Rapid Creek Waterways Assessment

Department of Lands, Planning and the Environment NT Govt.

Geomorphic Assessment

IW033600-ECH-RP_Rapid Creek Geomorphic Assessment001| Draft for comment

12 June 2015

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Project manager:	Peter Saunders
Author:	Chris Dwyer & Erika Crowley
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Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
1st Floor, 54 Ovens Street
Wangaratta VIC 3677
T +61 3 5721 5291
F +61 3 5721 8357
www.jacobs.com

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Contents

Executive Summary

The Department of Lands, Planning and the Environment (DLPE) has engaged Jacobs to conduct a geomorphic assessment of the Rapid Creek corridor.

Rapid Creek is the largest freshwater system in the Darwin City Area. It is highly valued by the Darwin community for its ecological features and visual amenity, as evidenced by the use of pedestrian and bicycle paths alongside the creek. However, Rapid Creek has a history of flooding, resulting in the inundation of residences in the suburb of Millner. The balance between mitigation of these flooding impacts and the protection of the creek's ecological features is strongly debated.

In November 2013, an arboreal survey identified approximately ninety (90) fallen or leaning trees that were causing, or had the potential to cause, obstruction of the creek between McMillans Road and the Jingili Water Gardens. In response to this survey, it was suggested that the identified trees might be removed or trimmed to decrease channel blockages and, potentially, improve the creek's ability to pass flows. However, flood studies previously undertaken by SKM (now Jacobs) suggest that the removal of vegetation may have only marginal benefits in reducing flooding. Further, the removal of vegetation could have an adverse effect on the geomorphic stability of the waterway. This is partly due to the risk that decreasing roughness will increase stream power, velocity and erosion.

Therefore, this geomorphic assessment of the creek has been undertaken to determine:

- the existing stability of the creek;
- the likely impacts of vegetation removal on stream regime and stability; and
- the type of works that can be undertaken to mitigate flooding impacts and maintain the waterway in an essentially stable state with natural rates of erosion and regeneration.

The findings and recommendations from this report will form an input into the Rapid Creek Condition Maintenance Plan, currently being prepared by Jacobs, and inform future decisions regarding the maintenance of the creek corridor.

A creek walk was undertaken on 5 May 2015. Vegetation, particularly *Syzygium angophoroides*, was found to play an important role in providing bank stability and preventing bank erosion. Additionally, rock bars were visible between Kimmorley Bridge and the Jingili Water Gardens Footbridge, and also aided in channel stability by preventing lateral movement of the creek. Downstream of Trower Road, the creek essentially becomes a Mangrove swamp, with a defined tidal channel. A major sewer crossing in this has the potential to impact flooding.

Overall, there do not appear to be significant blockages along Rapid Creek that could constitute a risk to increased flooding. However, vegetation blockages were observed between the Water Gardens Footbridge and the tidal zone upstream of Trower Road (where the greatest flooding impacts occur). These blockages are directing flow towards the eroding banks of the creek, resulting in sediment deposition and likely causing further erosion. Additionally, culvert blockages were observed upstream of McMillans Road and Henry Wrigley Drive.

As a result of these observations, the following recommendations are made for Rapid Creek:

- The efficiency of road crossings along Rapid Creek should be maintained to prevent blockages and avoid damage to these assets. Therefore, regular maintenance of blockages occurring within 15m upstream and downstream of the Henry Wrigley Drive culvert, Kimmorley Bridge (culvert) and Trower Road bridge should occur. This will provide a stable approach and exit to each structure.
- Investigate construction of Gross Pollutant Traps (GPT) at drainage inlets to reduce the amount of rubbish present in the creek channel.
- Investigate and manage instabilities in the vicinity of the Water Gardens Footbridge, including the removal of mid-stream vegetation blockages, and increase bank stability. A plan to reduce vegetation blockages can be developed as part of the Rapid Creek Condition Maintenance Plan.

It is not necessary (in most places) to remove fallen or leaning trees and logs, as was suggested in response to the 2013 arboreal survey of the creek. Removal of these trees will increase the creek channel capacity by a very marginal amount, and will not significantly reduce flooding impacts or frequency.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to describe the geomorphic assessment of Rapid Creek, in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Introduction

1.1 Project Setting / Rationale for Study

The Department of Lands, Planning and the Environment (DLPE) has engaged Jacobs to conduct a geomorphic assessment of the Rapid Creek corridor.

Rapid Creek is the largest freshwater system in the Darwin City Area and is highly valued by the Darwin community. The creek has experienced flooding (most recently in 2011) which has resulted in the inundation of residences in the suburb of Millner. The balance between mitigation of these flooding impacts and protection of the creek's ecological features is a strongly debated topic within both community and political groups.

In November 2013, Arafura Tree Services conducted an arboreal survey of the creek between McMillans Road and the Jingili Water Gardens. The study identified eighty-nine (89) fallen or leaning trees, predominantly Black Wattle (*Acacia auriculiformis*), that were obstructing the channel or were likely to obstruct the channel in the near future. In response to this survey, it was proposed that the identified tress might be removed or trimmed to decrease channel blockages and, potentially, improve the creek's ability to pass flows.

However, flood studies previously undertaken by SKM (now Jacobs) suggest that the removal of vegetation may have only marginal benefits in reducing flooding. Further, the removal of vegetation could have an adverse effect on the geomorphic stability of the waterway. This is partly due to the risk that decreasing roughness will increase stream power, velocity and erosion. Additionally, the removal of some vegetation (such as Mangroves) can be futile due to the extent of the maintenance required to prevent re-establishment.

