Lower Goulburn Quarterly Outcomes Newsletter

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In this issue

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In the spotlight

What have we learnt from the 2020-21 monitoring year?

By Simon Treadwell

Introduction

Over the five years of the Goulburn Selected Area LTIM Project (2014–20), and now the first two years of the MER Program, environmental water has been delivered to the lower Goulburn River to enhance native fish spawning, reduce the extent of bank erosion and enhance opportunities for the establishment and maintenance of water dependant vegetation on the riverbanks, contribute to overall ecosystem carbon production, and optimise conditions for macroinvertebrate abundance.

Environmental water has been delivered every year as spring freshes and to augment regulated baseflows throughout the year. Winter and autumn freshes have also been delivered in some years, and environmental water has been used to slow the rate of water level drawdown following some natural high flows.

In 2020–21, around 239 GL of environmental water was delivered in the lower Goulburn River. Commonwealth Environmental Water (CEW) contributed 151 GL to this total. Environmental water was used in (Figure 1):

- Winter – to slow the rate of drawdown and extend the duration of natural high flows
- Spring – to augment a natural fresh in September/October to support vegetation and to deliver a later fresh in November to promote native fish spawning. This sequence of events included an extend recession after the first fresh to delay vegetation germination until after the November fish spawning fresh
- Autumn – to deliver a fresh in combination with higher Inter Valley Transfers (IVT), extend the duration of drawdown and maintain baseflows to minimise bank surcharge and mass-failure that can happen as a result of rapid flow drawdown

The following sections present highlights and learnings from the 2020-21 monitoring.

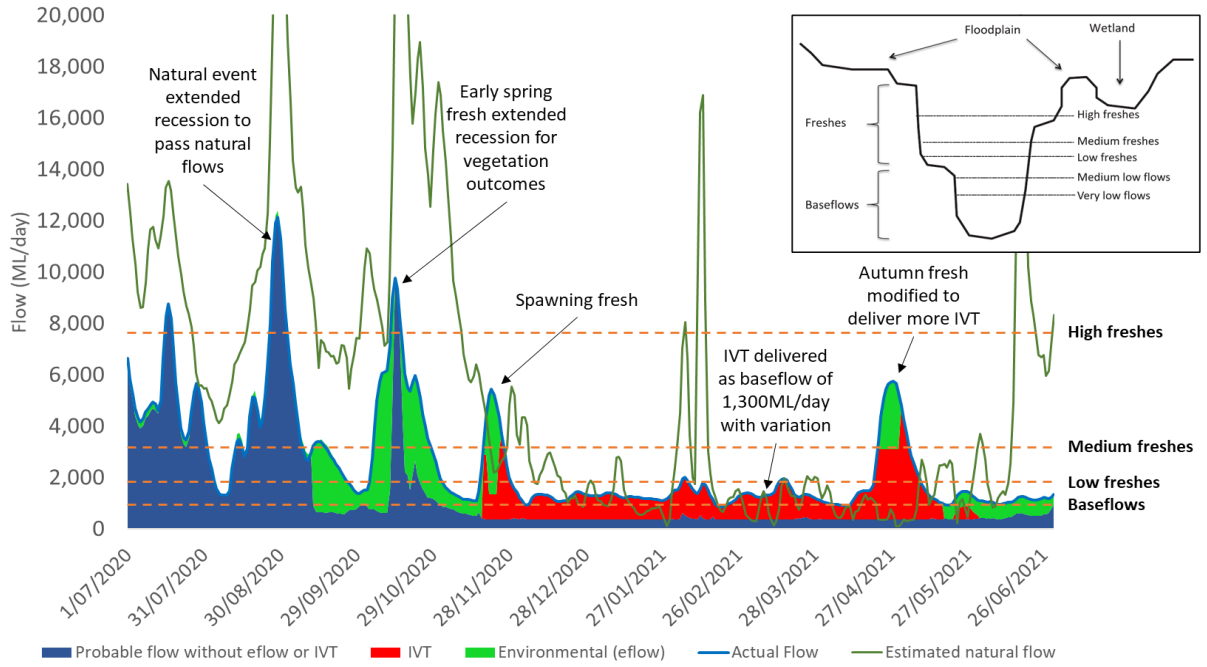

Figure 1: Relative sources of water contributing to total Goulburn River flows in 2020–21 (https://fchmccoys.hydronet.com/) at McCoy's Bridge and specific flow components targeted by particular CEW deliveries. Inset shows the general flow components targeted with CEW in the lower Goulburn River. Note, bankfull flow is ~28,000 ML/day.

Bed and bank condition and vegetation outcomes

Monitoring and analysis from 2020-21, along with observations from previous years, highlights that the sequencing of both natural and planned environmental water events, and particularly the antecedent flow conditions, is important for the likely effects of future flows on bank condition (erosion and deposition) and sediment/seed deposition dynamics. The results suggest that:

- Natural, CEW delivered events and IVT deliveries all result in varying amounts of erosion. Erosion tends to occur across the inundated surface of the bank and deposition occurs on the lower bank. The greater the height of bank inundated the more distributed the erosion and the lower the overall magnitude of erosion. This means erosion associated with natural and CEW events is spread across a wider bank zone than erosion associated with IVT flows, which tends to result in more severe erosion within a narrow band lower on the bank. This is highlighted in Figure 2, which shows that freshes resulted in less erosion and more deposition than the IVT event, which also recorded higher erosion in the most severe erosion category (>30 mm).
- The higher the tributary contribution to flow events, the greater the sediment deposition and the greater the abundance and diversity of seed deposition.
- The interval between events appears to be a factor in erosion and deposition characteristics. If freshly deposited sediment from one event has not had time to consolidate on the banks before the next inundation event, it is more likely to be removed and carried away from the site during the action.

The outcomes from these results suggest that it is important to:

1. Consider the flow volume and duration of previous events so as to not inundate the same areas of bank for long periods of time. This will reduce the likelihood of additional erosion within those flow bands.
2. Deliver flows that gradually rise and fall over a wide bank zone to minimise the duration of time flows are concentrated in a narrow band and allow for deposition in areas of past IVT-related notching near the toe of the bank.
3. Attempt to increase sediment and seed content of flows by passing natural flow events where possible and piggybacking CEW on tributary inflows.

