

# 1 **Designing for nature doesn't cost the Earth**

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30

31 **Abstract**

- 32 1. A key barrier to the development of nature positive cities is the unknown cost of  
33 implementing novel urban design elements. Strict budgets and government approval  
34 processes make it challenging for developers to trial new approaches, meaning most  
35 developments rarely deviate from 'business-as-usual' (BAU). Further research is  
36 urgently needed to overcome this barrier to innovation and help mainstream concepts  
37 like Biodiversity Sensitive Urban Design (BSUD).
- 38 2. We sought to estimate the relative cost of BSUD actions intended to enhance habitat  
39 and mitigate threats for native fauna, while also providing health and well-being benefits  
40 for people. We shortlisted 18 actions proposed for public greenspaces including  
41 alternative planting designs, habitat analogues and elevated watering points for wildlife.  
42 We employed expert elicitation to estimate the cost of implementing these actions in a  
43 greenfield community development in peri-urban Melbourne, Australia. We recruited six  
44 practitioners whose expertise spanned engineering, landscape architecture, urban  
45 planning and design, integrated water management, urban heat mitigation and public  
46 lighting. Participants were primed with background information and asked to  
47 independently assess the feasibility, opportunities and challenges of each action, and  
48 estimate the relative cost of implementing each action compared to BAU. We then  
49 facilitated an online workshop where participants were encouraged to reach a  
50 consensus on the relative cost of each action. We also conducted a literature review on  
51 the potential co-benefits of integrating nature into urban developments.
- 52 3. Our experts concluded that 15 of 18 actions (83%) were likely to cost the same, or only  
53 slightly more, than a BAU approach. Actions that focused on creating diverse habitat  
54 structure were deemed particularly valuable, as they were likely to result in biodiversity  
55 benefits and were estimated to cost the same as BAU.

56 4. Cost-benefit analysis should also consider the substantial co-benefits of prioritising  
57 nature; we summarise these benefits and argue that their economic valuation could  
58 further motivate the uptake of BSUD.

59 5. These results suggest that BSUD is both feasible and relatively affordable to incorporate  
60 into a community development. We conclude that cost need not be a barrier to  
61 innovation in the design of urban spaces that benefit people and nature.

62

### 63 **Keywords**

64 Biodiversity Sensitive Urban Design; cost-benefit analysis; housing development; nature-based  
65 solutions; nature positive; urban design; urban planning.

66

## 67 **1. Introduction**

68 Urbanisation poses a significant threat to global biodiversity (Aronson et al., 2014; Simkin et al.,  
69 2022), with natural habitats increasingly being replaced by anthropogenic environments (Angel  
70 et al., 2011; Newbold et al., 2015; Seto et al., 2011). Conversely, cities often function as  
71 biodiversity hotspots and support a range of threatened species (Ives et al., 2016; Soanes &  
72 Lentini, 2019), demonstrating the importance of protecting and restoring biodiversity in urban  
73 spaces (Dearborn & Kark, 2010). Incorporating nature into urban developments is not just  
74 critical for conservation; it also contributes positively to the health and well-being of people living  
75 in these landscapes (Buxton et al., 2024; Cox et al., 2017; Hanski et al., 2012; Keith et al.,  
76 2024) and delivers a range of critical ecosystem services including cooling, flood mitigation and  
77 carbon storage (Davies et al., 2011; Livesley et al., 2016; Säumel et al., 2016). Unsurprisingly,  
78 enhancing and bringing nature back to cities has emerged as an important sustainability  
79 objective around the world (Nilon et al., 2017; Xie & Bulkeley, 2020). This is evident in the  
80 'nature positive' movement (Nature Positive Initiative, n.d.) and the Kunming-Montreal Global  
81 Biodiversity Framework (Convention on Biological Diversity, 2022b), particularly Target 12  
82 which aims to “enhance green spaces and urban planning for human well-being and  
83 biodiversity” by increasing “the area and quality, and connectivity of, access to, and benefits  
84 from green and blue spaces in urban and densely populated areas sustainably” (Convention on  
85 Biological Diversity, 2022a). The road to achieving nature positive urban development is still  
86 paved with uncertainty (Humphrey et al., 2025), but one potential avenue is via the use of  
87 frameworks that prioritise biodiversity in new developments such as Biodiversity Sensitive  
88 Urban Design (Garrard et al., 2018) or Animal Aided Design (Weisser & Hauck, 2025).  
89  
90 Biodiversity Sensitive Urban Design (or BSUD) provides a framework to directly integrate  
91 ecological considerations into the urban development process (Garrard et al., 2018; Kirk et al.,

92 2021). BSUD aims to create urban environments that make a positive on-site contribution to  
93 native biodiversity, with principles applicable across a range of development types, from a single  
94 building to an entire urban precinct or housing development (Garrard et al., 2018). The BSUD  
95 framework is intended to guide urban planners, designers and developers in incorporating  
96 biodiversity considerations into the development process from the outset, by following five key  
97 principles: 1) maintain and introduce habitat; 2) facilitate dispersal; 3) minimise threats and  
98 disturbances to fauna; 4) facilitate natural ecological processes; and 5) improve potential for  
99 positive human-nature interactions (Garrard et al., 2018; Kirk et al., 2021).

100

101 The concept of BSUD and the broader notion of urban biodiversity conservation have gained  
102 significant traction in recent years (Bush et al., 2023; Nilon et al., 2017; Pierce et al., 2020).  
103 BSUD is now recognised in multiple disciplines and mandated in policy in state legislation (ACT  
104 Government, 2023; Mennen, 2023) and local government management plans (Banyule City  
105 Council, 2025; Bekessy et al., 2024). However, despite widespread appreciation for the benefits  
106 of integrating and conserving biodiversity in cities, there is still a large implementation gap with  
107 numerous barriers to overcome (Soanes et al., 2023).

108

109 A key obstacle to mainstreaming BSUD is the unknown cost of implementing novel urban  
110 design elements. Strict budgets and current government approval processes make it  
111 challenging for even the most visionary developers to trial new approaches, meaning most  
112 developments rarely deviate from 'business-as-usual' (BAU). Uncertainty is an eternal blocker to  
113 innovation (Pannell et al., 2006) and has hampered the uptake of new agricultural technologies  
114 (Eastwood & Renwick, 2020; Marra et al., 2003), renewable energy sources (Eleftheriadis &  
115 Anagnostopoulou, 2015; Foxon & Pearson, 2008), and electric vehicles (Berkeley et al., 2017,  
116 2018). Further research is urgently needed to reduce the uncertainty surrounding BSUD and

117 empower developers and design practitioners to trial new approaches that benefit people and  
118 nature.

119  
120 Expert knowledge and judgement are commonly used in applied conservation biology to inform  
121 decision-making, particularly when data is insufficient, funding is limited or systems are  
122 inherently complex (Burgman, 2005; Martin et al., 2012; McBride et al., 2012). In recent years,  
123 expert elicitation has been applied to a range of ecological problems in cities including aligning  
124 urban forest management plans with broader sustainability goals (Bassett et al., 2024),  
125 identifying potential opportunities for green infrastructure to enhance ecosystem services (Elliott  
126 et al., 2020), and quantifying the habitat connectivity requirements of urban wildlife species  
127 (Courtney Jones et al., 2025). Despite the potential for bias, elicitation studies with small groups  
128 of diverse experts are typically considered valuable sources of information (McBride &  
129 Burgman, 2012; Travers et al., 2023), especially when expert responses are combined to  
130 reduce variation between individuals (Bennett et al., 2023; Hemming et al., 2018). Sourcing  
131 expertise across the multiple different disciplines working in urban development can provide a  
132 compelling way to reduce the uncertainty around BSUD implementation, while real-world data  
133 continues to be gathered from early adopters.

134  
135 Here we seek to overcome a key barrier to innovation in residential housing by estimating the  
136 relative cost of implementing actions for nature in a greenfield community development in peri-  
137 urban Melbourne, Australia. We undertook a structured expert elicitation process with a diverse  
138 group of six practitioners involved in the planning, design and construction of residential housing  
139 developments, and reviewed the literature on the potential co-benefits of integrating nature into  
140 urban spaces. We aimed to: 1) produce a list of BSUD actions intended to benefit people and  
141 nature in public greenspaces; 2) engage with experts to assess the feasibility and identify the  
142 opportunities and challenges of including each action in our case study development; 3) provide

143 relative estimates of the financial cost of implementing each action compared to a business-as-  
144 usual scenario; and 4) summarise the potential co-benefits of investing in nature to provide a  
145 more thorough cost-benefit analysis for future development projects.

146

## 147 **2. Methods**

### 148 **2.1 Case study site**

149 This study used a proposed greenfield community development site as a case study. The site  
150 was located on the unceded lands of the Taungurung and Wurundjeri Woi Wurrung people in  
151 Melbourne's northern growth corridor, in south-eastern Australia. Melbourne is Australia's most  
152 populated city, currently home to 4.9 million residents and 2.1 million residential dwellings  
153 (Australian Bureau of Statistics, 2021). Over the next 25 years, the city is expected to grow  
154 substantially to accommodate 9 million people and 3.2 million homes (Department of  
155 Environment, Land, Water and Planning, 2019). Greenfield community developments are  
156 common around the northern, western and south-eastern fringes of the city where the majority  
157 of new development is now taking place (Growth Areas Authority, 2012). Our case study site  
158 covered an area of ~740 hectares of agricultural land, and included plans for approximately  
159 8000 new homes, a town centre, three schools and a number of restored public greenspaces.

160

### 161 **2.2 Biodiversity Sensitive Urban Design actions**

#### 162 *2.2.1 Identifying biodiversity objectives and targets*

163 Following established best practice for Biodiversity Sensitive Urban Design (BSUD)  
164 implementation (see Kirk et al., 2021), we initiated the process for our case study greenfield  
165 community development by identifying biodiversity objectives and target species through  
166 participatory stakeholder engagement. A BSUD workshop was conducted in April 2021 with 19  
167 external participants representing the key stakeholders including the current landholder, local

168 government, Victorian Planning Authority, relevant environmental consultancies, and local  
169 environmental groups. Ethics approval for this workshop was granted by RMIT University's  
170 College Human Ethics Advisory Network (CHEAN 2021-24363-14229).

171  
172 The workshop employed a two-part approach to develop both human-centric biodiversity  
173 objectives and identify focal species for the project. In the first session, participants engaged in  
174 a visioning exercise to conceptualise the future character of the greenfield community  
175 development. This process yielded seven overarching biodiversity objectives that translate  
176 ecological concepts into accessible, human-centric goals, including: 1) integration of community  
177 and nature; 2) diverse natural features reflecting varied habitats; 3) recognisable species with  
178 cultural and seasonal connections; 4) biodiverse native vegetation; 5) prominent natural  
179 soundscapes; 6) incorporation of Indigenous knowledge in land management; and 7) accessible  
180 green pedestrian corridors.

