Engineering a conservation refuge: Wetland restoration for critically endangered species

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Key points

- Integrated hydrological, ecological and landscape design is being used to restore more than 35 hectares of floodplain wetland and woodland habitat within the Upper Yarra WWTP buffer land.
- The project establishes a climate-resilient conservation refuge and breeding location for the critically endangered Helmeted Honeyeater and lowland Leadbeater's Possum.
- Water balance and hydraulic modelling demonstrate that natural catchment flows can sustain wetlands in average years, with recycled water supporting habitat during drought.
- Wetland creation will improve effluent quality and strengthen protection of the Birrarung/Yarra River while delivering biodiversity outcomes.
- Co-design with the Traditional Custodians enabled the integration of culturally valued environmental outcomes into the restoration.

Abstract

Yarra Valley Water (YVW), in partnership with leading experts in ecological restoration, floodplain management, hydrology, threatened species conservation and the site's Traditional Custodians, is restoring floodplain wetland function and establishing woodland and wetland habitat across more than 35 hectares at the Upper Yarra Wastewater Treatment Plant (WWTP). The project will create a climate resilient conservation area and breeding location for the critically endangered Helmeted Honeyeater and lowland Leadbeater's Possum within the treatment plant's buffer land. The design integrates three key elements: hydrological design of wetlands and watering regimes, detailed planting design specifying species and spatial arrangement, and a master plan that unifies ecological, cultural, landscape and future operational objectives. The hydrological restoration considered water quality to evaluate potential water sources and landscape hydraulics to understand floodplain responses to proposed interventions. Water balance modelling indicates that, in average years, catchment flows will provide sufficient water to meet the desired seasonal wetland regime, while during prolonged dry periods, supplementary recycled water from the WWTP will be required to sustain habitat vegetation. The creation of additional wetlands will deliver operational benefits for YVW, including improved effluent quality and consequently, enhance protection of the Birrarung/Yarra River. Co design with the Wurundjeri Woi-wurrung Aboriginal People has ensured the project integrates Culturally valued environmental outcomes within the restoration outcomes. Wetland restoration works and establishment-phase planting are scheduled for completion in December 2026.

Keywords

Wetlands restoration, recycled water reuse, climate resilience, habitat restoration, threatened species conservation

Introduction

It is estimated that approximately 3.4 million km^2 of inland wetlands have been lost globally since 1700 (Fluet-Chouinard et al., 2022), driven primarily by human interventions such as agricultural expansion and floodplain modification, including the establishment of wastewater treatment facilities. This loss

has degraded the hydrological and ecological functions of these landscapes and displaced many flora and fauna species from their natural habitats. At Yarra Valley Water's Upper Yarra WWTP, the loss of wetland function and habitat has reduced the availability and connectivity of habitat for the critically endangered Helmeted Honeyeater (HeHo) and lowland Leadbeater's Possum (LLBP) (Figure 1).

Figure 1 Helmeted Honeyeater (*Lichenostomus melanops cassidix*) and Leadbeater's Possum (*Gymnobelideus leadbeateri*)

The Upper Yarra WWTP is located in Launching Place, a rural township situated on the Birrarung (Yarra River, hereafter referred to as the Birrarung), 54 km east of Melbourne. The region's land use is predominantly agricultural, reflecting both the topography and proximity to the Birrarung. Located within the floodplain of the Birrarung (Figure 2), it is an area that historically supported lowland swamp forest vegetation communities, providing habitat for HeHo and LLBP (Greening Australia, 2020). The lower portion of the WWTP site, which forms part of the facility's buffer area, has been heavily modified through extensive clearing of vegetation, excavation, and regrading of the landform, resulting in the loss of the original floodplain topography. These interventions have disrupted surface water flows across the site, altering the hydrology of natural wetlands and billabongs.