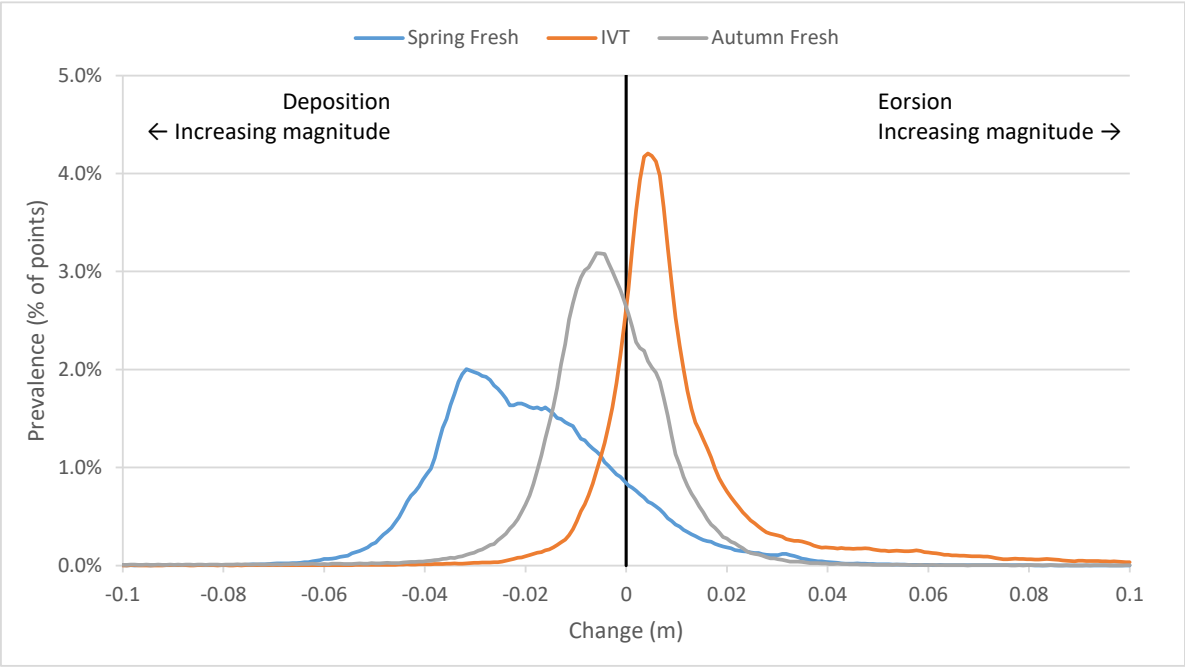

Figure 2: Histogram showing prevalence and magnitude of change at Loch Garry for the three 2020-21 monitored flow events.

Vegetation monitoring over previous years and again in 2020-21 has shown that the cover of water dependant vegetation tends to increase across the bank elevation zone equivalent to the magnitude of the spring fresh. Turf mat sampling again confirmed that seed and sediment deposition on banks is highest when tributaries contribute a larger proportion of the flow event.

In 2020 two spring freshes were delivered, one in October to promote vegetation and one in November to support native fish spawning. In previous years when two spring freshes had been delivered, the second fresh resulted in the loss of juvenile plants that had germinated in response to the first event. In an attempt to avoid this occurring in 2020 an elevated baseflow was maintained between the two freshes to suppress vegetation recruitment on the lower bank until after the November event. Monitoring after the November event showed the cover of water dependent plants on the lower bank was low, but that germination did subsequently occur on the lower bank in early summer.

Following the recession of the November fresh, a narrow band of fringing vegetation germinated and established around the level of IVT delivery on the lower bank. This band of vegetation became reasonably well established and set seed in autumn 2021 prior to the autumn fresh. However, vegetation was still absent below the level of IVT flows due to prolonged inundation. The results do indicate however, that the current strategy of capped IVT flows and some variability in IVT flow delivery has resulted in increased fringing vegetation compared to the period 2017-19 when IVT levels were much higher.

This year's monitoring outcomes in conjunction with observations from previous years reinforces the management necessary to promote the recovery of vegetation along the river fringe:

1. Synchronise freshes with tributary flows where possible to enhance propagule supply.
2. Provide low flows for 6-8 weeks following the recession of the early spring fresh to promote recruitment of vegetation before delivering higher flow pulses for environmental (e.g. late spring fresh for native fish) or consumptive (i.e. IVT) purposes. Further windows of low flows should be provided over the growth season (Dec-Mar) to promote plant growth, flowering, seed set and vegetative expansion.
3. The total number of days plants are inundated by >25 cm over recommended baseflow levels over summer should not exceed 40 days and individual inundation events should be less than two weeks.
4. Provide adequate periods of low flows between inundation events to allow plants to recover.
5. All effort should be made to avoid submergence of plants (do not exceed recommended baseflows) during flowering or seed set. This period varies among species but is most commonly the summer months.

6. In some years provide low flows for ~13 weeks following the recession of the spring fresh to allow plants to set seed and replenish the local soil seed bank.
7. Provide successive years of low summer flows (do not exceed recommended baseflows) to increase the spatial extent and propagule supply of water dependant species in the fringing zone

Native Fish outcomes

In the 2020-21 annual fish population surveys, nine native and three exotic species were collected from the ten survey sites. The nationally threatened trout cod has now been collected in annual fish surveys in two consecutive years and four out of the past seven years. Spawning of trout cod was also detected for the fourth year in a row. Other species of conservation significance collected were Murray cod, silver perch and Murray River rainbowfish. A single unspecked hardyhead and a single young-of-year golden perch were also recorded. Similar to previous years, the small-bodied Australian smelt was the most abundant species collected, and the exotic carp was the most abundant large-bodied species collected. The abundance of Murray River rainbow fish was substantially higher than previous years.

Spawning of golden perch was detected in mid-October coinciding with the early spring fresh and water temperature around 17°C. Spawning of golden perch and silver perch was also detected in late November coinciding with the November fresh and water temperature around 22-23°C.

The results from 2020 further strengthen our previous conclusions that the probability of spawning of golden perch is related to discharge, with greatly increased spawning probability at flows between about 3500–4000 ML/day when water temperatures exceed ~18.6°C. Furthermore, flow conditions prior to spawning freshes are also important, with positive relationship between the probability of spawning and the average flows over the 5 weeks prior to spawning; put simply, the higher the prior flows, the higher the probability of spawning.