181  
182 The second session focused on selecting target species for the development. Participants were  
183 briefed on 12 ecologically feasible candidate species that also offered community engagement  
184 opportunities. After a discussion evaluating species against the previously identified biodiversity  
185 objectives, participants voted on their preferences. As votes were evenly distributed across  
186 eight species, subsequent consultations with ecological experts and Traditional Owner  
187 representatives (Wurundjeri Woi wurrung Cultural Heritage Aboriginal Corporation) further  
188 narrowed the selection to a five final target species: Australian Emperor Dragonfly (*Anax*  
189 *papuensis*), Growling Grass Frog (*Litoria raniformis*), Superb Fairy-wren (*Malurus cyaneus*),  
190 Blue-banded Bee (*Amegilla* spp.), and Swamp Wallaby (*Wallabia bicolor*) (see Table S1 for  
191 details of species ecology). These five species represent diverse taxonomic groups  
192 encompassing both aquatic and terrestrial organisms that either currently occur at the site, are  
193 present in the surrounding area, or could feasibly be restored given appropriate habitat

194 provision (Atlas of Living Australia, 2023). The selected species collectively depend on various  
195 vegetation types and food sources, functioning as umbrella species for a range of regional,  
196 native wildlife.

197

### 198 *2.2.2 Identifying key locations for biodiversity action*

199 During an additional workshop with the development project team (November 2023), we used  
200 these target species to interrogate the existing precinct masterplan for the development and  
201 identify key locations or land-use types where BSUD actions would be both appropriate (from an  
202 ecological perspective) and feasible (from an urban design perspective). We identified three  
203 main areas of public land where delivery of positive outcomes for nature could be maximised:  
204 streetscapes, linear active transport corridors, and small community parks (see Fig. 1 for  
205 example renders). Focusing design interventions on these three land-uses offered strategic  
206 advantages for urban biodiversity conservation in a residential development. These land-uses  
207 are under developer control, enabling direct implementation of BSUD during the development  
208 phase. Although large public open spaces (including remnant vegetation areas and restored  
209 natural ecosystems) are frequently addressed during the broader precinct planning process,  
210 these smaller-scale urban elements can also provide critical opportunities to extend nature  
211 positive actions throughout a development. Focusing on these 'everyday' spaces not only  
212 contributes towards urban biodiversity conservation, but can enable greater and more equitable  
213 access to the benefits for residents.



214

215 **Figure 1.** The three public greenspaces considered in this study: **a)** Streetscapes; **b)** Linear  
216 active transport corridors; and **c)** Small community parks. Renders were generated in

217 MidJourney (version 6) using 35 mm/landscape architecture style, a warm green and orange  
218 colour palette, and an aspect ratio of 2:1. Images were then finalised in Adobe Photoshop  
219 (version 25.6).

220

221 Well-designed streetscapes (Fig. 1a) contribute significantly to urban biodiversity by establishing  
222 habitat patches and corridors that enhance ecological connectivity (Bell et al., 2025; Brown et  
223 al., 2024; Fernández-Juricic, 2000; Hwang et al., 2025). Integration of BSUD elements within  
224 streetscapes also provides multiple co-benefits, including stormwater management, mitigation of  
225 urban heat island effects, and improved air quality, creating healthier environments for residents  
226 (Säumel et al., 2016; Tan et al., 2022). Biodiverse streetscapes enhance the aesthetics of urban  
227 developments, encouraging pedestrian activity and facilitating human-nature interactions  
228 (Kowarik et al., 2025; Stoia et al., 2022). Native street plantings may also inspire street  
229 gardening activities among residents, fostering environmental stewardship and strengthening  
230 social cohesion within developing communities (Doll et al., 2023; Ligtermoet et al., 2025; Phillips  
231 et al., 2023).

232

233 Nature-integrated active transport networks in urban environments provide multiple ecological  
234 and social benefits (Fig. 1b). Pedestrian and cycling paths complemented by native vegetation  
235 essentially form linear parks, encouraging sustainable transport and exercise (Herath & Bai,  
236 2024; Stoia et al., 2022). When appropriately designed, active transport links can  
237 simultaneously function as wildlife corridors, enabling species movement through urban  
238 landscapes and enhancing ecological connectivity (Hardy et al., 2022; Kirk et al., 2021; Lynch,  
239 2019).

240

241 Small parks (Fig. 1c), when designed with appropriate habitat resources, are capable of acting  
242 as stepping stones between larger habitat remnants while maintaining recreational and play

243 spaces for local communities (Croeser et al., 2024; Egerer et al., 2024). However, typically  
244 these small open spaces are designed with limited vegetation and amenity (mainly lawn areas  
245 and playground equipment), creating underutilised spaces. Adding BSUD elements, even  
246 simple native vegetation beds, will deliver additional benefits including water conservation, soil  
247 stabilisation, and increased shading. Introducing biodiversity-friendly elements will also increase  
248 visual cues to care, establishing a sense of place that complements the broader neighborhood  
249 character while creating focal points for immediate residents and reducing the likelihood of park  
250 neglect (Hoyle et al., 2019; Li & Nassauer, 2020).

251

### 252 *2.2.3 Identifying key design actions for costing*

253 Considering the ecology of the five target species, and each of the three land-uses, we  
254 identified a series of design actions that would ensure both the provision of habitat resources  
255 and mitigation of key threats. These actions could be grouped into four main themes: 1) “Habitat  
256 Analogues or Design Features”; 2) “Surface Area or Land Cover Design”; 3) “Vegetation or  
257 Planting”; and 4) “Water”. “Habitat Analogues or Design Features” included a range of elements  
258 that typically might be added to provide specific resources that may be missing in a landscape,  
259 such as nesting or roosting sites. This theme also included specialised structures for crossing  
260 roads, and design elements such as seating or play equipment with integrated resources that  
261 support biodiversity. “Surface Area or Land Cover Design” actions were actions that might  
262 slightly alter the master planned land-use allocations. Any changes that increased the total area  
263 or enhanced the typical planting palette were grouped as “Vegetation or Planting” actions.  
264 “Water” actions covered any urban design elements that would involve how water was  
265 controlled within the landscape. Grouping these actions allowed our expert panel to focus  
266 specifically on the elements that they felt most strongly aligned with their expertise. To further  
267 facilitate the expert panel, seven actions were identified as priorities for the development, either  
268 because these design elements would benefit a large number of different species, or because

269 they provide important but often overlooked resources (see Table 1 for a full list of the proposed  
270 BSUD actions).

271

### 272 **2.3 Expert participants**

273 With the assistance of the landholder, we recruited four practitioners whose expertise spanned  
274 engineering, landscape architecture, urban planning and design, integrated water management  
275 and urban heat mitigation. All four practitioners were familiar with the case study site and had  
276 significant expertise working on greenfield community development projects in Greater  
277 Melbourne. However, throughout the expert elicitation process (see section 2.4), it became  
278 apparent that our participants lacked the required expertise to comment on wildlife-friendly  
279 lighting products. As a result of this knowledge gap, we recruited two additional practitioners  
280 with experience in public lighting (specifically related to products that reduce light pollution),  
281 bringing our total number of participants to six.

282

### 283 **2.4 Expert elicitation process**

284 We employed expert elicitation and a simplified version of the IDEA protocol (see Courtney  
285 Jones et al., 2025; Hemming et al., 2018) to assess feasibility, identify opportunities and  
286 challenges, and estimate the relative cost of implementing each action compared to a BAU  
287 scenario in a greenfield community development. Typically, the IDEA protocol involves four  
288 steps: 1) *Investigate*, where experts are posed a series of questions and asked to respond  
289 individually; 2) *Discuss*, where participating experts are invited to a facilitated workshop where  
290 their deidentified responses are shared and they talk through different interpretations, reasoning  
291 and evidence; 3) *Estimate*, where the experts provide a second and final set of independent  
292 responses to the same set of questions; and 4) *Aggregate*, where the facilitators mathematically  
293 combine the expert responses into a single value (Hemming et al., 2018).

294

295 For the purpose of this study, we conducted our expert elicitation in two phases. In Phase 1, we  
296 were specifically interested in gathering qualitative responses to a list of questions, so we only  
297 followed the *Investigate* and *Discuss* steps. First, we compiled a detailed spreadsheet with  
298 information on each BSUD action including a description, rationale, target fauna species,  
299 proposed location (streetscapes, linear active transport corridors, and/or community parks),  
300 potential relevance to different disciplines (landscape architecture, engineering, integrated water  
301 management, urban design, urban heat mitigation and/or public lighting), and some example  
302 installations across Australia. Once the experts had familiarised themselves with this  
303 information, we asked them to individually respond to five questions regarding the feasibility,  
304 opportunities and challenges of implementing each action in the case study development  
305 (*Investigate*). Experts were asked to only comment on those actions that fell within their self-  
306 determined area of expertise. The five questions included:

- 307 1. How possible is it to deliver/build/implement this action from your discipline's perspective  
308 (ranging from 'easy to implement' through to 'blue sky thinking')?
- 309 2. What are the opportunities and challenges relating to this action?
- 310 3. Would this be a 'stand-alone' cost or could it be included in an existing BAU solution  
311 (i.e., integrated into existing or planned infrastructure)?
- 312 4. Where would you locate this action in our case study greenfield community  
313 development?
- 314 5. How would you rank this action in terms of deliverability? (ranging from 'low hanging  
315 fruit' to 'extreme measure' etc.)

316  
317 We then facilitated an online workshop where the participating experts were presented with the  
318 deidentified responses, and were encouraged to discuss their thoughts and reasoning  
319 (*Discuss*). At the conclusion of this workshop, we compiled the participant responses and  
320 facilitator notes taken during discussions.

321  
322 In Phase 2, we followed all four steps of the IDEA protocol: *Investigate*, *Discuss*, *Estimate* and  
323 *Aggregate*. Here, we posed one final question which asked the experts to independently  
324 estimate the relative cost of implementing each action in our greenfield community development  
325 compared to a BAU scenario (*Investigate*). Experts were directed to categorise each action  
326 relevant to their area of expertise as: 1) Cheaper; 2) Approximately the same; 3) Slightly more;  
327 4) A lot more; or 5) Prohibitively more expensive than BAU. When experts expressed  
328 uncertainty around their estimates, we went with the more conservative (or higher) cost estimate  
329 given. Again, we held an online workshop where we shared the anonymous responses and  
330 facilitated a discussion around any differences in opinion (*Discuss*). Throughout these  
331 discussions, we encouraged experts to reach a consensus decision on the relative cost of each  
332 action, which occasionally involved experts revising their initial responses (*Estimate*). Following  
333 the workshop, we collated the revised responses, confirmed the consensus decision for each  
334 action, and calculated the percentage of actions that fell within each costing category  
335 (*Aggregate*).

336  
337 In total, we worked through this expert elicitation procedure twice - once with the four original  
338 experts, and once with the two public lighting experts who were recruited later in the study  
339 following the identification of a key knowledge gap. The latter experts only commented on the  
340 installation of wildlife-friendly public lighting in the case study site. All participating experts were  
341 offered co-authorship on this paper.

