Ecological Survey and Bellgrove Residential Development at 52 Kippenberger Avenue

Prepared for:
Aurecon

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Common smelt, caught in the Cam River near 52 Kippenberger Ave

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1 Executive Summary

Residential development (Bellgrove North) is proposed at 52 Kippenberger Avenue transforming the existing rural land to residential.

Stage 1 of Bellgrove North (subject to this application) contains approximately 20.8ha and is the first step in development of BRL's wider landholding. Stage 1 will comprise general and medium density residential development yielding approximately 200 lots/dwellings, provision for a local commercial area, retention of the heritage homestead for residential use, and associated roading, landscaping, stormwater management and reserve networks.

The Bellgrove Stage 1 Development Area, and its associated downstream perennial reaches of the Cam/Ruataniwha River, were subject to an ecological survey on the 15 March, and 21April 2021.

The Stage 1 Area incorporates two ephemeral channels, the Cam /Ruataniwha River channel, and the Northern Flow Channel. Both channels contain no permanent aquatic habitat of natural origin, at least in recent decades. In addition, the inverts of the channel contained no aquatic vegetation, nor did the soils indicate protracted periods of inundation during the surveys.

However, the Stage 1 Area also includes a lined constructed pond which is included on site as a maintained ornamental pond near the homestead. East of the Stage 1 Area, perennial flow commences from a springhead just east of the site boundary. This may be a wetland under the RMA definition as it has developed a natural ecology, but it is certainly not a natural wetland under the recent NPS-FM definition. However, suspected eastward overflow, or ground seep, from this constructed pond forms an "induced wetland" as explained in a recent MFE guideline, a habitat with the same ecological status as a NPS-FM natural wetland (Ministry for the Environment 2021).

Further downstream of the Stage 1 site, and Kippenberger Avenue, aquatic values, both for fish and invertebrates, indicate "good" stream health, but with a highly unusual fish community. Anthropogenic reasons may be the cause of the low fish diversity and unusual species composition.

While no fish were found in the Stage 1 Area, during rain events there may be upstream fish passage for fish in the Cam/Ruataniwha River channel, especially eels, and possibly the occasional brown trout. These fish could venture eastwards from perennial habitat east of the site along the Cam/Ruataniwha River channel. This has anecdotally occurred in in the past, as both species have been reported from the ornamental constructed pond at the homestead. For this reason, we recommend that the re-contoured Cam River channel does not incorporate pools or deeper reaches which could trap fish when the storm water level recedes.

There is no ecological reason for a buffer strip for the Cam River channel to exceed a width of 10 m, although this width is preferred for sediment control, nutrient uptake, and providing an ecological dispersal path to permanent aquatic habitats further downstream. A width less than this may compromise some or all of these functions, which are important to maintain the high stream health characteristics downstream of Kippenberger Avenue.

The Northern Flow Channel: is lacking merit for aquatic ecology, and not directly connected to the high ecological values downstream of Kippenberger Avenue. We consider a minimum riparian width is adequate for this Channel.

We recommend several riparian plant species for the Cam / Ruataniwha River Channel which may benefit the aquatic ecology in downstream habitats. It is our understanding they have been incorporated into the draft landscape plans. We also recommend that a wetland specialist, in conjunction with a Landscape architect, be involved in the wetland restoration around the area of the induced wetland, and the preparation of a restoration plan. We recommend monitoring the wetland plants for five years to ensure their ecological dominance over existing weed species.

2 Introduction

The figure below indicates the proposed development stages of Spring Grove (Fig. 1).

