Between bedrock and a hard place: Managing bank erosion in a constrained urban environment

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Key points
- Incorporating technology in waterway condition assessments.
- Accurately capturing baseline data to establish existing waterway condition.
- Managing erosion in constrained urban environments.

Abstract

Bank erosion in urban environments can pose a significant risk to infrastructure, private and public land and local ecology, with waterways typically having limited ‘room to move’ in these highly constrained environments. Toongabbie Creek, a significant tributary to the Parramatta River had undergone bank erosion following successive weather events. The City of Parramatta requested a systematic (and repeatable) creekbank survey to identify existing erosion sites throughout the reach.

A bank erosion survey was conducted on foot and supplemented with a video survey captured by drone to understand existing conditions at the site. The waterway was broken down into sub-reaches with each being assigned a ‘good’, ‘moderate’ or ‘poor’ based on existing condition. A risk assessment was undertaken on the low and moderate condition sub-reaches, by examining threats and their likelihood of occurrence, which was used to determine the priority sites for targeted intervention.

This paper presents the learnings of this project, which ultimately resulted in the development and delivery of a repeatable creekbank survey to assist council in tracking bank erosion in a sensitive, urban environment.

The interface between the waterway corridor and the urban environment is often a sensitive area, typically with an inadequate buffer zone. Erosion that progresses out beyond a natural state of equilibrium and without adequate control mechanisms may pose a significant risk in urban environments where infrastructure is often adjacent to the Top of Bank. Providing council with a tool for monitoring and categorising bank erosion will improve their ability to manage, prioritise, and respond to the risk.

Keywords

Bank erosion, erosion management, technology

Introduction

Erosion is a natural process within waterways, however, clearing of vegetation and changes to the hydrological regime can result in accelerated bank erosion and loss of land, which is particularly problematic in constrained urban environments. Whilst erosion is a naturally occurring process, anthropogenic changes to a system can exacerbate this process, altering the natural hydrological regime of a catchment. This often includes an increase in impervious surfaces which subsequently causes decreased lag times and increased flow rates. Waterways situated in these urban environments often lack native vegetation and the lateral ‘room to move’ present in unmodified settings and bank and bed erosion can impact infrastructure and private land.

Since the late 1700’s Toongabbie Creek has been subjected to human impacts, initially significant land clearing for agricultural purposes before the establishment of residential and industrial land usage. Although riparian vegetation density and continuity have improved since then, urbanisation has limited the width of the riparian zone and invasive species are abundant throughout the creek. Construction of private and public assets has largely been undertaken close to the Top of Bank, increasing the risk and impact of bank erosion and elevating the significance of correct management practices.

The City of Parramatta commissioned an Erosion Management Plan (EMP) for an 8km reach of Toongabbie Creek, upstream from its confluence with the Parramatta River. This paper summarises the key findings of that investigation and discusses their implications for urban waterway management.

Components of the EMP

Given the constraints and environmental factors present along the creek, it was important to deliver a program that would enable CoP to accurately monitor the condition of the reach in-house so that any acute changes could be quickly identified and responded to. The first step was to understand the existing condition of the creek to establish a baseline against which future changes could be compared. As such, the EMP was informed by the following tasks:

- Design and implementation of a systematic (and repeatable) creekbank survey that identified existing erosion sites along both banks of the 8km reach, including:
- Desktop condition assessment using LiDAR, historical imagery and GIS Layers.
- On ground condition assessment.
- Mapping, ranking and prioritising sites along the reach based on their condition and proximity to threatened infrastructure, services, property, and vegetation.
- Identification and development of appropriate potential mitigation measures for priority sites along with the estimate cost of implementation.

Systematic, repeatable creekbank survey

A desktop analysis was initially undertaken to characterise the study area and identify points of interest for further investigation during the on-ground assessment. Multi-temporal LiDAR was used to identify topographic changes that had occurred, including erosion and deposition of material (Figure 1).