342

### 343 **2.5 Investigating potential co-benefits**

344 During our discussions with the project team and expert participants, several co-benefits were  
345 identified. Co-benefits are additional, positive environmental, social or economic outcomes that  
346 could be achieved by implementing BSUD actions during development. Assessing the economic

347 value of these co-benefits was beyond the scope of this study; however, all co-authors  
348 recognised that formally identifying the co-benefits would provide additional motivation, beyond  
349 cost, for developers to consider BSUD innovations. To explore the potential co-benefits of  
350 investing in nature in an urban development, we conducted a review of published literature. We  
351 used the proposed BSUD actions (identified in section 2.2.3) as a starting point and searched  
352 for any evidence of co-benefits for people in urban environments.

353

## 354 **2.6 Data compilation and visualisation**

355 To identify the key themes and concepts that emerged during expert discussions, we used an  
356 inductive thematic approach (Thomas, 2006) to inspect the participant responses and facilitator  
357 notes for keywords and themes. To summarise and visualise the estimated cost of the proposed  
358 BSUD actions, we produced a relative frequency histogram using the package ‘ggplot2’  
359 (Wickham, 2016) in R version 4.4.3 (R Core Team, 2025) and R Studio version 2024.12.1.563  
360 (Posit Team, 2025). We also produced an infographic to summarise the co-benefits identified in  
361 the literature review using Adobe Illustrator 30.2.1 (Adobe Inc., 2026).

362

## 363 **3. Results**

### 364 **3.1 Biodiversity Sensitive Urban Design actions**

365 Following our stakeholder workshops, and accounting for the likely location and general design  
366 requirements of our three main land-use types, we identified a list of 18 potential BSUD actions.  
367 These were linked directly to the ecology of the target species and taxonomic groups and were  
368 intended to enhance habitat resources and mitigate potential threats, while also providing health  
369 and well-being benefits for residents in the case study development (Table 1). These 18 actions  
370 spanned a range of approaches from imbedding novel habitat design features, to altering

- 371 planting palettes, integrating water sensitive and biodiversity sensitive design elements, and
- 372 adjusting spatial planning to create more physical space for nature.

373 **Table 1.** The 18 BSUD actions proposed for the case study site. The \* denotes actions that are considered essential to delivering  
 374 BSUD outcomes in the greenfield community development. The shading indicates different themes including habitat  
 375 analogues/design features (actions 1-8), surface area/land cover design (9-11), vegetation (12-15) and water (16-18).

No.	Action	Definition	Rationale	Target species	References
1	Above road wildlife crossing structures for major roads	A single rope ladder or canopy bridge measuring 8 m long x 0.5 m wide, installed at a height of 3-4 m above a residential street. The crossing structure is supported on either side by an upright pole.	Help facilitate species movement across the busier access streets, minimising wildlife-vehicle collisions.	Benefits a range of different species, especially arboreal mammals.	(Smith et al., 2015; Soanes et al., 2024; Young et al., 2023)
2	Habitat analogues attached to lighting infrastructure or other pole-based infrastructure	Three wooden nest boxes attached to a single upright pole at a height of 3-6 m. The boxes can be slightly altered to suit the different species needs, and potentially could also be used for plants. The pole is installed in a community park.	Add nesting, roosting and vegetation resources, especially in places where new trees will take a while to mature and provide these resources. Specific designs can be altered for different target species.	Blue-banded bees Superb fairy-wren	(Jaworski et al., 2022; Parker et al., 2022; Ranalli et al., 2025)
3*	Sandy, rocky and muddy areas with logs	An area of sand, gravel or mud with a pile of rocks and a couple of logs. The area is incorporated into a community park and measures 2 m x 2 m.	Many native invertebrate, frog and lizard species use bare ground and dead wood for nesting or foraging. Benefits a wide range of species.	Blue-banded bees Superb fairy-wren Growling grass frog	(Antoine & Forrest, 2021; Brown et al., 2020; Heard et al., 2010; Korhonen et al., 2020)
4	Habitat walls at property boundaries (e.g., gabion walls or retaining walls)	A gabion wall constructed of galvanised steel baskets or cages, filled with natural rock. The wall measures 4 m long x 1.2 m high x 0.3 m deep. It divides the front gardens of two adjoining properties.	Encourages micro-habitats for invertebrates, amphibians and small reptiles. Cracks, crevices and rough surfaces increase the number of resting, hiding and even nesting places in the urban environment.	Blue-banded bees Superb fairy-wren Growling grass frog	(Croak et al., 2010; Manenti, 2014)
5	Nature play	A nature play area featuring a sand	Can provide resources for a range	Blue-banded bees	(Antoine & Forrest,

No.	Action	Definition	Rationale	Target species	References
	areas with novel habitat analogues	patch, water collection system, logs, rocks, and a space for building bush shelters. The play area is incorporated into a community park and measures 5 m x 5 m.	of species. This includes substrates that can be used for nest building elsewhere, in addition to water resources.	Superb fairy-wren Growling grass frog Emperor dragonfly	2021; Brown et al., 2020; Heard et al., 2010; Korhonen et al., 2020)
6	Seating that incorporates vegetation and/or habitat analogues	A wooden park bench with vertical lattices on either end and a canopy above to encourage climbing vegetation. The bench itself measures 1.8 m long x 0.5 m high x 0.4 m deep. The lattices and canopy are 1.8 m high. The bench is installed in a linear active transport corridor.	Increased opportunities to include vegetation with foraging resources and cover. Similar to #4, these structures could be designed to include insect hotels for specific species.	Blue-banded bees Superb fairy-wren Growling grass frog Emperor dragonfly	(Khodashenas & Taji, 2024; Kuta & Mican, 2025)
7*	Wildlife-friendly public lighting	Public lighting that is 2700 K (or no greater than 3000 K), positioned at a low-height (approximately 4.5-6 m), with full cut-off optics, and 0 ° upward light component. Lighting is installed in a community park along two standard pedestrian paths (~1.8 m wide) which are used by foot traffic only.	Artificial light at night (ALAN) has a range of negative effects on species in urban environments. It disrupts sleep cycles, increases stress, changes the behavior of nocturnal animals, and impacts reproduction across many taxa, including birds, mammals and invertebrates.	Swamp wallaby Emperor dragonfly Growling grass frog	(Bennie et al., 2018; DCCEE, 2023; Dimovski & Robert, 2018; Gaston et al., 2012)
8	Wildlife underpasses for major roads	A small wildlife underpass positioned beneath a speed bump on a residential street, measuring 8 m long x 0.7 m wide x 0.25 m high. The entry points on either side of the road are protected by guard walls that measure 0.3 m high x 0.3 m long.	Roads are a major barrier and potential source of mortality for many species. These underpasses can be small and designed to benefit ground-dwelling species.	Swamp wallaby Superb fairy-wren Growling grass frog	(Goldingay et al., 2022; Smith et al., 2015; Soanes et al., 2024; Taylor & Goldingay, 2010)

No.	Action	Definition	Rationale	Target species	References
9	Permeable paving in a residential footpath	A section of grass block permeable paving in a residential streetscape, measuring 1.8 m wide x 20 m long.	At a minimum, permeable paving improves urban plantings by increasing access to water and air. Taken further, grass pavers can be used with ground cover plants to actively increase biodiversity.	All species	(Atkins, 2018; Bonthoux et al., 2019; Leidekker, 2022)
10	One wide footpath and one narrow footpath	A residential street measuring 20 m in length, with a standard footpath (1.8 m wide) on one side of the road, and a narrow footpath (1 m wide) on the other. Could be combined with a nature-strip gardening program for residents.	Allows for a larger volume of streetscape planting, with more provision of resources for a range of species.	Blue-banded bees Superb fairy-wren Growling grass frog Emperor dragonfly	(Bell et al., 2025; Ligtermoet et al., 2021; Marshall et al., 2019b, 2019a; Säumel et al., 2016)
11	Winding path/road edge/verge to create 'nature pockets' in streetscapes	A residential street measuring 20m in length, with a winding footpath and four larger garden bed 'pockets' spaced approximately 5 m apart. Pockets of vegetation could also include seating elements.	Allows for a larger volume of streetscape planting, with more provision of resources for a range of species.	Blue-banded bees Superb fairy-wren Growling grass frog Emperor dragonfly	(Bell et al., 2025; Ligtermoet et al., 2021; Marshall et al., 2019b, 2019a; Säumel et al., 2016)
12*	High level of mid-storey vegetation cover and connectivity	A stretch of linear active transport corridor measuring 20 m long x 9 m wide with 60% vegetation coverage and gaps of <3 m between garden beds.	The most important design recommendation for increasing biodiversity in the urban landscape. The availability of mid-storey vegetation is a key limiting factor for a wide range of taxonomic groups.	All species	(Gross, 2018; Humphrey et al., 2024; Ikin et al., 2015; Le Roux et al., 2014; Threlfall et al., 2017)

No.	Action	Definition	Rationale	Target species	References
13*	Minimum number of native tree species per unit area	A stretch of linear active transport corridor measuring 20 m long x 9 m wide with a minimum of five different native tree species (e.g., <i>Acacia implexa</i> , <i>Angophora costata</i> , <i>Eucalyptus melliodora</i> , <i>Eucalyptus sideroxylon</i> and <i>Banksia integrifolia</i> ).	Typical urban plantings have limited numbers of tree species, especially along streets. Increasing tree species boosts biodiversity and increases the number of resources and resilience of the landscape to seasonal changes.	All species	(Berthon et al., 2021; Ebeling et al., 2008; Scherber et al., 2010; Tartaglia & Aronson, 2024)
14*	Minimum of 50% garden bed coverage in public greenspaces	A community park measuring 1 ha in size with at least 50% garden bed cover.	Lawn has low biodiversity value and, in some contexts, contributes to species loss where it encourages large, invasive or aggressive species. Impermeable surfaces act as barriers to movement and negatively impact soil health and biodiversity. More garden bed coverage therefore provides valuable space for biodiversity.	All species	(Brown et al., 2024; Gross, 2018; Sockhill et al., 2025; Threlfall et al., 2017)
15*	Terraced native planting with mowable groundcover at edges	Terraced vegetation in a garden bed measuring 5 m x 1.5 m in a linear active transport corridor.	Increases mid-storey vegetation while allowing for sightlines to be maintained, along with key cover and resources being positioned further from people (minimising disturbances for wildlife).	All species	(Gross, 2018; Sharmin et al., 2024; Threlfall et al., 2017)
16*	Elevated bird waterers	A single pole with four elevated water troughs, positioned 3-4 m off the ground. The water refills automatically using a battery operated pump system. The bird waterer is located in a community	Elevated watering systems allow species to access water safely, away from feral predators (cats, foxes and domestic dogs). Damp areas underneath the waterer can also benefit a range of species.	Superb fairy-wren Growling grass frog Emperor dragonfly	(Gibbons et al., 2023; Town of Victoria Park, 2026; Van Helden et al., 2024)

		park. The height and design of the waterer can vary to appeal to different groups.			
17	Ephemeral wetland within 500 m of creek	A pond measuring 4 m x 4 m x 0.3 m deep, constructed within 500 m of a creek in a linear active transport corridor.	Positioning additional ephemeral wetlands in other low-lying areas increases the number and type of resources provided for a range of different species.	Swamp wallaby Growling grass frog Emperor dragonfly	(Ancillotto et al., 2024; Goertzen & Suhling, 2013; McKinney et al., 2011; Perron & Pick, 2020; Scheffers & Paszkowski, 2013)
18	Vegetated rain garden for stormwater capture	A vegetated rain garden measuring 1 m wide x 4 m long, positioned in a residential street.	Water flowing off the street can be captured to increase vegetation growth and the number and diversity of plant species being used in the streetscape. Benefits a range of species.	Growling grass frog Emperor dragonfly	(Atkins, 2018; Kazemi et al., 2011; J. Wang et al., 2024)

378 **3.2 Feasibility, opportunities and challenges**

379 During the first round of expert elicitation, our participants provided answers to five key  
380 questions that interrogate the feasibility, challenges and opportunities in implementing  
381 Biodiversity Sensitive Urban Design (see Table S2 for expert responses).

