Erosion explosion: a journey down Brisbane's most eroded creek

Sheyanne Frisby[1], James Teague[2], Misko Ivezich[2]

1 Alluvium, Brisbane, QLD, 4006. Email: sheyanne.frisby@alluvium.com.au

2 Alluvium, Byron Bay, NSW, 2479. Email: james.teague@alluvium.com.au and misko.ivezich@alluvium.com.au

Key Points

- Oxley Creek is one of the most actively eroding waterways in South East Queensland and includes a series of lake systems which are remnants of sand mining.
- Hydraulic result highlights the challenges of developing a rehabilitation plan due to the low energy zones within the lakes which trap coarse sediment and limit sediment supply to downstream reaches.
- By considering the broader system, a better understanding of the ecosystem services can be established helping to identify beneficiaries of works and potential funders

Abstract

Brisbane's Oxley Creek has been heavily impacted by sand mining in the late 20th century which has triggered major channel incision. Compounded by pressure from dense and rapid urbanisation in the catchment, Oxley Creek is now one of the most actively eroding waterways in South East Queensland with approximately 700,000 m^3 of sediment lost from 13 km of stream between 2009 and 2023. The erosion is having major impacts on water quality, instream and riparian health, built assets and the social amenity values of the urban waterway.

A series of geomorphic investigations occurred either side of the 2022 Brisbane flooding allowing erosion from a single event to be assessed. Other investigations included a reach scale bed grade assessment, hydraulic and sediment transport potential modelling, along with an ecosystem services evaluation.

Broad reach scale management is required when assessing complex and highly modified systems. This includes considering sediment transport continuity through the system to understand where sediments might deposit depending on their particle size. The assessment also highlighted the importance of transboundary waterway management with Oxley Creek spanning two major local government areas and an active Defence training base. By considering the broader system, a better understanding of the ecosystem services impacted by stream erosion can be established. This helps to identify beneficiaries of works and potential funders by quantifying the economic benefits of rehabilitation. Demonstrating the ecosystem services provided to beneficiaries can increase the feasibility of large reach scale management programs resulting in better environmental and economic outcomes.

Keywords

Erosion, geomorphology, waterway management, sand mining, Oxley Creek, rehabilitation, ecosystem services, sediment transport

Introduction

The Oxley Creek catchment is an integral natural asset within Brisbane that provides important environmental, social, and economic values to the region. Changes to hydrology and sand extraction has led to widespread channel incision within lower Oxley Creek which has resulted in catastrophic channel change and impacts on the environmental, social, and economic values. This paper summarises recent geomorphic investigations and rehabilitation feasibility assessments for Oxley Creek.

Background

Oxley Creek is approximately 70 km in length and is a major tributary of the Brisbane River. The headwaters rise in the granite uplands of Mount Perry and flow in a north easterly direction to its confluence with the Brisbane River at Tennyson. The Oxley Creek catchment is approximately 270 km² that spans two main local government jurisdictions: Logan City Council and Brisbane City Council (BCC) and extends into Ipswich City Council (ICC) at its headwaters. The catchment area that sits within the LCC and ICC is approximately 120 km² and contains the upper and mid reaches of Oxley Creek with the lower reach spanning 150 km^2 sitting within BCC.

Oxley Creek itself has a largely intact riparian corridor, as such the waterway provides recreational opportunities and urban cooling for the suburbs adjoining it as well as residual habitat for terrestrial and aquatic fauna. The major tributaries, also maintain a reasonable riparian vegetation corridor through the forested hillslopes and the urbanised areas in the mid and lower catchment. The Greenbank Military Training Area is located in the mid catchment. Areas of the floodplain within the Greenbank Military Training Area are nationally important wetlands containing predominately coastal and sub-coastal floodplain tree swamp habitat.

The Greenbank Military Training Area was acquired for Military purposes in the 1950's. Prior to the acquisition, the land was used for logging and cattle grazing although it is also understood that the area may have also been used for some military purposes during World War 2, prior to its acquisition. Today, the land continues to be used for military training but also serves as a flora and fauna reserve and is relatively undeveloped.

The Oxley Creek catchment has undergone extensive and rapid changes over the years since European settlement. The mid to lower catchment has been heavily impacted by urbanisation which has changed runoff characteristics. Additionally, there are several online and offline lake systems along Oxley Creek which are the remnants of large-scale sand extraction.

