Federation Bridge Debris Control - Draft

Stage 1 – Options Assessment

27th APRIL 2023

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Acronyms and Abbreviations

Acronym	Definition
AHIMS	Aboriginal Heritage Information Management System
BSC	Byron Shire Council
EPA	NSW Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act
FRMP	Flood Risk Management Plan
FRMP	Flood Risk Management Study
HAT	Highest Astronomical Tide
LEP	Local Environment Plan
MCA	Multi-criteria Analysis
RMS	Road and Maritime Services, Transport for NSW
TEC	Threatened Ecological Community
TfNSW	Transport for New South Wales

Executive Summary

Byron Shire Council (BSC) has commissioned Arcadis to undertake an assessment of possible control measures (structural or otherwise) to resolve the issues associated with accumulation of debris under Federation Bridge. This report is the first Stage (1) of several and provides the options assessment and recommended option to then be carried forward into design and implementation (Stages 2 and 3).

Federation Bridge is a multi-span bridge on Murwillumbah Road that crosses Brunswick River in Mullumbimby, NSW and connects the eastern and western sides of Mullumbimby township and Billinudgel township to the north.

The requirement for debris controls measures for Federation Bridge to be investigated, were based on one of the recommended outcomes given in the North Byron Floodplain Risk Management Plan (FRMP) (WMA, 2020a). Due to the substantial community support for debris control measures, implementing debris control measures for Federation Bridge and Billinudgel Railway Bridge was adopted as a high priority in the North Byron FRMP.

The purpose of this document is to undertake the options assessment, via a Multi-Criteria Analysis (MCA) process to determine the most viable debris control measure(s) available in order to minimise the debris accumulation under Federation Bridge, and to reduce the impact of debris especially during flood events.

Key Constraints Guiding Analysis

Federation Bridge

- Federation Bridge is situated on a slight bend of Brunswick River and is skewed; river flows are not directly parallel to the river. Structural options will need to take this into account and may impact the effectiveness of the option.
- Federation Bridge is located on Mullumbimby Road is a key road, connecting the Mullumbimby Township to Billinudgel.

Heritage

- Federation Bridge is in the heritage schedule (European) of the Council's Local Environment Plan (BSC, 2014).

Community amenity

- The navigability of Brunswick River particularly important amenity as many paddle or boat along its length.
- Palm Park and Heritage Park located in the eastern foreshore and a boat ramp is located just downstream of Federation Bridge.

Environment

- The study area has several environmental constraints. Brunswick River is classified as a Key Fish Habitat and is a wildlife corridor. On the foreshore, there are pockets of High Value Vegetation and EPBC Threatened Ecological Communities. Additionally, Koala Habitats and Flying Fox Camps are located just upstream of Federation Bridge.

Assets and Infrastructure

- A water main is located on the upstream side of Federation Bridge, extending along the span of the bridge.

Authority Stakeholders

- Brunswick River is Crown Waterway; any work needs be approved RMS Waterway Operations and any impacts to the Environment approved by the EPA. Additionally, the foreshore includes private land holders, and BSC owned and managed Crown Lands.
- Federation Bridge itself is a TfNSW owned and operated asset.

Sources of debris

East bank upstream of Federation Bridge is a popular site for illegal camping, which has been a source of anthropogenic debris. Further upstream in Azlea Street and Riverside Drive is also a problem area for illegal dumping.

However, the bulk of the debris accumulated by Federation Bridge is observed as woody debris. Confirmed by an Arcadis site visit and by the BSC Bush Regeneration team, who noted that the majority of woody debris in the river were dead Camphor Laurels, which have accumulated significantly in the river due to being poisoned on the riverbank as an uncontrolled and unauthorised means for removal.

Options Assessment

The options were developed through extensive consultation with BSC teams and external stakeholders and solutions which have been implemented globally. A holistic approach to the options identification was developed looking at onsite structural, source control (embankment and instream), community and regeneration involvement. Initially a Long List was developed for all possible options, which was then shortened based on feedback on constraints from internal and external project stakeholders. The Short List included five possible options and a Business as Usual (do nothing) solution, and are given below:

Short List of Options
Option 1 Structural: Debris fins
Downstream and/or upstream triangular structure to direct debris away from the Bridge, attached vertically at bridge piers. Debris fins allow debris to continue traveling in the flow in a directed manner by enabling realignment of debris. For Federation Bridge, this will reduce blockage as the piers are skewed to the upstream flows. Some debris removal is required to ensure fins are clear.
Option 2 Structural: Debris sweeper
Vertically aligned polyurethane cylinders which rotate freely. Sweepers are attached to the piers where debris accumulates upstream and downstream side of a structure to direct debris downstream. Periodic debris removal is required to ensure the debris sweeper is clear and free to rotate.
Option 3 Camphor Laurel management and bush regeneration
This option targets the removal of Camphor Laurel, much of which have been poisoned and are dead on the foreshore, contributing to significant to woody debris entering Brunswick River. After the initial effort of Camphor Laurel removal, ongoing bush regeneration activities can address long term erosion control to further minimise debris. This is supplemented by community awareness and Landcare engagement for safer and effective methods of Camphor Laurel Management. Additionally, manual debris removal at Federation Bridge is expected on a as-needed basis, however, it is anticipated the need will become less frequent as the foreshore is regenerated.
Option 4 Targeted Flood Event Management
This option aims to minimise the accumulation of debris at Federation Bridge by removing man made and woody debris on foreshores before a forecasted flood event or rainy season at Federation Bridge. Additionally, prompt post flood event debris removal ensures debris does not enter the river during a subsequent flood event.
Option 5 Periodic Removal and habitat creation
This option removes debris on mainly on the foreshore (anthropogenic and woody debris) on a scheduled basis. The woody debris is redistributed for the benefit of in-river habitat creation or erosion control.
Option 0 Business as Usual - do nothing

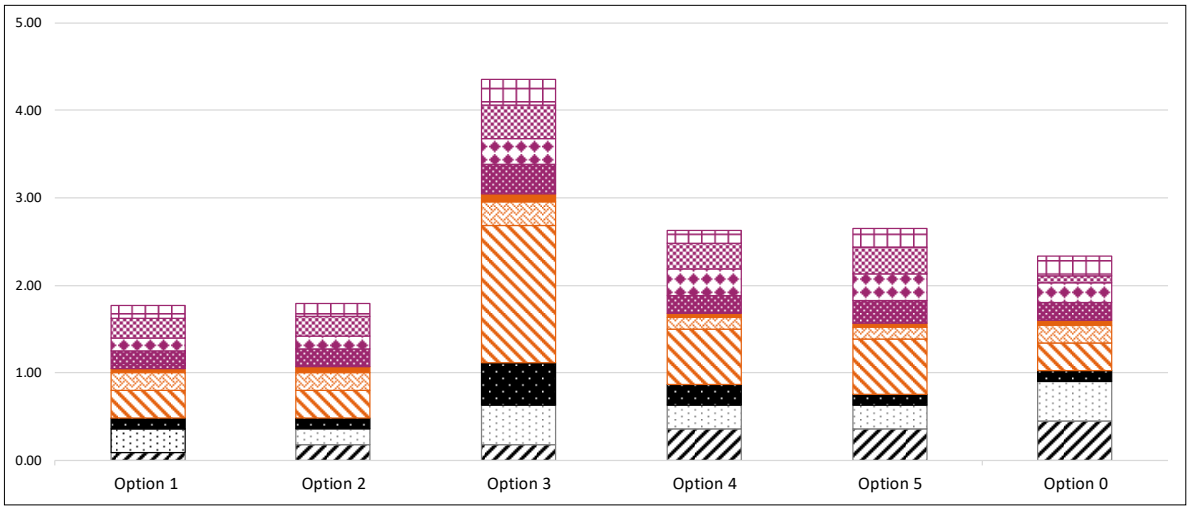
Short List of Options
Operational maintenance of Brunswick River is managed by Road and Maritime Services to maintain navigability. Council has no existing debris process as it is not under Council jurisdiction. Any debris removal on the foreshores is not captured as a flood mitigation benefit.

The above options were seen as most viable for the site and most likely to succeed, and incorporates different approaches for controlling debris including structural, source control and ongoing maintenance.

An MCA was then applied to the defined Short List, with the following criteria and objectives:

1. Financially Responsible: economic feasibility of the option
2. Right Infrastructure and People: effectiveness, safety, complexity and environmental constraints
3. Satisfied Customers and Stakeholders: community and authority stakeholder satisfaction of the solution.

The outcomes of the MCA are outlined in the graph below.



	Structural: Debris fins	Structural: Debris sweeper	Camphor Laurel management and bush regeneration	Targeted Flood Event Management	Periodic Removal at foreshores and habitat creation	Business as Usual - Do Nothing
Rank	6	5	1	3	2	4
Score	1.83	1.86	4.47	2.73	2.755	2.38
% Score	37%	37%	89%	55%	55%	48%

Satisfied Customers and Stakeholders

- Authority stakeholders, licenses and approvals
- Community amenity, disturbance, perception and acceptance
- Heritage including aboriginal relics & sacred sites, European heritage, approvals
- Environmental impacts

Right Infrastructure and People

- Construction and commissioning complexity
- Health and Safety during construction, commissioning and operation
- Efficacy, Operations and Maintenance

Financially Responsible

- Funding Potential
- Operational costing (30 year scenario)
- Capital Costs

Recommendations

Based on the MCA outcome, *Option 3 Camphor Laurel Management and Bush Regeneration* has scored the highest out of the five options and the Business as Usual. Although this option has a high initial cost outlay, the likelihood of securing funding is high. Additionally, this solution scored the highest out all solutions for its effectiveness – addressing the woody debris at the source, preventing debris loads entering Brunswick River. Other management options, *Options 4 Targeted Flood Events* and *Option 5 Period Debris Removal* scored just above the Business as Usual. These options, although contributing to wider environmental benefits, are

somewhat reactive solutions. However, elements of *Option 4* and *5* are valid and could be undertaken in conjunction with preferred *Option 3.*

Structural *Options 1* and *2* scored the lowest, due to the high capital and ongoing maintenance costs in order to ensure the effectiveness of these solutions. If not maintained, these controls could exacerbate the debris accumulation.

Recommendations

Due to the deviation from the initial options of a structural debris control option, the outcomes need to be presented to the BSC Flood Committee and approved. Next steps are to explore potential fundings options and develop a business case, which outline flood mitigation benefits as well as wider environmental and community benefits.

1 Introduction

Byron Shire Council has commissioned Arcadis to undertake an assessment of possible control measures (structural or otherwise) to resolve the issues associated with accumulation of debris under Federation Bridge. This report is the first Stage (1) of several and provides the options assessment and recommended option to then be carried forward into design and implementation (Stages 2 and 3).

1.1 Project Context and Background

One of the responses to the recent flooding of the northern rivers region in NSW in the last 5 years was the development of the BSC Flood Committee and the North Byron Floodplain Risk Management Plan (FRMP) (WMA 2020) with BSC being the key stakeholders of the Plan. Now completed, BSC is in the process of implementing the recommended actions.

One key action, the purpose of this project, included the requirement for development of Debris control measures for Federation Bridge (and Billinudgel Railway Bridge[1], not included in this assessment). The recommendation was:

- Flood Modification Measures – FDC - Implement debris control measures for Federation Bridge and Billinudgel Railway Bridge

A community consultation process during the preparation of the FRMP indicated that the community considers the removal of blockages and debris from streams and rivers to be one of the most important factors for managing flood risk in the catchment. There were a considerable number of anecdotal comments from community members about soil and debris causing blockages at structures and increasing flooding impacts to nearby residences. This was of particular concern to residents in Mullumbimby who have observed debris accumulated on Federation Bridge and the Billinudgel Railway Bridge namely during the 2017 floods (and the more recent 2022 floods) which affected the east coast of Australia.