Figure 2. Aerial image of Upper Yarra Treatment Plant site at Launching Place, 63km east of Melbourne

A key impediment to recovering populations of HeHo and LLBP is the current lack of high-quality swamp forest habitat. Historic clearing for farming and agriculture, including on the Upper Yarra WWTP site, has resulted in the loss of most lowland swamp forests across Victoria. With fewer than 40 LLBP and 250 HeHo remaining in the wild, the establishment of new swampy riparian habitats is essential for their continued survival. It is within this landscape that YVW, in partnership with Wurundjeri Woi-wurrung Cultural Heritage Aboriginal Corporation, Zoos Victoria, Melbourne Water, the Victorian Government Department of Environment, Energy and Climate Action (DEECA), North East Link Project (NELP) and Jacobs, is restoring 35 hectares of native vegetation to establish new habitat for the HeHo and LLBP.

Considering the broader landscape context, the Upper Yarra WWTP restoration site will form part of the Liwik Barring Landscape Conservation Area, which encompasses over 3000 hectares of public land reserves and crown land water frontages throughout the Yarra Valley (DELWP and PV, 2021). This expansive area plays a crucial role in providing connectivity along the Birrarung, and linking various habitat restoration projects across the region. Holistically, the success of habitat restoration works is contingent on the connectivity between the new habitat area and the wider environment. Habitat connectivity is a key consideration when promoting the persistence of the HeHo and LLBP populations over a wider area. When species are able to establish and move between territories over a wide geographic range, their intrinsic risk of extinction decreases due to increased genetic diversity.

Research by Greening Australia in 2020, identified this section of the Yarra Valley, within which the Treatment Plant is located, as an area of high habitat restoration potential for HeHo and LLBP. The Treatment Plant is located along the southern slopes of Mt Toolebewong, at the base of a series of valley systems that drain cool air from the mountains over the site towards the Birrarung. This make**s** it ideal to support the key habitat species, *Eucalyptus camphora* (Greening Australia, 2020). The requirements of the project were to identify the hydrological processes and alterations required to enable the revegetation of the floodplain with swamp forest vegetation communities identified by Greening Australia and Zoos Victoria.

Exerting the greatest influence over the overall habitat regeneration outcomes, is the degree to which a natural swampy riparian floodplain hydrology can be restored. A hydrological regime unable to support the required watering requirements of the target vegetation species can result in die back and reduced regeneration of eucalypt plant species and fragmentation of animal populations. Yellingbo Nature Conservation Reserve which is home to remaining wild populations of HeHo's and LLBP's, illustrates this point (DCCEEW, 2024; Menkhorst, 2008). Altered floodplain hydrology arising from historical levee and drainage works has adversely impacted the existing habitat and threatens the stability of the Yellingbo population and thus the continued survival of the two species.

The project builds upon lessons learned from other habitat restoration projects in the Yellingbo Nature Conservation Reserve (Greet, 2015) and Haining Farm Conservation Park. A common issue relates to the availability and supply of water not meeting the requirements of vegetation (areas often too wet or too dry) and an inability to manage water flows. Design complexity arises from the modified hydrological conditions and the ambiguity surrounding the land's initial, unaltered state.

Whilst the unaltered natural flow state can be inferred from the landscape, it cannot be completely verified to provide a basis for design, making hydrological restoration challenging and complex in nature. In the face of a warming climate, with hotter and dryer conditions, water availability and management is even more of an issue. The flexibility at Upper Yarra, with a recycled water source and ability to adaptively manage water to meet the requirements of the vegetation, presents an opportunity to establish a climate resilient habitat for the two species. Importantly, the habitat is being established within the secure buffer lands of an operational treatment plant where access, watering regimes and

site management can be tightly controlled. This provides opportunities for active intervention and adaptive management that are not readily available in many existing conservation reserves.

The design uses low-intervention civil works (containment banks, swales, spillways etc.) to create depressions and various flow paths to retain water longer on the floodplain. Along with an appropriate water regime, these interventions will enable the establishment of the mix of woodland and wetland vegetation relied upon by the threatened species. A mix of source waters, including catchment runoff, inundation via overbank flow from the Birrarung during flooding and supplementary recycled water provided from the Treatment Plant will provide drought resilience to the restoration site.