Therefore, this geomorphic assessment has been undertaken to assess the existing stability of the creek and determine the likely impacts of vegetation removal on stream features and channel stability. The report will form an input into the Rapid Creek Condition Maintenance Plan, currently being prepared by Jacobs, and inform future decisions regarding the maintenance of the creek corridor.

1.2 Creek Location

Rapid Creek originates in the Marrara Swamp at the eastern end of Darwin International Airport (DIA). In this location the creek is confined through a flood control weir which attenuates peak discharge and delays floodwaters. Downstream, the creek flows north-west through riparian and open woodland and into estuarine reaches where it eventually discharges into the Beagle Gulf.

Road crossings of Rapid Creek occur at Henry Wrigley Drive, McMillans Road (Kimmorley Bridge) and Trower Road, as shown in Figure 1-1.

1.3 Project Scope

This report describes the geomorphic assessment of the Rapid Creek corridor from the Flood Control Weir to the sea. A creek walk has been completed with the aim of:

- assessing the geomorphic condition of the creek;
- identifying emerging issues; and
- identifying actions that can be undertaken to mitigate flooding impacts and maintain the waterway in an essentially stable state with natural rates of erosion and regeneration.

As a result, the creek was divided into five (5) geographic reaches with distinct geomorphic characteristics and issues:

- Reach 1 – the Flood Control Weir to the Yankee Pools;
- Reach 2 – the Yankee Pools to Kimmorley Bridge;
- Reach 3 – Kimmorley Bridge to Water Gardens Footbridge;

- Reach 4 – Water Gardens Footbridge to the tidal zone upstream of the Trower Road Bridge; and
- Reach 5 – the tidal zone upstream of the Trower Road Bridge to Casuarina Beach.

The area upstream of the Flood Control Weir was not included in the scope of this assessment.

A status report of the Darwin City Council drain outfalls along the creek (from the Flood Control Weir to the sea) will be provided as an appendix to the Rapid Creek Condition Maintenance Plan.

Figure 1-1: Rapid Creek catchment area

2. Reach 1 - Flood Control Weir to Yankee Pools

2.1 Reach description and map

Reach 1 extends from the Flood Control Weir to the Yankee Pools east of Henry Wrigley Drive, as shown below in Figure 2-1. The purpose of the Flood Control Weir is to attenuate peak discharges and delay floodwaters from the upstream catchment (including the RAAF Base Darwin). A pedestrian path runs alongside the creek (within 5-10m of the left bank) over the entire reach.

The Reach 1 riparian zone is several tree widths wide and, as a result, has some ecological value for the creek in what is otherwise an urban environment. The channel is relatively stable. Vegetation on the creek banks and within the riparian zone assists in maintaining this stability. The creek is a laterally active channel (meaning it is free to meander across the narrow floodplain in this reach), and has minor bed erosion and significant bank erosion. It is likely that the creek is partially confined by rock bars (which were not visible during the creek inspection).