The build-up of the debris has minimal effect on afflux and as part of the flood model assessment in the North Byron Flood Risk Management Study and Draft plan (WMA, 2020). Flood modelling shows that with a 25% blockage factor there a minimal increase in flood levels. However, it has been observed and reported by residents that as the debris load increases a dam effect is created, that when it fails (due to upstream hydrostatic pressure), a wave generates and propagates downstream, worsening the impacts of flooding on the foreshores of the Brunswick River downstream of Federation Bridge.

Due to the substantial community support for debris control measures, implementing debris control measures for Federation Bridge and Billinudgel Railway Bridge was adopted as a high priority in the North Byron FRMP.

1.2 Purpose of this Document

The purpose of this document is to carry out the recommended action from the FRMP surrounding debris management by undertaking an options assessment to determine the most viable debris control measures in order to minimise accumulation at Federation Bridge, and to reduce the impact of debris especially during flood events.

This document outlines the following steps in Stage 1 of this project which includes:

[1] It is noted any structural control measure implemented for the Federation Bridge site will not impact the Billinudgel Bridge, however any source control measure will enable debris reduction for both sites.

- **Long List**: Generation of a Long List of options including discrete structural, source control and maintenance options.
- **Liaise with Key stakeholders:** To understand key constraints of implementing controls and managing debris at the Federation Bridge.
- **Short List**: A Go / No Go assessment was applied to this Long List; some options were not carried on for further assessment due to expense or technical infeasibility specific to Federation Bridge.
- **Multi Criteria Analysis:** The options marked for further assessment were combined into a Short List of control options to which an MCA was then applied to provide a preferred outcome.
- **Preferred outcome:** A preferred outcomes is then provided within this document along with recommendations for the implementation of Stage 2.

1.3 Data and key documents

Data and background information for this options assessment was gathered from various sources including previous studies, site visit, interview with various stakeholders and BSC held data.

Source	
Previous Studies	• North Byron Floodplain Risk Management Plan (WMA, 2020a) • North Byron Floodplain Risk Management Study and Draft Plan (WMA, 2020b) • Coastal Zone Management Plan for the Brunswick estuary (BSC, 2018) • B2585 Federation Bridge – Condition Assessment Report (SMEC, 2019)

Stakeholders Engagement	Additional information was gathered via discussions from internal BSC teams and external stakeholders including:
	• NSW Environment Protection Authority (EPA) – Flood Programmes
	• Road and Maritime Services (RMS) – Waterway Operations
	• Transport for New South Wales (TfNSW) – Northern Asset Management Bridges
	• Byron Shire Council
	  ○ Flooding and Drainage
	  ○ Bush Regeneration
	  ○ Biodiversity and Coastal Management
	  ○ Waste Management

GIS Layers	• Environmental Constraints • BSC Asset Layers Arcadis generated layers from data collation: • Potential Camphor Laurel management areas • 2022 EPA Brunswick River Clean-Up
Online map	Byron Shire Council online mapping tool
Site Visit	Arcadis site visit - 22nd February 2023
Desktop Study	Supporting Literature

2 Site Definition

2.1 Site Description

Federation Bridge is a multi-span bridge on Murwillumbah Road that crosses Brunswick River in Mullumbimby, NSW. It connects the eastern and western sides of Mullumbimby township and Billinudgel township to the north. The Study Area also includes Brunswick River and the foreshores upstream Federation Bridge, given in the below figure.

Figure 2.1 Study Area Federation Bridge and Brunswick River

2.2 Structural Condition of Federation Bridge

The bridge is a 7-span reinforced concrete bridge and constructed circa 1930 and is comprised of cast in-situ, reinforced concrete piles pile caps, pier columns, beams, headstocks and deck (SMEC 2019).

TfNSW commissioned SMEC to undertake a condition assessment in 2019. With the bridge assessed to be in a 'fair' condition; some patch repairs had been undertaken in the past with localised cracking observed. At the time of the 2019 report, some repairs to the decking had also been recently undertaken. Further diagnostic testing revealed that that chloride induced corrosion has initiated in the pile caps and pier columns, greater than the accepted threshold level for this corrosion process. It is understood that maintenance of Federation Bridge is expected to be undertaken in the coming funding year.

Additionally, during consultation with asset owners, TfNSW Bridge Maintenance, for this study, it was stated that the observed debris is likely have little impact on the structural integrity on Federation Bridge, and the debris issue was not a concern to the design life of the bridge from their perspective.

2.3 Federation Bridge Site Debris

In developing the most effective debris control factors, it is crucial to understand the key factors which lead to debris accumulation under Federation Bridge.

Three key factors contribute to debris potential at are site are (Barthelmess and Rigby 2009)

1. Debris availability (source of debris),
2. Debris mobility (size, type and characteristics), and
3. Debris transportability (pathways).

Debris is usually transported in the thalweg (deepest points through the cross section) of a river, as seen in **Figure 2.1.1**; debris tends to be transported on the outer bends of a meandering river, as with the Brunswick River, with debris deposition and accumulation in these locations.

Figure 2.1.1 Generalised plan view of the path of floating debris in a meandering river

Debris accumulation at Federation Bridge has been observed in the middle two piers, which is also the thalweg, providing some impact to the navigability of the river. The accumulation increases in size, with a curved upstream edge as more floating debris (drift) is transported via the thalweg. The accumulation is typically as deep as the trapped pier, the scour protection of the bridge piers also contributes to snagging debris. Larger woody debris act also acts as a filter by trapping smaller floating debris and possibly sediment. Typically, the size and location of a jam depends on the size of the stream and the size of the trees. (Diehl, 1997). However, it has been observed that the effective span of Federation Bridge is wider than the observed floating debris.

Observed debris accumulation is primarily woody debris, however, investigation into whether or not other anthropogenic debris has contributed to debris loads, was carried out via a site visit, consultation with BSC Coastal, Bush and Waste management teams as well as the EPA. Outcomes are given below:

BSC Coastal Management and Bush Regeneration Teams have indicated that the foreshore is home to large volumes of potential woody debris. And the debris is typically lighter dead hardwood such as Camphor Laurel which would be prone to float and be transported down Brunswick River. This was also observed during a site visit by the Arcadis team in February 2023 (Section 2.2).

2.4 Site Visit 22nd February 2023

A site visit was conducted on the Brunswick River within the estuarine section, around Mullumbimby approximately 400m upstream and downstream of the Federation Bridge. The purpose of this visit was to inspect the foreshores in the study area, to ascertain source and type of the debris load. The Figure below provides a locality of the site visit.

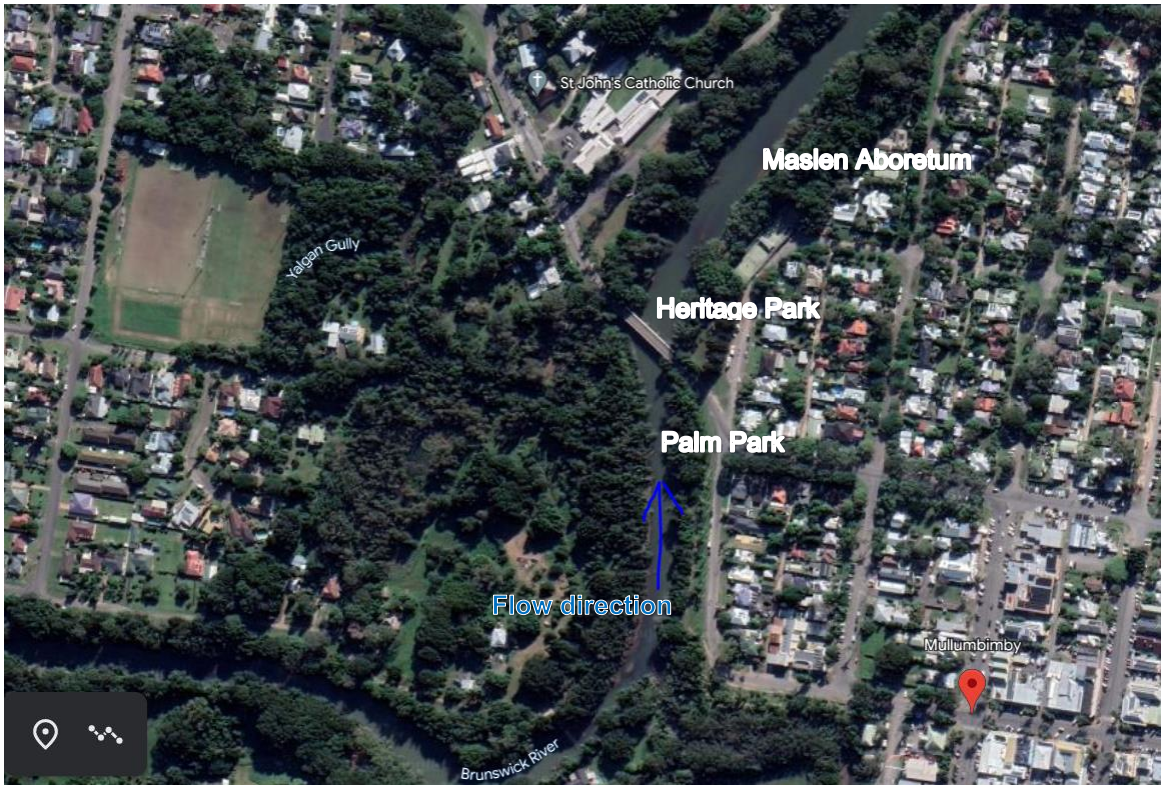


Figure 2.4.1 Site Visit – Observed Locations

Federation Bridge

Federation Bridge is situated on a slight bend of Brunswick River and is skewed. It was observed that the bridge piers are not aligned directly parallel to the flow of the river, resulting in a higher chance of snagging or accumulation of debris.

Upstream of Federation Bridge

The eastern side of the Brunswick River (Palm Park) holds significant forest and vegetation with access down to the edge of the river. This area, approximately 400m, from the bridge to the next bend of the river is maintained by BSC and is free from woody debris except for numerous fallen palm fronds, **Figure 2.2.1**, which may contribute to river debris. Reasonable access to the river and from the road indicates it can be (and is) well maintained, therefore limits debris from this area.

The western side of the rivers upstream of the bridge hold several short gullies and tributaries which are heavily forested with no or limited access. Significant debris and dead wood (including numerous dead, still standing Camphor Laurels) were sighted in the river or on the banks (**Figure 2.2.3**). It is noted that landholders in this area is a mix of private, crown and council.

Downstream of Federation Bridge

The eastern side of the river (Heritage Park) holds significant forest and vegetation with access down to the edge of the river. This area, approximately 400m from the bridge to the next bend of the river is maintained by

BSC and is reasonably free from wooded debris. Reasonable access to the river and from the road indicates it can be (and is) well maintained. It is noted there is an arboretum here managed by a local community group, Landcare, which indicates effective management with limited wooded debris sighted.

The western side of the river holds significant flood storage with several layers or “steps” leading to the river bank, allowing for significant forest growth below the bridge level but above the Highest Astronomical Tide (HAT). This would allow for significant debris accumulation during dry times, then release during high water levels of the river. Large woody debris, mainly trees, where sighted falling into the river on this side.

Figure 2.2.1 Palm Fronds at Palm Park

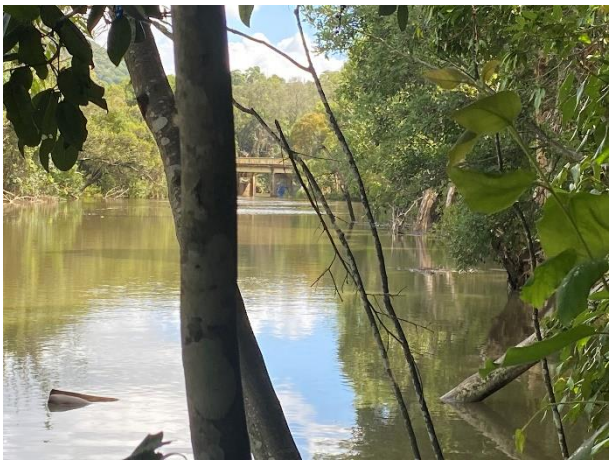


Figure 2.2.2 Palm Park looking downstream to Federation Bridge

Figure 2.2.3 Palm Park looking across Brunswick River at west banks

Figure 2.2.4 Downstream of Federation Bridge on the eastern side of Brunswick River looking at the western bank

Observed Debris Types and Pathways

Debris was mostly woody debris from coming from small branches to large trees. There was limited to no anthropogenic debris from littering indicating recent clean-up, or community awareness and effective Council management.

