway	HL	Box Culvert LF	M-H	91
Upper North Coast	Clar - 43	Clarence	Goolang Creek	off Armidale Road	-29.9259813	152.7420846	2	Causeway	HL	Remove	M	112
Upper North Coast	Clar - 64	Clarence	Sawyers Creek	Moorheads Road	-29.2294900	152.6268850	3	Causeway	HL, LF	Remove	M	112

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Upper North Coast	Clar - 45	Clarence	Four Mile Creek	Sheep Station Road	-30.1875159	152.5222541	2	Causeway	V, LF	Bridge	M	125
Upper North Coast	Clar - 46	Clarence	Charon Creek	Sheep Station Road	-30.1761650	152.5179883	2	Causeway	HL	Remove	M	125
Upper North Coast	Clar - 58	Clarence	Mookima Wybra Creek	Welsh Road	-29.0332100	152.5686517	3	Causeway	V, LF	Bridge	M	125
Upper North Coast	Clar - 34	Clarence	Flaggy creek	Meyers Road	-29.6328000	152.8026000	3	Causeway	HL	Box Culvert LF	M	142
Upper North Coast	Clar - 42	Clarence	Blaxlands Creek	off Armidale Road	-29.9095964	152.7879940	2	Causeway	V, LF	Bridge	M-L	160
Upper North Coast	Clar - 62	Clarence	Bugilbar Creek	Off Clarence Way	-29.1959533	152.6027517	3	Causeway	HL, V, LF	Bridge	M-L	160
Upper North Coast	Clar - 47	Clarence	Chinamans Creek	Sheep Station Road	-30.1859867	152.5407467	2	Causeway	HL, LF	Remove	M-L	178
Upper North Coast	Clar - 51	Clarence	Marengo Creek	Marengo Road	-30.1594187	152.3781634	2	Pipe Culvert	WD, V	Box Culvert LF	M-L	178
Upper North Coast	Clar - 06	Clarence	Unnamed watercourse	Carrs Drive	-29.4529000	153.3297000	3	Box Culvert	V	Box Culvert LF	M-L	212
Upper North Coast	Clar - 56	Clarence	Southions Creek	Tindal Road	-29.6345250	152.8248683	3	Box Culvert	HL, V	Box Culvert LF	M-L	212
Upper North Coast	Clar - 35	Clarence	Clear Water Creek	Gilmores Lane	-29.9602000	153.0779000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	M-L	229
Upper North Coast	Clar - 48	Clarence	Little Falls Creek	Armidale Grafton Road	-30.3211650	152.4117333	2	Box Culvert	HL, LF	Bridge	L	248
Upper North Coast	Clar - 52	Clarence	Jackass Creek	Marengo Road	-30.1600933	152.3769617	2	Causeway	V, LF	Box Culvert LF	L	270
Upper North Coast	Clar - 26	Clarence	Cloghers Creek	Layton Range Road	-29.9922483	152.7565433	2	Box Culvert	HL	Box Culvert LF	L	291
Upper North Coast	Clar - 41	Clarence	Boiling Down Creek	Rushforth Road	-29.8097122	152.8472759	3	Causeway	V, LF	Box Culvert LF	L	291
Upper North Coast	Clar - 29	Clarence	Unnamed watercourse	Glens Creek Road	-29.8936000	152.7015000	4	Causeway	HL	Box Culvert LF	L	325
Upper North Coast	Clar - 44	Clarence	Maloneys Creek	Mulquinneys Road	-29.8230308	152.9582844	3	Pipe Culvert	HL, WD, LF	Box Culvert LF	L	325
Upper North Coast	Clar - 55	Clarence	Cowans Creek	McLennans Lane	-29.6880998	152.9057037	3	Causeway	B	Bridge	L	325
Upper North Coast	Clar - 60	Clarence	Cleveland Creek	Clarence Way	-29.0558100	152.5992367	4	Pipe Culvert	HL, V, L	Bridge	L	325
Upper North Coast	Clar - 63	Clarence	Brindle Swamp Creek	Clarence Way	-29.2266083	152.6151633	3	Causeway	HL, WD, V	Box Culvert LF	L	325
Upper North Coast	Clar - 09	Clarence	Unnamed watercourse	South Arm Road	-29.5399000	153.1712000	3	Pipe Culvert	V	Box Culvert LF	L	352
Upper North Coast	Clar - 31	Clarence	Unnamed watercourse	Glens Creek Road	-29.8690000	152.6816000	4	Pipe Culvert	HL, WD	Box Culvert LF	L	352
Upper North Coast	Clar - 57	Clarence	Wongabri Creek	Cangai Road	-29.5685233	152.5441233	3	Causeway	HL, LF	Box Culvert LF	L	352