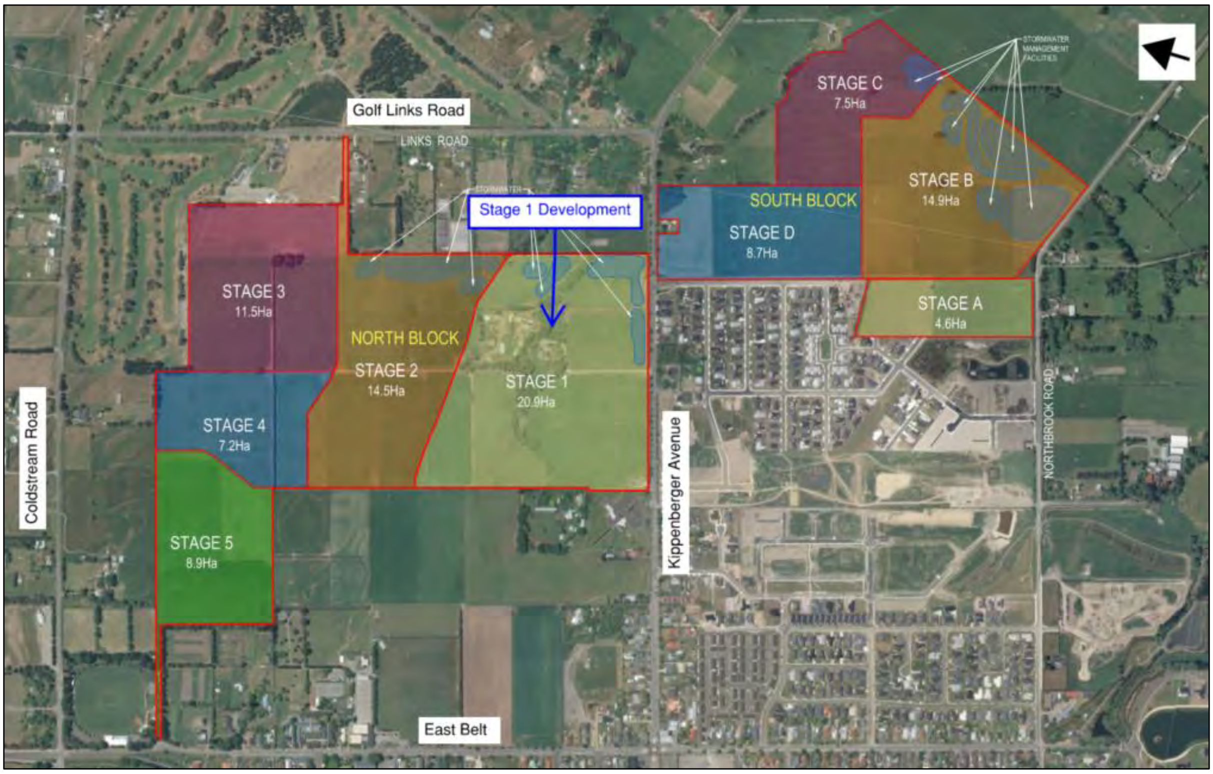


Figure 1. The proposed development stages of the Bellgrove subdivision.

2.1 Proposal

The development of Stage 1 of Bellgrove North at 52 and 76 Kippenberger Avenue (**the site**) will involve the following:

- development of approximately 20.8 ha of land for the purpose of delivering:
  - approximately 200 residential lots / dwellings with a mixture of medium density (200 m² to 499 m²) and general residential (>500 m²);
  - a large residential lot (approximately 2,950m²) around the Bellgrove Historic Homestead (note the historic homestead will be retained);
  - a commercial lot for future commercial development (approximately 5,000 m²);
  - a larger residential super lot (approximately 2,400 m²) for future development;
- the subdivision layout includes the establishment of an internal road layout comprising a mixture of collector and local roads and cul-de-sacs. In addition, an integrated network of shared paths is proposed through the proposed esplanade and stormwater reserves; and
- establishment of two new intersections to Kippenberger Avenue (a four-legged roundabout at Kippenberger Avenue / MacPhail Avenue and a new T-intersection);
- remediation of contaminated land;
- the associated construction of the development will include:
  - vegetation clearance and grading of the site;

  - earthworks to establish the site including installation of infrastructure, road network, landscaping and to achieve appropriate furnished floor levels;
  - construction phase stormwater discharge
  - dewatering
  - noise and traffic generation
  - residential dwelling construction
- stormwater discharges associated with construction and operation of the site;
- wastewater discharges associated with the operation of the site;
- the realignment of the Cam/Ruataniwha River and Northern Flow Channel;
- creation of a Western Bypass Channel; and
- establishment of esplanade reserves.

The site is currently zoned for rural land use and subdivision, land use and resource consent for Bellgrove Stage 1 are proposed to be lodged to the Environmental Protection Authority (EPA) under the under the COVID-19 Recovery (Fast-track Consenting) Act 2020 (FTCA). The land is currently used for pastoral grazing, with some residential land use around the homestead.

The proposal will involve landscaping in the vicinity of what is now a dry swale but historically may have represented the headwaters of the Cam/Ruataniwha River. The landowner is proposing a minimum 7m-wide area from the edge of the realigned Cam / Ruataniwha River corridor to the proposed residential allotment boundaries instead of the required 20 m width stipulated by the operative and proposed Waimakariri District Plans. This width allows for an effective (minimum) 10 m-wide offset from the invert of the channel. The width varies for the length of the Cam / Ruataniwha River corridor through the site, with the narrowest point (7m) being on the western reach though the site.