There was significant wooded debris littered within the floodplain storage area of the banks, which is above the HAT but below the bridge. It is suspected this large volume of woody debris is the result of the 2022

February / March flood events. This indicates that during river flooding from the upstream catchment, where the river level will be elevated, this debris will be mobilised into the river flow impacting the bridge.

As Federation Bridge is situated on a bend in the river, these gullies tend to accumulate debris which then drifts in and around the bridge with the changing tides. Some areas of the bank look to be subject to scour, which also increases the chance of becoming a collection point for debris. It was also noted that the Camphor Laurels along the river bank have shallow roots and are not effectively holding the bank together.

2.5 Debris and Flood Events

The observed debris accumulating under Federation Bridge is predominantly woody debris reported by the local community. **Figure 2.5.1** shows picture supplied by local community member which is typical of what is observed.

Figure 2.5.1 Debris Accumulation under Federation Bridge (Local Community Member, 2022)

Figure 2.5.2 Debris Accumulation under Federation Bridge during 2022 Flood Event (Local Community Member, 2022)

2.5.1 2022 EPA debris removal

After the 2022 east coast flood, in particular the Northern Rivers the region of NSW, the EPA conducted a debris removal operation on 22nd – 26th August 2022. Only large anthropogenic debris was targeted.

Figure 2.5.3 2022 debris collection data (EPA, 2022) (Debris type categorisations include overlaps in types; the largest items have been listed first in the description)

Figure 2.5.3 shows approximate locations of debris collected and cleared from the Study Area, also showing type and volume of the debris collected. As expected, larger debris items have been predominately on the outer bends of Brunswick River. Larger items were predominately building material and chemical drums. Smaller items were mainly small and hard plastic.

As seen in the Figure, much of the debris collected in the direct vicinity of Federation Bridge is located upstream and predominately soft and hard plastic. It is suspected the source is this debris has been transported down and snagged in woody debris but also generated from illegal camping on the eastern bank at and upstream of Federation Bridge.

The above findings indicates that the existing wooded debris would be joined by anthropogenic debris during a large flood, where inundation occurs beyond the normal flood plain storages and river's banks.

2.6 Local context

A desktop study along with the site visit was carried out to understand the local context of the study area in order to inform the constraints of debris control options.

2.6.1 Community Amenity

Federation Bridge and the Brunswick River is enjoyed by the community with Palm Park and Heritage Park located in the eastern foreshore and a boat ramp just downstream of Federation Bridge. It is understood that

the location is also popular for fishing and Brunswick River's navigability is a particularly important amenity as it a popular location to paddle or boat (PCFML, 2022).

Federation Bridge and Mullumbimby Road, are key transport assets, connecting Mullumbimby Township to Billinudgel. Any closures would require road users to greatly increase their travel time, requiring a circumnavigation of the town to cross.

The east bank upstream of Federation Bridge is also a popular site for illegal camping, which has been a source of anthropogenic debris, including plastic litter. However, in recent years, illegal camping has been controlled with signage as well as regular enforcement officers patrolling the area (BSC, 2023).

2.6.2 Environment

Vegetation Communities and Habitats

The study area is also of high environmental value (**Figure 2.6.1**), with the Brunswick River is classified as a Key Fish Habitat, as per the DPI's Fisheries Spatial Data Portal (DPI, 2023). Additionally, the foreshores are home to high environmental value vegetation communities, and threatened ecological communities (as per the EPA). Examples of fauna includes, flying fox camps located on the foreshores directly upstream of Federation Bridge, and koala habitats within approximately 500 metres.

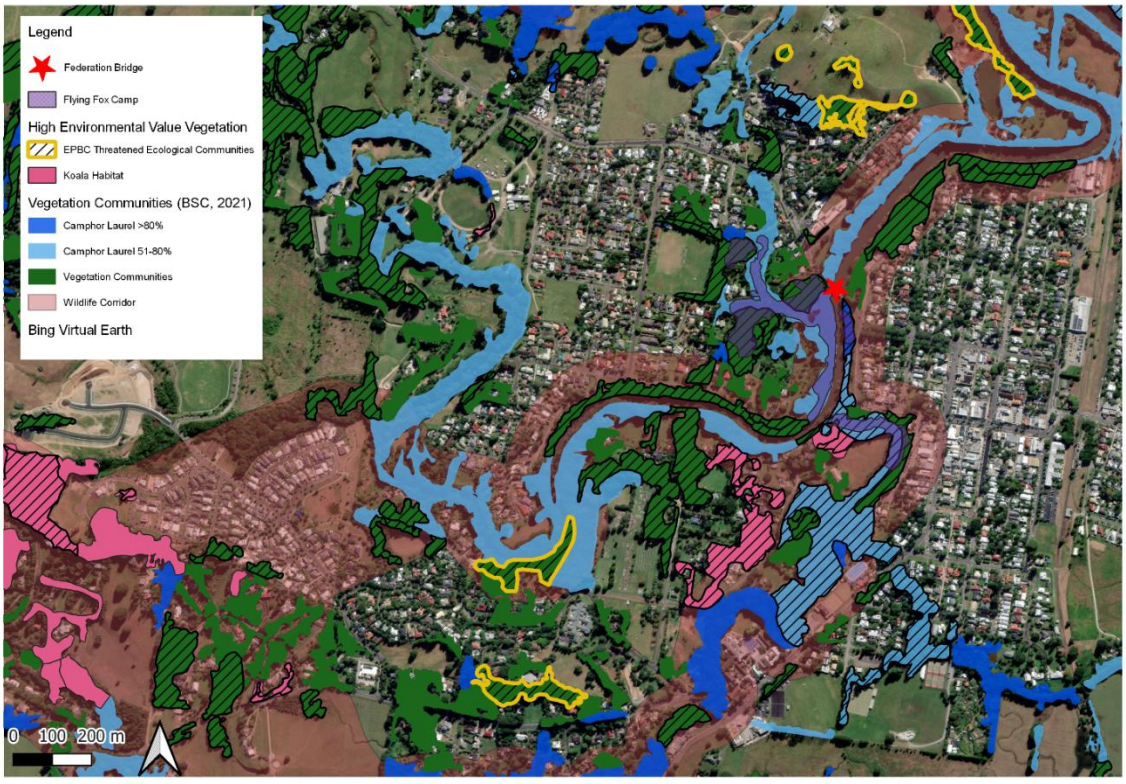


Figure 2.6.1 Federation Bridge and Brunswick River Environmental Constraints (BSC, 2021)

Extensive invasive flora species have been identified with Camphor Laurel dominating much of the foreshore as seen in **Figure 2.6.1**. There is also significant erosion along the banks Brunswick River and Mullumbimby Creek (BSC, 2018), where Camphor Laurel is causing undercutting due to their shallow root system (DPI, 2023), seen in **Figure 2.6.2.**

Figure 2.6.2 Camphor Laurel undercutting banks on Brunswick River in the Study Area

Recent ground truthing (work undertaken separate to this study) show a number of dead Camphor Laurel adult trees on the foreshore of Brunswick River, either already entering or on the verge of entering Brunswick River, contributing to the debris loads (**Figure 2.6.3**, approximately 2.5km upstream of Federation Bridge). It is suspected that poisoning Camphor Laurel has been undertaken as an effort to remove Camphor Laurel. Additionally, the Figure also demonstrates other invasive species such as bamboo entering Brunswick River.

Figure 2.6.3 Dead Camphor Laurel and bamboo logs in Brunswick River (ground truthed by BSC 2023)

Key Fish Habitat

Removing large native woody debris from waterways is listed as a key threatening process under the *Fisheries Management Act*. Details of which are outlined in DPI's Threat Abatement Plan (DPI, 2007). Other relevant statutes include the Rivers and Foreshores Improvement Act 1948, Water Act 2000, Roads Act 1993 or the Fisheries Management Act 1994.

Removing woody debris in waterways falls under the NSW Native Vegetation Act 2003 which outlines the controls of clearing or removal of dead and exotic vegetation from prescribed streams such as Brunswick River due to the waterway being a Key Fish habitat. Through BSC's existing work in Bush Management, it understood that they have sought clarity in regard to removing Camphor Laurel debris in Brunswick River and consent has been provided, noting the species is non-native and invasive. Additionally, emergency approval can also be granted in situations such as during an actual or imminent flood event.

Illegal Dumping

Illegal dumping regularly occurs upstream of Federation Bridge, contributing to anthropogenic debris loads. Two problem areas have been identified as Riverside Drive and Azelea Street. An example of accumulated debris, which has the potential to reach Federation Bridge can be seen in **Figure 2.6.4**. This is currently being managed by BSC through signage and fine enforcement.

Figure 2.6.4 Illegal Dumping on Azalea Street (BSC, January 2023)

2.6.3 Cultural Heritage

Federation Bridge is in the heritage schedule (European) of the Council's LEP (BSC, 2014), however is not a listed item on any other heritage schedules.

A search for the study area was done in the Aboriginal Heritage Information Management System (AHIMS) and returned no sites or places **(Appendix B**). It is noted that this is not a comprehensive search, and any further works which are done in the study area may require a more detailed heritage study

2.6.4 Byron Shire Council Managed Utilities and Areas

Council Assets and managed areas surround the bridge and include:

- Critical council services (water main) are located on the upstream side of Federation Bridge, extending along the span of the Bridge.
- Footpaths and cycleways are also located on the eastern foreshore of Brunswick River in Palm Park.
- Palm Park is Council managed open space.
- Although not Council's operational responsibly, Federation Bridge also includes a footpath and cycleway.

Figure 2.6.5 shows Council managed utilities and areas

2.6.5 Foreshore management and key stakeholders

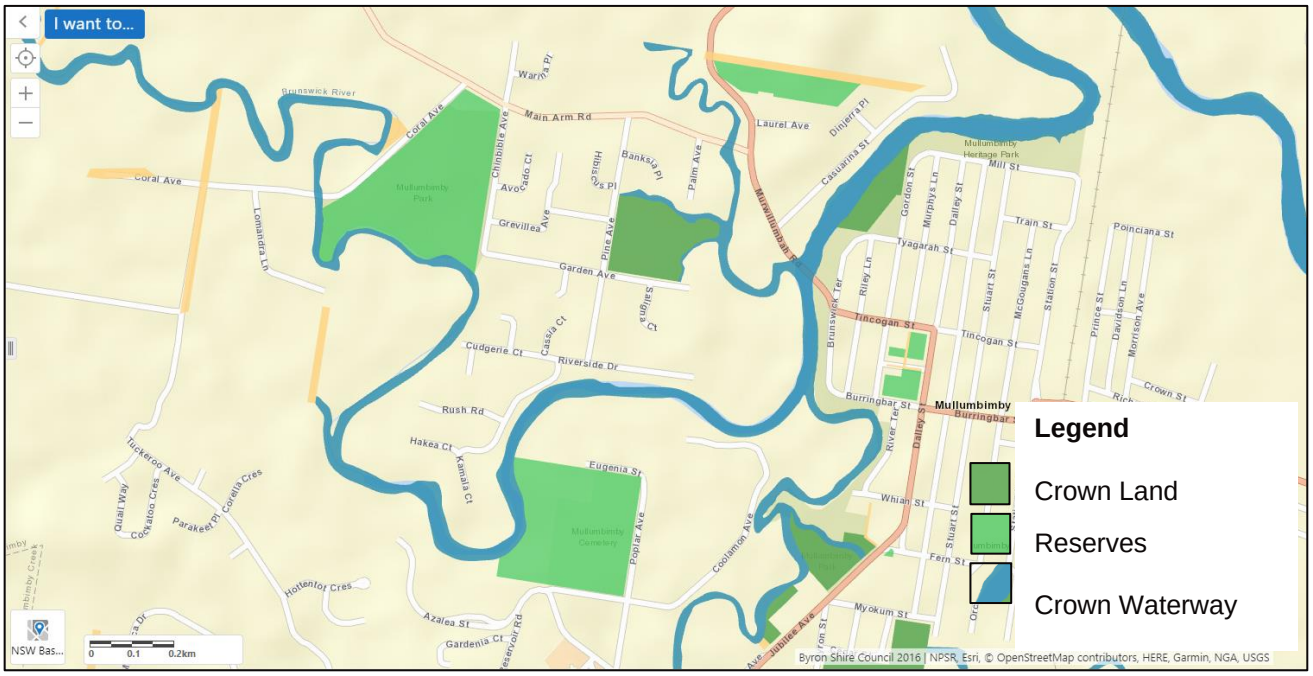


Figure 2.6.6 Authority Stakeholders of Study Area

The Study Area has a number of authority stakeholders as seen in **Figure 2.6.6**.