Upper North Coast	Clar - 54	Clarence	Cowans Creek	Off Gwydir Highway	-29.6852167	152.8910700	3	Causeway	V	Remove	L	363
Upper North Coast	Clar - 25	Clarence	Cloghers Creek	Layton Range Road	-29.9967000	152.7620000	3	Causeway	LF	Box Culvert LF	L	392
Upper North Coast	Clar - 53	Clarence	Bruisers Creek	Old Grafton Road	-29.7663750	152.2604583	3	Pipe Culvert	V, LF	Bridge	L	392
Upper North Coast	Clar - 65	Clarence	Pinch Creek	Tyringham Road	-30.2207467	152.5610300	3	Box Culvert	HL, LF	Box Culvert LF	L	392
Upper North Coast	Clar - 02	Clarence	Unnamed watercourse	Frickers Road	-29.9153000	152.7037000	3	Causeway	HL	Box Culvert LF	L	419
Upper North Coast	Clar - 49	Clarence	Pheasant Creek	Eight Mile Lane	-29.7857433	153.0345433	3	Pipe Culvert	HL	Bridge	L	433
Upper North Coast	Clar - 36	Clarence	Running Creek	Off South Arm Road	-29.5049900	153.1843143	3	Pipe Culvert	LF	Box Culvert LF	L	472
Upper North Coast	Coff - 01	Clarence	Orara river	Casuarina Lane	-30.2514000	153.0380000	1	Box Culvert	HL, V	Fishway	H	4
Upper North Coast	Coff - 12	Clarence	Bucca Bucca Creek	Swans Road	-30.2410346	153.0952637	2	Causeway	HL	Bridge	M	122

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Upper North Coast	Coff - 16	Coffs Harbour Waterways	Dirty Creek	Barcoongere Way	-29.9687367	153.1751183	3	Causeway	HL	Bridge	M	142
Upper North Coast	Coff - 17	Coffs Harbour Waterways	Sugar Mill Creek	Off Pacific Highway	-30.2161567	153.1501867	3	Ford	WD, LF	Box Culvert LF	M-L	178
Upper North Coast	Coff - 18	Coffs Harbour Waterways	Sugar Mill Creek	Pacific Highway	-30.2203321	153.1460937	3	Box Culvert	HL, LF, L	Box Culvert LF	L	248
Upper North Coast	Coff - 15	Coffs Harbour Waterways	Poundyard Creek	Shearer Drive	-30.1015450	153.1780333	3	Pipe Culvert	HL	Box Culvert LF	L	291
Upper North Coast	Coff - 05	Clarence	Unnamed watercourse	Bucca Road	-30.1494000	153.0740000	3	Pipe Culvert	HL, V	Box Culvert LF	L	325
Upper North Coast	Coff - 11	Coffs Harbour Waterways	Coffs Creek	Bennetts Road	-30.2875567	153.0731200	3	Pipe Culvert	HL, LF	Box Culvert LF	L	352
Upper North Coast	Coff - 13	Coffs Harbour Waterways	Treefern Creek	West Korora Road	-30.2742517	153.1041350	3	Pipe Culvert	HL	Box Culvert LF	L	392
Upper North Coast	Coff - 07	Clarence	Unnamed watercourse	Bucca Road	-30.1416000	153.0584000	3	Box Culvert	HL, LF	Box Culvert LF	L	419
Upper North Coast	Coff - 14	Coffs Harbour Waterways	Treefern Creek	Off Vera Road	-30.2733400	153.1030833	3	Pipe Culvert	HL	Box Culvert LF	L	472
Upper North Coast	Guyr - 03	Clarence	Mann River	Off Red Range Road	-29.7601117	151.8275967	1	Causeway	HL, V, LF	Remove	H	25
Upper North Coast	Guyr - 01	Clarence	Timbarra river	Leamons Road	-29.5770000	152.1233000	1	Pipe Culvert	HL, V	Box Culvert LF	H	39
Upper North Coast	Guyr - 12	Clarence	Diehard Creek	Old Grafton Road	-29.6757000	152.0881000	2	Causeway	HL	Box Culvert LF	M	125
Upper North Coast	Guyr - 02	Clarence	Surveyors Creek	Dandara Trail	-29.5333500	152.3120667	3	Pipe Culvert	HL, V, LF	Box Culvert LF	M-L	199
Upper North Coast	Guyr - 06	Clarence	Leather Jacket Creek	Old Grafton Road	-29.7175000	152.1019000	3	Pipe Culvert	HL, V	Box Culvert	L	291
Upper North Coast	Guyr - 10	Clarence	Leather Jacket Creek	Old Grafton Road	-29.7178000	152.1280000	3	Box Culvert	HL, V	Box Culvert LF	L	291
Upper North Coast	Guyr - 11	Clarence	Mogoo Swamp	Pinkett Road	-29.9671000	152.0201000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	291