Oxley Creek is Brisbane's only sand-based creek. These sand deposits both within the channel and floodplain were extensively mined during the later 20th century, resulting in the creation of a series voids. These voids are now the lakes that characterise much of the lower reaches of Oxley Creek. However, their effects are much more extensive. The extraction of sand from the stream channel has triggered major channel instabilities and channel metamorphosis in several areas with extensive erosion still occurring (Figure 1).

Figure 1. Oxley Creek in the upper erosion zone through the Greenbank Military Training Area

Despite poor condition of large sections of Oxley Creek, there are several locations that offer significant value. Communities benefit from Oxley Creek's recreational value such as fishing, canoeing, rowing and skiing. The many lakes offer access and proximity to green space and parklands which are important for community health and wellbeing.

Oxley Creek and its extensive riparian corridor support healthy terrestrial and aquatic ecosystems. Much of the creek is classified as core koala habitat, including all the Greenbank Military Training Area which consists of 45 km^2 of bushland reserve (Figure 2). There have been several native fauna species sighted within the catchment including some listed as endangered under the *Queensland Nature Conservation Act* (1992) or the *Federal Environmental Protection and Biodiversity Conservation Act* (1999). Sightings have included the swift parrot, spotted-tailed quoll, easter grey kangaroo, glossy black cockatoos, powerful owls and grey headed flying foxes (Markwell, K. et al. 2020). There are 50 native fish species which have been recorded within the Greater Brisbane catchment, of which 44% require unimpeded movement between estuarine and freshwater habitats to complete their life cycle or maintain their species distribution (Markwell, K. et al. 2020).

In addition to the community and ecological values of Oxley Creek, it also offers natural management of nutrient runoff from the expanding urban areas that surround it offering the protection of Moreton Bay from sediment pollution.

Figure 2. Oxley Creek with Brisbane City in the background

Historical channel change

The Oxley Creek area assessed has been divided into six zones as shown in Figure 3. The upper erosion zone is primarily comprised of the Greenbank Military Training Area which is upstream of the Greenwood Lakes (Mid deposition zone). The lower erosion zone extends from the Larapinta Polo Club Lakes towards Learoyd Road which also includes the Paradise Lakes.

Multi-temporal aerial imager analysis

Historical imagery shows that sand extraction started in the middle to late 1960's around the Greenwood and Paradise Lakes with the impact on Oxley Creek apparent almost immediately, particularly within the upper erosion zone. A historic imagery analysis between 1946 and 2023 enabled the headward progression to be plotted so an estimated erosion rate could be determined. The distance of erosion progression was based on an assessment of channel width and bed visibility. As Oxley Creek has eroded, the width of the creek has increased significantly, allowing the visual assessment to be undertaken. The results of this assessment are shown in Figure 3 with arrows indicating the erosion extent for each year assessed within the lower and upper erosion zone.

It is estimated that the headward progression of streambed incision within the upper erosion zone of Oxley Creek is occurring at a rate of approximately 149 m per/year. In the lower erosion zone, the headward incision was moving at an approximate rate of 23 m per/year until the early 2000's where progression appears to have significantly accelerated to a rate of approximately 123 m per/ year.