Brunswick River and Foreshore

Brunswick River is a Crown waterway, with any clearing of debris approved by RMS Waterway Operations and a navigational assessment undertaken prior. A marine notice advising the general public of the works would be issued and the works would need to be done under certain conditions as required by RMS e.g. buoys, management of the channel.

EPA is responsible for the health for the waterway. Any works in Brunswick River and banks will also require consent and approval by EPA.

Foreshore areas managed by Council are either owned by the Crown or Council, with some areas and bank locations accessible via private land only, with permission from private land holders required prior to access or source control works being carried out.

Federation Bridge

Federation Bridge is a TfNSW owned and operated asset. Any works on Federation Bridge will require consent from TfNSW. Additionally, ongoing management of any additional structural works would likely fall to TfNSW's remit.

3 Options Long List Assessment

3.1 Options Long List

A Long List of options was generated capturing a comprehensive list of possible debris control options which have been applied to bridges globally as well as specific to the Federation Bridge. These options were developed in conjunction with BSC Flood, Coastal Management and Biodiversity and Bush Regeneration Teams, and includes controls specific the study area,

This stage of option development is to ensure that all options are considered with go / no go assessment applied (outlined in Section 3.2.2). The 22 options generated are discrete interventions which address debris accumulation at Federation Bridge via intervention at different stages of debris pathways.

The Long List of options can be viewed in **Table 3.4**. This matrix shows the characteristics of each option including:

- Location,
- If the option is effective during a flood event,
- Size of debris addressed, and
- Debris pathway's point of interception.

The Long List of options were categorised into Debris Control Options as per in **Table 3.1**.

Table 3.1 Debris Control Options

Debris Control Options Types	Control No. Prefix	Description
Structural Solutions	S.x	A physical structure to either deflect or collect the debris in Brunswick River.

River Bathymetry	D.x	Adjustment of river bathymetry to reduce debris accumulation in and around bridge
Source Control	SC.x	Minimise the volume of debris entering Brunswick River.
Community Engagement	C.x	Community awareness and engagement activities.
Manual Removal	M.x	Removal of debris as it accumulates at Federation Bridge.
Do Nothing	DN	No further intervention or investment for debris controls.

Debris control options have been further categorised into sub-types to further explain the controls option types. For example, Structural Solutions (S) in **Table 3.2** can be located at different points of the river for different purposes; a debris deflector attached to Federation Bridge allows debris to go downstream whilst another structural control such as a boom collects debris upstream of the bridge.

Table 3.2 Debris Control Type

Debris Control Sub-Type	Description
Upstream Structure	A physical structure located upstream of Federation Bridge
Bridge Amendment Structure	A physical structure attached to Federation Bridge
Bathymetry Adjustment	Change of the riverbed profile of Brunswick River to amend river flow patterns to either collect or encourage debris to flow downstream
Source Control	Minimises the volume of debris loads entering Brunswick River
Maintenance	Vegetation and litter maintenance upstream of Federation Bridge
Community Engagement	Engagement of community groups and residents to increase awareness of impact of debris
Bank Adjustment	Changes to profiles of Brunswick River banks

Option characteristics also include the point of interception of the debris' pathway including:

- Collected or managed at the source,
- Deflected downstream of Federation Bridge,
- Collected in Brunswick River either upstream or at Federation Bridge.

Table Debris 3.3 Debris Pathway Intervention

Debris Pathway Intervention	Description
Source	Prevents debris to entering Brunswick River by collecting debris on the foreshores.
Deflection	Allows debris to pass downstream of Federation Bridge, potentially allowing debris accumulation at downstream structures.
Collection	Collects debris to allow for removal or re-distribution

Additionally, debris controls are implemented at different locations in the study area. **Figure 3.1.1** shows these locations.

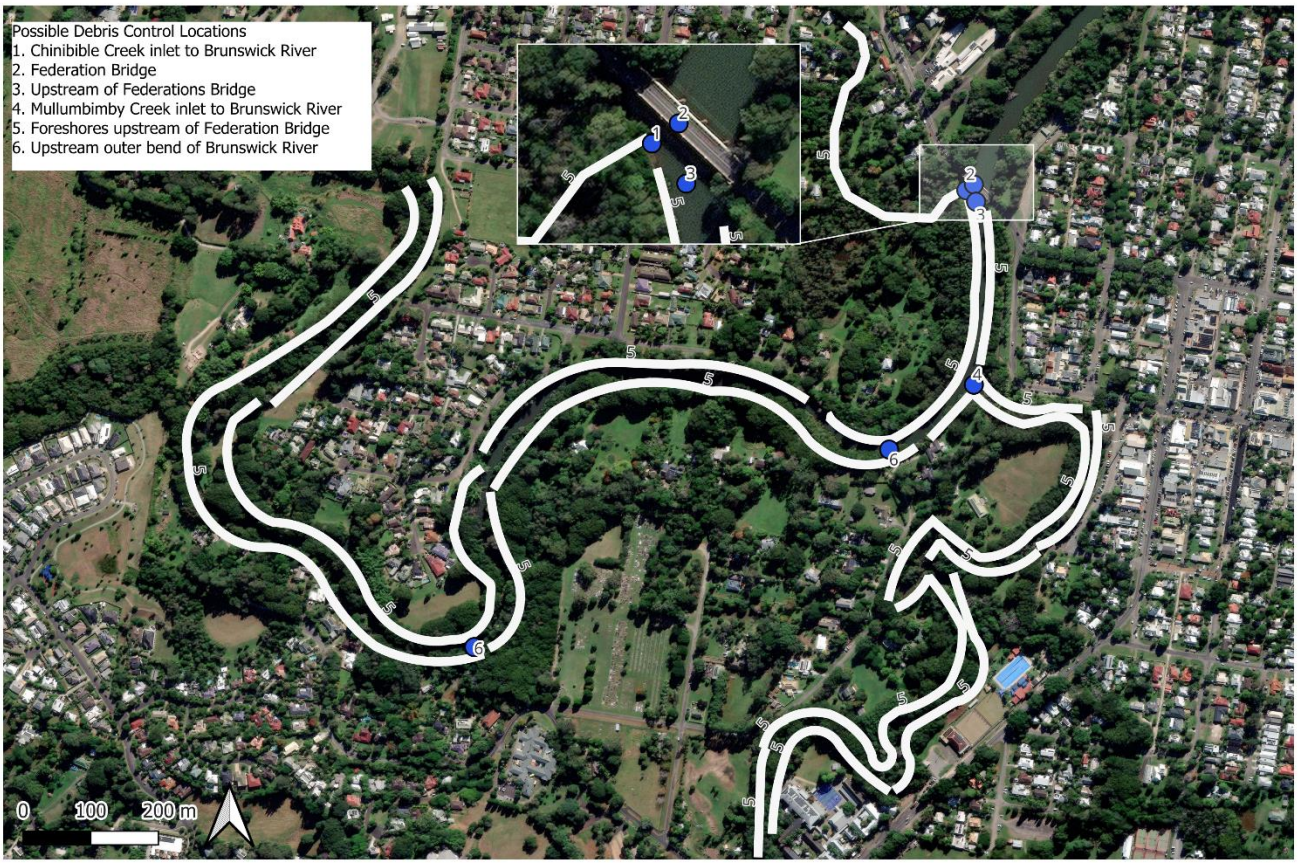


Figure 3.1.1 Possible Debris Control Locations – Options Long List

Table 3.4 Options Long List Characterisation

Control Number	Options - Long List	Description	Solution Location	Designed for Flood Event	Debris Control Type	Debris Size			Debris Pathway Interception		
						Small	Medium	Large	Source	Deflecting	Collection
						Small sticks, leaves, litter	Branches, large sticks	Large branch limbs, logs, whole trees	Preventing debris to entering Brunswick River	Allows debris to pass downstream of bridge	Collects debris to allow for removal or re-distribution
Structural Solutions (Please refer to Appendix A for example images)											
S.1	The Treibholzfange debris-detention device	Consists of circular posts driven into the riverbed upstream of the device usually in a V-formation. Depending on the geometry of the posts, the structure is able to capture or deflect debris. Is able to collect larger debris upstream of bridge if poles are placed closer together.	3		Upstream Structure		✓	✓		✓	✓
S.2	Debris booms	Floating device designed to collect floating surface debris.	1, 3, 4		Upstream Structure	✓	✓				✓
S.3	Debris fins	Downstream and/or upstream triangular structure to direct debris away from the bridge, attached vertically at bridge piers. Debris fins allow debris to continue traveling in the flow in a directed manner by enabling realignment of debris. For Federation Bridge, this will reduce blockage as the piers are skewed to the upstream flows.	2, 3		Upstream Structure		✓	✓		✓	
S.4	River training structures	Attempts to capture debris by adding training walls and/or weirs out form the side of the riverbanks. May run 20% of the way across the river.	3	✓	Upstream Structure / Bathymetry Adjustment	✓	✓	✓			✓
S.5	Debris sweeper	Vertically aligned polyurethane cylinders which rotate freely. Sweepers are attached to the upstream side (and downstream) of a structure and is intended to direct debris downstream.	2	✓	Bridge Amendment Structure		✓	✓		✓	
S.6	Debris deflectors	A V-shaped vertical grids Consist of either wood or metal oriented in a pair of vertical grids that come together in a “V” shape, with the apex pointing upstream. They can either be used to collect debris with grates or used to deflect debris downstream.	3		Bridge Amendment Structure		✓	✓		✓	✓
S.7	Trash racks	Racks and screens on upstream stormwater outlets to collect debris, reducing debris loading on Brunswick River.	1, 4, stormwater culverts		Source Control	✓	✓		✓		✓
S.8	Furling / Net	Furling (net) allows the device to be lifted out of the water in the event that debris is present in the flow, located at Federation Bridge.	2, 3		Bridge Amendment Structure	✓	✓	✓			✓