In addition to routine monitoring, in 2020 larval drift sampling was undertaken in the Murray River upstream and downstream of the Goulburn River confluence to determine the relative proportion of larval drift in the Murray River that is coming from the Goulburn River. Spawning of golden perch and silver perch was detected in the Murray River both upstream and downstream of the junction over a longer time frame encompassing late October to late November than in the Goulburn River. There was no noticeable increase in the catches of golden perch eggs in the Murray River following spawning in the Goulburn River, indicating a minimal effect of Goulburn River larvae on the pool of larvae in the Murray River at this time. However, catches of silver perch eggs in the Murray River downstream of the junction increased slightly in late November, coinciding with spawning in the lower Goulburn River.

Metabolism

In 2020-21 the stream metabolism monitoring program was augmented to include a specific assessment of water column (or pelagic) metabolism as well as whole stream metabolism. The measurement of water column metabolism has enabled us to attribute the relative sources of primary production, and hence carbon production, to either algae suspended in the water column or algae and microbes attached to benthic surfaces such as bed and bank sediments and submerged snags.

Overall rates of primary production and respiration in the Goulburn River in 2020-21 were similar to previous years and typical of those in the southern Murray-Darling Basin. Across the entire seven-year data set of LTIM and MER, the highest primary production rates have been recorded during the summer, corresponding to the warmest temperatures and greatest light availabilities, and the lowest rates occur in winter.

With seven years of data now available, we have analysed the amount of organic carbon that CEW contributes to the Goulburn River for a range of flow events at McCoy's Bridge (Figure 3). Over this period it is estimated that CEW produced nearly a quarter (21%) of the organic carbon produced in the river (454 of 2156 Tonnes). From an ecological perspective, CEW-enhanced production was most important in winter and spring when 23-52% and 17–58% of all carbon production was associated with CEW, except in years with high natural winter flows when the CEW contributed carbon is much lower. CEW contributes very little carbon in summer because flows are either low (with no CEW contribution) or dominated by IVT delivery. Most CEW-assisted carbon production occurs where CEW contributes to medium to large volume freshes (3,000-7,000 ML/day) in spring and autumn.

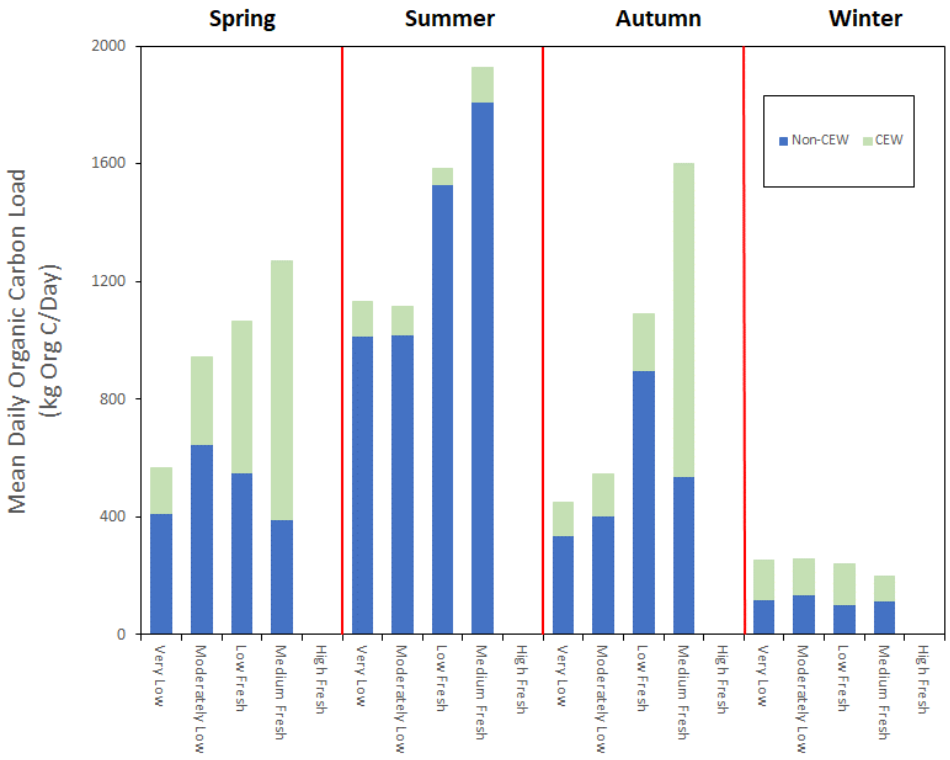

*Figure 3: Estimated mean daily loads of organic carbon created by primary production, stratified by season and flow category (see **Error! Reference source not found.**1 for category definitions). Data are from 2014 to 21 and pooled across all sites*

With regards to the relative proportions of benthic versus pelagic metabolism, pelagic primary production ranged from 1-25% of the daily primary productivity at the sites, demonstrating that the great majority of whole stream primary production was occurring on the riverbed. The creation of carbon via benthic primary production is likely to contribute a greater benefit as a food resource for macroinvertebrates and fish in the Goulburn River because the carbon is retained within the local system. Carbon generated by pelagic metabolism is transported downstream in the flow and contributes to food resources further downstream in the Murray River. Rates of whole-stream and pelagic metabolism appear to be related to light availability. Hence, ensuring a lower flow in summer would increase light penetration to the stream bed and promote benthic primary production.

The outcomes of this analysis highlights:

1. The importance of CEW contributions to organic carbon creation, especially in winter and spring.
2. Low flows in summer are preferable for maximising benthic carbon production. Hence, IVT flows in the lower Goulburn River may be limiting the amount of benthic primary production over the summer months by reducing the amount of light that reaches the riverbed.

Macroinvertebrates

In 2020-21 macroinvertebrate sampling occurred before and after the November fresh. More than 75,000 macroinvertebrates from 54 taxa (different species, genera or families of macroinvertebrate) were collected across all sampling periods. This was up from the total of 49,000 collected in 2019-20. The most common taxa were mites, water bugs, the mayfly (Baetidae), the caddisfly (Leptoceridae) and shrimps (Atyidae). The average abundance of all these taxa increased after the November 2020 fresh with the highest abundances occurring in January and February 2021. Similarly, macroinvertebrate biomass (mostly associated with crustaceans – shrimps and prawns), was also highest in summer.