Traditional Custodian values

Initially, YVW had a single project objective: establish a new home for the HeHo and LLBP by restoring habitat and floodplain hydrology at the Upper Yarra WWTP. However, through partnering with Wurundjeri Corporation, a second, complementary and interlinked objective emerged: to support and re-establish features of Aboriginal cultural value, alongside the recovery of the two species. The transition from a singular objective to a more holistic approach was strongly influenced by the existing partnership between YVW and Wurundjeri Corporation.

It is through the partnership that two key messages from the Wurundjeri Woi-wurrung people became clear:

- The importance of protecting the Birrarung, and a preference for improved effluent water quality outcomes; and,
- The importance of restoring Manna Gum (*Eucalyptus viminalis*) within the habitat.

In support of these values, the restoration included additional permanently inundated wetland areas which provide not only refuge for fauna during drought periods, but also contribute to improved water quality of recycled water prior to discharge to the Birrarung. Additionally, the ecological design includes significant numbers of Manna Gum within the habitat area.

Wetland system overview

Figure 3 shows the proposed layout of the wetlands. There are two main wetland systems:

1. Seasonal Wetlands system, wetland cells A, B, C and D – these are priority habitat restoration wetlands. Minor excavation works are required to create or expand shallow seasonal wetland areas (<30cm deep) to support swampy forest vegetation communities.
2. Permanent / semi-permanent deeper marsh wetlands, wetland cells E, F and G – these deeper marsh wetlands function to further improve water quality prior to discharge to the river system and will provide a water source and aquatic vegetation favoured by local wetland birds and frogs.