Control Number	Options - Long List	Description	Solution Location	Designed for Flood Event	Debris Control Type	Debris Size			Debris Pathway Interception		
						Small	Medium	Large	Source	Deflecting	Collection
						Small sticks, leaves, litter	Branches, large sticks	Large branch limbs, logs, whole trees	Preventing debris to entering Brunswick River	Allows debris to pass downstream of bridge	Collects debris to allow for removal or re-distribution
S.9	Debris retaining basin	A bend of a channel, where debris can be collected in flood conditions using their inertia to get them into the basin. Functional only when the water level reaches a threshold level; debris will still be transported below water level threshold.	1, 4, 6	✓	Upstream Structure	✓	✓	✓	✓		✓
S.10	Bridge pier adjustment	Adjustment of existing piers to reduce skew and increase the potential for deflecting debris.	2	✓	Bridge Amendment Structure	✓	✓	✓		✓	
River Bathymetry											
D.1	Dredging	Adjustment of river bathymetry to reduce debris accumulation in and around bridge - pump and redistribute dredge material in other areas (scour).	3		Bathymetry Adjustment	✓	✓	✓		✓	
Source Control											
SC.1	Bush Regeneration	Bush regeneration on the foreshore upstream of Federation Bridge to minimise erosion and in turn, minimise woody debris. Foreshore is part of BSC's Bush Regeneration Programme.	5		Maintenance	✓	✓	✓	✓		✓
SC.2	Litter and illegal dumping minimisation	Minimisation of debris generated from illegal dumping and dumping, and littering via signage, action and reporting.	5		Community Engagement	✓	✓	✓	✓		✓
SC.3	Debris removal on foreshore - emergency removal before flood events	Removal of woody debris, litter and illegally dumped materials before forecasted flood event or rainy season.	5	✓	Maintenance	✓	✓	✓	✓		✓
SC.4	Debris removal on foreshore - after flood event	Removal of debris (SES, EPA, Council etc.) after major flood events of woody and anthropogenic debris, woody material deposited at banks by receding flood waters. Debris removal after flood event prevents debris accumulation in subsequent flood events.	5		Maintenance	✓	✓	✓	✓		✓
SC.5	Debris removal on foreshore - periodic and regular debris removal	Periodic and regular removal of debris on the foreshore upstream of Federation Bridge.	5		Maintenance	✓	✓	✓	✓		✓

Control Number	Options - Long List	Description	Solution Location	Designed for Flood Event	Debris Control Type	Debris Size			Debris Pathway Interception		
						Small	Medium	Large	Source	Deflecting	Collection
						Small sticks, leaves, litter	Branches, large sticks	Large branch limbs, logs, whole trees	Preventing debris to entering Brunswick River	Allows debris to pass downstream of bridge	Collects debris to allow for removal or re-distribution
SC.6	Debris removal - removal of dead Camphor Laurel and other invasive species	Removal invasive species, in particular dead Camphor Laurel, upstream in Brunswick River, Mullumbimby Creek, Chinbible Creek. This includes identified collapsing bamboo approximately 1km upstream of Federation Bridge.	5		Maintenance		✓	✓	✓		✓
SC.7	Redistribution of woody debris for habitat creation and erosion management	Removal of debris and some wooded material. Debris to either be removed or woody material to be re-distributed for bank stabilisation purposes and/or create fish habitats.	5		Bank Adjustment	✓	✓	✓	✓		✓
Community Engagement											
C.1	Landcare engagement	Support Landcare - Brunswick Valley Landcare to in regeneration and river rehabilitation projects along the river and adjacent.	5		Community Engagement		✓	✓	✓		
C.2	Community education of effective of Camphor Laurel management	Community engagement and education on safe and effective methods for Camphor Laurel removal.	Mullumbimby town and open spaces on Brunswick River		Community Engagement	✓	✓	✓	✓		
Manual Removal at Federation Bridge											
M.1	Manual debris removal at Federation Bridge	Regular removal of debris accumulating at Federation Bridge (as opposed to intercepting debris prior to its accumulation at Federation Bridge).	2		Maintenance	✓	✓	✓			✓
Do Nothing											
Do Nothing	Do Nothing - business as usual	Debris is removed when reported by the local community and approvals are applied for on as needed basis or within existing foreshore management programmes. Foreshore management activities are undertaken without benefits of flood mitigation impacts captured.	-		Maintenance		✓	✓			✓

3.2 Options Long List Go / No Go

After compilation of the Long List and dissemination to the BSC project team, a preliminary Go / No Go assessment was applied to the Options Long List, by Arcadis, using the following Go / No Go criteria shown in **Table 3.5 below**. The criteria were also informed by feedback from the stakeholder consultation process.

Table 3.5 Options Long List No Go Criteria

Objective	No Go Criteria
Financially Responsible	• Very high capital expenditure required e.g. major structural works to Federation Bridge • Unsustainable operational expenditure is required e.g. frequent and intensive ongoing maintenance is prohibitive
Right Infrastructure and People	• Likely worsen flood impacts during a major flood event • Major adverse impacts to local ecology and surrounding environment • Control measure is not effective or could worsen debris accumulation
Satisfied Customers and Stakeholders	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge during operations or construction phase

The resulting Long List assessment shown given in **Table 3.6** below and was used to develop Short List options. This was again circulated to the BSC project team who agreed on the selected Short List options.

Table 3.6 Options Long List Go / No Go Assessment

Control Number	Options - Long List These options are individual actions which BSC can take to address debris.	No Go Project Criteria			
		Financially Responsible	**Right Infrastructure and People**	**Satisfied Customers and Stakeholders**	
		• CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	• May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
Structural Options					
S.1	The Treibholzfange debris-detention device		✗ This device may worsen impacts during a flood event. If excessive debris accumulates during the flood event, this may increase river levels upstream.		No May worsen flood impacts during a flood event
S.2	Debris booms		✗ During a flood event, although preventing debris from reaching Federation Bridge, accumulation of debris at creek inlets may worsen the flood water levels upstream in Mullumbimby Creek and Chinbible Creek.		No May worsen flood impacts during a flood event
S.3	Debris fins	Further assessment			Yes
S.4	River training structures	Further assessment			Yes

		No Go Project Criteria			
Control Number	**Options - Long List** These options are individual actions which BSC can take to address debris.	**Financially Responsible**	**Right Infrastructure and People**	**Satisfied Customers and Stakeholders**	
		• CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	• May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
S.5	Debris sweeper	Further assessment			Yes
S.6	Debris deflectors		✗ If not maintained or cleared prior to unexpected flood event, or if excessive debris accumulates during the flood event, this may contribute to the worsening of water levels upstream and cause damage to Federation Bridge.		No May worsen flood impacts during a flood event
S.7	Trash racks		✗ If not maintained or cleared prior to unexpected flood event, may worsen flood water levels upstream of inlet creeks. Additionally, does not address the woody debris along foreshores of Brunswick River.		No May worsen flood impacts during a flood event

		No Go Project Criteria			
Control Number	**Options - Long List** These options are individual actions which BSC can take to address debris.	**Financially Responsible**	**Right Infrastructure and People**	**Satisfied Customers and Stakeholders**	
		• CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	• May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
S.8	Furling / Net	✗ Load of the net with collected debris combined with a grabber will likely require costly reinforcement works to the bridge.			No Prohibitively costly due to major structural works
S.9	Debris retaining basin		✗ Not widely applied and usually used as an option of last resort for large volumes of debris in larger rivers. Due to the volume of the debris observed under Federation Bridge and the relatively small width of Brunswick River at Federation bridge, this option is not technically suitable.		No Not effective due to the volume of debris and width of Brunswick River
S.10	Bridge pier adjustment	✗ Bridge pier adjustment will require costly major structural works.		✗ Works will require lengthy bridge closures causing	No Impacts on local residents due to bridge closures

Control Number	Options - Long List These options are individual actions which BSC can take to address debris.	No Go Project Criteria **Financially Responsible** • CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	**Right Infrastructure and People** • May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	**Satisfied Customers and Stakeholders** • Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
				travel disruptions to local residents.	
River Bathymetry					
D.1	Dredging	✗ Costly maintenance will be required to ensure river bathometry's deflection effectiveness.	✗ Dredging will likely have adverse effect the ecology of the river which is classified as key fish habitat.	✗ Periodic dredging works will affect navigability and community amenity of the river.	No Prohibitively costly, adverse environmental impacts and navigability
Source Control					
SC.1	Bush Regeneration	Further Assessment			Yes
SC.2	Litter and illegal dumping minimisation		✗ Observed debris under Federation Bridge is predominantly woody debris and not debris generated by illegal dumping (e.g. furniture, whitegoods etc.). Additionally, EPA clean up		No Likely not a effectiveness solution due to relatively small volume

		No Go Project Criteria			
Control Number	**Options - Long List** These options are individual actions which BSC can take to address debris.	**Financially Responsible**	**Right Infrastructure and People**	**Satisfied Customers and Stakeholders**	
		• CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	• May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
			data shows larger of these items tend not to be deposited at Federation Bridge but on the outer bends up and downstream of Brunswick River.		
SC.3	Debris removal on foreshore - emergency removal before flood events	Further Assessment			Yes
SC.4	Debris removal on foreshore - after flood event	Further Assessment			Yes
SC.5	Debris removal on foreshore - periodic and regular debris removal	Further Assessment			Yes
SC.6	Debris removal - removal of dead Camphor Laurel and other invasive species	Further Assessment			Yes
SC.7	Redistribution of woody debris for habitat	Further Assessment			Yes

Control Number	Options - Long List These options are individual actions which BSC can take to address debris.	No Go Project Criteria			
		Financially Responsible	**Right Infrastructure and People**	**Satisfied Customers and Stakeholders**	
		• CAPEX e.g. major structural works to Federation Bridge • OPEX e.g. frequent and intensive ongoing maintenance is prohibitive	• May worsen flood impacts during a flood event • Major adverse impacts to local ecology • Engineering solution not technically effective	• Completely removes navigability of Brunswick River • Causes either frequent or lengthy closures to Federation Bridge	Option to consider in Short List
	creation and erosion management				
Community Engagement					
C.1	Landcare engagement	Further Assessment			Yes
C.2	Community education of effective of Camphor Laurel management	Further Assessment			Yes
Manual Removal at Federation Bridge					
M.1	Manual debris removal at Federation Bridge	Further Assessment			Yes
Do Nothing					
Do Nothing	Do Nothing - business as usual	Baseline Scenario			Yes

4 Options Short List Assessment

4.1 Options Short List

The options Short List was generated using the options from the Long List which had not been excluded in the Go / No Go assessment discussed in Section 3. To create robust debris control measures, Long List options have been combined. This Short List has further been informed by BSC through feedback from the Long List and further external stakeholder engagement with EPA, RMS and TfNSW.

Table 4.1 Debris Control – Options Short List

Short List Debris Options		Description
Option 1	**Structural: Debris fins**	
S.3	Debris fins	Downstream and/or upstream triangular structure to direct debris away from the Bridge, attached vertically at bridge piers. Debris fins allow debris to continue traveling in the flow in a directed manner by enabling realignment of debris. For Federation Bridge, this will reduce blockage as the piers are skewed to the upstream flows. Some debris removal is required to ensure fins are clear.
Option 2	**Structural: Debris sweeper**	
S.5	Debris sweeper	Vertically aligned polyurethane cylinders which rotate freely. Sweepers are attached to the piers where debris accumulates upstream and downstream side of a structure to direct debris downstream. Periodic debris removal is required to ensure the debris sweeper is clear and free to rotate.
Option 3	**Camphor Laurel management and bush regeneration**	
SC.6	Debris removal - removal of dead Camphor Laurel and other invasive species	This option targets the removal of Camphor Laurel, much of which have been poisoned and are dead on the foreshore, contributing to significant to woody debris entering Brunswick River. After the initial effort of Camphor Laurel removal, ongoing bush regeneration activities can address long term erosion control to further minimise debris. This is supplemented by community awareness and Landcare engagement for safer and effective methods of Camphor Laurel Management. Additionally, manual debris removal at Federation Bridge is expected on a as-needed basis, however, it is anticipated the need will become less frequent as the foreshore is regenerated.
SC.1	Bush Regeneration	
C.2	Community education of effective of Camphor Laurel management	
C.1	Landcare engagement	
M.1	Manual debris removal at Federation Bridge	
Option 4	**Targeted Flood Event Management**	
SC.3	Debris removal on foreshore - emergency removal before flood events	This option aims to minimise the accumulation of debris at Federation Bridge by removing man made and woody debris on foreshores before a forecasted flood event or rainy season at Federation Bridge. Additionally, prompt post flood event debris removal ensures debris does not enter the river during a subsequent flood event.
SC.4	Debris removal on foreshore - after flood event	
M.1	Manual debris removal at Federation Bridge	

Short List Debris Options		Description
Option 5	**Periodic Removal and habitat creation**	
SC.5	Debris removal on foreshore - periodic and regular debris removal	This option removes debris on mainly on the foreshore (anthropogenic and woody debris) on a scheduled basis. The woody debris is redistributed for the benefit of in-river habitat creation or erosion control.
SC.7	Redistribution of woody debris for habitat creation and erosion management	
M.1	Manual debris removal at Federation Bridge	
Option 0	**Business as Usual - do nothing**	
Do Nothing	Debris removal when reported by the community.	Operational maintenance of Brunswick River is managed by Road and Maritime Services to maintain navigability. Council has no existing debris process as it is not under Council jurisdiction. Any debris removal on the foreshores is not captured as a flood mitigation benefit.