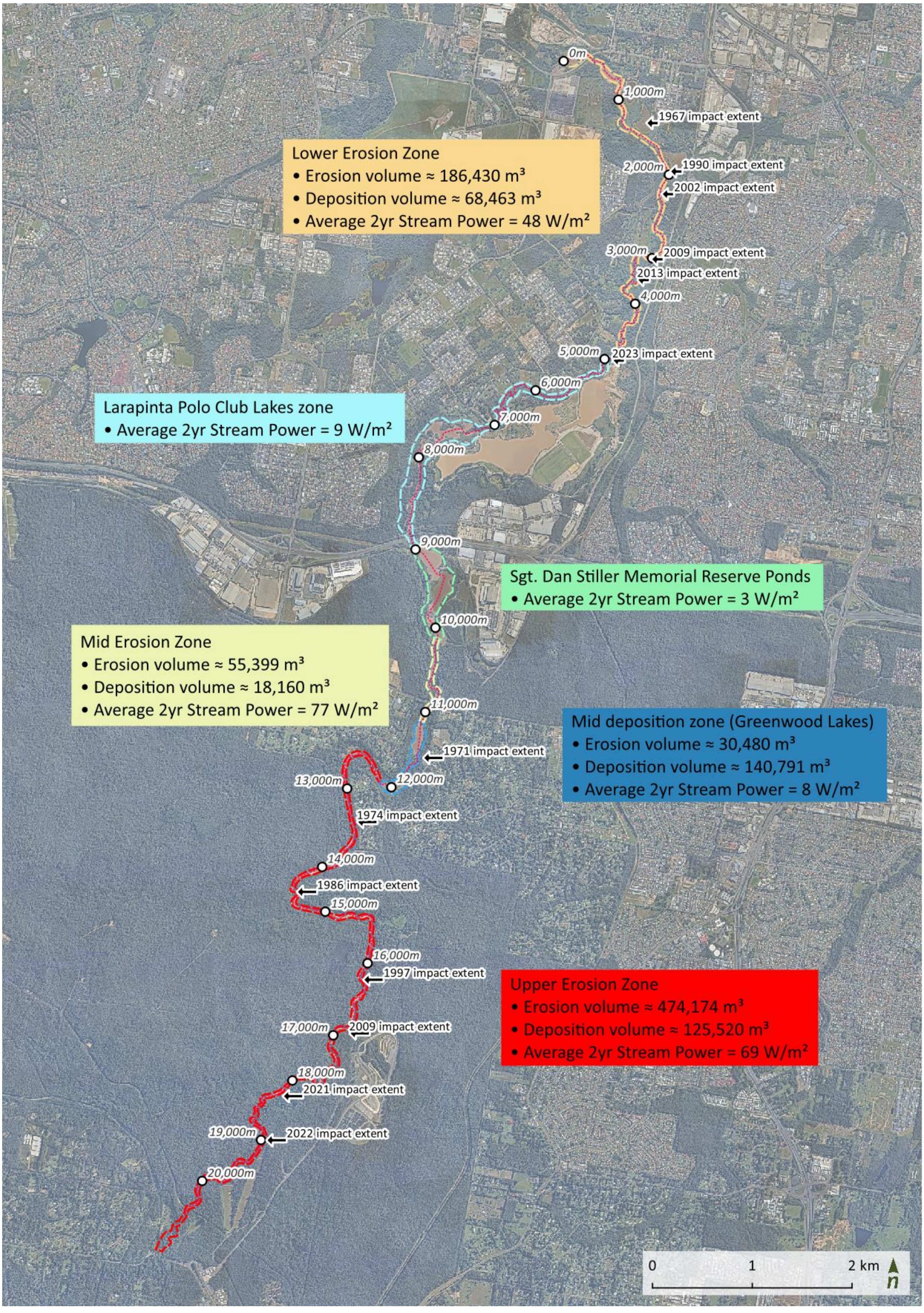

Figure 3. Key waterway zones, erosion, deposition and stream power results and headward progression year indicators derived from historical imagery (Imagery: Nearmap 2024).

LiDAR analysis

The headward progression of streambed incision has resulted in a cross-sectional profile that is far wider and deeper than its pre disturbed form. Figure 4 shows the typical pre-disturbed and incised channel form for Oxley Creek. There has been between a 135 to 185 m^2 increase in cross sectional area within the erosion zones.

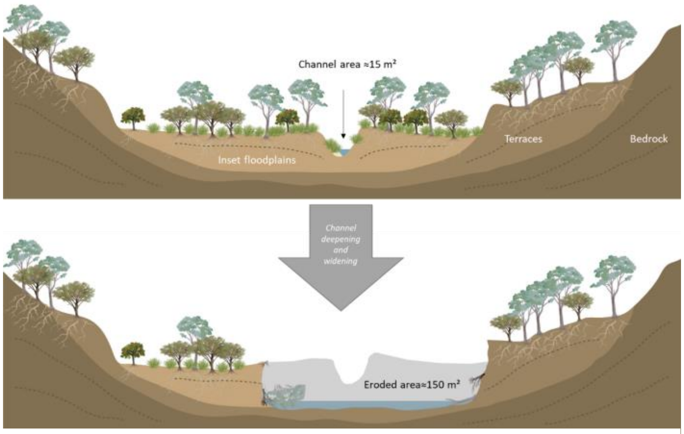

Figure 4. Increase in cross-sectional area as a result of channel change, top diagram shows the pre-disturbed cross sectional channel area, and the bottom diagram highlights the eroded area

