Reducing nutrients: what to do at the site

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CRC for Water Sensitive Cities

Strategy 1. Increase nutrient uptake in the riparian zone

Suitability of strategy: most suitable where surface stormwater flows into or through the riparian zone; where a significant amount of groundwater flows laterally from the catchment to the stream; and/or where the floodplain is well-developed. Most effective where nutrient pollution occurs via overland or groundwater flow (e.g. septic tanks, golf course).

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
1a. See all actions in *Repairing riparian function: what to do at the site* factsheet, Strategy 3	The riparian zone is a naturally important nutrient filter: it cleans surface and subsurface water flowing laterally from the catchment towards the stream, as well as water that flows from the stream overbank into riparian land and associated wetlands.	See *Repairing riparian function: what to do at the site* factsheet, Strategy 3, actions 3a–3m.	[1-5]	See associated factsheet

Strategy 2. Increase nutrient processing in the hyporheic zone

Suitability of strategy: most suitable where natural bed material is highly porous (e.g. gravel, to a lesser extent sand) and where the climate creates periods of low flow.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
2a. Remove impermeable channel lining or daylight pipe	Impermeable channel lining (e.g. concrete) on an urban drain/ stream prevents interaction of surface water with shallow groundwater, thus limiting hyporheic activity.	Where natural material surrounding the concrete channel is porous.	[5, 6]	
2b. Reduce the velocity of instream flow See *Repairing flow: what to do at the site* factsheet, Strategy 2, for specific actions	Stream water is more likely to downwell into the hyporheic zone[1] when flows are relatively slow.	See *Repairing flow: what to do at the site* factsheet, Strategy 2, for the suitability and effectiveness of individual actions.	[4, 6-10]	See associated factsheet

[1] The wetted area among the sediments below and alongside rivers, inhabited by many animals (Boulton and Brock, 1999)

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
Reduce flow volume See *Repairing flow: what to do at the site* factsheet, Strategy 1, actions 1a –1g	As the volume of water in the channel gets smaller, a proportionally larger proportion of it will pass through the hyporheic zone and be exposed to nutrient transformation.	See *Repairing flow: what to do at the site* factsheet, Strategy 1, actions 1a–1g for the suitability and effectiveness of individual actions.	[6]	See associated factsheet
2c. Reconfigure the channel to improve sinuosity[2]	Reconfiguring the channel to increase sinuosity will slow flow (as per action 2b) and increase instream hydraulic diversity – both of which will promote the vertical exchange of water.	Where channel form is stable. Where bed material is highly porous. Where there is enough land around the stream for channel redesign. Where earthworks don't pose a significant risk to the existing riparian vegetation.	[11]	[12-17] See also RVR Meander tool
2d. Establish a pool-riffle sequence	Increases variation in hydraulic head to stimulate vertical exchange of water.	Where bed material is highly porous. Where stream depth is relatively shallow. Where the stream channel is stable such that riffles won't get washed away. Where sedimentation is low, such that riffles won't be buried. Where climate creates periods of low flow as the slower flows increase the capacity of the hyporheic zone to process nutrients.	[10, 11, 18-20]	[14]
2e. Install boulders and large woody debris (LWD)	Boulders and LWD increase instream hydraulic diversity and promote downwelling into the hyporheic zone. Debris dams (i.e. concentrations of leaves) often form around logs and boulders, creating carbon-rich anoxic environments that are hotspots for denitrification. The carbon from debris dams also supports microbial transformation of nutrients in the hyporheic zone.	Where logs and/or boulders would naturally have occurred but are now rare. Where bed material is highly porous. Where stream depth is relatively shallow such that boulders and LWD will create marked hydraulic diversity that will promote up/ downwelling.	[9, 11, 20]	[14, 17, 21-26]
2f. Create many small habitat patches of 2e and 2f, rather than a few large patches	Nutrient processing typically occurs at the downwelling end of hyporheic flow paths. Therefore reach-scale nutrient processing will be enhanced by many small patches rather than a few large patches.	Streams where anoxic conditions (i.e. denitrification) occur within short subsurface flow paths. This action may not be appropriate where long subsurface flow paths are required for denitrification (e.g. highly porous bed sediments, high velocity flows).	[27]	
2g. Plant native trees in stream-side zone	Eucalypt leaves break down at a slower rate than non-native species. This allows carbon to persist in the system for longer and act as a source of C for microbial nutrient processing in the hyporheic zone.	Where the riparian vegetation has been cleared.	[11]	[25] See associated factsheet

[2] The extent of meandering of a body of water (Boulton and Brock, 1999)