4.2 MCA Objectives and Criteria

To select a preferred option from the developed Short List, a multi-criteria analysis was undertaken. The criteria and objectives for assessment were developed in conjunction with the BSC project team. The resulting MCA criteria has been split into three key objectives as per **Table 3.1.1** below.

Table 4.2.1 Option overarching objectives

Objective	Description
Financially Responsible	The solution is economically feasible. This objective includes initial outlay (environmental and other impact assessments, conceptual and detailed design, river flow assessments, condition assessments, ground-truthing etc.) capital (construction) and ongoing operational and maintenance costs of the options, as well as the likelihood of receiving funding for all phases of the option.
Right Infrastructure and People	The solution is technically effective at minimising debris accumulation at Federation Bridge and can be safely and easily implemented and operated with minimal impacts to the surrounding environment.
Satisfied Customers and Stakeholders	The solution has minimal impact on community's amenity of Brunswick River, to First Nation and European heritage values. Additionally, landowners and authorities are satisfied with the solution with minimal processes for licenses and approvals to implement solution.

The criteria, and their weightings, of each of the overarching objectives can be seen in **Table 4.2.2.** The weightings of each criterion have been carefully considered, taking into account the constraints as outlined in this report. Weightings of criteria and objectives have been aligned with BSC's priorities and identified constraints.

Table 4.2.2 MCA Objectives, Weightings and Scores

	35%			40%				25%		
	Financially Responsible			**Right Infrastructure and People**				**Satisfied Customers and Stakeholders solution**		
	30%	30%	40%	70%	15%	5%	15%	35%	35%	30%
Score	Opinion of Initial outlay and Capital Costs	Opinion of Operational Cost over 30 years	Funding Potential	Efficacy, Operations and Maintenance	Health and Safety during construction, commissioning and operation	Construction and commissioning complexity	Environmental impacts	Heritage including aboriginal relics & sacred sites, European heritage, approvals	Community amenity, disturbance, perception and acceptance	Authority stakeholders, licenses and approvals
5	< $100,000	< $300,000	Funding available for all phases	Major positive impact or benefit associated with the criteria. Simple to satisfy criteria.						
4	$100,000 - $200,000	$300,001 - $600,000	Likely that the option will receive funding for most phases	Moderate positive impact or benefit associated with the criteria. Simple to satisfy criteria with minor modifications.						
3	$200,000 - $500,000	$600,001 - $900,000	May receive partial funding for all phases or operational phases	Neutral positive impact or benefit/challenge associated with the criteria.						
2	$500,000 - $1,000,000	$900,001 - $1,500,000	Unlikely to receive funding for most phases	Moderate negative impact or challenge associated with the criteria. Small difficulties in satisfying the criteria.						
1	>$1,000,000	> $1,500,000	Unlikely to receive funding for any phases	Major negative impact or challenge associated with the criteria. Difficult to satisfy the criteria.						

4.3 MCA Process

An MCA was undertaken for each of the short-listed options, using objectives and criteria as described in the previous section and considering constraints as outlined in this study. The MCA was facilitated by Arcadis with key BSC teams engaged on 19th April 2023 and refinement in the following days. The following sections detail the outcomes of the assessment with final scorings for each option.

4.3.1 Option 1 Structural: Debris Fins

Option 1 Structural: Debris Fins	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	**1**	Circa $1,000,000 Assumes structural works are required to reinforce the Bridge due to the age and condition. Assumes 2 concrete fins on middle piers (where debris tends to accumulate) are constructed. Environmental impact assessment, heritage assessment and bridge condition assessments, river flow assessments will be required prior to any design works and construction.
Opinion of operational costing (30 year scenario)	**3**	Circa $900,000 Due to the skew of the bridge and reports from existing debris fins, clearing and maintenance will likely be required. (Sheeder and Johnson, 2008 cited by Bridge Engineering Center, 2012).
Funding Potential	**1**	TfNSW is the asset owner of Federation Bridge and is responsible for the operational maintenance. Additional structural elements which increase maintenance cost will likely not be funded by TfNSW, due to their asset maintenance programme and the priority given to Federation Bridge in the region.
Right Infrastructure and People		
Efficacy and performance, Operations and Maintenance	**1**	Due to the skew of the bridge in the river, the piers are not directly parallel to flow of the river, the effectiveness of the solutions is unlikely to be satisfactory and may exacerbate the problem; fins are most effective in very high flow velocities where fins and piers are parallel to flows (Bridge Engineering Center, 2012). Additionally, fins are only effective for floating debris; debris which is lodged on bridge piers may further trap debris. Although the structure itself will require little monitoring and maintenance, clearing debris may still be required. The control does not reduce debris loads into the river; does not address source of debris.
Health and Safety during construction, commissioning and operation	**3**	Construction works require working on a waterway and could also require working at height. These works can be appropriately risk assessed.
Construction and commissioning complexity	**2**	Construction will require large machinery access close to the waterway and/or the bridge. Large concrete fins will require cranes and barges to be put in place. A water main is also located on the upstream side of the bridge.
Environmental impacts	**3**	Commissioning and construction works may disturb habitats on the foreshore and fish habitats. During operation, could create more fish habitat in Brunswick River.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	**2**	Federation Bridge is in the heritage schedule (European) of the Council's LEP (BSC, 2014). No registered Aboriginal sites and places in the study area (Appendix B)
Community amenity, disturbance, perception, and acceptance	**3**	Construction requires lengthy bridge closures for structural works. Debris fins may interfere with community amenity and navigability of the river

		due to the skew of Federation Bridge; fins are required to be placed parallel to the flow. Fins may be viewed as a pro-active solution to debris management at the bridge.
Authority stakeholders, licenses, and approvals	**2**	Requires several permits and approvals. Debris fins will require TfNSW consent and adoption as the asset owners. Fins will be constructed in a Crown Waterway and will require permitting from RMS. Brunswick River is a key fish habitat and will require the relevant environmental assessments.

4.3.2 Option 2 Structural: debris sweeper

Option 1 Structural: Debris Sweeper	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	2	Circa $500,0000 Assumes minimal structural works are required to reinforce the bridge. Assumes 2 sweepers middle piers (where debris tends to accumulate) are constructed. Environmental impact assessment, heritage assessment and bridge condition assessments, river flow assessments will be required prior to any design works and construction.
Opinion of operational costing (30 year scenario)	2	Circa $1,500,000 Ongoing maintenance is required to ensure sweepers continue to rotate freely; any debris interfering with debris sweepers may worsen debris build up. (Bridge Engineering Center, 2012).
Funding Potential	1	TfNSW is the asset owner of Federation Bridge and is responsible for the operational maintenance. Additional structural elements which increase maintenance cost will likely not be funded by TfNSW, due to their asset maintenance programme and the priority given to Federation Bridge in the region
Right Infrastructure and People		
Efficacy and performance, Operations and Maintenance	1	Debris sweepers only addresses floating debris; debris which settles at bottom of bridge piers may interfere with performance of the sweeper. Where debris sweepers have been implemented, they have generally been labelled as having poor performance (Bridge Engineering Center, 2012) due to the need for regular maintenance and debris interference (not floating debris).
Health and Safety during construction, commissioning and operation	3	Construction works require working on a waterway and could also require working at height. These works can be appropriately risk assessed.
Construction and commissioning complexity	3	Construction will require minimal reinforcement work to Federation Bridge. A barge is likely needed to work in the waterway. A water main is also located on the upstream side of the bridge.
Environmental impacts	3	Commissioning and construction works have minimal impact to habitats on the foreshore and fish habitats.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	2	Federation Bridge is in the heritage schedule (European) of the Council's LEP (BSC, 2014). No registered Aboriginal sites and places in the study area (Appendix B)
Community amenity, disturbance, perception, and acceptance	3	Debris sweepers will unlikely interfere with community amenity and not affect the navigability of the river.
Authority stakeholders, licenses, and approvals	2	Requires several permits and approvals. Debris fins will require TfNSW consent and adoption as the asset owners. Works will require works in a Crown Waterway and will require permitting from RMS. Brunswick River is a key fish habitat and will require the relevant environmental assessments.

4.3.3 Option 3 Camphor Laurel and Bush Management

The following figure shows areas upstream of Federation Bridge of the proposed bush management areas that are likely to contribute to woody debris loads entering Brunswick River. Approximately 3.2km of the foreshore have been recently cleared of dead and selected live Camphor Laurel species (vegetation community layer is of 2021) by BSC Bush Regeneration Team. This option estimates a further 2.57km of remediation is required.

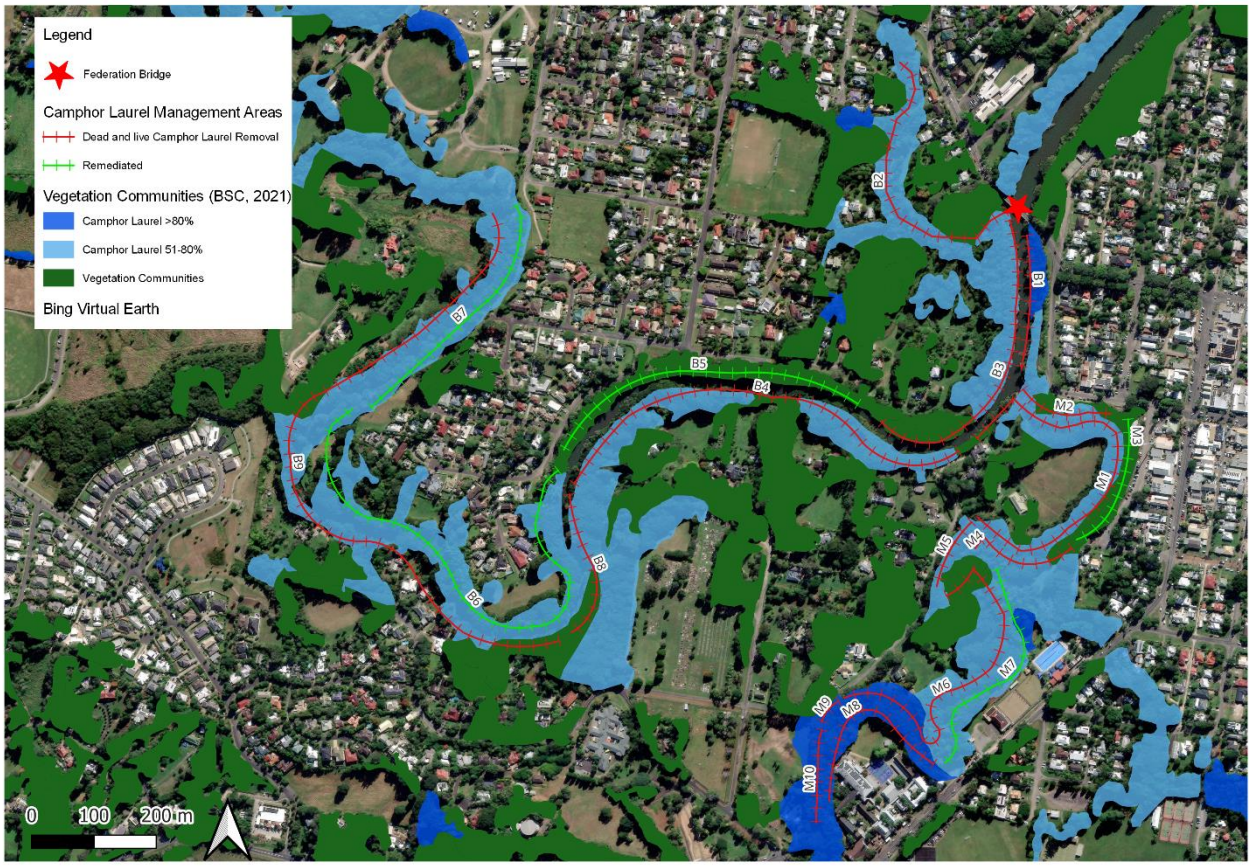


Figure 4.2 Option 3 Camphor Laurel Management Areas

Option 3 Camphor Laurel and Bush Management	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	2	Circa $572,000 This estimate is based on previous quotes procured by council, which considers cranes and machinery that may be required to reach the banks of Brunswick Rivers, and to remove larger dead Camphor Laurel.
Opinion of operational costing (30 year scenario)	5	Circa $220,000 Assumes ongoing bush management required after Camphor Laurel removal and requires minimal re-planting. Manual removal of debris is likely still required prior to initial of remediation.
Funding Potential	4	Solution is likely to gain funding due to the wider benefits the solution creates, not only an effective flood mitigation control. Funding sources may include EPA and DPE. Assumes community awareness and Landcare support can be delivered via existing BSC grants due to similar overarching objectives.
Right Infrastructure and People		