Upper North Coast	Guyr - 14	Clarence	Leather Jacket Creek	Old Grafton Road	-29.7175000	152.1265000	3	Ford	HL, LF	Box Culvert LF	L	325
Upper North Coast	Guyr - 09	Clarence	Unnamed watercourse	Mount Mitchell Road	-29.9292000	151.7383000	3	Pipe Culvert	HL, V, LF	Box Culvert LF	L	325
Upper North Coast	Guyr - 05	Clarence	Butterleaf Creek	Ten Mile Road	-29.5283583	152.1112483	3	Box Culvert	HL, LF	Box Culvert LF	L	325
Upper North Coast	Guyr - 08	Clarence	Morven Creek	Coxs Road	-29.3820200	152.0488217	3	Pipe Culvert	HL, V	Box Culvert LF	L	325
Upper North Coast	Guyr - 07	Clarence	Sheep Station Creek	Pinkett Road	-29.8301000	151.8989000	3	Pipe Culvert	HL, V	Remove	L	363
Upper North Coast	Kyog - 32	Clarence	Glen Elgin Creek	Morven Road	-29.6002367	152.0010417	3	Pipe Culvert	HL, V	Box Culvert LF	L	363
Upper North Coast	Kyog - 31	Clarence	Leather Jacket Creek	Old Grafton Road	-29.7138000	152.1503000	3	Box Culvert	HL	Box Culvert	L	392
Upper North Coast	Kyog - 29	Clarence	Rocky Creek	Square Range Road	-29.7917100	151.8852983	3	Pipe Culvert	HL, V	Box Culvert LF	L	433
Upper North Coast	Seve - 38	Clarence	Unnamed watercourse	Old Ben Lomond Road	-29.9829000	151.6953000	4	Pipe Culvert	HL, V	Box Culvert LF	L	450

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Upper North Coast	Seve - 27	Clarence	Lambs Valley Creek	Lambs Valley Road	-29.8061467	151.8133667	4	Causeway	HL, V	Box Culvert LF	L	450
Upper North Coast	Seve - 03	Clarence	Lambs Valley Creek	Old Koora Road	-29.8099067	151.8073900	4	Causeway	HL, V	Box Culvert LF	L	450
Upper North Coast	Seve - 39	Clarence	Marowan Creek	Old Ben Lomond Road	-29.9443000	151.7121000	3	Pipe Culvert	V	Maintenance	L	472
Upper North Coast	Seve - 04	Clarence	Middle Creek	Greenhouse Road	-29.7808783	151.8725450	4	Pipe Culvert	V	Box Culvert LF	L	472
Upper North Coast	Seve - 06	Clarence	Rocky Creek	Greenhouse Road	-29.7888283	151.8879183	3	Pipe Culvert	V	Box Culvert LF	L	501
Upper North Coast	Seve - 16	Clarence	Perrys Swamp Creek	Nutrition Station Road	-29.7221000	151.8643000	3	Pipe Culvert	V	Box Culvert	L	504
Upper North Coast	Seve - 05	Clarence	Sheep Station Creek	Square Range Road	-29.8388167	151.8733400	4	Causeway	V	Box Culvert LF	L	504
Upper North Coast	Seve - 14	Clarence	Oban River	Kookabrookra Road	-30.0193000	152.0585000	1	Causeway	HL, LF	Box Culvert LF	H	35
Upper North Coast	Seve - 40	Clarence	Aberfoyle River	Aberfoyle Road	-30.2528981	152.0154094	2	Box Culvert	HL, V	Box Culvert LF	M	102
Upper North Coast	Seve - 43	Clarence	Nowlands Backwater	Waverley Road	-30.1640700	151.9527767	3	Causeway	HL, LF	Box Culvert LF	L	352
Upper North Coast	Seve - 18	Clarence	Johns Creek	Waverley Road	-30.2194000	151.9206000	3	Causeway	HL, LF	Remove	L	363
Upper North Coast	Seve - 41	Clarence	Kangaroo Creek	Off Armidale Grafton Rd	-30.4377418	152.3198782	3	Causeway	HL	Remove	L	392
Upper North Coast	Seve - 29	Clarence	Connaughtmans Creek	Dyamberin Road	-30.2692117	152.1966950	3	Causeway	V, LF	Box Culvert LF	L	433
Upper North Coast	Seve - 35	Clarence	Long Swamp Creek	Naylors Road	-30.1715817	151.9550800	3	Causeway	HL, LF	Box Culvert LF	L	433
Upper North Coast	Seve - 13	Clarence	Stuttering Dicks Ck	Paddys Gully Road	-30.0674900	151.8864000	3	Causeway	V	Box Culvert LF	L	433
Upper North Coast	Seve - 32	Clarence	Kangaroo Creek	Old Ebor Road	-30.3019550	152.1730900	3	Causeway	HL, LF	Box Culvert LF	L	450