Patterns observed in 2020-21 were similar to those in 2019-20. The specific factors leading to increased macroinvertebrate abundance and biomass are still not clear; spring flows, natural seasonal variation in temperature and increased availability of organic carbon in summer may all be important factors. Notably, outcomes of the metabolism monitoring show that the largest amounts of organic carbon are produced in summer, this period also

coincides with the highest abundances and biomass of macroinvertebrates. It is possible that macroinvertebrates are responding to the increased carbon availability, rather than flows specifically. Over coming years, as we gather more concurrent data on carbon production and macroinvertebrate biomass, further analysis will be undertaken to explore relationships between the availability of organic carbon and macroinvertebrate abundance or biomass.

Implications for future management of environmental water

Results from monitoring in 2020-21 build further on those from previous years and the following observations are notable for informing future management of environmental water in the Goulburn River:

- Results underscore:
    - the importance of winter and spring freshes for depositing sediment and seeds on riverbanks with minimal erosion, particularly if associated with concurrent tributary inflows,
    - the importance of timing and magnitude of spring freshes for promoting water-dependant vegetation (early spring) and golden perch and silver perch spawning (late spring/early summer),
    - the contribution that CEW flows make to enhancing the amount of organic carbon generated by primary production as a potential food resource for macroinvertebrates and fish when delivered any time throughout year.
- In 2020-21 CEW was used to help maintain a high base flow between the early spring fresh for vegetation and the late spring fresh for fish spawning. This high base flow aimed to prevent germination of vegetation immediately following the early spring fresh so that young plants would not be affected by the later spring fresh. Seedlings were observed following the late spring fresh, so this strategy may have helped delay germination.
- Despite changes to the way IVT flows were delivered over the last two summers (capped monthly volumes and pulsed flows), results indicate that negative impacts are still occurring, albeit much less severe than pre-2019. These include notching and erosion of the upper banks, and the loss of water dependent vegetation established on the lower bank in the previous spring as a result of prolonged inundation. The loss of bank vegetation is concerning because bank condition monitoring has shown that where vegetation does exist it helps reinforce the banks against erosion and promotes sediment deposition. Hence the high volumes of IVT delivered represent a compounding problem by causing a loss of vegetation as a result of the extended inundation, which then exposes banks to further erosion associated with the IVT flow itself. Furthermore, additional metabolism investigations in 2020-21 revealed the importance of benthic metabolism for supporting ecosystem food webs, but that IVT flows may limit the amount of benthic metabolism that can occur over summer. The results demonstrate there have been some benefits associated with the revised operating rules, but more work is needed to further minimise negative effects.
- Analysis of multi-year results has highlighted the importance of event sequencing and the need to consider the magnitude of prior events and time since last event when planning future environmental water deliveries. In particular, it is important to not inundate the same areas of bank that were inundated in previous events for long periods of time. This will reduce the likelihood of additional erosion within those flow bands.

Based on the cumulative outcomes of LTIM monitoring from 2014 to 2019, and the MER Program over 2019-21, the following recommendations are made:

1) **At least one spring fresh is prioritised every year**. The specific timing and duration of the fresh depends upon the target ecological endpoints: early spring for vegetation or late spring/early summer when temperature exceeds 18.6°C for golden perch and silver perch spawning. If two spring freshes are considered in a single year, there is a risk that native vegetation that germinated following the first fresh could be drowned by the second fresh before it has a chance to establish. In this case, consideration should be given to providing at least 8 weeks between events to allow vegetation to establish, or to maintain an elevated baseflow to delay germination until after the second fresh.
2) **Where environmental water allocations allow, deliver a winter fresh.** This will help deliver sediment and seed to the banks and further enhance the likelihood of good vegetation establishment in association with subsequent

spring freshes. Where possible, CEW for winter freshes should be delivered in unison with natural high flow events in tributary streams downstream of Goulburn Weir as these natural events carry a large sediment and seed load.

3) **Continue to inform operational solutions to better manage high IVT volumes.** New rules for IVT deliveries introduced in 2019 appear to have helped reduce risks of mass bank collapse. However, in 2020-21 erosion was still high and vegetation was still impacted by the extended duration of inundation. Specific recommendations are to:

   - Continue to support variable, pulsed delivery of IVT flows to avoid stable water levels that lead to excessive notching.
   - Provide further information about the ecological benefit of: reducing the number of days that flows exceed 1000 ML/day over the IVT period to less than 55 days, reducing the total number of days plants are inundated by >25 cm over summer to 40 days or less, and limiting individual inundation events to less than two weeks.
   - Advise that maximum rates of flow recession following the IVT period should be within current levels (or lower) to avoid bank surcharging and mass failure.
   - Support current practices to avoid delivering long duration events in autumn that inundate the same bank bands that were inundated during IVT delivery; this may help to prevent additional erosion.
   - Continue to include the MER Program team in the decision-making process to improve ecological outcomes when delivering environmental water and IVTs.

   Further changes to operational rules are being introduced in 2021–22 and results from the associated monitoring will contribute to our knowledge about how to deliver IVT flows while minimising negative ecological impacts.

4) **Continue to investigate the potential to deliver overbank flows.** Overbank flows are not delivered as part of the Goulburn environmental flows program. However, the results from the LTIM and MER monitoring underscore the importance of organic carbon input to the system as a potential food resource for macroinvertebrates and fish, and confirm that although in-channel flows can still create additional organic carbon, overbank flows remain the main source of significant carbon input to the channel.

5) **Undertake targeted research.** Results from the individual monitoring programs raise interesting questions relating to sequencing of results (e.g. this year's vegetation data) and the links between results of different monitoring disciplines (e.g. primary production and macroinvertebrate biomass). Future monitoring programs should include research projects aimed at investigating these and other links between the components of the larger monitoring program.

More details of the outcomes of Goulburn MER monitoring can be found in the Goulburn MER 2020-21 Annual Summary Report and the Goulburn MER 2020-21 Annual Scientific Report available on the Commonwealth Environmental Water web site: https://www.awe.gov.au/water/cewo/publications/2020-21-goulburn-mer-annual-reports

Catchment conditions and flow: October-December 2021

As planned, a spring fresh was delivered using environmental water in October (Figure 4). Rainfall in late October and the risk of exceeding river operational limits reduced the peak flow. Rainfall also led to a small spill at Goulburn Weir that extended the duration of the event.

In November baseflows between 600 and 1,000 ML/day were targeted to encourage the recovery of vegetation on the lower bank. This also allowed bank condition information to be captured lower on the bank which has not been possible in previous years.