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
2h. Add coarse sediment (i.e. gravel) to the stream bed	Adding coarse sediment will increase the porosity of the stream bed and facilitate hyporheic exchange, which can promote denitrification if flow paths are long enough such that water becomes oxygen depleted.	At high value locations. In systems where bed material has low permeability. Where peak streamflow will not wash away the coarse sediment. Where the coarse sediment will not be filled in by fine sediment (i.e. covered by silt or sand). In most locations repairing sources or coarse sediment (See *Repairing Geomorphology: what to do at the site and catchment* factsheet, Actions 2c and 2d) and allowing the channel to naturally adjust will be more effective over the longer term.	[11]	Gravel can be added in one location and flow can naturally redistribute it [28]
2i. Use flushing flows to clean gravel beds and other permeable bed material	Flushing flows remove fine sediment from gravel beds, increase the porosity of the stream bed and promote hyporheic exchange.	In depositional areas of the stream where fine sedimentation is a problem. Most readily implemented where an upstream flow control structure (dam, weir) allows manipulation of flow.	[29, 30]	
2j. Promote the presence of bioturbating fauna	Animals that burrow into the bed sediment (e.g. chironomids, worms, mussels) create small channels that promote the downward movement of water into the hyporheic zone.	Where bioturbating fauna are abundant. Care should be taken not to promote a midge outbreak, particularly in still backwater habitats.	[6]	

Strategy 3. Increase nutrient processing instream (excl. hyporheic)

Suitability of strategy: most suitable where the channel's surface area to volume ratio is relatively high (i.e. small channel as opposed to a large river).

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
3a. Reduce the velocity of instream flow See *Repairing flow: what to do at the site* factsheet, Strategy 2	The ability of biofilms to take up nutrients increases when water flows more slowly, because it increases the contact time between nutrients in the water column and the biofilm.	Where the site has a small catchment – i.e. where catchment-scale stormwater management is feasible. Where the waterway contains (or will contain) hard surfaces that biofilms establish on (e.g. cobbles, logs, leaves). See *Repairing flow: what to do at the site* factsheet, Strategy 2, for the suitability of specific actions.	[5, 31]	See associated factsheet

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
3b. Reduce flow volume See *Repairing flow: what to do at the site* factsheet, Strategy 1, actions 1a–1g	Reducing the volume of water in the waterway increases the proportion of the water that is in contact with surface biofilms – thus a proportionally larger amount of water can be cleaned by biofilms as waterway volume decreases.	Where the site has a small catchment – i.e. where catchment-scale stormwater management is feasible.	[4, 5, 7]	See associated factsheet
3c. Increase hotspots of microbial processing (i.e. create debris dams, backwaters, add LWD)	Carbon is essential for microbial processing of nutrients, thus it is important to create instream structures that trap leaves. This can be supported by adding logs or boulders or creating low-flow backwater areas.	Most sites, particularly small streams that naturally have high inputs of leaves – i.e. forested small- to medium-sized streams.	[4, 9, 11, 20]	
3d. Establish macrophyte beds	Macrophytes can be very efficient at taking up nutrients from stream water, as well as bed and bank sediments. Note, nutrients will be recycled within the system (i.e. no net loss) unless macrophytes are periodically harvested.	Where channel form is stable such that macrophyte beds won't get washed away. Where scouring urban flows have been managed. Sedges are most likely to survive if planted in low-velocity areas such as the inside of meander bends.	[32, 33]	[34, 35]
3e. Add clays that bind phosphorous	Clays have a strong ionic charge and can bond to charged dissolved nutrients, such as PO4 taking nutrients out of solution. Natural clays or specially designed clay (e.g. Phoslock) can be used.	At high value locations. In systems where phosphorus is a management priority (P-limited). Lowland sites where water velocity over sediments is low – i.e. clay won't just be washed downstream.	[36, 37]	[36, 37]
3f. Install floating wetlands	Floating add P-binding clays wetlands take up inorganic nutrients (NOX, PO4) from the river water.	In deep slow-flowing water (e.g. lowland river sites, weir pools). In highly modified systems only.	[38, 39]	[38, 39]

Strategy 4. Minimise nutrient release from stream bed and bank sediments

Suitability of strategy: most suitable where fine sediments are abundant and rich in nutrients, and where the nutrients stored in sediments are bioavailable.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
4a. Increase the oxygen concentration of the water using natural (e.g. riffles, plants/algae) or engineered approaches (e.g. aerators)	Increasing the oxygen concentration of instream water is beneficial because it promotes nutrient processing in general. It also creates oxidative conditions (high pH) that promote the binding of phosphorus to sediments.	In high value locations where oxygen levels are prone to crash (e.g. low flows during warmer months, history of algal blooms, high levels of dissolved organic carbon). Riffles are appropriate if water depth in the site is relatively shallow (i.e. a riffle can be constructed). Aerators are appropriate where the water is deeper.	[40, 41]	Aerator [42] Riffles [14, 43]
4b. Stabilise fine sediments on the bed and bank of the waterway using plants and controlling unwanted bioturbating fish species	Fine sediments, particularly clays, store large quantities of nutrients – particularly phosphorus. Stabilising sediments instream and on the stream bank by using macrophytes and by controlling bioturbating fish species (e.g. common carp) can reduce the release of nutrients into the water column.	Where the water is shallow and clear enough so that macrophytes can establish. Where scouring urban flows will not wash them away. Where common carp or goldfish or other non-native bioturbating species are present.	This factsheet	[25]