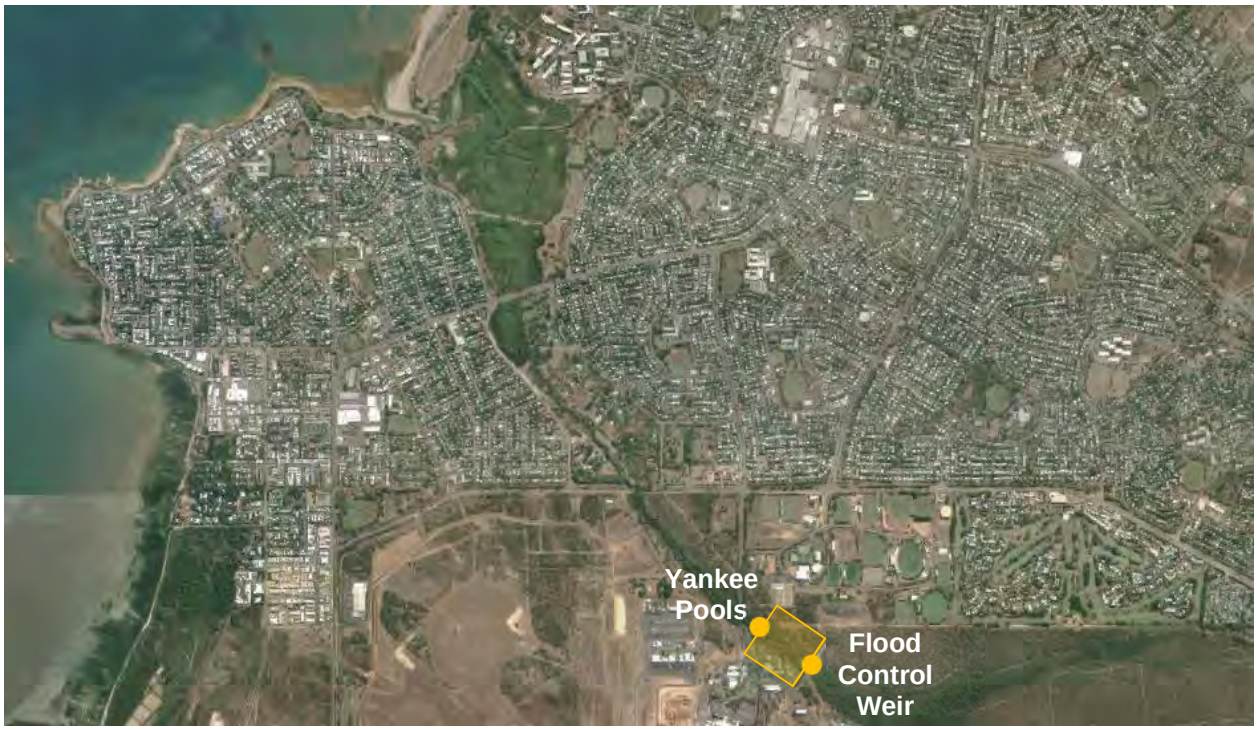


Figure 2-1: Location of Reach 1 – Flood Control Weir to Yankee Pools

2.2 Key Geomorphic Issues

Active bank erosion and isolated bed deepening are evident over much of Reach 1. This appears to be because the creek has become naturally channelized downstream of the flood control weir (leading to increased velocities) and because the limited presence of rock bars allows the channel to be laterally active. Additionally, there is some erosion of the pedestrian path running alongside the creek. The footpath poses a risk of further erosion in Reach 1 as it efficiently captures some overbank flows and acts as a flow path in high flow events.

It is expected that the flood control weir may trap some sediment and debris at the beginning of the reach, reducing the potential for debris blockages to develop downstream. This may also contribute to Reach 1 erosion because the water entering the reach has a low sediment load and, therefore, a higher potential to erode the channel.

There is some rock which has been mobilised from the flood control weir over a number of flood events and deposited in the channel further downstream in the reach (refer to Figure 2-2 (b)). This has a negligible impact on the capacity of the channel and should be left as is. The rock removal has created some unevenness on the face of the weir and has the potential to impact its structural integrity. However, the weir appears to be essentially stable and there is sufficient depth of rock (a minimum of two (2) rock diameters) to maintain structural integrity.

The removal of vegetation and logs from the channel in Reach 1 is not desirable, as this could decrease channel roughness, increase velocities within the channel and riparian zone, and further exacerbate bank erosion. Furthermore, many of the logs in the channel provide significant habitat for aquatic species, including fish. These logs do not have a build-up of debris around them, indicating they do not constitute significant channel blockages and will not have a significant impact on flooding.

Examples of the reach characteristics are given below in Figure 2-2.

(a) Flood control weir

(b) Creek channel (immediately downstream of the Flood control weir)

(c) Logs across the creek channel

(d) Pedestrian path

Figure 2-2: Photographs of Reach 1 – Flood Control Weir to Yankee Pools (5 May 2015)

(e) Localised bank erosion **(f)** Vegetation providing bank stability

Figure 2-2 (continued): Photographs of Reach 1 – Flood Control Weir to Yankee Pools (5 May 2015)

2.3 Key Recommendations

The following recommendations are made for Reach 1:

- Do not remove vegetation or logs. If required, some logs may be realigned to minimise localised instabilities.
- Encourage vegetation (particularly of *Syzygium angophoroides*) along the channel bank to improve long-term bank stability.
- Monitor erosion of the pedestrian path to ensure a scour channel is not formed. Consideration could also be given to re-grading the path, such that it no longer acts as a flow path in high flow events, or providing erosion protection along the path.

3. Reach 2 – Yankee Pools to Kimmorley Bridge

3.1 Reach description and map

Reach 2 extends from the Yankee Pools to Kimmorley Bridge and includes the Henry Wrigley Drive culvert crossing, as shown below in Figure 3-1. Within this reach the Rapid Creek channel has little bed or bank erosion. Like Reach 1, the creek is a laterally active channel and is partially confined by rock bars (which were not visible during the inspection). Vegetation on the creek banks and within the riparian zone, in particular the fibrous roots of *Syzygium angophoroides,* assist in maintaining bank stability.

Figure 3-1: Location of Reach 2 – Yankee Pools to Kimmorley Bridge

3.2 Key Geomorphic Issues

Similar to Reach 1, Reach 2 of Rapid Creek is inherently stable and has good ecological value, although the riparian zone is not particularly wide. Native trees *Syzygium angophoroides* are abundant in this reach and contribute to bank stability by creating a fibrous root mat. Rock bars are also present within the reach. This prevents bank and bed erosion due to high channel velocities.

There is little debris collected on fallen trees and logs, indicating that they do not contribute to significant blockages of the cross section. Additionally, there are some minor mid-stream islands present which appear to be stable, like the banks of the main channel.

A corroded galvanised pipe/utility crossing is located at water level upstream of the Henry Wrigley Drive culvert (refer to Figure 3-2 (e)), and creates a minor blockage. It is not likely to have any significant impact on flooding. However, it does capture some debris.

Upstream of the Henry Wrigley Drive culvert there also exists some minor debris blockages with the potential to reduce the efficiency of the crossing. Therefore, there is a need to maintain the channel immediately upstream and downstream of the culvert to remove blockages and ensure efficiency.

Furthermore, a large drain enters the creek from the west immediately upstream of Kimmorley Bridge. It appears that this outfall has contributed a sediment load to the location which, in turn, has become heavily vegetated. At present, the vegetated bar partially blocks the approach to the Kimmorely Bridge (culvert). This has the potential to impact the efficiency of the crossing and increase upstream flooding. Therefore, the outfall and surrounding area should be regularly maintained, like the Henry Wrigley Drive culvert, and sediment and vegetation should be removed. A consistent distance for debris relocation/removal at the Henry Wrigley Drive culvert and Kimmorley Bridge is provided in Section 7.

There may also be potential to construct a sediment trap in the drain to limit sedimentation immediately downstream in Rapid Creek.

Examples of the reach characteristics are given below in Figure 3-2.