382

383 Several key themes emerged from the discussions and individual comments. The panel  
384 expressed general enthusiasm for both the participatory costing process and the proposed  
385 BSUD actions, identifying several opportunities to enhance the environmental and economic  
386 value of the interventions. Multiple participants highlighted potential synergies with other  
387 development objectives, such as integrated water management initiatives, and possibilities for  
388 improved recycling and upcycling of construction materials (such as gabion walls or innovative  
389 seating constructed from building waste). The concept of community education and  
390 engagement was discussed, particularly in relation to incorporating BSUD actions (such as  
391 wildlife crossing structures, habitat analogues and wildlife-friendly public lighting) into a broader  
392 wayfinding strategy for the development. Some participants identified additional opportunities to  
393 expand actions to new areas, or to implement more ambitious versions of the proposed features  
394 (such as reducing impervious surfaces by the creation of single-footpath residential streets, or  
395 adding permeable paving to car parks).

396

397 Despite the overall enthusiasm, the panel identified several significant implementation  
398 challenges that extended beyond simple cost considerations. Experts expressed concern about  
399 the feasibility of advocating for these nature-based actions in place of business-as-usual  
400 development practices, anticipating resistance to change and difficult conversations with various  
401 stakeholders. Long-term maintenance emerged as a critical concern, with questions raised  
402 about asset ownership, responsibility allocation, and whether maintenance personnel would be  
403 appropriately trained and willing to manage any novel infrastructure types. Additionally, experts

404 identified potential regulatory barriers related to permissions, approvals, standards, and  
405 planning guidelines for innovative features such as above-road wildlife crossings, wildlife-  
406 friendly lighting, and mid-storey vegetation plantings.

407

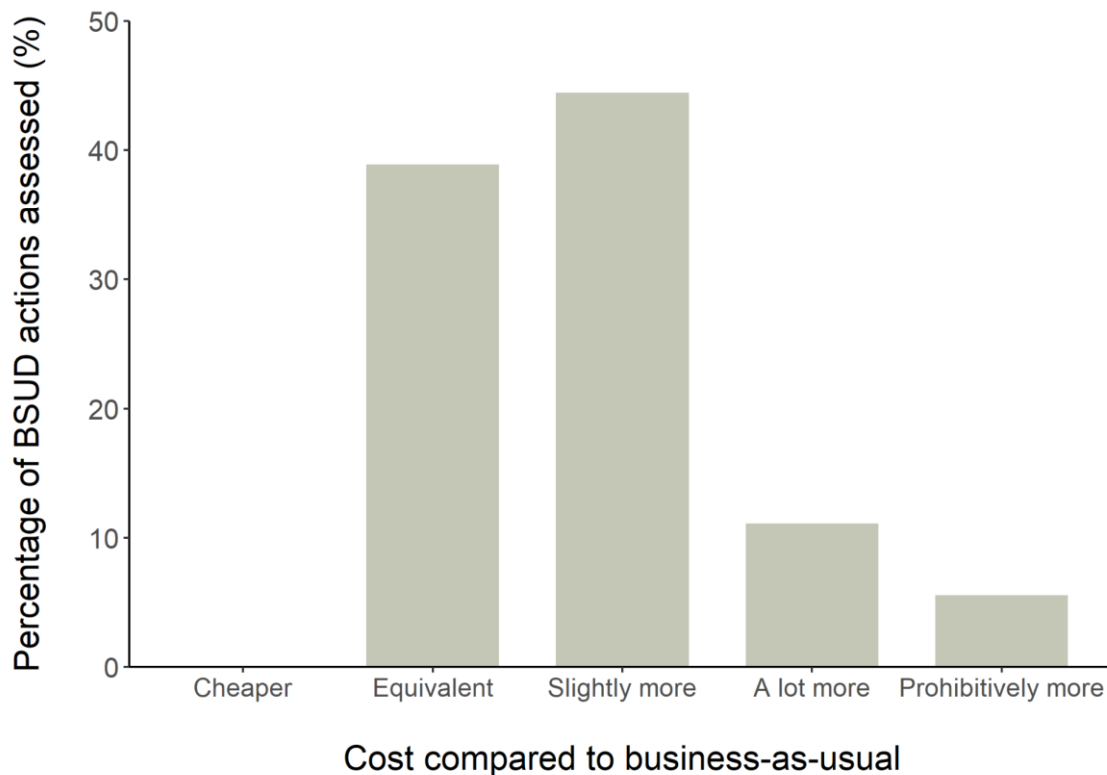
408 Further challenges were identified regarding potential conflicts between biodiversity objectives  
409 and other urban design priorities or public preferences. Panel members noted possible tensions  
410 with canopy cover and urban cooling targets, car parking requirements, and anticipated public  
411 resistance to certain design elements (including sandy, rocky, or muddy areas, winding paths  
412 with naturalistic features, mid-storey vegetation, and larger garden beds). Safety concerns were  
413 raised regarding nature play elements and water-based features, while experts also highlighted  
414 the scarcity of successful precedents for certain interventions (particularly permeable paving in  
415 residential footpaths) in comparable greenfield community developments. Finally, the panel  
416 emphasised the importance of local site conditions, particularly soil characteristics, in  
417 determining the feasibility and success of water sensitive design actions.

418

### 419 **3.3 Relative financial cost of implementing BSUD actions**

420 Our experts estimated that the majority of BSUD actions assessed (15/18 or 83%) were likely to  
421 cost the same, or only slightly more, than a BAU approach (see Fig. 2). The actions estimated  
422 to cost the same as BAU included the creation of sandy, rocky and muddy areas with logs;  
423 nature play areas with novel habitat analogues; one wide footpath and one narrow footpath; a  
424 high level of mid-storey vegetation cover and connectivity; a minimum number of native tree  
425 species per unit area; terraced native planting with mowable groundcover at edges; and an  
426 ephemeral wetland within 500m of a creek (see Table S3 for a breakdown of the estimated cost  
427 of each action). Those considered to be only slightly more expensive than a BAU scenario were  
428 the installation of above road wildlife crossing structures; the addition of habitat analogues  
429 attached to lighting infrastructure or other pole-based infrastructure; habitat walls at property

430 boundaries; wildlife-friendly public lighting; seating that incorporates vegetation and/or habitat  
 431 analogues; a winding footpath, road edge or verge to create ‘nature pockets’ in streetscapes; a  
 432 minimum of 50% garden bed coverage in public greenspaces; and vegetated rain gardens for  
 433 stormwater capture (Table S3). Two of the 18 actions (11%), namely the installation of wildlife  
 434 underpasses for major roads and elevated bird waterers, were estimated to cost a lot more than  
 435 BAU (Fig. 2; Table S3). The use of permeable paving in a residential footpath was considered to  
 436 be the most expensive action (compared to BAU), and was deemed to be prohibitively  
 437 expensive for a typical greenfield community development project (Fig. 2; Table S3). None of  
 438 the 18 actions were assessed as cheaper than a BAU approach (Fig. 2).  
 439



440  
 441 **Figure 2.** A summary of the estimated relative cost of implementing 18 actions for biodiversity in  
 442 a greenfield community development. Most actions (15/18 or 83%) were estimated to cost the  
 443 same or only slightly more than a BAU approach.

444

### 445 **3.4 Co-benefits of investing in biodiversity**

446 Discussion with our expert panel and combined with a survey of the literature uncovered 12  
447 potential co-benefits of investing in nature in urban developments. These co-benefits can be  
448 summarised under the broad themes of: 1) Maintaining urban liveability; 2) Addressing climate  
449 change; 3) Enhancing human health and well-being; and 4) Providing financial gains (see Fig. 3  
450 for an overview of the potential co-benefits). All 18 of the BSUD actions we proposed were  
451 predicted to have additional benefits for people, with many likely to bring a range of co-benefits.  
452 For example, a number of actions were predicted to help mitigate urban heat, reduce air and  
453 noise pollution, and better manage water in a residential landscape. Actions that led to an  
454 increase in the extent of permeable surfaces (Liu et al., 2018; J. Wang et al., 2018) or  
455 vegetation (Hiemstra et al., 2017; Rakoto et al., 2021) were expected to reduce heat via  
456 localised cooling and shading. Urban greening interventions, particularly the planting of trees,  
457 were expected to improve air quality (Jayasooriya et al., 2017; Leung et al., 2011) and reduce  
458 ambient noise levels around roads (De Carvalho & Szlafsztein, 2019; Klingberg et al., 2017; Ow  
459 & Ghosh, 2017). Permeable paving (Tota-Maharaj et al., 2024), vegetation (Green et al., 2021)  
460 and integrated water management actions, such as the creation of wetlands (Malaviya & Singh,  
461 2012) or vegetated rain gardens (Sharma & Malaviya, 2021), were similarly predicted to  
462 enhance flood mitigation and stormwater management capacity in a housing development.

463

464 Several proposed actions may also help to mitigate the impacts of climate change (Fig. 3).  
465 There is some evidence that the planting of appropriately selected shrub and tree species may  
466 increase carbon sequestration (Davies et al., 2011; Jin et al., 2023; Y. Wang et al., 2021).  
467 Actions such as decreasing the intensity of public lighting (Gaston et al., 2012), implementing  
468 urban greening (Quaranta et al., 2021; Skelhorn et al., 2016; B. Zhang et al., 2014) and

469 integrating wetlands into greenspaces (Tian et al., 2025) may reduce energy consumption and  
470 emissions for local residents, businesses and government authorities.