Option 3 Camphor Laurel and Bush Management	Score	Assessment
Efficacy and performance, Operations and Maintenance	5	This solution targets the dominating source of debris accumulating at Federation Bridge – dead Camphor Laurel upstream of Federation Bridge. It is anticipated as the bulk of Camphor Laurel is removed; woody debris accumulation will significantly decrease. It assumed that minimal ongoing bush management will be required. Community awareness of safe and effectiveness ways to manage Camphor Laurel will also minimise debris loads. Will also help reduce debris accumulation at other bridges.
Health and Safety during construction, commissioning and operation	4	Works require the removal of large dead trees in hard to access areas. Cranes and machinery can be used to ensure safe working. These works can be appropriately risk assessed.
Construction and commissioning complexity	4	Some pockets of difficult to access areas on the foreshores due to dense bushland, however, relatively straight forward initial and ongoing works.
Environmental impacts	5	Removal of invasive species will encourage growth of native vegetation. Additionally, the shallow nature of the Camphor Laurel roots undercuts banks of Brunswick River; remediation will have wider environmental benefits including addressing erosion. It is noted that flying fox camps and koala habitats are within this option; removal of trees will be undertaken in a controlled and selective fashion. Increasing flora diversity will further encourage more diverse fauna to create habitats.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	4	No registered Aboriginal sites and places in the study area (Appendix B), however, a detailed assessment may be required.
Community amenity, disturbance, perception, and acceptance	5	Solution engages the community and other stakeholder groups (Landcare). Increase quality of vegetation communities on the foreshores will benefit amenity of the study area. Removal of vegetation will cause minimal disturbance to local community.
Authority stakeholders, licenses, and approvals	4	Majority of the area is either Council managed Council owned; minimal licenses and approvals are required. There are some pockets of privately owned land; however it is noted that landowners are not permitted to mow or disturb vegetation 10m from riparian areas.

4.3.4 Option 4 – Targeted Food Event Management

Option 4 Targeted Flood Event Management	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	4	Circa $200,000 Assumes upfront effort to remove debris (woody and anthropogenic) in the first years of the management plan. Requires procurement of barge and other equipment.
Opinion of operational costing (30 year scenario)	3	Circa $670,000 Assumes debris removal before and after a major flood event is required every 5 years, approximate 2.5km upstream of Brunswick River and in the foreshores.
Funding Potential	2	Unlikely to receive funding for ongoing debris removal before and after flood events.
Right Infrastructure and People		
Efficacy and performance, Operations and Maintenance	2	The nature of this plan is based around predicting flood events and weather (and climate patterns), which is difficult to plan and mobilise prior to a flood event. Additionally, removing debris after a flood event is a reactive solution and does not address the effects of debris accumulating at Federation Bridge during a flood event. This solution is labour intensive for the duration of the solution, requiring a team to be mobilised at short notice.

Option 4 Targeted Flood Event Management	Score	Assessment
Health and Safety during construction, commissioning and operation	2	Removing anthropogenic debris and waste in the waterway and the foreshore can be hazardous due to the type of debris, and the size and weight.
Construction and commissioning complexity	3	Removing debris could have access difficulties, especially bulky items. However, most of the foreshore is accessible for this activity.
Environmental impacts	4	Removing anthropogenic debris has environmental benefits for local flora and fauna, as well preventing anthropogenic debris into Brunswick River.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	4	No registered Aboriginal sites and places in the study area (Appendix B), however, a detailed assessment may be required.
Community amenity, disturbance, perception, and acceptance	4	Solution will increase the amenity of area, with periodic removal litter and illegally dumped debris. Clearing debris will have minimal disturbance of the community. However, this solution may be perceived as a reactive solution as opposed preventative.
Authority stakeholders, licenses, and approvals	2	Council do not have the authority to remove debris in the Crown Waterway. Any works need to be approved by RMS and a notice needs to be posted prior to any works to advise waterway uses of the navigational impediment. Some approvals may be granted during emergency flood events. Council is able to remove debris in Council owned and managed areas. There are also some pockets of privately owned land.

4.3.5 Option 5 – Periodic Removal and Habitat Creation

Option 5 Periodic Removal and habitat creation	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	4	Circa $200,000 Assumes upfront effort to remove debris (woody and anthropogenic) in the first years of the management plan. Requires procurement of barge and other equipment.
Opinion of operational costing (30 year scenario)	2	Circa $1,020,000 Assumes removal of debris (anthropogenic and woody) every 2 years and redistribution of woody debris for bank management and habitat creation.
Funding Potential	1	Unlikely to receive funding due to the relatively large ongoing operation costs.
Right Infrastructure and People		
Efficacy and performance, Operations and Maintenance	2	This solution does not address debris during flood events and only removes debris every 2 years. Redistribution of woody debris may also result in contributing to debris load in other parts of Brunswick River. This solution is labour intensive for the duration of the solution. Additionally, some monitoring will be required for created fish habitats.
Health and Safety during construction, commissioning and operation	2	Removing anthropogenic debris and waste in the waterway and the foreshore can be hazardous due to the type of debris, and the size and weight.
Construction and commissioning complexity	2	Removing debris could have access difficulties, especially bulky items. However, most of the foreshore is accessible for this activity.
Environmental impacts	4	Removing anthropogenic debris has environmental benefits for local flora and fauna, as well preventing anthropogenic debris into Brunswick River. Additionally, actively creates environmental value in fish habitats.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	4	No registered Aboriginal sites and places in the study area (Appendix B), however, a detailed assessment may be required.

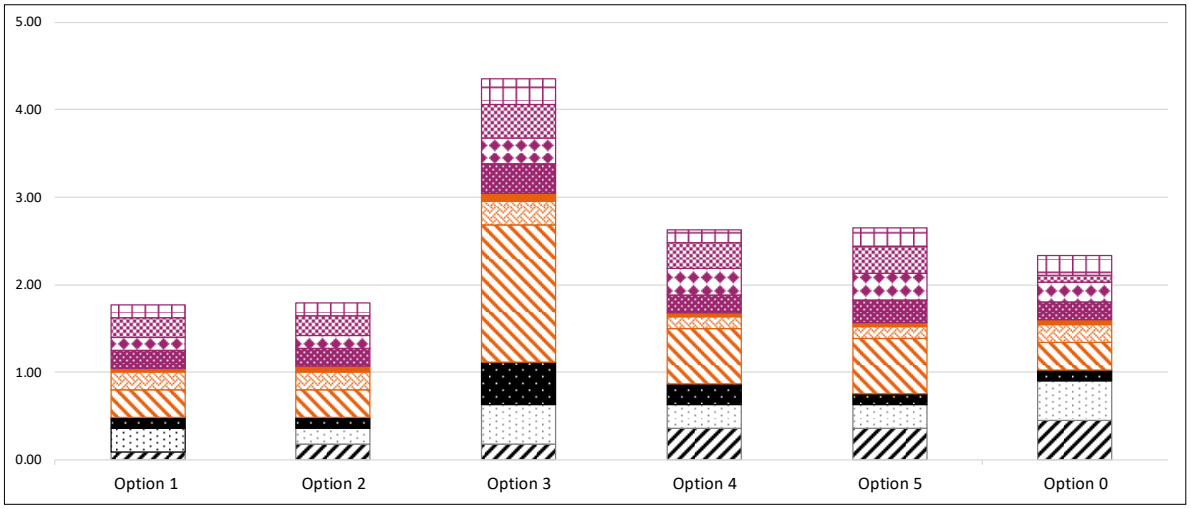
Option 5 Periodic Removal and habitat creation	Score	Assessment
Community amenity, disturbance, perception, and acceptance	4	Solution will increase the amenity of area, with periodic removal litter and illegally dumped debris. Clearing debris will have minimal disturbance of the community. However, this solution may be perceived as
Authority stakeholders, licenses, and approvals	3	Council do not have the authority to work in the Crown Waterway. Any works need to be approved by RMS and a notice needs to be posted prior to any works to advise waterway uses of the navigational impediment. Approvals will also be required for habitat creation in Brunswick River by DPE. Council is able to remove debris in Council owned and managed areas. There are also some pockets of privately owned land.

4.3.6 Option 0 – Business as Usual

Option 0 Business and usual	Score	Assessment
Financially Responsible		
Opinion of Initial outlay / Capital costs	5	Business as usual – no additional financial outlay.
Opinion of operational costing (30 year scenario)	5	Business as usual – no additional financial outlay.
Funding Potential	1	Business as usual – no additional financial outlay.
Right Infrastructure and People		
Efficacy and performance, Operations and Maintenance	1	No active management will further worsen debris accumulation at Federation Bridge.
Health and Safety during construction, commissioning and operation	3	Business as usual – debris removal as needed.
Construction and commissioning complexity	3	Business as usual – no change.
Environmental impacts	3	Business as usual – no change.
Satisfied Customers and Stakeholders		
Heritage including aboriginal relics & sacred sites, European heritage, approvals	3	Business as usual – no change.
Community amenity, disturbance, perception, and acceptance	1	Inaction of addressing debris accumulation is not acceptable to community.
Authority stakeholders, licenses, and approvals	3	Business as usual – no change.

4.3.7 MCA Summary and Outcomes

The MCA resulting scores are given below.



	Structural: Debris fins	Structural: Debris sweeper	Camphor Laurel management and bush regeneration	Targeted Flood Event Management	Periodic Removal at foreshores and habitat creation	Business as Usual - Do Nothing
Rank	6	5	1	3	2	4
Score	1.83	1.86	4.47	2.73	2.755	2.38
% Score	37%	37%	89%	55%	55%	48%

Satisfied Customers and Stakeholders

- Authority stakeholders, licenses and approvals
- Community amenity, disturbance, perception and acceptance
- Heritage including aboriginal relics & sacred sites, European heritage, approvals
- Environmental impacts

Right Infrastructure and People

- Construction and commissioning complexity
- Health and Safety during construction, commissioning and operation
- Efficacy, Operations and Maintenance

Financially Responsible

- Funding Potential
- Operational costing (30 year scenario)
- Capital Costs

Figure 4.3.1 Short List Options MCA - Results Graph

As seen in the Figure above, *Option 3 Camphor Laurel Management and Bush Regeneration* has scored the highest out of the five options and the Business and Usual (do nothing) solution . Although this option has a high initial cost outlay, the likelihood of securing funding is high. Additionally, this solution scored the highest out all solutions for its effectiveness – addressing the woody debris at the source, preventing debris loads entering Brunswick River, which would help all bridge structures downstream of the source control point. It also provided significant environmental benefit by removing an invasive flora species allowing for further regeneration and bank stabilisation (through replacement of Camphor Laurels with native floras)

Structural *Options 1* and *2* scored the lowest, due to the high capital and ongoing maintenance costs in order to ensure the effectiveness of these solutions. If not maintained, these controls could exacerbate the debris accumulation.