Upper North Coast	Seve - 33	Clarence	Unnamed waterway	Guyra Ebor Road	-30.2910000	152.1662000	3	Box Culvert	HL, LF	Maintenance	L	472
Upper North Coast	Seve - 10	Clarence	Doughboy Creek	Old Ebor Road	-30.3478217	152.2037517	3	Causeway	HL, V	Box Culvert LF	L	472
Upper North Coast	Seve - 37	Clarence	Scabby Creek	Old Ebor Road	-30.3592162	152.2177321	3	Causeway	HL	Box Culvert LF	L	501
Upper North Coast	Seve - 36	Richmond	Websters Creek	Robb Road	-28.5315348	153.1760688	2	Pipe Culvert	HL, V	Bridge	M-H	91
Upper North Coast	Seve - 01	Clarence	Sandy Creek	Sandy Creek Road	-28.6934750	152.6390950	2	Causeway	LF	Box Culvert LF	M	125
Upper North Coast	Seve - 34	Clarence	Little Creek	Unnamed off Bruxner Hwy	-28.9046317	152.6772716	3	Pipe Culvert	LF	Box Culvert LF	L	392
Upper North Coast	Tent - 23	Clarence	Timbarra River	Off Upper Rocky River Rd	-29.2118550	152.2455433	1	Causeway	HL, LF	Remove	H	6
Upper North Coast	Tent - 26	Clarence	Nelson Creek	Rocky River Road	-29.0709683	152.3487717	2	Causeway	HL, LF	Box Culvert LF	M-H	64
Upper North Coast	Tent - 22	Clarence	Quigeram Creek	Billarimba Road	-29.1604372	152.2152467	2	Causeway	HL	Remove	M-H	70
Upper North Coast	Tent - 27	Clarence	Tin Creek	Rocky River Road	-29.0576245	152.3552042	2	Causeway	HL	Bridge	M-H	77
Upper North Coast	Tent - 24	Clarence	Hortons Creek	Rocky River Road	-29.1689850	152.3297500	2	Causeway	HL, LF	Bridge	M-H	91
Upper North Coast	Tent - 44	Clarence	Maryland River	Wylie Creek Road	-28.5494850	152.1146383	2	Causeway	V, L	Remove	M-H	91
Upper North Coast	Tent - 28	Clarence	Tin Creek	Rocky River Road	-29.0582493	152.3554720	3	Causeway	HL, LF	Bridge	M-L	160
Upper North Coast	Tent - 29	Clarence	Long Creek	Rocky River Road	-29.0340917	152.3610700	3	Causeway	HL, V, LF	Box Culvert LF	M-L	160
Upper North Coast	Tent - 25	Clarence	Peg Leg Creek	Rocky River Road	-29.1231150	152.3560633	2	Causeway	HL	Box Culvert LF	M-L	178
Upper North Coast	Tent - 36	Clarence	Long Creek	Rocky River Road	-28.9968917	152.3817100	3	Causeway	HL, V	Box Culvert LF	M-L	212

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Upper North Coast	Tent - 37	Clarence	Long Creek	Rocky River Road	-28.9954250	152.3818767	3	Causeway	HL, WD, V	Box Culvert LF	M-L	212
Upper North Coast	Tent - 01	Clarence	Tea Tree Creek	Long Gully Road	-28.9665000	152.3913000	3	Causeway	HL, LF	Box Culvert LF	M-L	229
Upper North Coast	Tent - 43	Clarence	Wylie Creek	Rivertree Road	-28.6414917	152.1262150	3	Causeway	HL, V	Box Culvert LF	L	248
Upper North Coast	Tent - 47	Clarence	Four Mile Creek	Paddys Flat Road	-28.8079850	152.4836717	3	Pipe Culvert	HL, WD, V	Box Culvert LF	L	248
Upper North Coast	Tent - 45	Clarence	Beaury Creek	Beaury Creek Loop Road	-28.4973483	152.4905900	3	Causeway	HL, WD, LF	Bridge	L	270
Upper North Coast	Tent - 02	Clarence	Saw Pit Creek	Cheviot Hills Road	-28.9098000	152.3909000	3	Box Culvert	HL	Bridge	L	291
Upper North Coast	Tent - 30	Clarence	Long Creek	Rocky River Road	-29.0333317	152.3616217	3	Causeway	HL, LF	Box Culvert LF	L	291
Upper North Coast	Tent - 34	Clarence	Long Creek	Rocky River Road	-29.0044950	152.3796333	3	Causeway	HL, V	Box Culvert LF	L	291
Upper North Coast	Tent - 35	Clarence	Long Creek	Rocky River Road	-29.0009283	152.3799750	3	Causeway	HL, V	Box Culvert LF	L	291
Upper North Coast	Tent - 31	Clarence	Long Creek	Rocky River Road	-29.0312300	152.3651633	3	Causeway	V, LF	Box Culvert LF	L	325