In response to a localised rainfall event, water was released from the Goulburn Weir in early November to prevent maximum storage levels being exceeded. Flows peaked at 2,500 ML/day downstream of the weir but attenuated to about 1,100 ML/day at McCoy's Bridge. More rain in mid-November extended the spill. Flows peaked at around 4,000 ML/day at McCoy's Bridge. Due to the small magnitude and duration of the spill event it was decided recession flows were not necessary.

Rainfall on the Broken and Sevens catchments in late November led to an unregulated pulse of 2,300 ML/day at McCoy's Bridge in early December. Following this pulse environmental water was used to maintain a baseflow between 700-1,000 ML/day.

Due to high unregulated flows in the Murray River no inter-valley trade deliveries to the Murray River via the lower Goulburn River occurred between October and December.

For those interested our hydrograph for flows in the lower Goulburn River are updated regularly and are available online at https://fchmccoys.hydronet.com/.

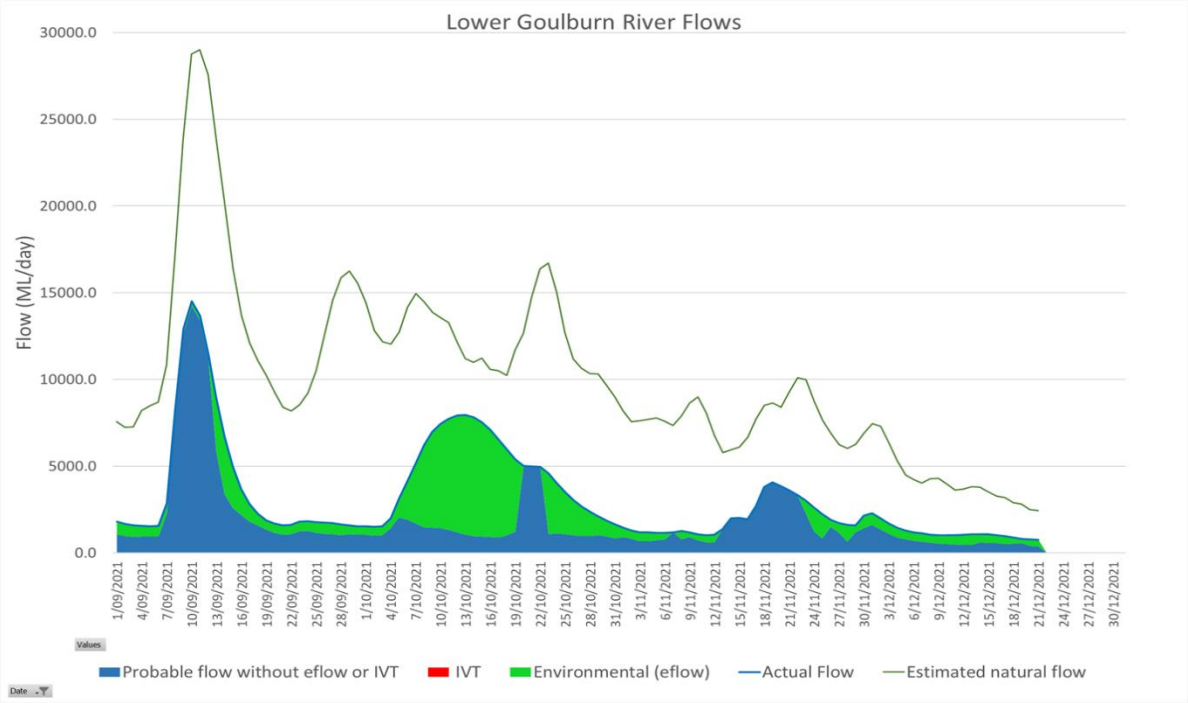

Figure 4: Hydrograph for the lower Goulburn River from October-December 2021 at McCoy's Bridge (data source https://fchmccoys.hydronet.com/).

Core monitoring

Fish

The focus of work in the last quarter has been the surveys of eggs and larvae using drift nets to detect spawning. Samples are currently being processed. Preliminary findings indicate that spawning of golden perch occurred in December following a high flow event. A new project has also commenced investigating the movement behaviours and habitat use of juvenile trout cod. The project is using telemetry techniques to determine movement and fine-scale ecohydraulic characteristics (e.g., depth, velocity) of habitats used by trout cod. This information can be used for instance to assess how flow delivery can be used to optimise or conversely, prove detrimental to critical habitat availability.

Figure 5: Trout cod being released after tagging (left) and tracking tagged fish using radio telemetry (right) (photos: Wayne Koster)

Riverbank vegetation

Vegetation surveys were carried out by ARI and GBCMA staff on the 13-14 December 2021 at McCoy's Bridge and Loch Garry as part of the Goulburn Flow MER program. Additional vegetation surveys were also carried out at Darcy's Track on the Goulburn River upstream of the confluence with the Broken River. This new monitoring is part of a state funded monitoring program to better understand responses of bank vegetation to unseasonal high flows associated with Inter-valley Transfers (IVTs).

Sites were monitored ~6 weeks after the recession of the spring fresh (peak discharge of 7,931 ML/day at McCoy's Bridge on 14 October 2021). Rainfall increased flows from around 1,500 ML/day to 3,700 ML/day at McCoy's Bridge on 21 November, falling to around 1,000 ML/day by 7 December. At the time of monitoring, flows were ~1,060 ML/day at McCoy's Bridge. The recent flow history indicates that there was only a brief window of low flows (i.e. ≤1,000 ML/day) favourable for the growth of littoral vegetation following the Spring Fresh.