Other management options, *Options 4 Targeted Flood Events* and *Option 5 Period Debris Removal* scored just above the Business as Usual (do nothing) solution. These options, although contributing to wider environmental benefits, are somewhat reactive solutions. However, elements of *Option 4* and *5* are valid and could be done in conjunction with preferred *Option 3.*

Table 4.2.1 Summary of MCA scoring of Options Short List

Objective Weighting	30%			45%				25%			
	Financially Responsible The solution is economically feasible. This objective includes capital and ongoing costs of the options, as well as the likelihood of receiving funding for all phases of the option.			**Right Infrastructure and People** The solution is effective and can be safely implemented with minimal impacts to the surrounding environment.				**Satisfied Customers and Stakeholders** The solution has minimal impact on user's amenity of Brunswick River, to First Nation and European heritage values. Additionally, land owners and authorities are satisfied with the solution with minimal processes for licenses and approvals to implement solution.			
Criteria Weighting	30%	30%	40%	70%	15%	5%	15%	35%	35%	30%	
Description	Initial outlay and Capital Costs	Operational costing (30 year scenario)	Funding Potential	Efficacy, Operations and Maintenance	Health and Safety during construction, commissioning and operation	Construction and commissioning complexity	Environmental impacts	Heritage including aboriginal relics & sacred sites, European heritage, approvals	Community amenity, disturbance, perception and acceptance	Authority stakeholders, licenses and approvals	**Weighted Score**
Option 1 Structural: Debris fins											
Downstream and/or upstream triangular structure to direct debris away from the bridge, attached vertically at bridge piers. Debris fins allow debris to continue traveling in the flow in a directed manner.	1	3	1	1	3	2	3	2	3	2	1.83
Option 2 Structural: Debris sweeper											
Vertically aligned polyurethane cylinders which rotate freely. Sweepers are attached to the upstream side of a structure and is intended to direct debris downstream.	2	2	1	1	3	3	3	2	3	2	1.86
Option 3 Camphor Laurel Management and Bush regeneration											
This option targets the removal of Camphor Laurel, much of which are dead on the foreshore, contributing to significant to woody debris entering Brunswick River. Supplemented by ongoing management.	2	5	4	5	4	4	5	4	5	4	4.47
Option 4 Targeted Flood Event Management											
This option aims to minimise the accumulation of debris at Federation Bridge by removing man made and woody debris on foreshores before a forecasted flood event or rainy season at Federation Bridge. Additionally, prompt post flood event debris removal.	4	3	2	2	2	2	3	4	4	2	2.73
Option 1 Periodic Removal and habitat creation											
This option removes debris on the mainly on the foreshore (anthropogenic and woody debris) on a scheduled basis. The woody debris is redistributed for the benefit of in-river habitat creation or erosion control.	4	3	1	2	2	2	4	4	4	3	2.76
Option 0 Business as Usual - do nothing											
Operational maintenance of Brunswick River is managed by Maritime for navigable. Council has no existing debris process as it is not under Council jurisdiction.	5	5	1	1	3	3	3	3	1	3	2.38

5 Conclusion

This report assessed possible debris control methods to address debris accumulation under Federation Bridge, with the aim of reducing their impacts during flood events. This study explored structural options on Federation Bridge, and management options that would intercept debris prior to entering Brunswick River, reducing debris loads.

These options were compiled into a Long List, then evaluated using a No / No Go assessment based on stakeholder and BSC project team feedback to remove options which were financially unfeasible, not practical, possibly exacerbate flood impacts, and have unmitigated impacts on environment and community amenity of the study area.

The remaining controls formed a Short List which were evaluated using an MCA and ranked:

1. Option 3 Camphor Laurel management and bush regeneration
2. Option 5 Periodic removal and habitat creation
3. Option 4 Targeted Flood Event Management
4. Option 0 Business as Usual – Do Nothing
5. Option 2 Structural: Debris Sweeper
6. Option 1 Structural: Debris Fins

Option 3 Camphor Laurel Management and Bush Regeneration scored the highest out of the options. Although this option has a high initial cost outlay, the likelihood of securing funding is high. Additionally, this solution scored the highest out all solutions for its effectiveness – addressing and mostly eradicating the woody debris at the source, preventing debris loads entering Brunswick River.

6 Recommendations

To progress the preferred *Option 3 Camphor Laurel Management and Bush Regeneration* the following is recommended.

1. **Presentation of preferred option to key stakeholders**: In order to progress the preferred *Option 3 Camphor Laurel Management and Bush Regeneration***,** the options will need to be presented to the Flood Committee whose members include:
    - Representation from the Mullumbimby Community
    - DPE
    - EPA
    - Internal BSC teams

It should be noted in this presentation that there has been deviation from original funded structural solution from the FRMP, however the preferred option, in consideration of the study, is appropriate and effective.

2. **Review of funding options:** Following the presentation of the preferred option to key stakeholders, review possible funding sources from DPE via floodplain management grants or coastal and estuary grants.
3. **Business Case:** Developing a business case will be required, including more detailed costs for initial outlay and further assessments, ongoing maintenance for operation activities. Flood mitigation benefits as well as wider environmental and community benefits should also be addressed**.**
4. **Stage 2 Management Plan**: Following this initial options assessment, the next steps, once approval and funding is gained, are to detail a Management Plan and possible funding requirements for O*ption 3*

Camphor Laurel management and bush regeneration. The Management Plan will detail the activities and their schedules to effectively remove dead and live Camphor Laurel and ongoing bush management.

As activities under this option fall mostly under Council's responsibility and similar activities have been carried out in the Study Area and the wider LGA, engagement with BSC's Coastal Management and Biodiversity Team and Bush Regeneration Team is required.

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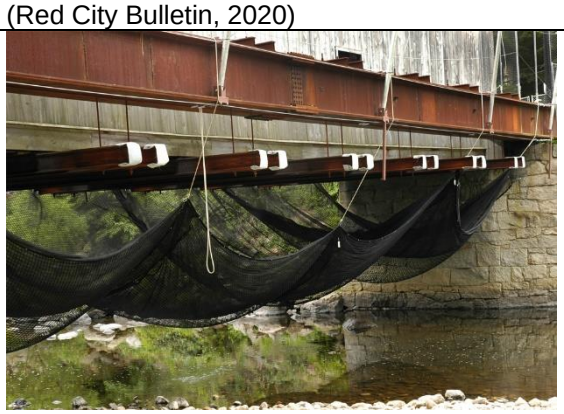
WMA Water, 2020b North Byron Floodplain Risk Management Study and Draft Plan, prepared for Byron Shire Council

Appendix A – Structural Debris Control Options Example Images

S.1	The Treibholzfange debris-detention device	 U.S. Department of Transportation (2005)
S.2	Debris booms	 https://www.elastec.com/products/floating-boom-barriers/trash-debris-boom/
S.3	Debris fins	 U.S. Department of Transportation (2005)
S.4	River training structures	 Figure 5.41. Bendway wiers on outer bank of Hatchie River looking upstream (TDOT). U.S. Department of Transportation (2005),
S.5	Debris sweeper	

		 Figure 5.45. Close up of a debris sweeper installed on the Cedar Creek in Washington.  Figure 5.44. Debris sweeper being installed on a bridge over Staunton River in Altavista, Virginia. U.S. Department of Transportation (2005)
S.6	Debris deflectors	 Figure 5.2. Steel rail debris deflector (looking downstream). U.S. Department of Transportation (2005)

S.7	Trash racks	 (Red City Bulletin, 2020)
S.8	Furling / Net	 (Protect Construction, 2022)
S.9	Debris retaining basin	 (After Wildfire, 2023)
S.10	Bridge pier adjustment	

Appendix B – AHIM Search

AHIMS Web Services (AWS)
Search Result

Your Ref/PO Number : Federation Bridge - 2

Client Service ID : 769077

Arcadis

580 George Street
Sydney New South Wales 2000

Attention: Christina Chiu

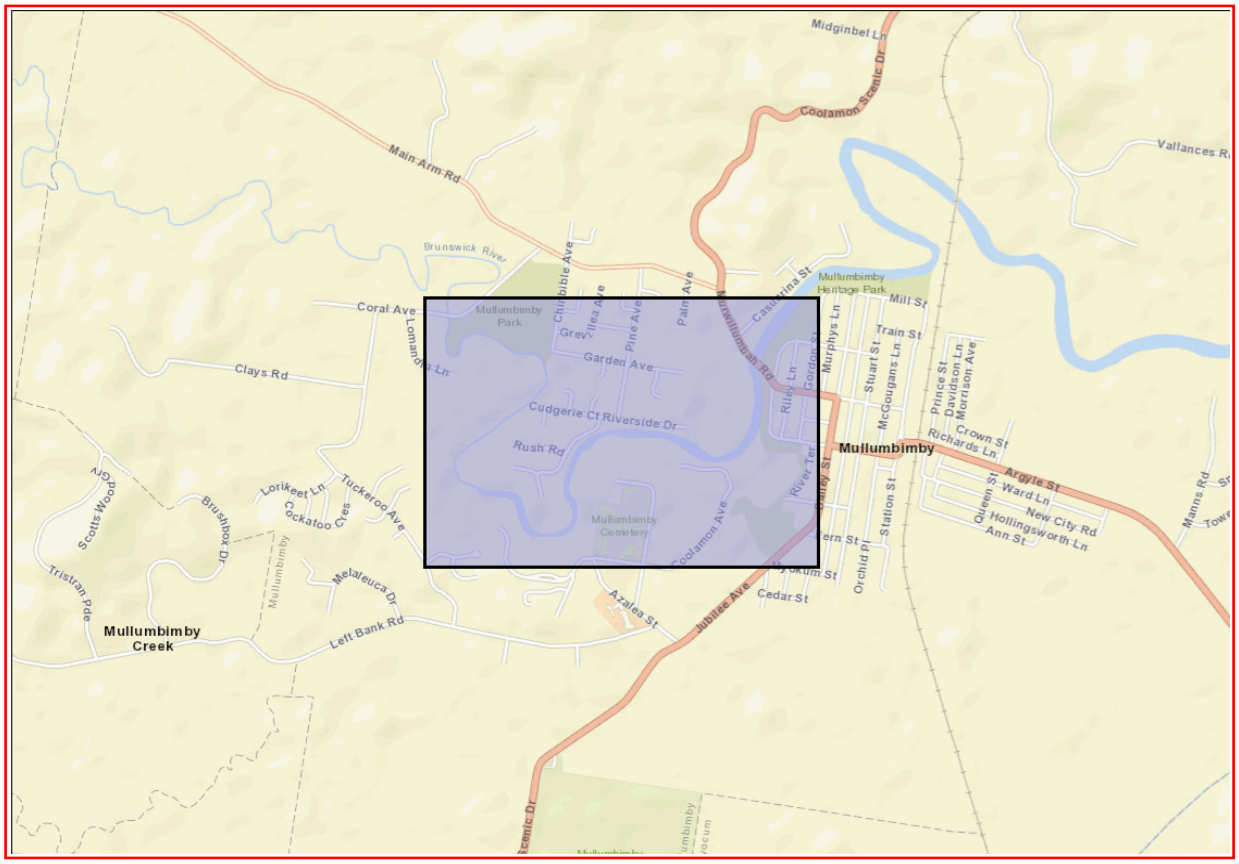
Email: christina.chiu@arcadis.com

Date: 30 March 2023

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -28.5574, 153.4837 - Lat, Long To : -28.5479, 153.4992, conducted by Christina Chiu on 30 March 2023.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of Heritage NSW AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (https://www.legislation.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Heritage NSW upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Heritage NSW and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date. Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

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