Upper North Coast	Tent - 38	Clarence	Long Creek	Rocky River Road	-28.9935100	152.3824850	3	Causeway	HL, WD	Box Culvert LF	L	325
Upper North Coast	Tent - 41	Clarence	Dismal Swamp Creek	Boonoo Boonoo Falls Rd	-28.8742883	152.1175333	3	Causeway	HL, V	Box Culvert LF	L	352
Upper North Coast	Tent - 33	Clarence	Long Creek	Rocky River Road	-29.0132183	152.3749267	3	Causeway	V, LF	Box Culvert LF	L	363
Upper North Coast	Tent - 04	Clarence	Barney Downs Creek	Off Bruxner Highway	-29.0439463	152.0928717	3	Pipe Culvert	LF	Box Culvert LF	L	392
Upper North Coast	Tent - 32	Clarence	Long Creek	Rocky River Road	-29.0248467	152.3676433	3	Causeway	LF	Box Culvert LF	L	419
Upper North Coast	Tent - 03	Clarence	Black Swamp Creek	Bruxner Highway	-29.0046467	152.1501750	3	Box Culvert	LF	Box Culvert LF	L	433
Upper North Coast	Tent - 42	Clarence	Bookookoorara Creek	Harrigans Lane	-28.7542250	152.0952467	3	Causeway	WD, V	Box Culvert LF	L	433
Upper North Coast	Tent - 21	Clarence	Johanna Creek	Kochs Road	-29.0667433	152.0856517	3	Causeway	HL, LF	Box Culvert LF	L	450
Upper North Coast	Tent - 46	Clarence	Unnamed waterway	Woodenbong-Urbanville Road	-28.4849749	152.5345130	3	Box Culvert	LF	Box Culvert LF	L	514
Mid North Coast	Armi - 13	Macleay	Chandler River	Fassifern	-30.4276117	152.0801783	1	Causeway	HL, LF	Box Culvert LF	H	41
Mid North Coast	Armi - 29	Macleay	Lagoon Creek	Private Road	-30.7518124	152.3363585	2	Causeway	B	Box Culvert LF	H	47
Mid North Coast	Armi - 07	Macleay	Wollomombi river	Chandler Road	-30.4316000	151.9905000	1	Pipe Culvert	V	Box Culvert LF	H	60
Mid North Coast	Armi - 25	Macleay	Commissioners Waters	Private Road	-30.5434453	151.7253973	1	Pipe Culvert	HL, V	Box Culvert LF	H	60
Mid North Coast	Armi - 24	Macleay	Gara River	Gara Road	-30.5777051	151.8099968	1	Causeway	HL, LF	Box Culvert LF	M-H	64
Mid North Coast	Armi - 16	Macleay	Pint Pot Creek	Chandler Road	-30.4490733	151.8750417	2	Pipe Culvert	HL, V, LF	Remove	M-H	77
Mid North Coast	Armi - 14	Macleay	Chandler River	Murrays Road	-30.4189067	152.0829467	1	Pipe Culvert	V	Box Culvert LF	M	102
Mid North Coast	Armi - 18	Macleay	Donald Creek	Private Road	-30.4741717	151.7340783	2	Pipe Culvert	HL, V	Box Culvert LF	M	142
Mid North Coast	Armi - 26	Macleay	Powers Creek	Private Road	-30.6041050	151.7811067	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	160
Mid North Coast	Armi - 27	Macleay	Powers Creek	Fosters Road	-30.5922100	151.7387933	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	199
Mid North Coast	Armi - 12	Macleay	Chandalina Creek	Private Rd off Doughboy Rd	-30.4018050	152.1254533	2	Pipe Culvert	HL, V	Box Culvert LF	M-L	229

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Mid North Coast	Armi - 10	Macleay	Station Creek	Private Rd off Doughboy Rd	-30.4999750	152.1005750	2	Causeway	HL	Box Culvert LF	L	325
Mid North Coast	Armi - 02	Macleay	Unnamed watercourse	Primrose Hill Road	-30.4780000	151.5723000	3	Pipe Culvert	HL	Box Culvert LF	L	392
Mid North Coast	Armi - 19	Macleay	Burying Ground Creek	Herbert Park Road	-30.4411917	151.7754567	3	Pipe Culvert	HL, LF	Box Culvert LF	L	392
Mid North Coast	Armi - 23	Macleay	Chinamans Creek	Chinamans Gully Road	-30.5511367	151.8825900	4	Pipe Culvert	V, LF	Box Culvert LF	L	419
Mid North Coast	Armi - 05	Macleay	Lambs Valley Creek	Chandler Road	-30.4282000	152.0097000	3	Causeway	LF	Box Culvert LF	L	433