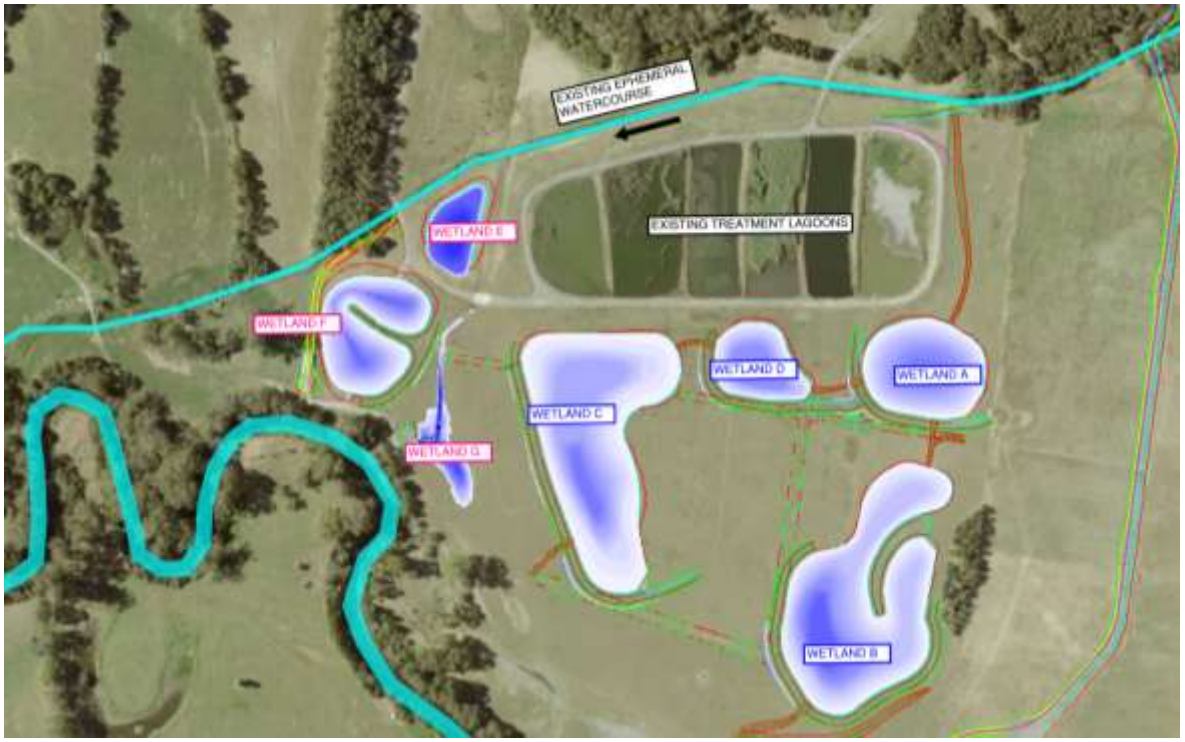

Figure 3 Site plan showing the proposed habitat wetlands

The systems are hydraulically independent of each other and will have differing primary water resources and water regimes to meet specific wetland system objectives. An overview of both wetland systems is provided below.

Seasonal wetlands

The season wetland system comprises four cells (A–D), designed based on the site topography, hydrological modelling, and target water depth requirements for restored vegetation. The primary water source for this system is an ephemeral watercourse north of the restoration area which flows east to west. Water is diverted from this watercourse into the seasonal wetland system, where it progressively flows across the system before discharging to existing billabongs. Fixed overflow structures have been created to maintain the target water levels in each wetland cell. Water balance modelling indicates that, in wet years (Figure 4), catchment flows meet the target watering regime without augmentation. In average years (Figure 5), supplemental recycled water is required to achieve approximately three filling events per season. In dry years (Figure 6), the system relies entirely on recycled water. Recycled water is supplied from the existing treatment lagoons.

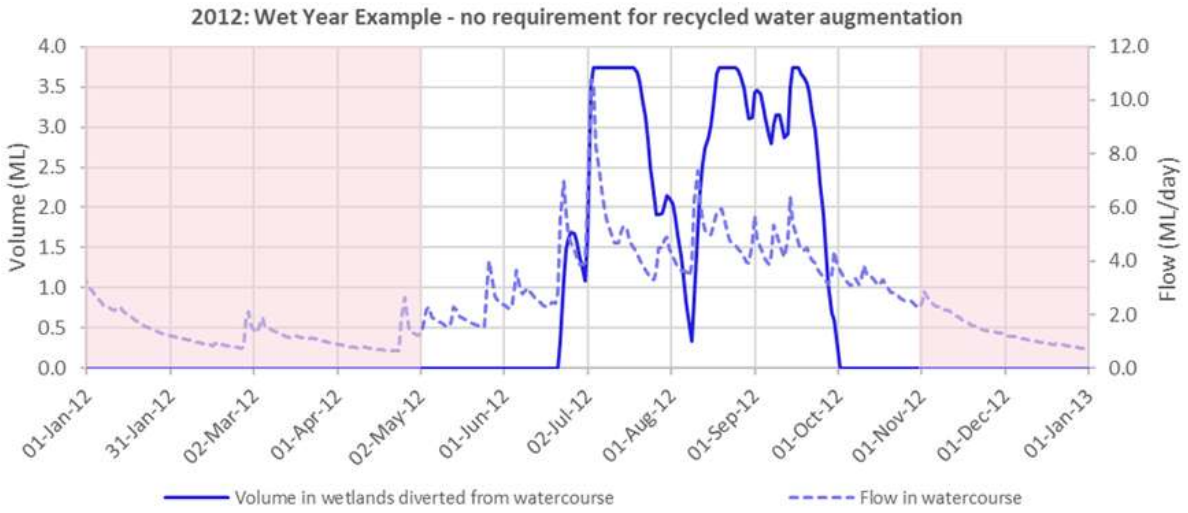

Figure 4 Diversion to Seasonal Wetlands – Wet Year The dry part of the year where no water is intended to be diverted to the wetland is blocked out (pink). In this example, the target water regime is achieved from natural filling of the wetlands from the watercourse and no augmentation with recycled water from the Treatment Plant is required