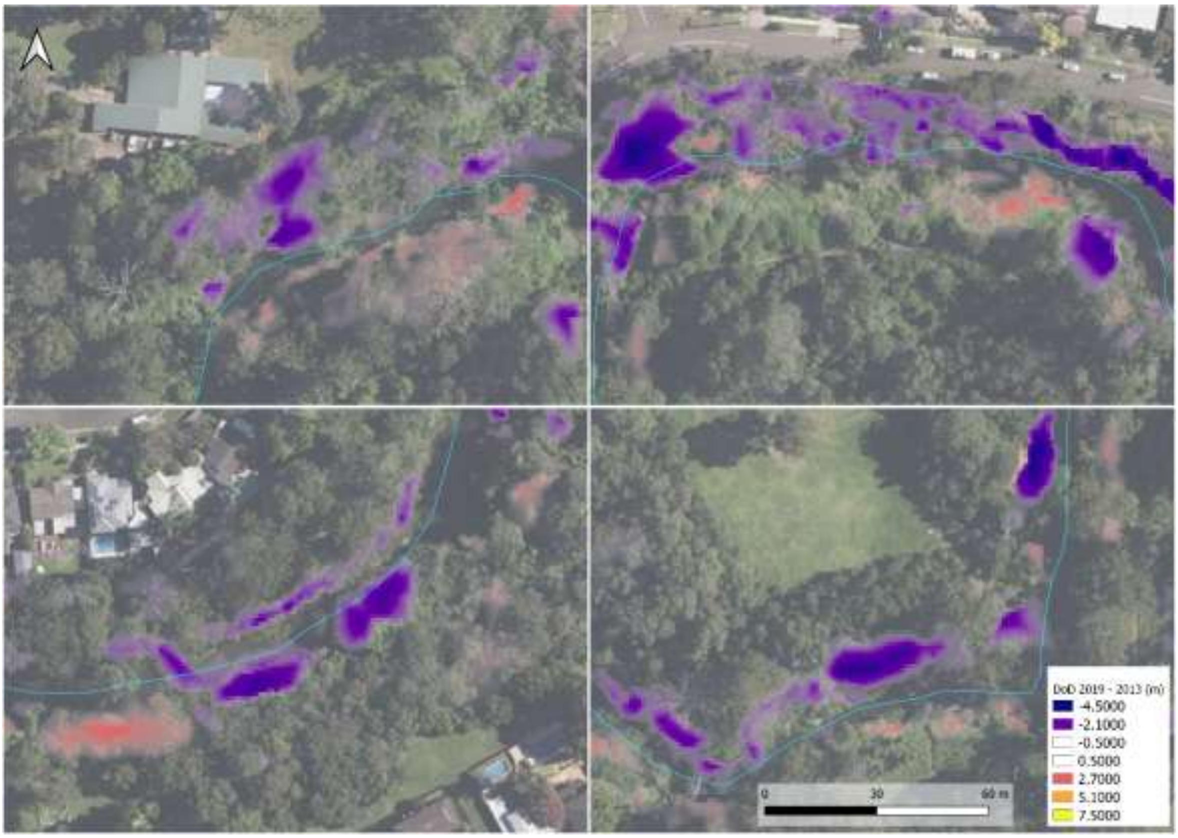

Figure 1 Multi-temporal LiDAR analysis of a sub-reach of the study area

Bed slope analysis is a useful tool to identify historic or active bed deepening (incision) within the waterway, however, where water is present in the channel during LiDAR capture can be problematic as the level of the water surface rather than the underlying channel bed is captured, making it difficult to identify pools and bedrock controls without field observation. Figure 2 shows the bed slope analysis for the 8km study reach.