(a) *Syzygium angophoroides* fibrous root mat

(b) *Syzygium angophoroides* fibrous root mat

(c) Logs (not constituting a significant blockage of the channel cross section)

(d) Mid-stream island

Figure 3-2: Photographs of Reach 2 – Yankee Pools to Kimmorley Bridge (5 May 2015)

(e) Pipe crossing upstream of Henry Wrigley Drive

(f) vegetation on deposited silt (immediately upstream of Kimmorley Bridge)

Figure 3-2 (continued): Photographs of Reach 2 – Yankee Pools to Kimmorley Bridge (5 May 2015)

3.3 Key Recommendations

The following key recommendations are made for Reach 2:

- Establish a debris and silt removal program in the vicinity of culverts that is consistent with other reaches. This can be achieved in the Rapid Creek Condition Maintenance Plan.
- Investigate opportunities to manage sediment inputs from the drain contributing to the blockage at Kimmorley Bridge.
- Investigate options to remove the small pipe crossing upstream of Henry Wrigley Drive, including directional boring to lower the pipe beneath the creek channel
- Do not remove *Syzygium angophoroides* and instead promote its growth

4. Reach 3 – Kimmorely Bridge to Water Gardens Footbridge

4.1 Reach description and map

Reach 3 runs from Kimmorley Bridge to the Water Gardens footbridge, located south-east of the Trower Road Bridge, as shown below in Figure 4-1. The reach is inherently stable due to the presence of a number of rock bars across both the channel bed and banks. Vegetation also assists in maintaining the stability of the reach. However, the rock bars appear to be the main stabilising feature.

A pedestrian and bicycle path runs parallel to the creek, on its western side, over most of the length of the reach. A gauging station is also present in this reach of the creek. This station features a concrete weir that forces a stable, measurable relationship between flow and water level. The weir appears to be stable and functioning. However, some maintenance, such as removal of debris in the vicinity of the weir, may be required to ensure ongoing accurate gauging.

Figure 4-1: Location of Reach 3 – Kimmorley Bridge to Jingili Gardens Bridge

4.2 Key Geomorphic Issues

Like Reach 2, *Syzygium angophoroides* is present throughout Reach 3 and appears to create a fibrous root mat which significantly aids in bank stability. There is also little debris on logs, which are not considered to contribute to significant blockages of the creek cross-section.

The creek appears relatively stable compared to other reaches. This appears to be due to the regular occurrence of rock bars maintaining bed and bank stability and limiting lateral erosion. As a result, the removal of vegetation within this reach may not cause significant instabilities. However, it would impact the ecological and visual values of the reach, the importance of which are demonstrated by the presence of the pedestrian and bicycle path. The visual amenity of the creek is impacted by the presence of rubbish and debris in a number of locations. This is due, in part, to a number of drainage outfalls in the reach which drain directly into the creek channel. These outfalls are stable. However, gross pollutant traps may improve the visual amenity and water quality of this reach.

The gauging station appears to be stable. However, if trees are not maintained in the vicinity of the structure, localised unstable hydraulic conditions may affect the approach flows to the weir and impact the ability to accurately gauge flow.

Examples of the reach characteristics are given below in Figure 4-2.

(a) Typical creek section with fibrous root mat creating bank stability

(b) Fallen trees (without captured debris)

(c) Creek section (with rubbish present)

(d) Rock bars

(e) Gauging station

(f) Pedestrian and bicycle path

Figure 4-2: Photographs of Reach 3 – Kimmorley Bridge to the Water Gardens Footbridge (5 May 2015)

4.3 Key Recommendations

The following key recommendations are made for Reach 3:

- Maintain vegetation (and potentially promote further vegetation) to improve the visual amenity and ecological values of the reach.
- Maintain outfalls and assess the potential to provide gross pollutant traps (to remove gross pollutants from the creek channel).
- Monitor and maintain creek blockages in the vicinity of the gauging station (if deemed necessary for efficient gauging)
- Establish a debris removal program in the vicinity of bridges consistent with other reaches. In particular, maintain an open channel 10-20m downstream of Kimmorley Bridge to maintain the structures efficiency (as discussed in Section 3)

5. Reach 4 – Water Gardens Footbridge to the Tidal Zone upstream of Trower Road

5.1 Reach description and map

Reach 4 runs from the Water Gardens Footbridge and the tidal zone upstream of Trower Road, as shown below in Figure 5-1. Although this reach is short in length, it is the section with the most visible instabilities. Historically, it also runs through the area subject to the greatest flooding impacts. Limited vegetation is present and a blocked drainage outfall at the downstream extent of the reach restricts the floodplain width and may contribute to instability. The location of the blocked drainage outfall is shown below in Figure 5-2.