471

472 All BSUD actions proposed in this study were expected to have a measurable positive impact  
473 on human health and wellbeing (Fig. 3). For instance, the creation of nature play spaces was  
474 likely to provide physical health benefits (Dankiw et al., 2020; Herrington & Brussoni, 2015),  
475 while urban greening interventions, particularly those that prioritise biodiverse plantings, are  
476 known to enhance mental health and wellbeing (Buxton et al., 2024; Spotswood et al., 2025;  
477 Wood et al., 2018). Wildlife-friendly lighting is also expected to benefit human sleep and  
478 wellbeing by reducing artificial light at night (Cupertino et al., 2023; Paksarian et al., 2020). The  
479 addition of inviting street furniture and pedestrian spaces can help build a sense of community  
480 (Francis et al., 2012; Qi et al., 2024). Well-maintained greenspaces with abundant vegetation  
481 can also reduce the incidence of violent crime (Stevens et al., 2024; Sukartini et al., 2021; Wolfe  
482 & Mennis, 2012), and enhance perceived safety among residents (Berdejo-Espinola et al.,  
483 2026). All 18 actions proposed to benefit biodiversity were expected to contribute to place-  
484 making or provide aesthetic benefits to people. This is particularly true for the construction of  
485 urban wetlands (Carter, 2015), vegetated rain gardens (Dobbie & Farrelly, 2024), and wildlife  
486 infrastructure, such as crossing structures and habitat analogues, which can enhance  
487 opportunities for positive human-wildlife interactions (Cox & Gaston, 2018).

488

489 Additionally, there are potential economic benefits to implementing actions for biodiversity in a  
490 greenfield community development (Fig. 3). House prices are known to be positively influenced  
491 by the proximity and size of greenspaces (Trojanek et al., 2018; Wu et al., 2015), particularly  
492 those that contain natural vegetation and waterbodies (Panduro & Veie, 2013), as well as the  
493 diversity of bird species in the local neighbourhood (Farmer et al., 2013; L. Zhang & Zhang,  
494 2025). Urban greening interventions may also help to attract consumers to retail businesses

495 (Joye et al., 2010; Wolf, 2005, 2009), resulting in higher patronage and healthier local  
496 economies.

ACTION	COOLING & SHADING	IMPROVED AIR QUALITY	FLOOD MITIGATION	STORM WATER CAPTURE	NOISE REDUCTION	CARBON STORAGE	REDUCED ENERGY USE	PHYSICAL HEALTH BENEFITS	MENTAL HEALTH BENEFITS	SOCIAL COHESION	PLACE-MAKING	ECONOMIC BENEFITS
 Infrastructure for wildlife	○	○	○	○	○	○	○	○	●	○	●	●
 Sandy, rocky, muddy areas	●	○	●	●	○	○	○	○	○	○	●	○
 Nature play areas	●	○	○	○	○	○	○	●	●	●	●	●
 Seating with vegetation	●	●	○	○	●	○	○	●	●	●	●	●
 Wildlife-friendly lighting	○	○	○	○	○	○	●	●	●	○	●	○
 Permeable paving	●	○	●	●	○	○	○	○	○	○	●	○
 Different footpath designs	●	○	○	○	●	○	○	●	●	●	●	●
 Urban greening actions	●	●	●	●	●	●	●	●	●	●	●	●
 Integrated water management	●	○	●	●	○	○	●	●	●	●	●	●
	URBAN LIVEABILITY					CLIMATE		HUMAN HEALTH & WELLBEING				FINANCIAL

497

498

**Figure 3.** A matrix indicating the potential co-benefits of investing in actions for nature. For simplicity, several BSUD actions have

499

been combined. For example, 'Infrastructure for wildlife' includes above road wildlife crossing structures, habitat analogues, habitat

500

walls at property boundaries, and wildlife underpasses. 'Different footpath designs' include one narrow footpath and winding paths or

501

roads to create 'nature pockets' in streetscapes. 'Urban greening actions' include more mid-storey vegetation, a greater diversity of

502 native canopy trees, more garden bed coverage, and terraced native plantings. 'Integrated water management' includes ephemeral  
503 wetlands and vegetated rain gardens. The co-benefit of 'Social cohesion' refers to improvements in the sense of community and a  
504 reduction in crime rates. 'Place-making' also includes the potential aesthetic benefits of BSUD actions. 'Economic benefits' refer to  
505 increases in house prices, shop patronage and small business profits.

506

## 507 **4. Discussion**

508 This study employed expert elicitation to assess the feasibility, opportunities and challenges,  
509 and estimate the relative cost of implementing a range of actions for biodiversity compared to a  
510 business-as-usual scenario, in a greenfield community development in Melbourne, Australia.  
511 We compiled a list of 18 potential BSUD actions which included novel habitat analogues, altered  
512 planting palettes, integrated water management actions, and the creation of more physical  
513 space for nature. Our experts concluded that most of the BSUD actions proposed (15/18 or  
514 83%) were not only feasible, but were likely to cost the same or only slightly more than a  
515 business-as-usual approach. Given the significant benefits predicted for biodiversity (in the  
516 current, global crisis), and the potential co-benefits for people (see Fig. 3), embedding BSUD  
517 actions in new housing developments should have broad appeal. Here we outline the  
518 opportunities and challenges of incorporating innovative designs for nature, and the key  
519 priorities and next steps needed to mainstream BSUD and nature positive cities.

520

### 521 **4.1 Designing for nature is cheaper than you think**

522 Innovation doesn't always come with additional expenses. There is an assumption that  
523 biodiverse or nature positive developments will cost more than BAU, but our results suggest  
524 otherwise. It is possible to design a residential suburb that supports people and nature, for only  
525 a slightly higher investment than a typical greenfield community development.

526

527 Nevertheless, three actions in this study were estimated to cost a lot more or prohibitively more  
528 than BAU: wildlife underpasses, elevated bird waterers and permeable paving. These actions  
529 are either entirely novel additions to the urban landscape (e.g., elevated bird waterers) and  
530 therefore have no clear point of comparison, or come with significant construction and  
531 engineering costs (e.g., wildlife underpasses). For the purpose of this research, we chose to

532 cost a premium permeable paving product which facilitated the growth of vegetation in between  
533 the pavers. There are a range of permeable pavers on the market, many of which are likely to  
534 be cheaper than the one we selected. So whilst we concluded that permeable paving would be  
535 prohibitively expensive for residential streetscapes, other comparisons have suggested it may  
536 cost a similar amount to non-permeable products (Murchland, 2025). The same is true for  
537 wildlife-friendly public lighting. Our experts emphasised that there is no single accepted  
538 definition for 'wildlife-friendly' or 'wildlife-sensitive' lighting, and products vary in their ability to  
539 minimise light pollution. We decided to focus on lighting that would maximise benefits for  
540 biodiversity, which involved additional modifications from current Australian lighting standards,  
541 and was therefore expected to be more expensive. It is highly likely that innovative products like  
542 permeable pavers and wildlife-friendly luminaries will become more affordable over time.

543

544 During our expert elicitation there were instances where experts expressed uncertainty around  
545 their cost estimates. In these situations, we always adopted the more conservative (i.e., more  
546 expensive) estimate, so it is possible that the cost of implementing BSUD in a greenfield  
547 community development could be even lower. Overall costs may also be reduced by finding  
548 synergies between different actions such as by pairing urban greening interventions with  
549 integrated water management actions.

550

551 Importantly, BSUD doesn't require an all-or-nothing commitment. While we identified 18  
552 potential design actions intended to promote habitat resources and mitigate threats to target  
553 fauna species, not all 18 actions are needed to support all target species. BSUD can be  
554 implemented at a range of spatial scales and commitment levels (Garrard et al., 2018), and  
555 even small-scale modifications to a BAU approach can have a lasting positive impact.

556

557 **4.2 Co-benefits of investing in actions for nature**

558 Although some BSUD actions may require a higher initial investment, it is likely that these  
559 actions will provide longer-term cost savings due to the range of co-benefits they provide for  
560 people (Rathod et al., 2026). Many of these potential co-benefits are difficult to economically  
561 quantify, particularly cultural and social benefits (Chan et al., 2012); however, there is ample  
562 evidence that designing for nature is worth the investment. We identified 12 potential co-benefits  
563 for people, with most proposed BSUD actions likely to provide multiple benefits from mitigating  
564 urban heat, to reducing energy use, enhancing human health and well-being, and increasing  
565 house prices (Fig. 3). If developers can overcome the higher upfront investment, actions for  
566 nature are likely to pay for themselves by bringing substantial benefits to residents in new  
567 housing developments. We conclude that investment in nature serves a dual purpose:  
568 conserving native species, habitats and ecosystems alongside improving urban liveability  
569 (Kowarik et al., 2025). However, to fully analyse the cost-benefit of future design actions,  
570 industry will require new ways to evaluate and measure these co-benefits.

571

572 **4.3 Opportunities and challenges of implementing BSUD**

573 During our expert elicitation, the participants highlighted numerous opportunities where BSUD  
574 could be better embedded into greenfield community developments, making initial  
575 implementation and on-going management easier. The key recurring themes were around  
576 community engagement and education, incorporating actions into existing infrastructure, and  
577 finding synergies to reduce costs and upcycle materials. Any deviation from BAU development  
578 will require a clear community engagement strategy to bring residents along on the journey, and  
579 outline the reasoning behind certain decisions (such as the implementation of different footpath  
580 designs or the addition of sandy, rocky and muddy areas). There are also opportunities to  
581 educate residents and visitors about broader biodiversity challenges via well-designed

582 messaging and signage which may motivate pro-environmental behaviors (e.g., Kusmanoff et  
583 al., 2022).

584

585 Despite these opportunities, our experts also identified a number of ongoing challenges, the  
586 most significant of which centred around asset ownership and maintenance. Several experts  
587 raised concerns about who would be responsible for novel assets such as habitat analogues,  
588 nature play spaces, wildlife crossing structures, wetlands and vegetated rain gardens. We did  
589 not focus on the maintenance phase in this study, but we acknowledge it is a critical hurdle to  
590 overcome. When implementing novel design elements, early engagement with local government  
591 is critical to address any ownership and maintenance concerns, and overcome barriers that may  
592 result from existing approval processes, frameworks and timelines. It may be necessary to  
593 move away from typical maintenance plans for housing developments. One solution is for  
594 developers to manage open greenspaces and assets for a longer period of time, and  
595 simultaneously engage the community to take stewardship of certain public spaces (such as  
596 streetscapes). This approach has been successful in a sustainable housing development in  
597 Cape Paterson, Victoria, Australia (B. Condon, personal communication, March 13, 2026). With  
598 this model, private citizens may pay an owners corporation fee which goes toward maintaining  
599 shared public spaces. Residents may also form organised groups and work in partnership with  
600 authorities to better manage greenspaces and novel designs (Mathers et al., 2015; Mattijssen et  
601 al., 2017). Similar approaches have been successful in past urban land-use innovations, for  
602 example encouraging community urban farm projects (Fox-Kämper et al., 2018; Hardman et al.,  
603 2022), or streetscape gardening programs (Doll et al., 2023; Gupta et al., 2025; Hunt et al.,  
604 2022) - once considered novel but now seen in cities across the world.