LiDAR provides a good indication of the extent and quantity of channel change that has occurred between a particular time period. LiDAR from 2009 and 2023 was used to develop a DEM of difference (DoD) which was then used to quantify the amount of erosion occurring over the 14-year period. The results of this assessment are provided in Figure 5 which shows the extents of erosional and depositional zones. Vertical elevation change (due to lateral bank retreat) in excess of three metres is visible across the majority of the upper, mid and lower erosion zones along with deposition up to three meters within the Greenwood Lakes mid deposition zone. Deposition quantities in the Greenwood lakes are subject to some changes in water level, however visual inspections of this are indicate that it is filling with sediments. Deposition within the Sergeant Dan Miller Memorial Reserve Ponds and the Larapinta Polo Club Lakes is difficult to quantify due to their permanent water levels, however extensive deposition is likely to be found in both lakes.

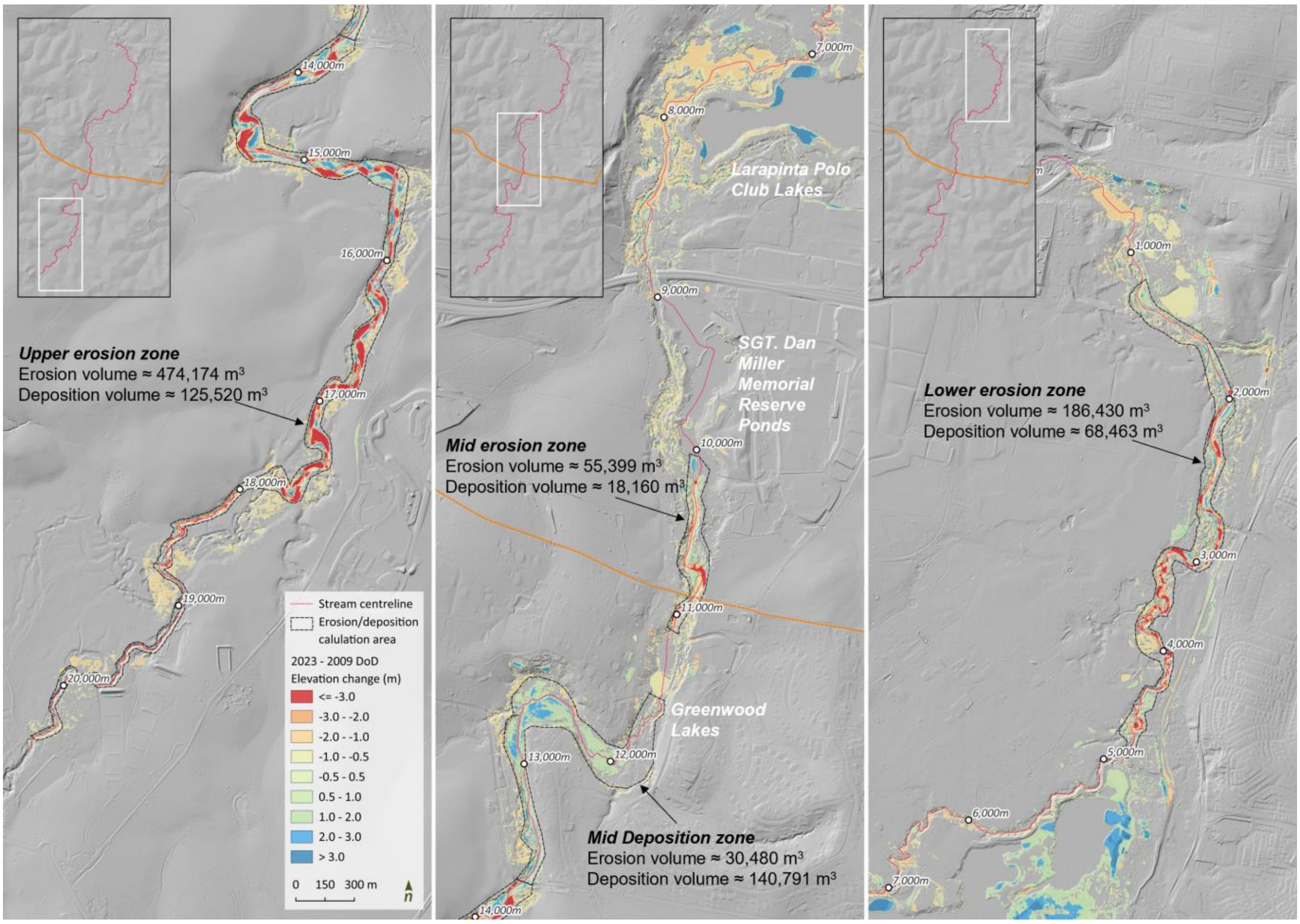

Figure 5. Oxley Creek DoD between 2009 and 2023 showing erosion and deposition volume estimates

Sediment transport and storage processes

Hydraulic and sediment transport potential modelling was undertaken using HEC-RAS 2D to understand the velocities, stream power and shear stresses occurring in Oxley Creek and to determine how sediments were being transported through the complex lake systems.