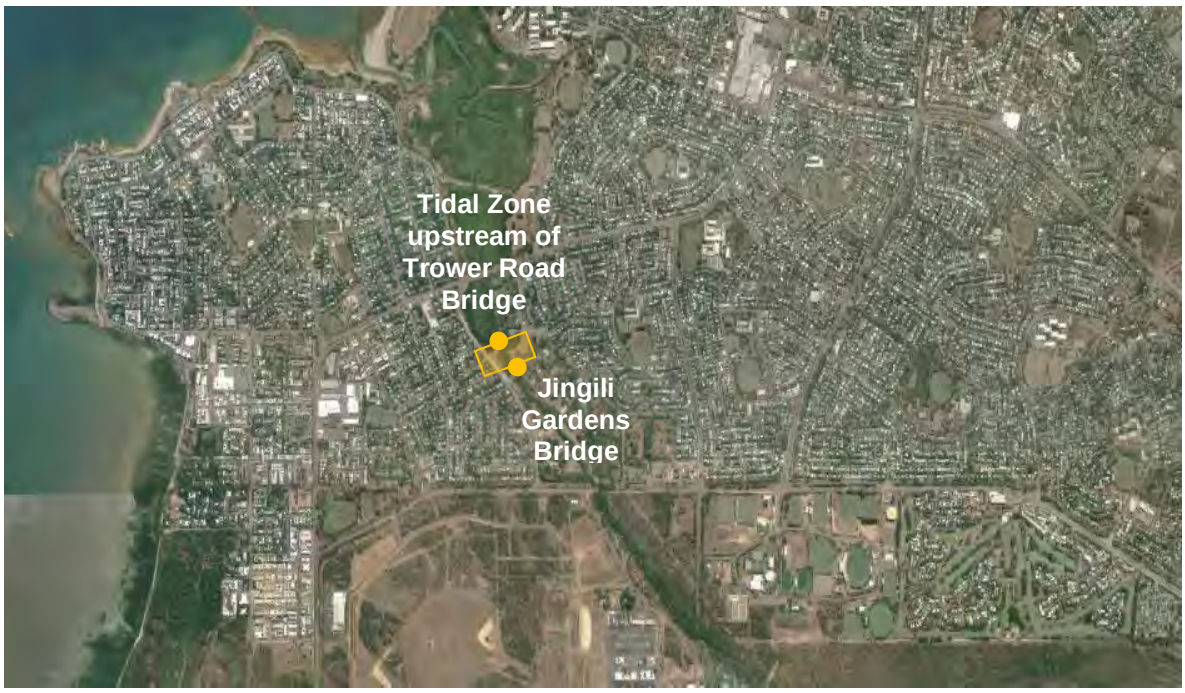


Figure 5-1: Location of Reach 4 – Jingili Gardens Bridge to Tidal Zone upstream of Trower Road

Figure 5-2: Location of the blocked drainage outfall in Reach 4

5.2 Key Geomorphic Issues

Significant lateral bank erosion is evident over much of Reach 4. This erosion appears to be caused by a number of issues including:

- a lack of observed rocky outcrops (particularly relative to Reach 3);
- localised mid-stream vegetation blockages which direct flow to the eroding banks and cause sediment deposition in locations such that further erosion occurs; and
- the blocked drainage outfall causing an increase in velocity in the immediate vicinity of the crossing and downstream headward erosion.

It appears some revegetation has been attempted in locations throughout the reach with limited success. To improve the stability of the reach, it is necessary to develop a plan to reduce vegetation blockages and redesign the drainage outfall or, alternatively, armour the bank with vegetation and rock protection.

Examples of the reach characteristics are given below in Figure 5-3.

(a) Water Gardens Footbridge (looking upstream)

(b) Dense vegetation causing localised blockages

(d) blocked drainage outfall

(c) bank erosion (as a result of the blocked drainage outfall)

(e) Attempted revegetation

Figure 5-3: Photographs of Reach 4 (5 May 2015)

5.3 Key Recommendations

The following key recommendations are made for Reach 4:

- Develop a plan that considers reducing vegetation blockages. This can be done as part of the Rapid Creek Condition Maintenance Plan.
- Control headward erosion at the drainage outfall
- Reconstruct the elevated drainage outfall pipe that restricts the floodplain width in this location and increases stream power in the channel. Alternatively, armour the creek banks with vegetation and rock protection

6. Reach 5 - Tidal Zone upstream of Trower Road to Casuarina Beach

6.1 Reach description and map

Reach 5 of Rapid Creek runs from the tidal zone upstream of Trower Road to Casuarina Beach, as shown below in Figure 6-1. There is dense Mangrove growth throughout this section of the creek, as is typical in estuarine habitats with salty tidal water.

Figure 6-1: Location of Reach 5 – Tidal Zone upstream of Trower Road to Casuarina Beach

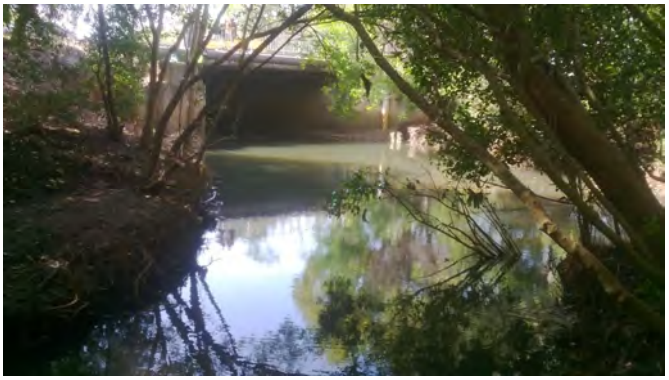
6.2 Key Geomorphic Issues

Reach 5 has sufficient gradient to allow an incised and defined channel to exist amongst the Mangroves. Mangrove root matter provides armouring to the bank of the creek, maintaining it in a relatively stable state. The channel capacity is relatively small in this reach, and minor flow events will cause inundation of the Mangrove swamp.