Mid North Coast	Armi - 17	Macleay	Chandler River	Guyra Ebor Road	-30.3150483	152.0537167	3	Pipe Culvert	HL, LF	Box Culvert LF	L	433
Mid North Coast	Armi - 20	Macleay	Armidale Creek	Green Hills Road	-30.3789983	151.8252250	3	Causeway	HL, LF	Box Culvert LF	L	433
Mid North Coast	Armi - 08	Macleay	Unnamed watercourse	Rockvale Road	-30.3010000	151.9741000	3	Causeway	HL	Box Culvert LF	L	472
Mid North Coast	Armi - 06	Macleay	Lambs Valley Creek	Tulloch Road	-30.4218000	152.0058000	3	Pipe Culvert	V	Box Culvert LF	L	486
Mid North Coast	Armi - 15	Macleay	Smiths Gully	Thorpleigh Road	-30.5112150	151.9519150	3	Ford	LF	Maintenance	L	486
Mid North Coast	Armi - 11	Macleay	Ponds Creek	Private Rd off Doughboy Rd	-30.5178467	152.1085300	3	Ford	LF	Box Culvert LF	L	504
Mid North Coast	Armi - 21	Macleay	Sandy Creek	Long Point Road	-30.5605650	151.9274433	4	Causeway	LF	Box Culvert LF	L	504
Mid North Coast	Guyr - 13	Macleay	Gara River	Tara Road	-30.1860533	151.7270683	2	Pipe Culvert	HL, LF	Bridge	M-L	178
Mid North Coast	Hast - 11	Hastings	Thone River	Byabarra Bagnoo Road	-31.5324000	152.5230000	1	Box Culvert	HL, LF	Box Culvert LF	H	6
Mid North Coast	Hast - 28	Hastings	Forbes River	Forbes River Road	-31.2946967	152.3135983	1	Ford	B	Remove	H	6
Mid North Coast	Hast - 14	Hastings	Wilson River	Clarefield Dungay Ck Rd	-31.2506517	152.6628570	1	Causeway	V	Remove	H	17
Mid North Coast	Hast - 30	Hastings	Wilson River	Off Scotts Plain Road	-31.2799599	152.6985046	1	Causeway	HL	Fishway	H	41
Mid North Coast	Hast - 17	Hastings	Bottlebrush Creek	Brill Brill Road	-31.2773717	152.6745733	2	Causeway	HL, WD	Remove	H	60
Mid North Coast	Hast - 24	Hastings	Toms Creek	Toms Creek Road	-31.5666700	152.4036967	2	Causeway	V, LF	Bridge	M-H	77
Mid North Coast	Hast - 26	Hastings	Toms Creek	Toms Creek Road	-31.5576433	152.3950117	2	Causeway	V	Bridge	M-H	91
Mid North Coast	Hast - 18	Hastings	Wrights Creek	Hill Street	-31.4391733	152.9171417	2	Pipe Culvert	LF	Bridge	M	102
Mid North Coast	Hast - 21	Hastings	Batar Creek	Cedar Loggers Lane	-31.6595433	152.6746817	2	Box Culvert	HL, LF	Box Culvert LF	M	112
Mid North Coast	Hast - 25	Hastings	Toms Creek	Toms Creek Road	-31.5612983	152.3994083	2	Causeway	HL, V	Bridge	M	125
Mid North Coast	Hast - 02	Hastings	Unnamed watercourse	Diamond Head Road	-31.6668000	152.8041000	3	Pipe Culvert	V, LF	Box Culvert LF	M-L	160
Mid North Coast	Hast - 12	Hastings	Pipers Creek	Ballengarra Road	-31.1565633	152.6992267	3	Causeway	HL, V	Bridge	M-L	199
Mid North Coast	Hast - 19	Hastings	Haydons Creek	Sancrox Road	-31.4445683	152.7928467	3	Causeway	V, LF	Box Culvert LF	M-L	212
Mid North Coast	Hast - 20	Hastings	Blue Creek	Bago Road	-31.5046550	152.7299050	3	Box Culvert	HL, LF	Box Culvert LF	M-L	212
Mid North Coast	Hast - 15	Hastings	Marlo Merrican Creek	Clarefield Dungay Ck Rd	-31.2305083	152.6652583	3	Box Culvert	HL, LF	Box Culvert LF	M-L	229
Mid North Coast	Hast - 13	Hastings	Oleary Creek	Barracks Road	-31.2302550	152.7560883	3	Pipe Culvert	WD, V	Box Culvert LF	L	270
Mid North Coast	Hast - 22	Hastings	Batar Creek	The Old Coach Road	-31.6614917	152.6734583	3	Box Culvert	HL, LF	Box Culvert LF	L	270
Mid North Coast	Hast - 06	Hastings	Partridge Creek	Fernbank Creek Road	-31.4058000	152.8566000	3	Pipe Culvert	V	Maintenance	L	291

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Mid North Coast	Hast - 29	Hastings	Pipeclay Creek	Off Pipeclay Creek Road	-31.4558133	152.6031833	3	Ford	HL, LF	Remove	L	291