605

#### 606 **4.4 Limitations of our approach**

607 While we used a rigorous expert elicitation approach to estimate the cost of implementing a set  
608 of BSUD actions, we acknowledge that costs are complex and estimating exact figures can be  
609 difficult. In bringing together our panel of experts, we deliberately aimed to cover a broad suite  
610 of expertise. This knowledge and experience enabled the discussion of a wide range of actions  
611 but did introduce challenges to the expert elicitation process. Our experts represented multiple  
612 disciplines and professions and often used different terminology, which required more  
613 discussion and a qualitative approach to understanding the costs. Further, estimating costs  
614 relative to business-as-usual needs to also account for economies of scale. An additional cost of  
615 \$50,000 AUD, for example, may be categorised as only “slightly more” expensive for a large  
616 community development with 5000 lots, but could be considered “significantly more” expensive  
617 for a smaller development site with only 200 lots. We tried to account for this potential variation  
618 in interpretation by using a specific case study scenario, but this limitation should be  
619 acknowledged when applying our results to other contexts.

620

621 We did not estimate the costs of ongoing maintenance in this study, but this is a key research  
622 gap. Maintenance costs are unlikely to be prohibitive given that some costs will be reduced  
623 following the implementation of BSUD (e.g., mowing of lawn) and others can potentially be  
624 outsourced to the community. In an ideal scenario, it would have also been beneficial to include  
625 the economic implications of new approaches potentially delaying a development project. This  
626 was also outside the scope of our study.

627

#### 628 **4.5 Key priorities and future directions**

629 There are many outstanding questions that currently prevent the mainstreaming of Biodiversity  
630 Sensitive Urban Design that could be resolved with future research. Some critical areas include  
631 quantifying the financial co-benefits of BSUD actions such as those described in Figure 3. It’s

632 likely that the economic benefits of implementing BSUD, including improved physical and  
633 mental health outcomes for residents, and reduced energy consumption and urban heat  
634 impacts, will accumulate to deliver more cost-effective approaches to urban development than  
635 BAU. Fine-scale spatial modelling tools could also help identify areas of high or low impact for  
636 investing in BSUD. Extending the current analysis to understand the costs of maintenance, as  
637 well as implementing BSUD in other urban settings such as residential infill, high density and  
638 retrofit developments, would be another useful avenue to pursue. Finally, the social impact of  
639 urban environments that are rich with nature is an understudied area. When developments  
640 encourage biodiversity, there is potential for positive spillover effects (Lauren et al., 2019) where  
641 residents may develop more supportive attitudes towards conservation or take part in pro-  
642 environmental behaviors, as has been observed for hikers visiting nature trails (Choi & Kim,  
643 2024).

644

#### 645 **4.6 Conclusions**

646 While there are numerous additional barriers to delivering nature positive cities, the cost of  
647 implementation should not be used as an excuse for slow innovation. Our work shows that, at  
648 least in the context of greenfield community development, many actions that will significantly  
649 benefit biodiversity are financially viable for developers. The inertia of business-as-usual  
650 approaches is likely to be a greater barrier, which will only diminish through the efforts of early  
651 adopters demonstrating the potential benefits to people, nature and the bottom line.

652

653 **5. Author contributions**

654 Holly Kirk, Sarah A. Bekessy and Victoria Cook conceived the ideas behind this study. Jacinta  
655 E. Humphrey, Holly Kirk and Sarah A. Bekessy designed the methodology, and Jacinta E.  
656 Humphrey and Holly Kirk collected and analysed the data. The original expert elicitation  
657 participants were recruited by Victoria Cook. Dom Blackham, Matthew Bradbury, James  
658 Horwood, Celeste Morgan, Clancie Shorter and Ray Verratti responded to the expert elicitation  
659 surveys and contributed to the online workshops. Bethany Kiss created the visuals and Jacinta  
660 E. Humphrey led the writing of the manuscript. All authors contributed to the editing of the final  
661 paper and approved its submission for publication. Sarah A. Bekessy and Holly Kirk secured the  
662 funding for the project.

663

664 Our study was conducted in southeastern Australia and brings together a diverse group of  
665 researchers and practitioners working in this region. The literature review component of our  
666 project did consider global publications; however, these were restricted to those published in  
667 English. We acknowledge that more could have been done to include studies published in local  
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669

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683

## 684 **7. Conflicts of interest**

685 The authors declare that they have no known competing financial interests or personal  
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687

## 688 **8. Data accessibility**

689 The data associated with this manuscript will be archived in the University of Melbourne  
690 Research Repository and is available in full from the corresponding author upon reasonable  
691 request.

692

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## Supporting Information

**Table S1.** The ecological needs of the five target fauna species selected for the project.

Species name	Similar species or groups	Resource needs	Barriers or threats	Dispersal distance	Current records	References
Australian Emperor Dragonfly ( <i>Anax papuensis</i> or other <i>Odonata</i> sp.)	Aquatic invertebrates, insectivorous species	Waterbodies, emergent vegetation, trees combined with open areas	Roads with heavy traffic, pesticides, poor water quality	Up to 3km	Could feasibly be restored to the site *	(Samways, 2024; Samways et al., 2025; Theischinger et al., 2021)
Growling Grass Frog ( <i>Litoria raniformis</i> )	Other frog species, reptiles and small terrestrial mammals	Waterbodies with vegetated edges, range of temperatures and salinities	Roads, noise and light pollution, cats	300m – 2km	Occur nearby (<1km)	(Hale et al., 2013; Heard et al., 2010)
Superb Fairy-wren ( <i>Malurus cyaneus</i> )	Other insectivorous birds, small nectarivorous birds	Dense mid-storey vegetation near open areas and long grass	Major roads and large gaps in habitat, cats	1 – 5km	Already present at the project site	(Braschler et al., 2020; Harrison et al., 2012; Parsons et al., 2008)
Blue-banded Bee ( <i>Amegilla</i> spp. or other <i>Apidae</i> sp.)	Other insect pollinators including native bee species, moths, butterflies and flies	Flowering native vegetation with a range of nesting resources	Roads with heavy traffic, pesticides	300m – 1km	Could feasibly be restored to the site *	(Brown et al., 2020; Gross, 2018; Koyama et al., 2018)
Swamp Wallaby ( <i>Wallabia bicolor</i> )	Other terrestrial marsupials, including kangaroo and echidna	Dense mid-storey vegetation with grasses	Roads	500m – 2km	Occur nearby (<1km)	(Di Stefano et al., 2009; Swan et al., 2009)

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\* It is important to note that there is often a lack of survey data for insects.

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1345 **Table S2.** Deidentified responses to the five original questions posed in the expert elicitation survey. The \* denotes actions that are  
 1346 considered essential to delivering BSUD outcomes in the development. Action definitions are available in Table 1.