Mean and median results were determined for key zones within Oxley Creek for hydraulic outputs including velocity, stream power and shear stress (Table 1). These results were calculated from the model results within the channel boundary only.

The results highlight large variations in sediment transport capacity within different sections of Oxley Creek. There is very low stream power, and as a result, low sediment transport capacity between the Sergeant Dan Stiller Memorial Reserve Ponds and the Larapinta Polo Club Lakes which accounts for 5 km of the waterway. There is also a large drop in stream power between the upper erosion zone and mid deposition zone.

Table 1. Summary of model results within each zone for the 2 year and 5 year ARI events

Zone	Velocity (m/sec)				Stream power (W/m^2)				Shear stress (N/m^2)			
	2 year ARI		*5 year ARI*		*2 year ARI*		*5 year ARI*		*2 year ARI*		*5 year ARI*	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Upper erosion zone	1.2	1.3	1.4	1.4	69.0	52.6	89.5	63.7	44.8	41.8	52.5	46.7
Mid deposition zone	0.6	0.6	0.7	0.7	7.9	3.0	10.6	4.3	9.9	5.8	11.9	7.2
Mid erosion zone	1.2	1.1	1.3	1.3	77.1	42.4	107.3	57.3	46.1	37.3	56.4	44.2
Sergeant Dan Stiller Memorial Reserve Ponds zone	0.4	0.4	0.5	0.5	2.6	0.4	3.8	0.8	3.1	1.2	4.1	1.7
Larapinta Polo Club Lakes zone	0.5	0.4	0.6	0.5	9.1	1.6	14.2	2.9	9.7	4.2	13.3	6.5
Lower erosion zone	1.0	0.9	1.0	1.0	48.2	22.5	53.8	25.8	33.3	25.3	35.9	27.1

The hydraulic modelling results in combination with several site visits to various locations along Oxley Creek suggest that the system, while eroding, is experiencing an overall lack of sediment supply. The upper erosion zone within the Greenbank Military area has a low sediment supply from the upper catchment, which is undeveloped, well vegetated, and not eroding. Oxley Creek through this zone will continue to erode and channel recovery is expected be slow given the current channel morphology and stream power. The sediment that is lost through this zone is then trapped in the mid deposition zone within the Greenwood lakes with model results showing that sediments are not readily mobilised, even during a flow event.

This process continues through the mid erosion zone with sediments becoming trapped within the Sergeant Dan Stiller Memorial Reserve Ponds zone. Continuing downstream, modelling indicates that as much as 90% of the total flow approaching the Larapinta Polo Club Lakes zone enters the lakes rather than continuing down the Oxley Creek channel. This would result in any remaining sandy sediments likely falling out of suspension through these extensive lakes, starving the lower erosion zone of coarse sediment supply. The reduction of coarse sediment supply can result in increased rates of channel erosion and reduce rates of channel recovery (Kondolf, G.M. 1997).

Several assessments including extensive site visits and aerial and drone imagery analysis suggest that while some sandstone bedrock has been exposed within the channel margins, no large areas of hard bedrock bed controls have been identified. It is therefore assumed that there are no formations sufficient to halt the progression of erosion from continuing upstream in any of the assessed zones. There is an old informal weir structure which was found at the upstream extents of the Greenbank Military Training Area. No detailed information was available on this structure; however, a visual assessment indicates it is unlikely to stop the progression of incision.

Rehabilitation feasibility assessment

Ongoing erosion within both the lower and upper erosion zones will have significant impacts both environmentally and to infrastructure including significant fine sediment and nutrient delivery to Moreton Bay. A 2024 study by Grinham, A. et al. confirmed that fine sediment deposition has been found across 98% of Moreton Bay presenting a 'significant threat to ecosystem health'. Erosion may also lead to potential breaching of the lakes system which will have environmental, flooding, water quality and amenity consequences.