Mid North Coast	Hast - 16	Hastings	Marlo Merrican Creek	Clarefield Dungay Ck Rd	-31.2269250	152.6672167	3	Box Culvert	V	Box Culvert LF	L	325
Mid North Coast	Hast - 27	Hastings	Bells Creek	Forbes River Road	-31.2958183	152.3150483	3	Pipe Culvert	HL, WD	Box Culvert LF	L	325
Mid North Coast	Hast - 08	Hastings	Unnamed watercourse	Oakes Court	-31.4098000	152.8304000	3	Pipe Culvert	V	Box Culvert LF	L	392
Mid North Coast	Hast - 23	Hastings	Rock Creek	Innes View Road	-31.6017646	152.4380910	3	Causeway	V	Box Culvert LF	L	517
Mid North Coast	Kemp - 10	Macleay	Dungay Creek	Dungay Creek Road	-31.1019000	152.6641000	1	Pipe Culvert	HL, V	Box Culvert LF	H	1
Mid North Coast	Kemp - 24	Macleay	Parrabell Creek	Dowlings Falls Road	-30.9296017	152.5880083	1	Pipe Culvert	V, LF	Box Culvert LF	H	11
Mid North Coast	Kemp - 02	Macleay	Warbro Brook	Mackenzies Creek Road	-30.9067000	152.4924000	2	Pipe Culvert	HL, V	Box Culvert LF	H	22
Mid North Coast	Kemp - 25	Macleay	Hickeys Creek	Secombs Lane	-30.8928633	152.6122150	2	Ford	HL, LF	Box Culvert LF	M-H	70
Mid North Coast	Kemp - 23	Hastings	Caswells Creek	Off Smiths Creek Road	-31.2133752	152.7601172	2	Causeway	B, LF	Box Culvert LF	M-H	91
Mid North Coast	Kemp - 08	Macleay	Unnamed watercourse	Boyters Lane	-30.9153149	153.0322684	3	Causeway	HL	Box Culvert LF	M	142
Mid North Coast	Kemp - 21	Macleay	Euroka Creek	Coucal Road	-31.1176455	152.7784799	3	Causeway	HL, V	Box Culvert LF	M	142
Mid North Coast	Kemp - 06	Macleay	Unnamed watercourse	Rainbow Reach Road	-30.9223000	153.0112000	3	Causeway	HL	Box Culvert LF	M-L	160
Mid North Coast	Kemp - 05	Macleay	Unnamed watercourse	Rainbow Reach Road	-30.9148000	153.0069000	3	Causeway	HL	Box Culvert LF	M-L	199
Mid North Coast	Kemp - 04	Macleay	Unnamed watercourse	Rainbow Reach Road	-30.9278000	153.0076000	3	Pipe Culvert	V	Maintenance	L	248
Mid North Coast	Kemp - 13	Macleay	Unnamed watercourse	McKenzies Creek Road	-30.8830000	152.4411000	3	Causeway	HL	Box Culvert LF	L	291
Mid North Coast	Kemp - 22	Macleay	Euroka Creek	Bottle Tree Lane	-31.1208800	152.7617233	3	Causeway	V	Bridge	L	325
Mid North Coast	Kemp - 20	Macleay	Gills Bridge Creek	Queen Street	-31.0969333	152.8282900	3	Causeway	V	Box Culvert LF	L	363
Mid North Coast	Kemp - 12	Macleay	Scotchys Creek	Tanban Road	-30.8470000	152.4717000	3	Causeway	HL	Box Culvert LF	L	433
Mid North Coast	Kemp - 09	Macleay	Unnamed watercourse	Boyters Lane	-30.9147000	153.0267000	4	Pipe Culvert	V	Maintenance	L	450
Mid North Coast	Kemp - 16	Macleay	Unnamed watercourse	Moparrabah Road	-30.9256000	152.5678000	4	Box Culvert	HL	Box Culvert LF	L	486
Mid North Coast	Namb - 13	Nambucca	Deep Creek	Sullivans Road	-30.5912233	152.9670783	1	Causeway	HL	Remove	H	4
Mid North Coast	Namb - 16	Nambucca	Taylors Arm	Private Road	-30.7586995	152.6534591	1	Causeway	HL	Remove	H	9
Mid North Coast	Namb - 14	Nambucca	Deep Creek	off Colemans Road	-30.6007275	152.9368836	2	Weir	HL	Remove	M-H	64
Mid North Coast	Namb - 15	Nambucca	Deep Creek	Cowins Road	-30.5971044	152.9274116	2	Pipe Culvert	HL, WD, V	Box Culvert LF	M-H	70
Mid North Coast	Namb - 04	Nambucca	Unnamed Watercourse	Valla Road	-30.6365000	152.8693000	3	Pipe Culvert	HL, V	Box Culvert LF	M	112
Mid North Coast	Namb - 07	Nambucca	Gumma Gumma Creek	Gumma Road	-30.7065000	152.9589000	3	Pipe Culvert	V	Box Culvert LF	M-L	212