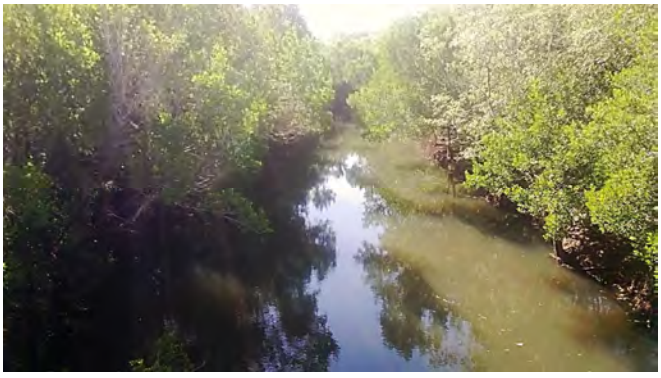
It is likely that Mangrove will remain the dominant vegetation type throughout Reach 5. Attempts to control Mangrove growth are likely to be unsuccessful as the extensive presence of Rhizome will lead to regrowth.

A major sewer crossing blocks the creek part way downstream of Trower Road. The crossing is elevated approximately 900mm above the creek bed. The removal or redesign of the crossing is likely to have a very large economic cost, and is unlikely to significantly increase channel capacity due to the limited cross-sectional area of the creek in this location. Removal or reconstruction of the sewer may increase the gradient of the channel upstream and, therefore, increase the creek's capacity to pass flows. However, the effects of this would not be seen upstream of Trower Road because the Trower Road bridge is a major restriction point for the creek. Furthermore, removal of the sewer will not reduce the risk of flooding the urban zone.

Examples of the reach characteristics are given below in Figure 6-2.

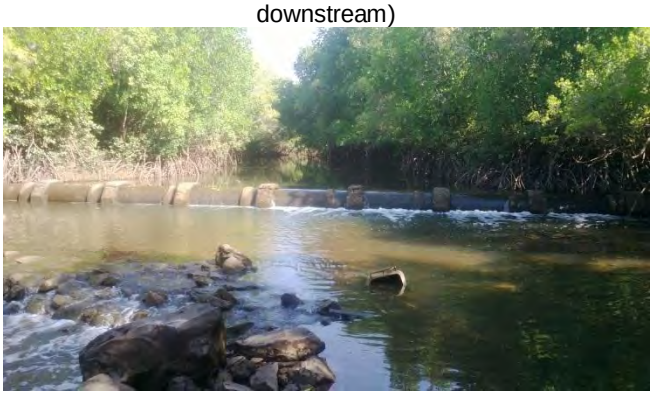


(a) Upstream of the Trower Road bridge



(b) Downstream of the Trower Road bridge (looking downstream)

(c) Typical vegetation (with Rhizomes)



(d) Sewer crossing (looking upstream)

(e) Downstream of the sewer crossing

(f) Channel cross-section (looking downstream towards Casuarina Beach)

Figure 6-2: Photographs of Reach 5 (5 May 2015)

6.3 Key Recommendations

The following key recommendations are made for Reach 5:

- Establish a debris removal program in the vicinity of Trower Road bridge consistent with that proposed for structures in other reaches.
- There are no immediate works which can be identified that would reduce the flood risk and assist in maintaining the channel. The channel is naturally self-scouring and is not greatly impacted by Mangrove. Therefore no physical works are recommended.
- Gross pollutant Traps at the many outfalls throughout the reach may also be considered in order to reduce the amount of gross pollutants in the creek.

7. Overall Findings and Recommendations

The following overall findings and recommendations are made for Rapid Creek:

- It is not necessary (in most places) to remove fallen or leaning trees and logs, as was suggested in response to the 2013 arboreal survey of the creek. Removal of these trees will increase the creek channel capacity by a very marginal amount, and will not significantly reduce flooding impacts or frequency.

- Overall, there do not appear to be significant blockages along Rapid Creek that could constitute a risk to increased flooding. However, vegetation blockages occur throughout Reach 4 (where the greatest flooding impacts occur). It is recommended that a plan to reduce vegetation blockages is developed for this reach as part of the Rapid Creek Condition Maintenance Plan (currently being prepared by Jacobs).