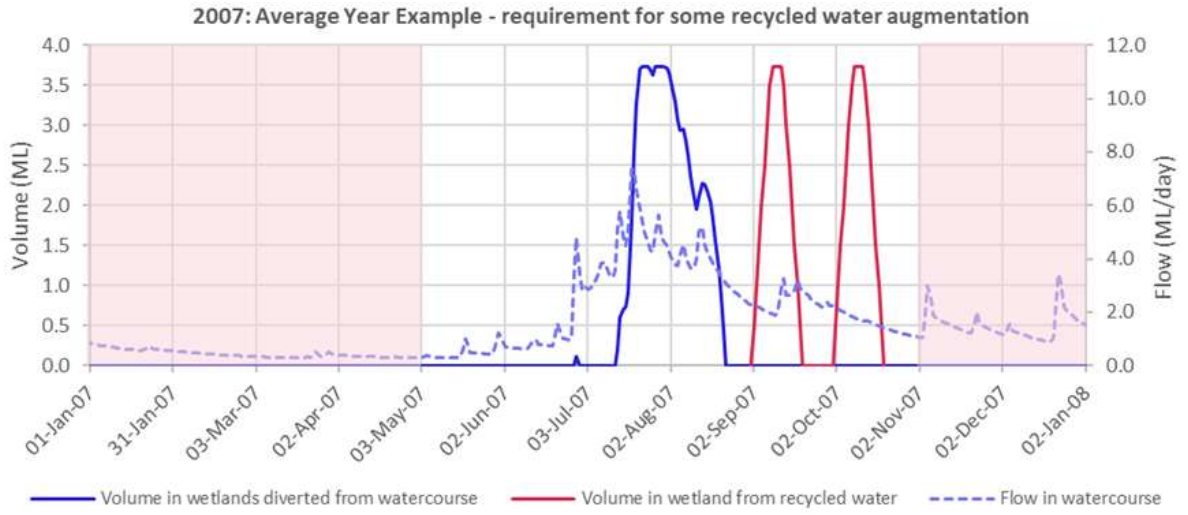

Figure 5 Diversion to Seasonal Wetlands – Average Year In this example, the target water regime is achieved from both natural filling of the wetlands from the watercourse and augmentation with recycled water from the Treatment Plant

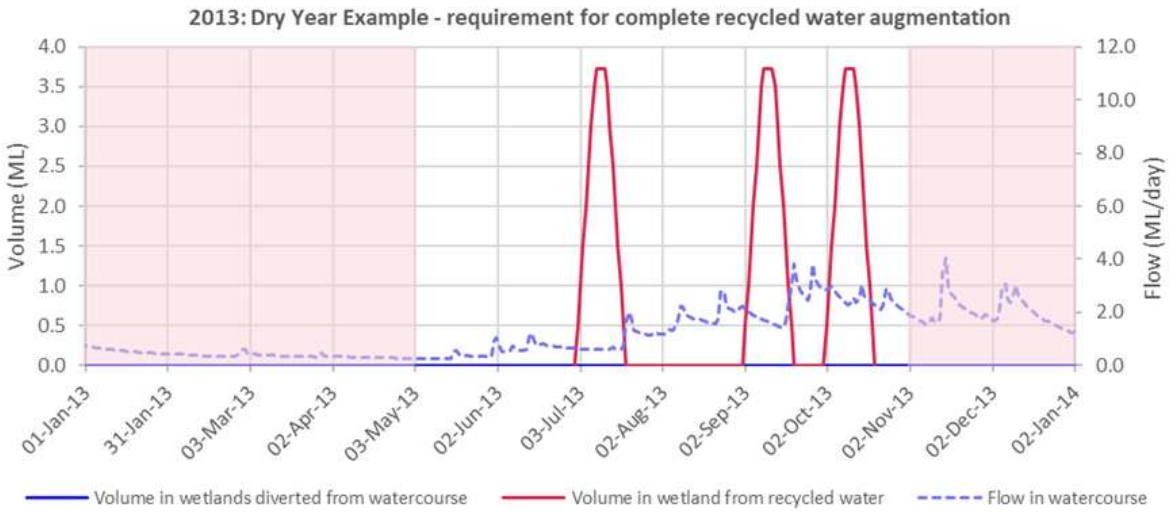

Figure 6 Diversion to Seasonal Wetlands – Dry Year. In this example, the target water regime is achieved by filling the wetlands solely with recycled water from the Treatment Plant