Mid North Coast	Namb - 01	Nambucca	South Creek	Jasper Creek Road	-30.6882000	152.7171000	3	Pipe Culvert	HL, WD	Maintenance	L	248
Mid North Coast	Namb - 02	Nambucca	Jasper Creek	Jasper Creek Road	-30.6882000	152.7108000	3	Causeway	LF	Box Culvert LF	L	291
Mid North Coast	Namb - 06	Nambucca	Unnamed watercourse	East Street	-30.7093000	152.9520000	3	Pipe Culvert	V	Maintenance	L	291
Mid North Coast	Tare - 02	Hastings	Starrs Creek	Burrawang Road	-31.7001300	152.5590500	2	Causeway	HL, LF	Bridge	H	41
Mid North Coast	Tare - 01	Hastings	Gylers Creek	Tallowood Lane	-31.7167800	152.5684100	3	Pipe Culvert	HL, LF	Box Culvert LF	M-L	212

HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris

Subregion	Crossing ID	Catchment	Watercourse	Road Name	Latititude	Longitude	Stream Class	Structure Type	Barrier Type	Remediation	Ranking	Priority Rank
Mid North Coast	Ural - 11	Macleay	Saumarez Creek	Elliot Road	-30.6518000	151.6552000	2	Causeway	HL, LF	Box Culvert LF	M-L	212
Mid North Coast	Ural - 01	Macleay	Salisbury Waters	Terrible Vale Road	-30.7878000	151.4921000	3	Causeway	HL, LF	Box Culvert LF	L	392
Mid North Coast	Ural - 04	Macleay	Unnamed watercourse	The Gap Road	-30.6887000	151.5305000	3	Causeway	HL	Box Culvert LF	L	392
Mid North Coast	Ural - 05	Macleay	Salisbury Waters	The Gap Road	-30.7047000	151.5439000	3	Causeway	HL, LF	Box Culvert LF	L	392
Mid North Coast	Ural - 08	Macleay	Mihi Creek	Linfield Road	-30.7181000	151.6722000	3	Box Culvert	HL, V	Box Culvert LF	L	433
Mid North Coast	Ural - 02	Macleay	Mihi Creek	Hillview Drive	-30.7722000	151.6413000	3	Box Culvert	HL	Box Culvert LF	L	450
Mid North Coast	Ural - 10	Macleay	Grose Creek	Enmore Road	-30.7201000	151.7225000	3	Box Culvert	S, LF	Box Culvert LF	L	450
Mid North Coast	Ural - 06	Macleay	Cook Station Creek	The Gap Road	-30.7361000	151.5512000	3	Pipe Culvert	V	Box Culvert LF	L	472
Mid North Coast	Walc - 12	Macleay	Yarrowitch River	Off Oaklands Road	-31.2080467	151.9859200	2	Pipe Culvert	HL, V, LF	Box Culvert LF	H	47
Mid North Coast	Walc - 08	Macleay	Stony Creek	Nine Mile Church Road	-31.1212183	151.7144450	2	Pipe Culvert	HL	Box Culvert LF	M-L	212
Mid North Coast	Walc - 09	Macleay	Maineys Creek	Off Oxley Highway	-31.0107017	151.6714683	2	Ford	V	Remove	L	291
Mid North Coast	Walc - 13	Macleay	Razorback Creek	Mooraback Road	-31.1759900	152.1325467	3	Pipe Culvert	LF	Box Culvert LF	L	352
Mid North Coast	Walc - 11	Macleay	Bullock Creek	Off Oxley Highway	-31.1203183	151.8385983	3	Causeway	HL, LF	Box Culvert LF	L	363
Mid North Coast	Walc - 04	Macleay	Scrubby Creek	Hazeldene Road	-30.8459000	151.7270000	3	Pipe Culvert	HL, V	Box Culvert LF	L	392
Mid North Coast	Walc - 07	Macleay	Draytons Creek	Blue Mountain Road	-30.8562000	151.6932000	4	Pipe Culvert	HL, V	Box Culvert LF	L	433
Mid North Coast	Walc - 10	Macleay	Tiara Creek	Private Road	-31.0867617	151.8241133	3	Ford	HL, LF	Remove	L	450
Mid North Coast	Walc - 05	Macleay	Draytons Creek	Hazeldene Road	-30.8464000	151.7136000	3	Pipe Culvert	V	Box Culvert LF	L	486
Mid North Coast	Walc - 06	Macleay	Unnamed watercourse	Hazeldene Road	-30.8526000	151.6966000	4	Pipe Culvert	V	Box Culvert LF	L	504
Mid North Coast	Walc - 02	Macleay	Emu Creek	Blue Mountain Road	-30.8952000	151.6880000	4	Causeway	HL	Box Culvert LF	L	512
HL = Headloss; V = Velocity; LF = Low Flow Depth; WD = Woody Debris												


aquatic habitat rehabilitation
making more fish
...naturally