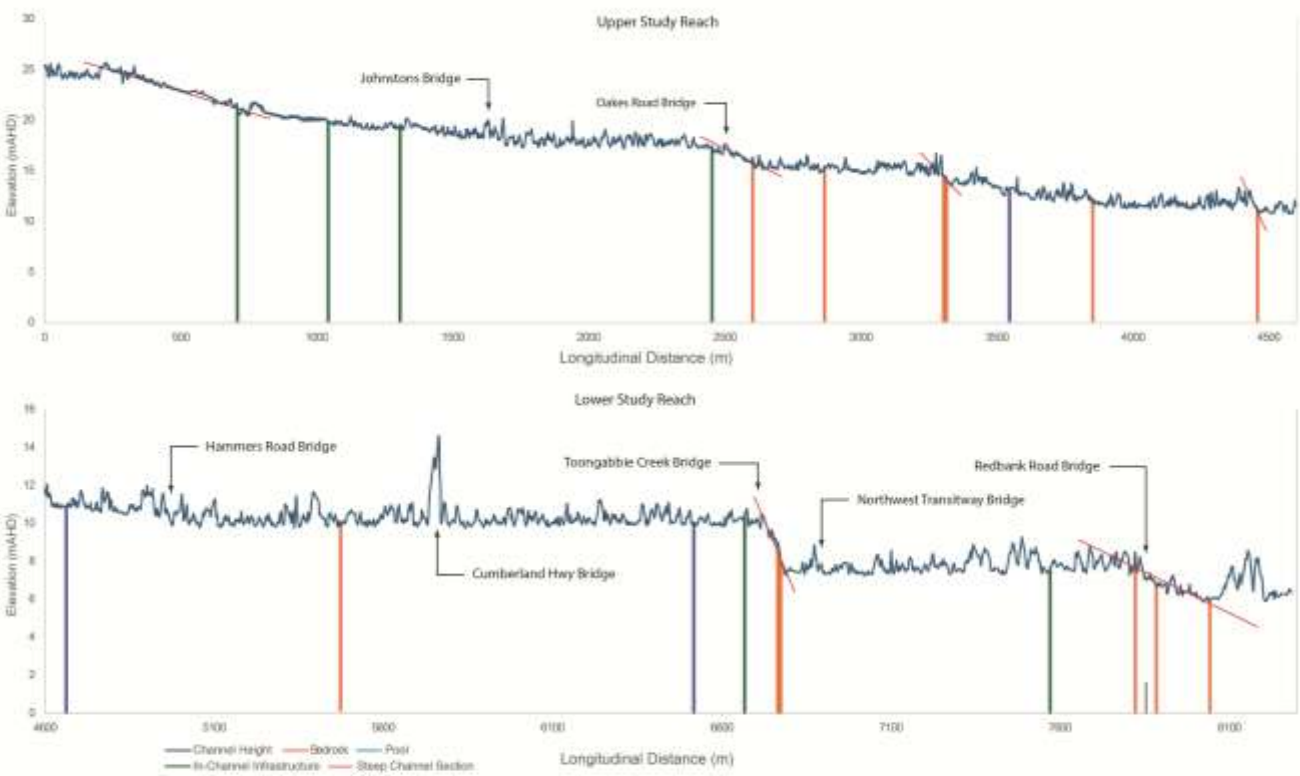

Figure 2 Bed slope analysis (based on LiDAR derived water surface height)

Vegetation within the waterway corridor serves an important function to the health and resilience of the waterway. An ecological vegetation assessment was carried out, focusing on classifying Plant Community Types (PCT's), identifying the presence, continuity and density of native species, and identifying invasive species and their proliferation and impact on native vegetation. In addition, vegetation density mapping (Figure 3) was prepared and filtered for specific canopy heights, to indicate the presence of significant, woody tree species that are important for soil stability cohesiveness.

Figure 3 Vegetation density for species over 5m within a section of the project area (Source: 2022 1m LiDAR

The on-ground survey recorded bank erosion type, bank material, vegetation condition, and presence of controls such as bedrock bars/outcrops or existing erosion control structures. Important features nominated during the desktop assessment were mapped for on-site investigation. Field teams mapped observations using ArcGIS mobile field mapping and recorded through photography and field notes. A full drone survey of the study area was also undertaken to capture areas that couldn't be accessed on foot and to provide additional perspective of the reach.

Site prioritisation

Ultimately, the creekbank survey was used to delineate sub-reaches in the study reach and to inform site condition ranking and prioritisation for intervention. Site prioritisation was undertaken in three stages:

1. **Initial Condition Ranking,** undertaken to delineate and rank sub-reaches of the study area based on physical condition.
2. **Risk Assessment** for the sub-reaches classified as moderate or poor was based on the likely future trajectory of the sub-reach with weighted values given to bank condition, vegetation condition, the location of the sub-reach within the waterway (i.e. outer bend). The presence and proximity of infrastructure to the waterway was also considered along with the value of these assets.
3. **Site prioritisation** for sites classed as medium, high or extreme risk including consideration of the future trajectory of the reach based on:

    - Erosion process and extent of the observed degradation
    - Presence or absence of factors that will naturally arrest or slow erosion such as bedrock and dense riparian vegetation.
    - Nature, significance and value of adjacent infrastructure.

Management Options Analysis

The final step of the EMP was determining management options for sites of medium and high risk, accounting for site constraints such as accessibility, constructability and co-benefit. Management options included ongoing monitoring of specific locations to high level concept design of intervention strategies such as rock armouring, bank reprofiling and reinstatement, and revegetation and weed management.

Findings

Ultimately, the study reach was found to be in a moderate to good condition considering the long history of modification to the hydrology of the site. A lack of riparian and ToB vegetation and, location on outer meander bends were the most common contributor to poor bank structure. The modified hydrological regime of the catchment has resulted in increased magnitude of flood flows, with urbanisation contributing to reduced response times during rain events and reduced sediment inputs. Bedrock bars and outcrops were found in multiple sections throughout the reach (Figure 4), indicating that large-scale channel incision is unlikely to occur in the future, although localised bed deepening may still occur. Bank erosion largely appeared to an event-based response during high flow events, which are likely to increase in both severity and frequency due to climate change. Vegetation found throughout the study area was dominated by invasive species which appeared to be inhibiting the establishment and continuity of native species, with ongoing weed management nominated as an effective management tool. Developing a robust baseline condition of the site to inform the EMP enabled CoP to prioritise initial works and justify and secure funding. Providing a tool and method with which they can undertake ongoing monitoring of waterway condition, the long-term overheads associated with engaging consultants for routine monitoring were removed, enabling funding to be directed to direct management.

Capturing a detailed drone survey of the study area provided an unparalleled perspective of the waterway condition, providing a means to revisit specific locations, or view areas that were unable to be accessed on foot and allowed us to compare sub-reaches using side-by-side video footage to better inform the condition assessment. This proved to be an invaluable tool in prioritising the locations for intervention.

Figure 4 Drone capture of bedrock within the study reach

Conclusions

This paper provides an example of the importance of undertaking robust desktop and field investigations when determining waterway condition in a constrained urban environment. The benefits of employing modern technology and methodologies to establish a baseline condition can be used to better inform future management practice.

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