Memo

Subject	Peer review
Project	Living Streams Design for the Lower Vasse River
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The City of Busselton engaged Alluvium Consulting to respond to a peer review by Hamilton et al. (2022) of its Living Streams concept design for the Lower Vasse River. The peer review adds further insight to the mechanisms causing and controlling cyanobacterial blooms and highlights aspects of the concept design that require further development and progressive monitoring. We agree with the reviewers' recommendations and especially value their insights into the biology of cyanobacteria at the site. However, we feel that they overlooked some aspects of hydrology and water quality that necessitate the construction of Stage 2 and possibly Stage 3 of the concept design

This memo comments on the review and offers recommendations for monitoring of project stages and for the scope of the detailed design of later stages. It also incorporates comments and recommendations from Hart (2022).

Key findings and recommendations of the review by Hamilton et al.

The Lower Vasse River is a seasonally eutrophic system. During winter and spring when temperature is low and water is flowing through the river, the cyanobacterial community, that may be present as akinetes and vegetative forms in sediments, cannot grow and accumulate fast enough to form surface blooms. During summer when flow ceases and temperature increases, populations of cyanobacteria rapidly grow and accumulate on the surface, depleting the available nutrient in the water column to the point where further growth ceases.

Dredging proposed for Stage 1 should be completed along the entire length of the lower Vasse River from the butter factory weir to the Busselton bypass. Dredging should be accompanied by an application of flocculant such as Phoslock to inactivate phosphorus that is resuspended during dredging operations. The effectiveness of Phase 1 should then be assessed.

Stage 2 should only proceed if Stage 1 is evaluated as providing insufficient control of algal blooms. There is a risk that the density and extent of vegetation in the wetlands is insufficient to adequately control algal blooms. The reviewers make no mention of the potential control of cyanobacteria through physical filtration of water flowing through the wetland.

Stage 3 should only proceed after Stages 1 and 2 have been implemented and evaluated. Although the replacement of channel water with solid instream structures will reduce the average residence time, there is a risk that their design may create areas of localised low flow and extended residence time that favour the formation of algal blooms.

Alluvium response to findings regarding Stage 1

We agree that dredging the entire river upstream to the Busselton bypass would remove a large source of nutrient from the system and could reduce the intensity and/or duration of algal blooms. We agree that the application of a flocculant during or soon after dredging would further reduce the risk of blooms in the short term. However, in common with Hart (2002), we are sceptical that flocculant application alone would be sufficient to control blooms in following seasons. While flocculants have been shown to remove phosphorus

from the water column, their ability to permanently fix phosphorus and prevent its release or resuspension is less well documented.

We agree that the outcomes of Stage 1 should be evaluated before proceeding to stage 2. Proposed evaluation questions and measures are described in Table 1.

Table 1 Evaluation of Stage 1

Evaluation question	Measure of success
Has dredging reduced the availability of phosphorus for algal growth?	Phosphorus release from sediment is lower after dredging than before. Methods follow Tulipani (2019)
	Total P in water does not rise after flow ceases. Standard DWER methodology is employed.
Has dredging reduced algal growth?	Algal cell count is lower in seasons following dredging. Standard DWER methodology is employed.
	Chlorophyl A and total suspended solids are lower in season after dredging than before and do not follow the seasonal pattern with peaks in summer. Standard DWER methodology is employed.
	Dissolved nitrogen and phosphorus are depleted more slowly in early summer in seasons after dredging than seasons before. Standard DWER methodology is employed

Alluvium response to findings regarding Stage 2

We agree that there is some uncertainty regarding the performance of the wetlands, particularly regarding the shading mechanism of action. We assessed the feasibility of achieving sufficient vegetation cover using studies from other parts of the world, and the estimate of the potential impact of shading on cyanobacteria comes from a laboratory study. The lack of in-situ data to support the design means that this mode of action is experimental, and will need to be rigorously evaluated.

However, the assessment of performance for removing suspended solids uses well-documented design standards from Australia and a study from a similar environment on the Swan Coastal Plain in Perth.

The concentration of phosphorus in water flowing into the lower Vasse River from the catchment each year is sufficient to maintain an algal-dominated eutrophic ecosystem even in the absence of any phosphorus release from sediments during the cease-to-flow period. Stage 1 alone cannot address this source and both Hamilton et al. and Hart have suggested that it will be difficult to control cyanobacteria in the long term without treating this source. We believe that this aspect of the problem necessitates the construction of Stage 2 for three reasons:

- Cyanobacterial blooms need to be reduced faster than nutrient concentration can be reduced through source control.
- Flocculation of phosphorus using the clay dosing system offers the potential to completely remove phosphorus from the river system if the sediment in the inlet pond is periodically removed. In contrast, flocculation in-situ results in the phosphorus remaining in the river, although in an unavailable form. The potential for the phosphorus to be remobilised is unknown.
- The wetlands offer the potential to physically remove algal cells via filtration through vegetation and potentially through soil in the case of the LIA site.

We agree that Stage 2 should also be evaluated and have proposed a framework in

Table 2. Each mode of action should be independently evaluated to optimise the operation of the wetland.

Table 2 Evaluation of Stage 2

Evaluation question	Measure of success
Has the clay dosing system removed phosphorus from the water?	Upon commissioning of the dosing system and prior to the establishment of vegetation, total and soluble P at the wetland outlet is lower than at the pump inlet.
	Total and soluble P in the river gradually reduces over several weeks.
Does wetland vegetation remove phosphorus?	With the dosing system turned off, total and soluble P at the wetland outlet is lower than at the pump inlet.
Does the wetland filter or physically remove algal cells?	Algal cell count is lower at the wetland outlet than the pump inlet.
	Hydraulic conductivity of LIA soils is measured along with groundwater levels and modelled subsurface flow from the wetland to the river is significant.
Does wetland vegetation interfere with the biology of algal cells?	Chlorophyll A concentration is lower at the wetland outlet than the pump inlet. The effect is greater than the reduction in algal cell count.

Alluvium response to findings regarding Stage 3

We agree that instream structures, if not properly designed, have the potential to create localised hydraulic conditions that promote rather than hamper the growth of algal cells. Accurate monitoring of river levels over the next few years will be required to determine the design elevation of the structures. Detailed hydraulic assessment using a 2D, and possibly 3D, fine-scale hydraulic model will be required during detailed design to determine the planform of the structures.

References

Hamilton DP, Burford MA, Sheldon F. 2022. Peer Review of the Living Streams Concept. ARI Report No. 2022-008 to City of Busselton. Australian Rivers Institute, Griffith University, Brisbane

Tulipani, S. 2019. Water Science Technical Series 84, Lower Vasse River water treatment trials 2016-18: Synthesis report, Department of Water and Environmental Regulation, Western Australia

Attachment 1

Hart B. 2022. Comments on Peer Review of Living Streams Concept. Water Science report 14 October 2022