Key observations

- The zone of moist soil varied with bank slope. The soil remained moist along flatter benches above the water level. On gently sloping banks, the soil was only moist within a few centimetres of the water's edge. In contrast, along steeper sloping banks the soil was dry immediately above the water's edge.
- Long sections of the river at both McCoy's Bridge and Loch Garry remain without vegetation within 1-2 m of the water's edge.
- Scattered sedges (*Cyperus eragrostis*/*Cyperus exaltatus*) were observed on the lower bank.
- *Cyperus exaltatus* (Tall Flat-sedge) on sloping banks appear to have decreased in cover and extent since surveys in March 2021. Similarly, along a small bench at McCoy's Bridge *Persicaria* (Knotweed) and the **Cyperus eragrostis* (Drain Flat-sedge) were lost between March and December 2021, but *Cyperus exaltatus* has remained relatively stable in extent (Figure 6)**.**
- Vegetation along the lower banks may increase over summer months if low flow conditions are maintained. Surveys in March 2022 will provide further data on the trajectory of vegetation in these zones.
- The extent of Creeping Knotweed (*Persicaria prostrata*) is still reduced in extent on the mid bank as previously reported in September 2021. The introduced perennial Coolah Grass (**Panicum coloratum*) and Common Tussock-grass (*Poa labillardierei*) on the mid bank appear relatively stable.
- Introduced annual grasses at higher elevations (for example Oats (**Avena* spp.), Great Brome (**Bromus diandrus*) and Rye Grass (**Lolium* spp.)) had mostly browned off.
- Germinants were sparse, but relatively common on the lower bank and mainly comprised species such as River Red Gum (*Eucalyptus camaldulensis*), *Cyperus* spp. and grasses.

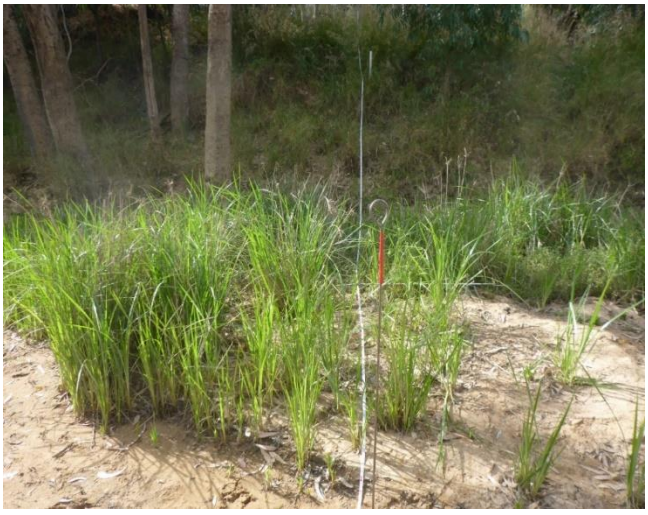

*Figure 6. Small bench near the boat ramp at McCoy's Bridge south bank. Although there has been a loss of Persicaria spp. and *Cyperus eragrostis between March (left) and December (right) 2021, Cyperus exaltatus has remained relatively stable in extent during this period. Note an asterisk (*) indicates an introduced species. Surveys in March 2022 will provide further data on the trajectory of vegetation at this location (Photos: Kay Morris)*

Macroinvertebrate condition

This quarter, macroinvertebrates were collected in December 2021, which was after an environmental flow in October and a smaller natural flow in November. Within the bait traps set amongst bank habitat (Figure 7), particularly in the lower sites there were more female crustaceans with eggs and smaller individuals caught during this sampling run compared to September 2021. This is consistent with previous year's results with breeding occurring between December and February. Lab processing of the macroinvertebrate began in December.

Figure 7. Banks in 2021 in the Goulburn River December 2021

Stream metabolism

Dissolved oxygen loggers remained in place over the October-December period. No specific additional activities were undertaken.

Bank condition

The focus for bank condition monitoring this quarter was the capture and analysis of bank condition information (derived from drone flights) for the 2021 spring fresh.

Due to a large amount of rain across August and September this year, flows were high prior to the spring fresh, and as such fresh deposits were evident on the bank both before and after the spring fresh. See below for some images of the Streamology drone and kayak in action, as well as some examples of riverbank *repair* where deposited sediment can be found in lower bank zones that have previously been deeply eroded.

Figure 8. Action shots of the Streamology team, drone and kayak out at Darcy's Track (left) and McCoy's Bridge (right) on the Goulburn River.

Figure 9. Before and after images of a bank at Darcys Track, showing fresh deposited sediment after the 2021 Spring Fresh

Thanks to assistance from some expert drone flying, the pre-spring fresh flights were completed in a single day, between large rain events in across the area. And during this trip there was even time to experiment with a new image capture method at Loch Garry that allows a 360 degree view of a given location, **click here** to view.

Key Findings:

Thus far, initial findings show:

- In the majority of cases environmental flows result in erosion that is more evenly spread across the entire bank face (rather than in defined zones on the bank) and therefore (1) erosion to the upper bank works to reset lower bank steepening, and (2) the erosion is shallower in depth. There are several banks, however, that show erosion is more significant lower down the bank.
- Deposits were thicker and more extensive on areas of upper bank with a shallower profile (less steep) and as such lower, steeper sections of bank showed less consolidated sediment.
- One initial hypothesis is that due to extensive and deep deposits to the upper bank (through mud-draping), erosion in these areas has been covered, and thus erosion is only expressed in these steeper lower sections where mud-drapes struggle to consolidate. This is something the team is keeping a close eye on.
- The spring fresh appears to have resulted in thicker and more extensive draped sediment deposits, which to extend to higher sections of the bank than the previous autumn fresh. These findings correspond with the fact that the spring delivery was bigger and was delivered during a period of high precipitation in the area.

Figure 10. Example of 3D model showing erosion (in red) and deposition (in blue) at a bank at Loch Garry. In this example deposition is thick and draped primarily over the upper bank zone

Next steps are to prepare for upcoming monitoring trips and to work through more terabytes of drone data for desktop analysis.

Contingency monitoring activities

Monitoring sediment and seed deposition using turf mats

The main focus for this quarter for sediment and seed monitoring using turf mats was (1) to continue the propagation of seeds in the Melbourne University greenhouse, and (2) to get out into the field and gather turf mat samples before and after the spring fresh. Propagation is coming along well, with all samples now in the greenhouse, the gathering of turf mats however was more challenging. Only McCoy's Bridge mats were retrieved prior to the Spring Fresh (due to heavy rain hampering access to other sites) and therefore, despite gathering all mats after the fresh had been delivered, we will only have data correlating to the Spring Fresh event – specifically – for the McCoy's Bridge site.

Initial observations from the most recent turf mat retrieval trip support findings from the drone analysis that deposition volumes were high and comprehensive at the majority of habitat types (different levels of bank). It will be interesting to compare how the sediment and seed volumes of the 2021 Spring Fresh differ from past events. Below are some examples of deposited sediment on turf mats.