Supporting documents

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Other useful tools

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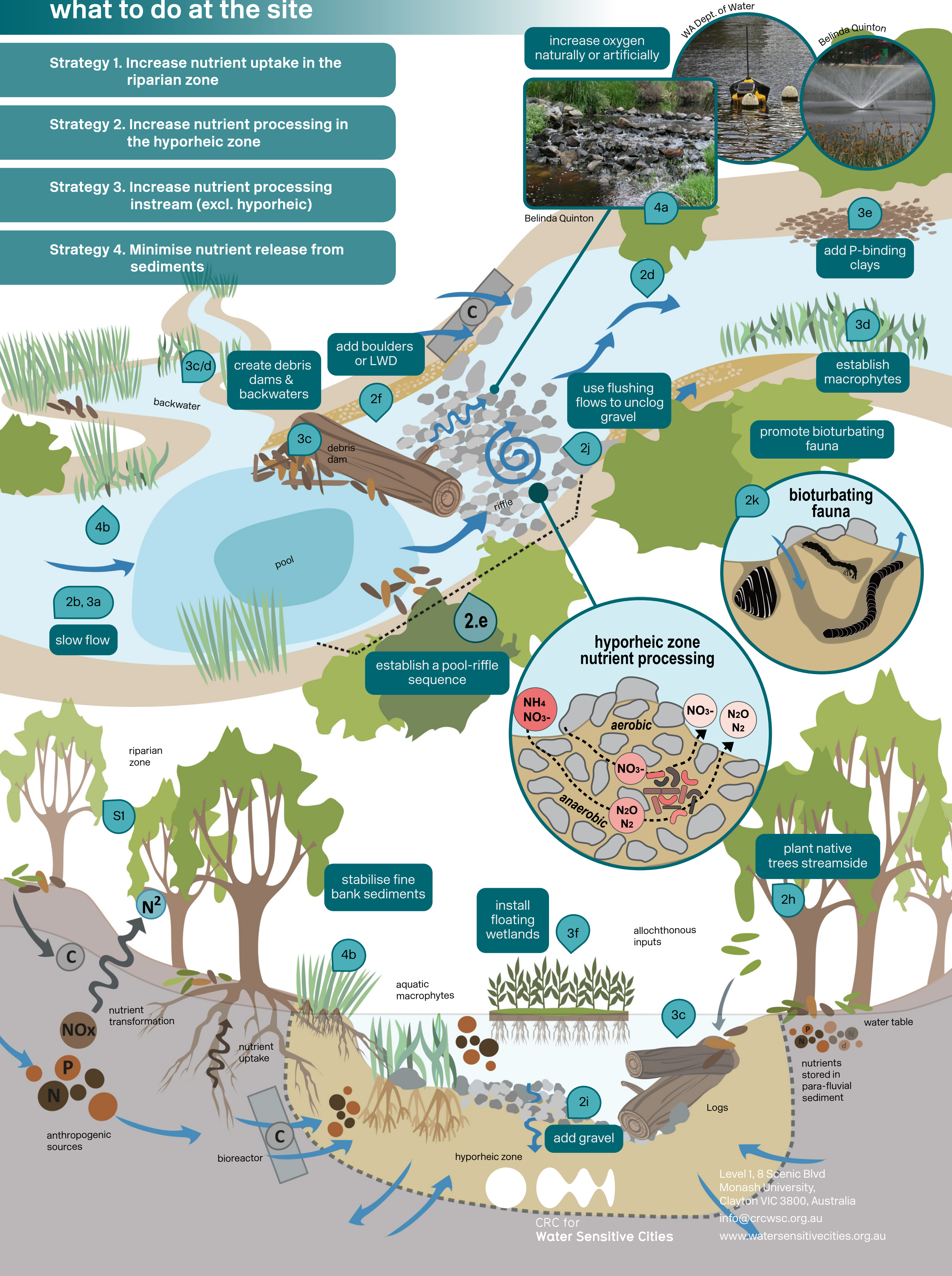
Strategy 2. Increase nutrient processing in the hyporheic zone

Strategy 3. Increase nutrient processing instream (excl. hyporheic)

Strategy 4. Minimise nutrient release from sediments



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