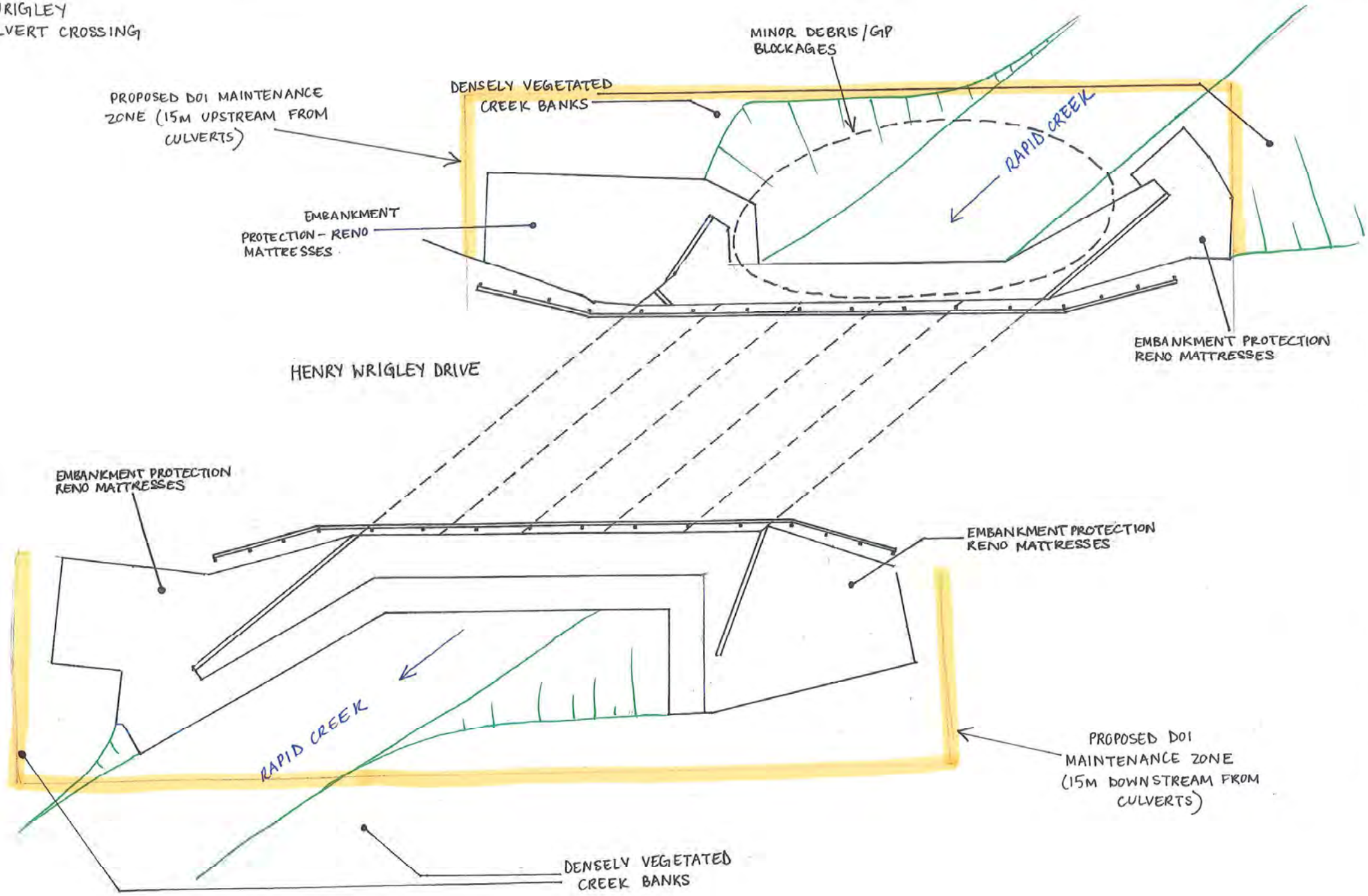
- The efficiency of road crossings along Rapid Creek should be maintained to prevent blockages and avoid damage to these assets. Therefore, it is recommended regular maintenance of blockages occur 15m upstream and downstream of each bridge, including Henry Wrigley Drive, Kimmorley Bridge and Trower Road (refer to Appendix A). This will provide a stable approach and exit to each structure.

- There is a significant amount of rubbish along the creek which can be partially attributed to drainage inlets. Construction of Gross Pollution Traps at drainage inlets should be investigated. This would be a matter for the Darwin City Council (DCC) and Darwin International Airport (DIA).

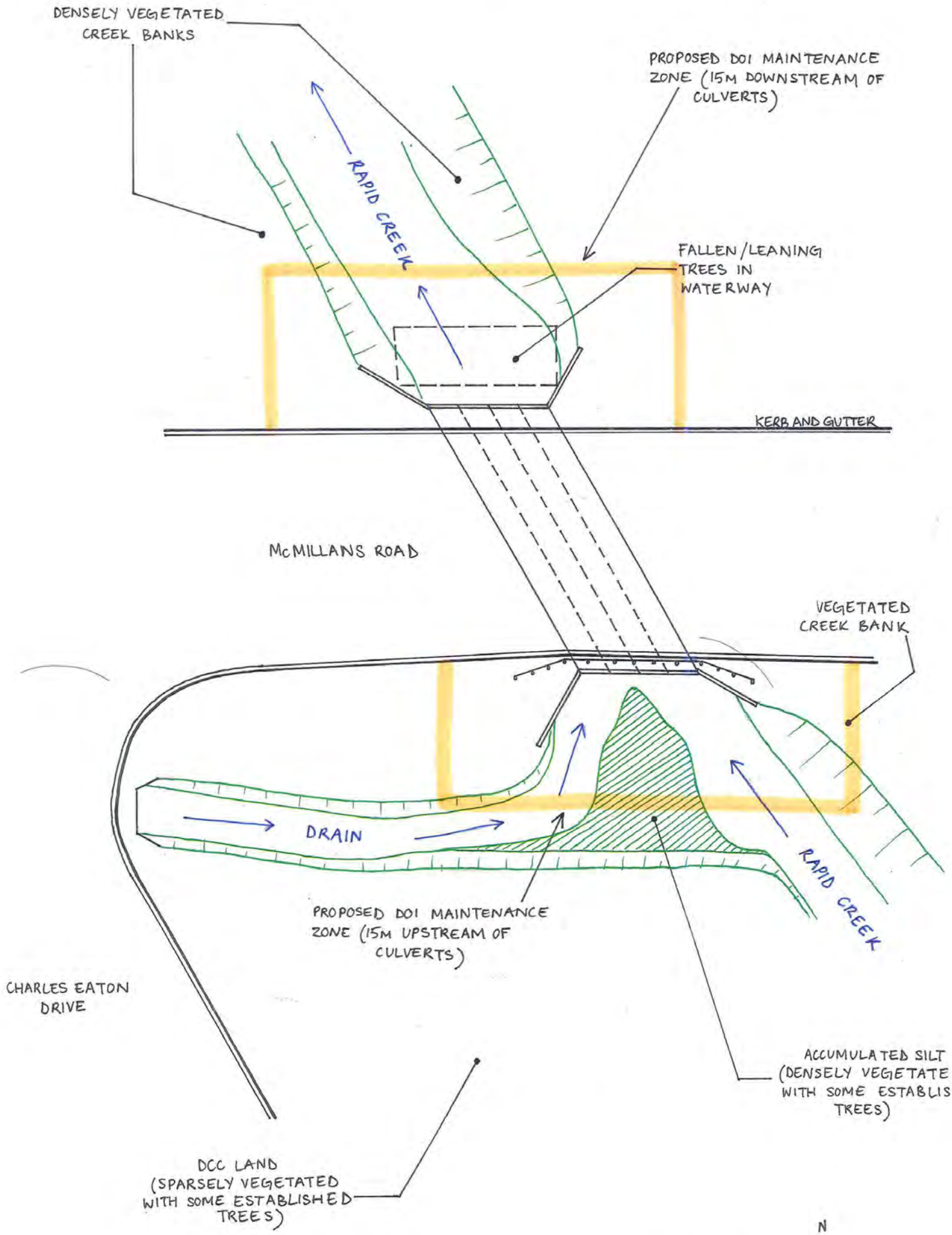
- Significant instabilities in the vicinity of the Water Gardens Footbridge should be further investigated and managed.