Figure 11. Examples of deposited sediment on turf mats at Loch Garry (left) and McCoy's Bridge (right)

This last turf mat retrieval is officially the final one planned, however discussions are under way regarding extending the monitoring. The next task for now is the analysis of the sediment and seed data for this last visit.

Research activities

Integrated Research Project

We are studying whether slackwaters (shallow, slow flowing habitats) are important areas for biodiversity and ecosystem processes. In late June 2021 we established a large field experiment to increase woody structure in slackwaters by driving hardwood garden stakes into the riverbed. We expect the stakes to accumulate and retain plant detritus, which is a source of food and habitat for small organisms (aquatic insects, shrimp, small fishes). We predict that areas with stakes will retain more detritus and will support large numbers of shrimp, insects and small fishes compared to Control areas without stakes.

Full details of the experimental design and methods are provided in Issue 9 of the Lower Goulburn Quarterly Outcomes newsletter. In brief: the field experiment was established in 24 slackwaters across 4 sites (3 Wide, 3 Narrow slackwaters per site). Slackwater area was standardised at 30 m long and each slackwater contains four replicate treatment areas (4 m X 2.5 m = 10 m^2): two 'Control' areas without stakes, and two 'Stakes' areas with stakes to trap and retain detritus.

Preliminary surveys

Prior to adding stakes to the riverbed (Pre-manipulation) surveys were conducted to quantify initial amounts of woody structure, vegetation, and plant detritus in all treatment areas. The experiment was established at flows of 1,000 ML/day, but all sites were fully submerged by freshes in winter (≤9,400 ML/day) and spring (≤14,400 ML/day), and by prolonged periods of elevated flow (>2000 ML/day) that prevented follow-up surveys in Spring.

The first post-manipulation surveys, completed in December, confirmed that the stakes (*n* = 1440) survived elevated flows at all sites. Seven stakes were damaged by cattle at Moss Rd. Some staked areas were trapping and storing detritus as intended (Figure 12), but preliminary figures suggest that, on average Stakes and Control treatments have lost detritus since the experiment started (Figure 13), presumably due to flushing flows in winter and spring. Control areas appear to have lost more detritus than staked areas but statistical analyses are pending.

A second post-manipulation survey will be conducted in late summer and we predict a stronger treatment effect at that time. Low summer flows, coupled with summer shedding of Eucalyptus leaves and bark, are expected to create much larger accumulations of detritus in our treatment areas.

Figure 12. A Stakes treatment area with accumulations of detritus (Photo: W. Bovill).

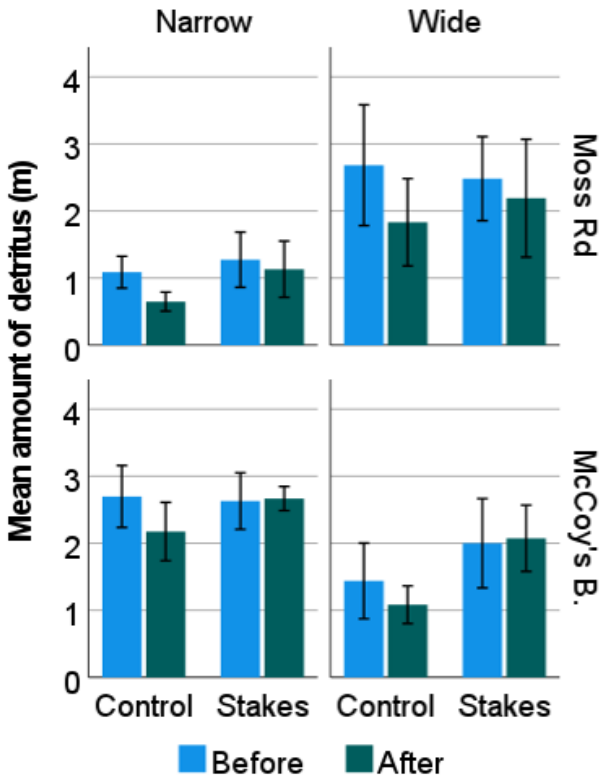

Figure 13. Mean (± 1 SE) amounts of detritus (fine, dead plant material) in Control vs Stakes treatments in June (before manipulation) and December (after manipulation). Data shown for two illustrative sites, analysis pending. Amount of detritus is presented as the total m recorded along 3 random, 2.5 m long transects per treatment area (treatment areas are 2.5 m wide).

Communications and engagement

Story Mapping

To reach more members of the community, a new tool has been created to share research findings. This tool is a story map, an interactive map platform that combines a mixture of content from videos, pictures, and infographics to explain how environmental flows affect fish, vegetation, physical habitat, stream metabolism and macro-invertebrates (Figures 14 & 15). Scientific research is presented in a new and exciting way to share information and updates with the community.

The story follows the journey of a droplet of environmental water through the entire Goulburn River, stopping to discuss the benefits of environmental water at different spots along the way.

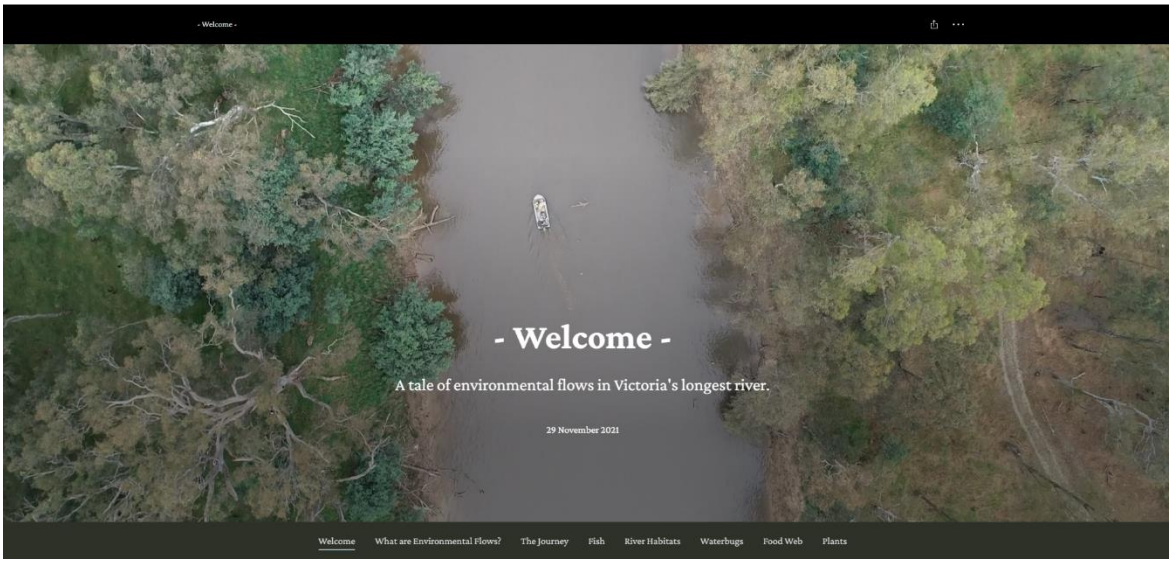

Figure 14. The story map welcome screen.