Deeper marsh wetlands

The deeper marsh wetlands are located in the western part of the site and comprise Cells E, F and G. Cells E and F are supplied with recycled water from the existing storage lagoons, while Cell G receives inflow from an existing surface drain connected to the ephemeral watercourse and remains hydraulically separate from the recycled water system.

These wetlands will be planted with vegetation adapted to permanent inundation and will function in a similar manner to the existing recycled water wetlands. By passing recycled water through these cells prior to discharge to the Birrarung, the wetlands provide an additional opportunity to improve water quality through the physical, chemical and biological processes characteristic of treatment wetlands. These include sedimentation, adsorption, plant uptake, microbial transformation of nutrients and increased exposure to sunlight, resulting in the further reduction of nutrients and other contaminants before discharge to the receiving environment.

The wetlands have been designed using simple, passive hydraulic controls that minimise operational requirements while maintaining flexibility in water level management. Recycled water is conveyed from the existing storage lagoons through Wetlands E and F before returning to the existing recycled water discharge line, ensuring compliance with the treatment plant's existing discharge licence. Wetland G is formed by constructing a low earthen spillway across an existing depression, requiring minimal earthworks and relying solely on natural catchment inflows.

Integrated water management

The availability of recycled water is a key feature of the wetland system. Using recycled water produced at the WWTP to support the swamp forest provides greater resilience during drought and, over the longer term, helps the ecosystem adapt to the impacts of climate change.

The creation of additional wetlands will also deliver operational benefits for YVW by improving the quality of recycled water discharged to the Birrarung, providing greater protection for the downstream receiving environment. In addition, the wetlands will help address gaps in the floodplain habitat network for threatened species.

The design prioritised passive, low-intervention principles to minimise ongoing operational and maintenance requirements while retaining flexibility to adjust watering regimes as conditions change. Earthworks were deliberately minimised, with much of the seasonal wetland design achieved through minor reshaping of the existing floodplain. This approach expanded and reconnected existing wetland

areas within the Birrarung floodplain, creating suitable conditions for vegetation establishment, restoration of floodplain processes and the development of habitat for threatened species.

While the physical infrastructure has been intentionally simplified, the site remains highly manageable from an operational perspective. The availability of recycled water, controllable diversion structures and restricted public access allows managers to respond rapidly to changing conditions, providing greater certainty for habitat establishment than is typically achievable in natural floodplain systems.

Wetland construction and establishment

Construction of the wetland cells, weir outfalls, bunds and recycled water supply system is complete. A herbivore exclusion fence has been installed around the perimeter of the habitat, with capacity to upgrade the fence to a predator proof fence in future (Figure 7). Site preparation and planting will be completed between August and December 2026 as part of a first establishment phase.

Figure 7 Photograph of constructed seasonal wetland on Birrarung floodplain, creek diversion structure and herbivore exclusion fence. Vegetation planting is planned to be undertaken between August and December 2026

The restored floodplain and woodland habitat will be managed as a closed, climate-resilient conservation refuge and breeding location for HeHo and LLBP. The location within the secure buffer lands of the Upper Yarra WWTP provides a highly managed environment where hydrology, vegetation establishment, access, herbivore impacts and future predator controls can be actively managed. This level of control reduces many of the pressures affecting existing populations elsewhere and creates a unique opportunity to establish a resilient habitat capable of supporting future species recovery programs.

Monitoring

A suite of monitoring has been implemented at the site to verify and assess the function and health of the habitat vegetation, water flow characteristics and water quality impacts.