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
1 - Above road wildlife crossing structures for major roads	<p><b>Consultant A</b> - This will be a question around quantity. In general, I think this will be moderately difficult as it will require authority approvals to cross the roads. It may be best to focus on open space corridors and green links.</p> <p><b>Consultant D</b> - Easy.</p>	<p><b>Consultant A</b> - There is opportunity to incorporate this item into a broader wayfinding strategy that may also include educational elements for residents.</p> <p><b>Consultant D</b> - Asset ownership and maintenance.</p>	<p><b>Consultant A</b> – A really rough guestimate would be around \$1,000 per lin.m. Most of the money would be in the structure (uprights and footings) - Approx \$50K to \$70K for uprights and footings.</p>	<p><b>Consultant A</b> - Focus on open space corridors to ensure connectivity.</p>	<p><b>Consultant A</b> - On the surface this one looks easy from a landscape perspective but will require civil / traffic approvals.</p>
2 - Habitat analogues attached to lighting infrastructure or other pole-based infrastructure	<p><b>Consultant A</b> - As above but would require power authority approval - they are notoriously difficult and reluctant to approve anything outside the norm. We could potentially increase the height of street signposts and use that.</p> <p><b>Consultant D</b> - Easy.</p>	<p><b>Consultant A</b> - As above - there are wayfinding and educational opportunities.</p> <p><b>Consultant D</b> - Asset ownership and maintenance.</p>	<p><b>Consultant A</b> - Would be relatively easy to cost with local fabricators. At a guess we would allow \$2000 - \$3,000 for an extended post and robust habitat box.</p>	<p><b>Consultant A</b> - No real limit and as to how widespread this item could be.</p>	<p><b>Consultant A</b> - This one also looks easy but requires approval from the electrical authority. Street signs could be an option. Vandalism is a slight concern, so we need to make sure they are out of reach and robust.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
3* - Sandy, rocky and muddy areas with logs	<p><b>Consultant A</b> - This one is easy to implement. Waterway corridors are an obvious opportunity, but this could be incorporated into any open space area. Wyndham City Council's BOBIT areas are a good precedent (see <a href="#">here</a>).</p> <p><b>Consultant B</b> - Hard in streets as we're aiming for 80% canopy cover. Easier in open spaces as there is more room.</p>	<p><b>Consultant A</b> - These are relatively easy to incorporate. Also, opportunities as above. The only challenge really is that people sometimes don't like these to be located near their homes.</p> <p><b>Consultant B</b> - Key challenge in providing canopy for cooling is the conflict with GGF habitat, which requires open, unshaded areas. Obvious challenge of community acceptance of what they might consider different and undesirable areas (particularly in streetscapes).</p>	<p><b>Consultant A</b> - No real additional cost over and above a BAU landscape outcome. It's a design outcome rather than an additional cost.</p> <p><b>Consultant B</b> - Not aligned with a pure cooling function but wouldn't add cost to (for example) planting more canopy trees in streets. Creation of larger areas of habitat in addition to the requirement for open space would generate an opportunity cost (less developable area).</p>	<p><b>Consultant A</b> - Can really be located anywhere in open space but would suggest it's better away from dwellings.</p> <p><b>Consultant B</b> - Location of habitat would presumably be guided by ecological site analysis. Connections to existing habitats, and large areas of future rehabilitated habitat (e.g. waterway and potentially wetlands).</p>	<p><b>Consultant A</b> - Easy.</p> <p><b>Consultant B</b> - Depends on scale but would be relatively simple to implement at a low level in medium/large open spaces.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
4 - Habitat walls at property boundaries (e.g., gabion walls or retaining walls)	<p><b>Consultant A</b> - There could be opportunity to incorporate this concept into development design guidelines. Where walls are required, this specification could be adopted.</p> <p><b>Consultant D</b> - Easy.</p>	<p><b>Consultant A</b> - Opportunity to incorporate an approved design standard as a design guideline for any walls within the development. As a value add, we could look at utilising waste generated from house construction (bricks, roof tiles etc.) to fill gabion baskets for walls. A good recycling initiative!</p> <p><b>Consultant D</b> - Asset ownership and maintenance.</p>	<p><b>Consultant A</b> - No doubt there would be an extra-over cost above a standard wall however, if designed carefully, it may not be a huge amount.</p>	<p><b>Consultant A</b> - Wherever walls are required. Could be incorporated into other landscape elements such as furniture and structures or feature fencing.</p>	<p><b>Consultant A</b> - No real issue other than perhaps additional cost over a 'standard' wall outcome. In an open space there could be entrapment considerations if near a play area.</p>
5 - Nature play areas with novel habitat analogues	<p><b>Consultant A</b> - The provided examples are great examples of successful nature play projects. This could help to inform the over landscape theming of the development with a focus on nature and sustainability. This then becomes a design challenge but is 'easy to implement'. Nature play can sometimes have a perceived safety risk but can be overcome through design and education.</p> <p><b>Consultant D</b> - Easy.</p>	<p><b>Consultant A</b> - Great theming opportunity.</p> <p><b>Consultant B</b> - Issues around playing near water (if too wet). Maintenance costs. Community acceptance - should be ok.</p> <p><b>Consultant D</b> - Asset ownership and maintenance.</p>	<p><b>Consultant A</b> - Really doesn't have to cost any more than any other 'standard' play offering.</p>	<p><b>Consultant A</b> - Parks.</p>	<p><b>Consultant A</b> - Easy, however there can be perceived safety hazards that we would need to work around.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
6 - Seating that incorporates vegetation and/or habitat analogues	<p><b>Consultant A</b> - This one is both easy and difficult at the same time. From a design sense this can easily be achieved in public furniture. Council often puts a maintenance / vandalism lens over furniture so some aspects of this may be difficult without early Council agreement.</p> <p><b>Consultant D</b> - Easy to implement.</p>	<p><b>Consultant A</b> - This could be a tremendous way to deal with some builder waste - a huge problem in development projects. [Company name] completed a park that reused dumped builder waste at Highlands (within Hume Council) but the thinking behind this could be taken so much further.</p> <p><b>Consultant D</b> - None.</p>	<p><b>Consultant A</b> - There would likely be a premium above traditional furniture. It is difficult to put a price to this without having design detail, but we would expect a 25-50% premium over traditional street furniture.</p> <p><b>Consultant D</b> - Would need to assess design against a standard detail - it will be more than the BAU.</p>	<p><b>Consultant A</b> - Estate wide public furniture.</p>	<p><b>Consultant A</b> - Should be easy but some aspects would need Council endorsement of the concept.</p> <p><b>Consultant D</b> - Easy.</p>
7* - Wildlife-friendly public lighting	<p><b>Consultant A</b> - This concept is gaining popularity and there are off-the-shelf products available: <a href="https://we-ef.com/uk/environment/wild-light-lp">https://we-ef.com/uk/environment/wild-light-lp</a>. From a landscape perspective, lighting in open space can be easily designed to achieve this. May be more difficult when dealing with streetscape lighting and electrical authorities.</p> <p><b>Consultant D</b> - Not sure - would need a lighting engineer to assess whether the proposal complies with public street lighting standards. These standards are about risk</p>	<p><b>Consultant A</b> - As above - there are wayfinding and educational opportunities.</p> <p><b>Consultant D</b> - Opportunities: heaps better! Risks: per question 1, Council would need to be comfortable that this is managed appropriately.</p> <p><b>Consultant E</b> - Opportunities: Better design with a layered lighting approach. People respond better to lighting that is considered and contextual, rather than simply brighter. Challenges: Public</p>	<p><b>Consultant A</b> - Can be easily priced. Gut feel is that there may be a slight premium above standard lighting. We-ef have proprietary products. Other brands most likely do also.</p> <p><b>Consultant D</b> - Would need advice from a public lighting consultant.</p> <p><b>Consultant E</b> - This is context dependent. What may be appropriate for a pedestrian pathway will differ from what is suitable for a public activity area. Can be integrated into BAU</p>	<p><b>Consultant A</b> - Open space. Streetscapes may be more challenging but not impossible.</p> <p><b>Consultant D</b> - Depending on the ability of the lights to conform to standards. If they conform then in theory anywhere, if they don't then in lower risk areas (not roads or key pedestrian links).</p> <p><b>Consultant E</b> - Council-owned assets such as shared user paths, pedestrian paths,</p>	<p><b>Consultant A</b> - Easy in the landscape.</p> <p><b>Consultant D</b> - Medium - it is a function of the ability for these lights to meet standards.</p> <p><b>Consultant E</b> - 3000K luminaires at conventional mounting heights (around 6m) is easily achievable and definitely "low-hanging fruit". Deliverability reduces as you move further away from common lighting practice. Although, the challenges are not extreme - they are primarily design-</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
	<p>management - it is a big issue for Councils. If the lights do not meet standards, then someone will need to take risk - Councils are generally not equipped to do this. Having said that it is proposed in parks so traffic risk should not be an issue.</p> <p><b>Consultant E</b> - The top end of the definition (i.e., 3000K at a height of 6m) is relatively straightforward. 3000K is common and readily available across most suppliers, but 2700K narrows product choice and increases design effort.</p> <p><b>Consultant F</b> - Developers generally support the implementation of Council's infrastructure guidelines as a minimum, and in some cases, have gone further by supplying smart nodes fitted to LEDs prior to installation. We anticipate this will occur more frequently as we progress with developing policy and procedure. The primary Network Distribution Service Provider in SA supplies and maintains lighting assets that</p>	<p>perception and security concerns - community consultation is needed. Cost and quantity implications - pole height is where the largest practical and cost challenges emerge. Lower mounting heights lead to decreased pole spacing and more luminaries being required. This can increase project costs quickly. Regulatory constraints are also a concern - power and road authority standards dictate public lighting (4000K for roads).</p> <p><b>Consultant F</b> - Opportunities: Less disturbance to wildlife, better sleep and improved wellbeing in people, reduced sky glow, energy savings, more options to incorporate Smart Lighting sensors (with potential cost savings), and improved visibility due to less glare and warmer lighting colours. Challenges: Changing perceptions in the public lighting and traffic</p>	<p>but will require greater design effort.</p> <p><b>Consultant F</b> - Wildlife-friendly lighting in a typical residential development is a BAU solution integrated into existing practices.</p>	<p>parklands, and public activity areas. Public activity areas (plazas, forecourts, promenades) are likely to have the greatest success as they support a mix of lighting and are not reliant on pole-mounted luminaires.</p> <p><b>Consultant F</b> - Any public land within a development. A case-by-case approach in public space projects.</p>	<p>led rather than technical barriers. Nothing within the provided definition of wildlife lighting approaches "extreme measures".</p> <p><b>Consultant F</b> - Wildlife-friendly lighting is a BAU solution and considered 'low hanging fruit' in terms of deliverability. Deliverability is generally possible with the right supporting guidelines, policy and procedure.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
	meet and exceed the study's definition of 'wildlife-friendly public lighting'.	engineering industry, and collaboration between disciplines.			
8 - Wildlife underpasses for major roads	<p><b>Consultant A</b> - Stockland provided a GGF underpass at The Grove: <a href="https://www.stockland.com.au/residential/news/frogs">https://www.stockland.com.au/residential/news/frogs</a>. This would be possible but likely very expensive and safety needs to be considered.</p> <p><b>Consultant D</b> - Easy to implement on the basis that Council (or other authority) approves and owns the asset.</p>	<p><b>Consultant A</b> - This would be possible but likely very expensive and safety needs to be considered. Opportunities to factor this into bridge / culvert designs along waterways.</p> <p><b>Consultant D</b> - Risks: There would be more complex details in some roads with respect to others (in terms of entry and exits/service clashes/depths) but all doable.</p>	<p><b>Consultant D</b> - Depending on depth and length - say 30m long x 450 (w) x 300 (h) culvert, 1 metre cover with entry/exit details and central grated pit - circa \$40k.</p>	<p><b>Consultant A</b> - Opportunities to factor this into bridge / culvert designs along waterways.</p> <p><b>Consultant D</b> - Where the experts say!</p>	<p><b>Consultant A</b> - I imagine the main barriers would be safety considerations and costs.</p> <p><b>Consultant D</b> - Easy.</p>
9 - Permeable paving in a residential footpath	<p><b>Consultant A</b> - Very possible. Car parking areas are a great opportunity. Open space areas are also a good opportunity. Footpaths could also be an option.</p> <p><b>Consultant B</b> - Medium difficulty - Ray to comment on buildability.</p>	<p><b>Consultant A</b> - Car parking areas are a great opportunity. Open space areas are also a good opportunity. Footpaths could also be an option. Costs and maintenance are usually the main challenges.</p> <p><b>Consultant B</b> - Opportunity in increasing canopy cover in streets (e.g.</p>	<p><b>Consultant A</b> - There is a cost premium but there are plenty of proprietary solutions.</p> <p><b>Consultant B</b> - Significantly more expensive than BAU.</p>	<p><b>Consultant A</b> - Could be adopted across the entire community in select areas.</p> <p><b>Consultant B</b> - Core purpose is to increase tree size and canopy cover to provide shade so this action would be targeted at areas that were highest priority for shade and cooling.</p>	<p><b>Consultant A</b> - Depends on where it is applied. There are easy areas and more challenging ones.</p> <p><b>Consultant B</b> - Difficult across development due to cost and lack of previous implementation examples.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
		<p><a href="https://research.usc.edu.au/esploro/outputs/journalArticle/The-growth-and-health-of-street/99449134702621">https://research.usc.edu.au/esploro/outputs/journalArticle/The-growth-and-health-of-street/99449134702621</a>). Needs testing in a Vic/Melbourne context.</p>			
10 - One wide footpath and one narrow footpath	<p><b>Consultant A</b> - Very possible but requires Council and authority support.</p> <p><b>Consultant D</b> - Easy, subject to council approval.</p>	<p><b>Consultant A</b> - Massive opportunity to consider alternative road reserve design to improve outcomes for trees. The challenge is authority support. Lower order streets could consider only one footpath....</p> <p><b>Consultant D</b> - Opportunities: Remove one footpath completely as per [Company name]'s "green streets" concept. Risks: Many but all doable.</p>	<p><b>Consultant A</b> - Doesn't have to cost any more than BAU. Authorities would need to consider longer term costs associated with alternate road reserve designs.</p> <p><b>Consultant D</b> - It can vary but we think 1% of overall construction cost.</p>	<p><b>Consultant A</b> - Could be across the entire development.</p> <p><b>Consultant D</b> - 60% of the street network could accommodate.</p>	<p><b>Consultant A</b> - From a design perspective - easy. From an approvals perspective - hard.</p> <p><b>Consultant D</b> - Medium - it is a function of urban design and traffic movement.</p>
11 - Winding path/road edge/verge to create "nature pockets" in streets	<p><b>Consultant A</b> - Things like kerb outstands are very possible. Will require Council endorsement of the concept.</p>	<p><b>Consultant A</b> - Council support of the concept will be critical. Car parking requirements are often the challenge to overcome.</p>	<p><b>Consultant A</b> - There will be a cost associated with additional kerb length and complexity in civil construction.</p>	<p><b>Consultant A</b> - Could be across the entire development.</p>	<p><b>Consultant A</b> - Moderate.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
12* - High level of mid-storey vegetation cover and connectivity	<p><b>Consultant A</b> - Very achievable. Largely a design challenge.</p> <p><b>Consultant B</b> - See comment above re: overshadowing habitat. Midstorey vegetation does not always provide the cooling effect of shading. Ideally would include species with high ET rates and some shading. And include water in the landscape...</p>	<p><b>Consultant A</b> - There are two main challenges to overcome: 1) Desire for 'usable' turf open space for recreation; 2) Sight line / CPTED concerns around middle storey vegetation. The answer to both of these is clever design.</p>	<p><b>Consultant A</b> - Can be easily priced. Gut feel is that there may be a slight premium above standard lighting. We-ef have proprietary products. Other brands most likely do also.</p>	<p><b>Consultant A</b> - Parks / reserves.</p>	<p><b>Consultant A</b> - Easy if carefully designed. 60% vegetation cover could be a challenge in some areas.</p>
13* - Minimum number of native canopy tree species per unit area	<p><b>Consultant A</b> - Very possible. Will need support during the master plan phase from Council. Some trees do not make for 'suitable' tree species due to form and habit, but these requirements should be fine.</p> <p><b>Consultant B</b> - Agree that diversity of tree plantings is a good thing. Tree dimensions have provided a field-tested palette of trees.</p>	<p><b>Consultant A</b> - Council support will be needed for the selected species and diversity.</p>	<p><b>Consultant A</b> - No real additional cost over and above a BAU landscape outcome. It's a design outcome rather than an additional cost.</p>	<p><b>Consultant A</b> - Could be across the entire development.</p>	<p><b>Consultant A</b> - Easy.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
14* - Minimum of 50% garden bed coverage in public greenspaces	<p><b>Consultant A</b> - This is possible, but design will need to carefully consider BSUD as well as community amenity of open spaces. Other uses such as picnic areas, play areas, kickabout etc. preclude garden bed planting.</p> <p><b>Consultant B</b> - Swapping irrigated grass to unirrigated native garden beds would potentially reduce the cooling effect.</p>	<p><b>Consultant A</b> - Primarily a design challenge. Usage of open space will need to be balanced.</p>	<p><b>Consultant A</b> - No real additional cost over and above a BAU landscape outcome. It's a design outcome rather than an additional cost.</p>	<p><b>Consultant A</b> - Parks / reserves.</p>	<p><b>Consultant A</b> - Moderate as open space usage will need to be considered.</p>
15* - Terraced native planting with mowable groundcover at edges	<p><b>Consultant A</b> - Easy.</p>	<p><b>Consultant A</b> - As mentioned, we need to ensure sight lines are maintained.</p>	<p><b>Consultant A</b> - No real additional cost over and above a BAU landscape outcome. It's a design outcome rather than an additional cost.</p>	<p><b>Consultant A</b> - Parks / reserves.</p>	<p><b>Consultant A</b> - Easy - Moderate as open space usage will need to be considered.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
16* - Elevated bird waterers	<p><b>Consultant A</b> - Possible but more difficult.</p> <p><b>Consultant D</b> - Easy to implement from an establishment point of view. The challenge will be who will own and maintain the asset. Will the water use be metered? Who will pay the water bill?</p>	<p><b>Consultant A</b> - As above - there are wayfinding and educational opportunities. Council will be difficult to get over the line on this one. I can foresee maintenance / cost concerns.</p> <p><b>Consultant D</b> - Opportunities: 3 to 4 metres is about the height of street signage. Challenges: Ownership of the asset. There will be some fiddly details like service connections, drainage points, safety in design etc.</p>	<p><b>Consultant A</b> - Cost will largely be in the water filling / servicing.</p> <p><b>Consultant D</b> - I don't think you would get much change from \$5k to \$10k for an elegant elevated "trough" structure, designed, manufactured, installed etc.</p>	<p><b>Consultant A</b> - Parks / reserves.</p> <p><b>Consultant D</b> - Where the experts reckon!</p>	<p><b>Consultant A</b> - Difficult. Costs and Council maintenance will be the issue.</p> <p><b>Consultant D</b> - Subject to ownership being confirmed then it should be easy. I think this is best suited with Council.</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
17 - Ephemeral wetland within 500 m of creek	<p><b>Consultant A</b> - Possible pending engineering design and spatial requirements.</p> <p><b>Consultant C</b> - Could be integrated with the wider stormwater harvesting and creek remediation strategy for the project which applies a chain of ponds typology along Kalkallo Creek this will have ponds that receive and store stormwater runoff, but will also have ephemeral sections of the creek corridor which are engaged with occasional flow when the ponds overtop and in more significant rainfall events. Design of these could be integrated with the creek remediation design. See precedent where this has been implemented (<a href="#">bio-sponges</a>).</p> <p><b>Consultant D</b> - Easy - we have done this at Merrifield to deal with the sodic soil issues.</p>	<p><b>Consultant A</b> - From a landscape perspective this one is fairly easy, The challenge will be the spatial constraints and engineering design.</p> <p><b>Consultant C</b> - In other development contexts, this would be seen as an additional land take outside a waterway corridor - but given the remediation strategy, this would be easier to integrate as sections of the main waterway corridor.</p> <p><b>Consultant D</b> - Opportunities: A better, more sustainable design. Risks: Non-standard design so authority approvals. Long term maintenance of the assets.</p>	<p><b>Consultant A</b> - From a landscape perspective, negligible costs above BAU. May actually be reimbursable under the scheme if within the MW corridor.</p> <p><b>Consultant C</b> - \$100/m2 as a rough cost for a planted, shallow excavated area. When integrated with waterway remediation, it is difficult to isolate as a standalone cost.</p> <p><b>Consultant D</b> - It can vary depending on the design - land budget is an opportunity from the BAU.</p>	<p><b>Consultant A</b> - Along waterways.</p> <p><b>Consultant C</b> - In between the harvesting ponds along Kalkallo Creek, and also in the low-lying wetland area identified in the waterway cross section near the intersection of Camerons Lane and Kalkallo Creek - 'Nature discovery' cross-section - see picture attached.</p> <p><b>Consultant D</b> - Part of the site wide SWMP.</p>	<p><b>Consultant A</b> - Low from an LA perspective.</p> <p><b>Consultant C</b> - Good deliverability as complimentary to plans. Harder for other sites where land would need to be allocated.</p> <p><b>Consultant D</b> - Medium.</p>
18 - Vegetated rain gardens for	<p><b>Consultant A</b> - Possible pending engineering design and spatial requirements. Passive irrigation is growing in popularity, however, for some</p>	<p><b>Consultant A</b> - Great opportunity to increase water supply to vegetation. There are maintenance requirements and cost</p>	<p><b>Consultant A</b> - Can potentially be expensive. Need to be carefully designed to get maximum functionality with minimal</p>	<p><b>Consultant A</b> - Could potentially be anywhere but probably best focussed in areas where more space is available.</p>	<p><b>Consultant A</b> - Moderate.</p> <p><b>Consultant C</b> - Good deliverability for rain gardens (known, done</p>