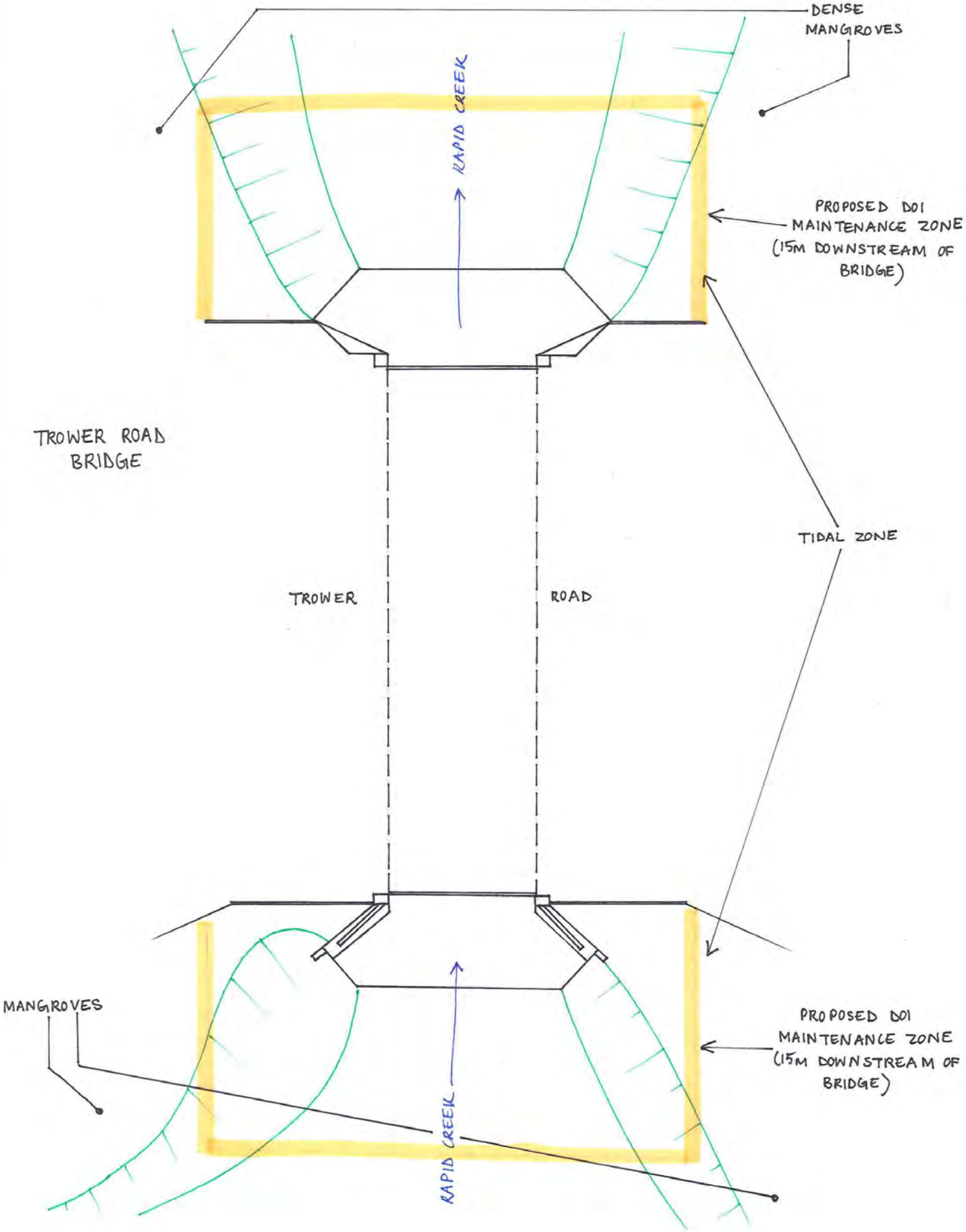
Appendix A. Proposed DOI Maintenance Zones at the Rapid Creek Major Structures (for further consideration)

HENRY WRIGLEY
DRIVE CULVERT CROSSING



McMILLANS ROAD CULVERT CROSSING (KIMMORLEY BRIDGE)




DENSE MANGROVES
RAPID CREEK
PROPOSED DOI MAINTENANCE ZONE (15M DOWNSTREAM OF BRIDGE)
TROWER ROAD BRIDGE
TIDAL ZONE
TROWER
ROAD
MANGROVES
PROPOSED DOI MAINTENANCE ZONE (15M DOWNSTREAM OF BRIDGE)
RAPID CREEK