Vegetation

Monitoring and maintenance of vegetation across the project area will be critical during the early establishment phase, with infill planting undertaken where plant mortality has occurred (Greening Australia, 2023). A network of permanent vegetation monitoring plots and transects will be established across the floodplain to assess vegetation establishment, growth and condition over time. Vegetation density, species composition and plant health will be assessed annually along each transect to

measure establishment success and growth rates. Monitoring will also include a reference transect on an adjacent property to provide a control for comparison.

Water

Routine monitoring of water quality has been implemented at the wetland outlets and will inform on the impact of vegetation on the reduction of specific contaminants, specifically nutrients, within any recycled water introduced into the wetland system. This monitoring is part of the larger suite of monitoring undertaken for the WWTP facility, required under the sites license to EPA Victoria.

An operational plan will be developed for the recycled water system and also the diversion channel to guide future operation of the wetlands, as well as specify ongoing monitoring requirements. Soil moisture probes will also be installed in a number of the seasonal wetlands as well as the billabong to inform watering regimes.

Additional groundwater bores have been installed south of the wetlands to monitor impacts to groundwater quality and ensure ongoing compliance with YVW's General Environmental Duty under the Environmental Protection Act 2017.

Monitoring results will be used to support an adaptive management framework for the site. The combination of controlled water sources, hydraulic infrastructure and restricted site access enables management actions to be implemented in response to observed vegetation, hydrological or water quality trends. This approach acknowledges the uncertainties inherent in floodplain restoration and provides a mechanism to progressively refine wetland operation and habitat management over time.

Conclusions

Inland wetlands are critical ecosystems at global, regional and local scales, supporting catchment health, water quality and biodiversity. The extensive historical loss and degradation of these systems has significantly reduced habitat availability and ecological function, reinforcing the importance of targeted restoration efforts such as those undertaken at the Upper Yarra WWTP.

Restoring wetlands in heavily modified landscapes presents inherent challenges. In many cases, the pre-disturbance condition cannot be directly observed and must instead be inferred from residual landscape features, reference sites and hydrological understanding. This uncertainty necessitates a pragmatic and adaptive design approach that balances ecological ambition with achievable site conditions. Water availability is a defining factor in wetland restoration success.

This project demonstrates that resilience can be enhanced through the integration of multiple water sources, including catchment inflows, overbank flooding and supplementary recycled water. The diversification of water inputs provides flexibility to respond to climatic variability, particularly under prolonged dry conditions.

The design approach adopted prioritises hydrological and ecological outcomes, favouring low-intervention and flexible solutions over heavily engineered systems. By working with existing landforms and reinstating naturalised flow paths through modest earthworks and simple control structures, the design enables adaptive management while minimising ongoing operational complexity and cost.

A key innovation of the project is the beneficial reuse of suitably treated recycled water to support wetland hydrology within a secure, actively managed conservation refuge. The ability to control water supply, access and habitat management provides a level of environmental stewardship not typically available in many restoration settings. This approach not only underpins habitat resilience during drought but also contributes to improved effluent quality prior to discharge to the Birrarung, demonstrating how water recycling can be integrated into broader landscape-scale ecological function.

Beyond hydrological restoration, the project delivers a range of co-benefits, including enhanced water quality, strengthened landscape connectivity and the creation of culturally meaningful environments

through co-design with Traditional Custodians. Importantly, the establishment of diverse wetland and woodland habitats provides a critical opportunity for the recovery of endangered species, including the Helmeted Honeyeater and lowland Leadbeater's Possum. Collectively, this project highlights how integrated, outcome-focused design can restore ecological function in highly altered environments, delivering resilient habitats and broad environmental and cultural benefits.

Acknowledgements

Greening Australia (2020) on behalf of YVW completed a feasibility study of the Upper Yarra Sewage Treatment Plant property for its capacity to support re-establishment of Helmeted Honeyeater and lowland Leadbeater's Possum habitat. An input to this Feasibility Study was an investigation by DesignFlow (2020) of opportunities for establishment of wetlands at the project site. The outcomes of these previous studies have formed inputs to the detailed design of habitat restoration wetlands.

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