Action	How possible is it to deliver / build / implement this action from your discipline's perspective?	What are the opportunities and challenges relating to this action?	How much would this action cost? Would it be a 'stand-alone' cost or could it be included in an existing BAU solution?	Where would you locate this action?	How would you rank this action in terms of deliverability?
stormwater capture	<p>Councils, smaller rain garden outcomes are becoming less popular due to the maintenance requirements.</p> <p><b>Consultant C</b> - Important to distinguish swales (horizontal flow) and rain gardens (vertical flow) here - see comment in Q2. Assuming we can focus on rain gardens / bioretention - these are implementable and common - though done with varying success. Very dependent on council know-how and maintenance.</p> <p><b>Consultant D</b> - Medium to difficult. There has been a wide degree of success long term with respect to rain gardens in urban settings. It needs full commitment from the Council for ongoing maintenance.</p>	<p>implications.</p> <p><b>Consultant C</b> - With the sodic soils on the project site I am nervous about the use of swales - if the dispersive soil layer is exposed and subject to moving water, there is a very significant risk of soil mobilisation and erosion - it would need to be lined and protected as is the case with the waterways - which will be more expensive than usual. Accordingly, I'm more in favour of discrete vegetated assets like rain gardens with vertical water movement through a constructed soil layer in this case.</p> <p><b>Consultant D</b> - Opportunities: distributed WQ has lots of benefits. Risks: Design, construction and maintenance. The industry produces lots of results!</p>	<p>maintenance requirements.</p> <p><b>Consultant C</b> - Within streets - small rain gardens could be \$2000/m2. Larger bioretention areas in open space would be more like \$300-500/m2.</p> <p><b>Consultant D</b> - Needs an assessment. It is not a one size fits all.</p>	<p>Could be in kerb outstands.</p> <p><b>Consultant C</b> - Pre-treatment of stormwater runoff is an important part of the IWM strategy to filter stormwater before it enters the chain of ponds harvesting system. Raingardens/bioretention should be included in streetscapes and should also be used in open space alongside the waterway corridor to treat runoff before it enters the ponds.</p> <p><b>Consultant D</b> - My gut is 25% of the project could accommodate this approach relatively easily.</p>	<p>before).</p> <p><b>Consultant D</b> - Medium.</p>

1348 **Table S3.** The consensus decision on the estimated cost of implementing each BSUD action,  
 1349 relative to a business-as-usual scenario. The \* denotes actions that are considered essential to  
 1350 delivering BSUD outcomes in the greenfield community development. The shading indicates  
 1351 different themes including habitat analogues/design features (actions 1-8), surface area/land  
 1352 cover design (9-11), vegetation (12-15) and water (16-18). Action definitions are available in  
 1353 Table 1.

No.	Action	Cheaper	Approx. the same	Slightly more	A lot more	Prohibitively more
1	Above road wildlife crossing structures for major roads			x		
2	Habitat analogues attached to lighting infrastructure or other pole-based infrastructure			x		
3*	Sandy, rocky and muddy areas with logs		x			
4	Habitat walls at property boundaries (e.g., gabion walls or retaining walls)			x		
5	Nature play areas with novel habitat analogues		x			
6	Seating that incorporates vegetation and/or habitat analogues			x		
7*	Wildlife-friendly public lighting			x		
8	Wildlife underpasses for major roads				x	
9	Permeable paving in a residential footpath					x
10	One wide footpath and one narrow footpath		x			
11	Winding path/road edge/verge to create 'nature pockets' in streetscapes			x		
12*	High level of mid-storey vegetation cover and connectivity		x			

No.	Action	Cheaper	Approx. the same	Slightly more	A lot more	Prohibitively more
13*	Minimum number of native tree species per unit area		x			
14*	Minimum of 50% garden bed coverage in public greenspaces			x		
15*	Terraced native planting with mowable groundcover at edges		x			
16*	Elevated bird waterers				x	
17	Ephemeral wetland within 500m of creek		x			
18	Vegetated rain gardens for stormwater capture			x		

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