Furthermore, there are several assets which have the potential to be impacted by the erosion. These include a number of assets which may impact the operation of the Greenbank Military Area including two range bunds, a bridge and a low-level creek crossing. If the incision propagates upstream of Greenbank Military area it has the potential to impact on public assets such as electricity poles, roads, bridges and utility infrastructure.

Continued erosion also threatens the amenity of the creek and lakes that the local community enjoy and value. Environmentally, the continued bank erosion and loss of vegetation will result in perverse outcomes for Oxley Creek overall. However, developing a rehabilitation plan for the creek proves challenging due to the complex issues that are occurring and lack of sediment supply to both the upstream and downstream erosion zones.

The recommended next steps in developing a rehabilitation strategy include:

- Assess the geomorphic trajectory of Oxley Creek without management
- Identify all asset and values which are likely to be impacted (roads, bridges, private property, defence assets, environment/social assets/values etc.)
- Gather cost implications of a do-nothing scenario based on outcomes of a workshop
- Undertake an economic analysis to estimate the economic impacts of the do-nothing scenario
- Identify options for stream management and undertake an assessment of risks

The importance of adopting an ecosystem services framework for business case

Ecosystem services are essentially the goods and services derived by humans from the environment (the natural capital in this case, the waterway and adjacent floodplain ecosystems). According to the Common International Classification of Ecosystem Services (CICES) presented Haines-Young and Potschin (2018), ecosystem services are typically categorised into four types:

- Social and cultural services: service directly experienced by humans (e.g., recreation, tourism, and aesthetic appreciation).
- Provisioning services: services that describe the material or energy outputs from ecosystems (e.g., commercial fishing within Moreton Bay).
- Regulating services: the services that ecosystems provide by acting as regulators (e.g., carbon sequestration).
- Supporting services: services that underpin other ecosystem services categories (e.g., habitats or species and maintenance of genetic diversity).

The application of a robust ecosystem services framework should involve scoping, identifying, and valuing services based on detailed asset data and flow-on impacts.

When looking to establish a rehabilitation strategy at a scale such as that required for Oxley Creek, it is important to adopt an ecosystem services framework. Establishing those who benefit from an ecosystem service can strengthen investment in rehabilitation and spread costs across several stakeholders. It also allows funders to recognise the value of natural assets in the same way they value other physical assets such as infrastructure.

Management considerations

Options for the rehabilitation of Oxley Creek are complex and require tradeoffs between existing competing ecosystem services. Importantly, channel recovery needs to focus on bed and bank stability to halt the headward progression erosion. This can be done through a program of streambed management which aims to limit bed incision and increase channel roughness and resistance at the upstream extent of the erosion zones. This will help protect the intact upstream channels. However, recovery within the eroded reaches largely hinges on the ability to provide improved sediment transport continuity through the system and remains a challenge due to the lakes. Reconfiguring the lakes is a huge undertaking both in engineering terms and cost and would require detailed investigations into how it would impact hydraulics, the environment and the current ecosystem services provided by the lakes.

Conclusions

Oxley Creek is a regionally significant system contributing high value both ecologically and to the community. Historical sand mining in the mid to late 1960's has triggered massive channel incision which has led to continuous erosion and degradation of the creek. While the mining voids now provide high value lake systems which hold an important place in Oxley Creeks present day form, they remain an obstacle for the rehabilitation of Oxley Creek. Despite high rates of sediment loss from parts of Oxley Creek, coarse sandy sediments are falling out of suspension within the lakes and not progressing downstream to aid in the recovery of lower reaches. Fine sediments, however, are likely progressing though the system and out to Moreton Bay, contributing to the sedimentation of the bay.

Understanding the entire system is critical to both the recovery of the Creek and determining the wider ecosystem services it provides. This lends itself to achieving better rehabilitation outcomes and stakeholder identification for project funding requirements.

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References

Grinham, A. et al. (2024) Nitrogen loading resulting from major floods and sediment resuspension to a large coastal embayment, Science of The Total Environment, 918, p. 170646.

Haines-Young, R., & Potschin M. (2018) Common International Classification of Ecosystem Services (CICES) V5.1 Guidance on the Application of the Revised Structure. Accessed at: https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf

Kondolf, G.M. (1997) Hungry water: Effects of dams and gravel mining on river channels, Environmental Management, 21(4), pp. 533–551.

Markwell, K. et al. (2020) Upper Oxley Creek Catchment Investigation, Brisbane: E2DesignLab