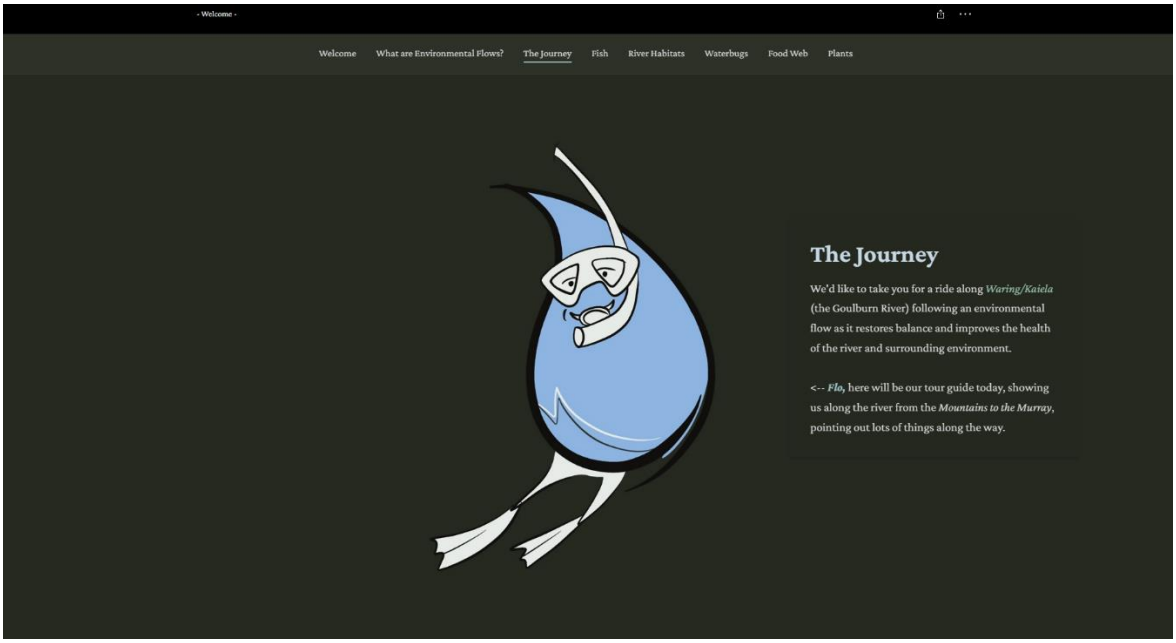

Figure 15. 'Flow' the environmental water droplet.

This tool can be accessed via the GB CMA website Goulburn River - a tale of environment flows in Victoria's longest river - GB CMA - Goulburn Broken CMA.

Ongoing engagement

The following activities were undertaken between October and December 2021.

- The benefits of environmental flows and monitoring continue to be highlighted in monthly columns (Country News (paid) – circulation 45,000; and Shepparton Adviser (free) – readership 70,000), stakeholder email updates, environmental water advisory group meeting presentations, social media and press releases.

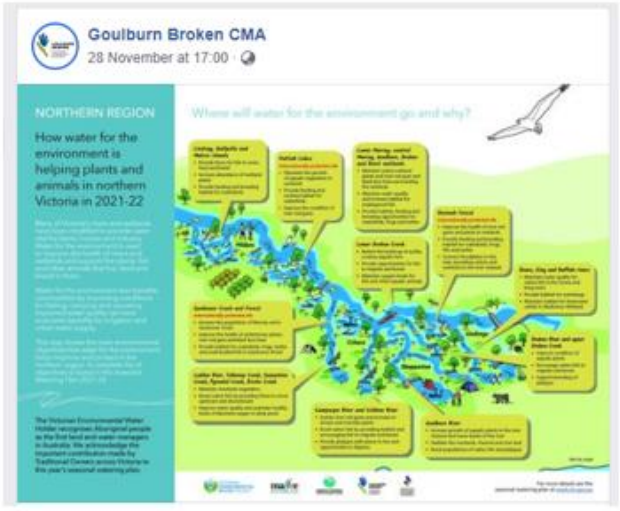

Figure 16. Social media examples

Activities calendar

Activity	Current quarter (Oct-Dec 2021)*	Upcoming quarter (Jan-March 2022)*
River flows		
Flow deliveries	Water for the environment used to maintain base flows and deliver a spring Fresh in October 2021	Variable baseflow between 700-1000 ML/day will be targeted between January and March. Baseflow may increase to ~1100 ML/day if IVT demands increase.
Monitoring activities		
Fish	Larval drift sampling and radio tracking	Radio tracking, processing larval samples
Vegetation	Post-spring fresh surveys (late October/early November)	Autumn fresh surveys
Macroinvertebrates	Post spring fresh survey. Laboratory processing	Monthly sampling between January-March. Laboratory processing.
Metabolism	Ongoing data logging and processing	Ongoing data logging and processing
Bank condition	Post-spring fresh surveys (late October/early November). Data analysis	Continuing data analysis and preparing for the next watering event.
Reporting and Evaluation activities		
Monitoring data entry	Ongoing as required	Ongoing as required
Annual report	Finalise and submit 20-21 Scientific report	
Contingency/Research activities		
Turf mat monitoring	Post-Spring fresh mat retrievals and placement. Seed and sediment analysis from pre- and post-spring retrievals.	Continuing seed and sediment analysis from pre- and post-spring retrievals.
Collaborative research projects	Data analysis (Survey 2). Spring survey and sampling of experiment. Sample processing (invertebrates).	Summer sampling of experiment (Invertebrates, fish). Sample processing (invertebrates).
Communication and engagement		
CMA led activities	Ongoing engagement activities*	Ongoing engagement activities*

** Field and engagement activities are dependent on Covid-19 restrictions*

Get in touch

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