There are locations where the offset width is significantly greater than 7m notably where the esplanade seamlessly integrates with the stormwater management areas and the curtilage of the historic homestead. For example, immediately north of Lot 50 the southern side of the esplanade reserve increases to a width of 18m.

AEL was commissioned to evaluate the ecology of the headwaters of the Cam/Ruataniwha River and the swale network upgradient and to the west. AEL was also to consider the impact of a reduction in esplanade width. In addition, AEL was requested to ecologically evaluate the swale to the north of the Cam/Ruataniwha River, which is a historic flood breakout channel. For the purpose of this report, this will be known as the Northern Flow Channel. Finally, AEL assessed whether there are any natural wetlands on the site, in accordance with the Ministry for the Environment’s guidance.

In addition, the developer proposes to realign the uppermost reach west of the homestead, providing a gentler meander pattern.

2.2 Physical Description

2.2.1 Cam/Ruataniwha River

The Cam/Ruataniwha River rises from 4 principal sources. Three main spring-fed waterways, known locally as the “3 Brooks”, feed the upper Cam River rising from around the township of Rangiora. The fourth source is from a perennial spring upstream of Kippenberger Avenue. The main aquatic and wetland habitats are depicted in Fig. 2, with the mapped GPS waypoints referred to in the text presented in Fig. 3 .

Figure 2. Map showing the boundary of the Stage 1 Site (red), Perennial Cam River (Coldstream) (blue), with brown lines indicate ephemeral reach. The flood breakout swale is also ephemeral.

Figure 3. The longitudinal survey range of the headwater survey on 26th May 2021. Points are waypoint numbers mentioned in the text.

2.2.2 Physical description of the Cam River headwaters

Photographs of this channel are provided in Appendix I. Upstream of the homestead the headwater swale is grazed and with no indication of aquatic life, including facultative or obligate hydrophytes (App. I, Figs i, ii). Further east and down-slope, the channel is fenced from grazing stock, and introduced soft herbs dominate, with areas of unkempt introduced grasses and shrubs (App. I, Figs. iii, iv). The dry upkept channel foliage persists eastwards, but is punctuated by a stock crossing at wpt 49 (Fig. 3, App. I, Fig v). During floods, water can flow across this crossing, but completely drains away.

West of the ornamental pond (wpt 47) the channel was dry, with a sward of exotic shrubs and bulbs lining the channel (App. I, Figs. vi, vii). Immediately upstream of the pond (wpt 46) a fluvial channel form can be discerned (App. I, Figs. viii, ix), and was an area where water temporarily pools during rain events. Immediately west of the ornamental pond (wpt 46), vegetation in the swale was dryland (App. I, Fig vii), but an old fluvial channel form was perceptible looking towards the ornamental pond at this location (App. I. Fig ix).

The man-made ornamental pond forms permanent aquatic habitat at the bottom of the homestead lawn (Site 1, Fig. 2, App. I, Fig. x). The base is plastic-lined to prevent the water draining to ground, and at the time of survey, the centre water depth was c. 0.4 m. The riparian area was planted with mature *Carex secta*, with some ferns and exotic umbrella sedge present. At the time, the water surface was largely obscured with a coating of the floating duckweed *Lemna minor* (App. I, Fig. xi). Within the water there was abundant woody debris present, derived from the overhead tree canopy. After 4 minutes of fishing (at 200 Volts) no fish were caught, although reportedly eels, and even a trout, has been observed.

Down gradient (east) from the pond (App. I, Fig. xii), there was no surface water, or aquatic plants, but the soil was soft and damp with a sward of grass. Its possible eels could slither up here during rain if the channel is wet, but trout would require water depth of 10 cm or more.

Further east, east of the access drive, the swale was dry with an excavated depression which reportedly fills with rainwater but is isolated from other aquatic habitats (App. I, Fig. xiii). Approximately further east, groundwater is visible when it rains, with the perennial spring 40 m eastwards, and over the site boundary in 7/8 Golf Links Road (Fig. 2, App. I, Fig. xiv). Immediately upstream (north) of Kippenberger Ave, the channel is sun-exposed, and obscured with a channel-choking sward of rafting exotic macrophytes, such as monkey musk (*Erythranthe guttata*) and watercress (*Nasturtium officinale*) (App. I, Fig xv). Downstream (south) of Kippenberger Ave culvert, flow is visible. Substrate in this reach is a mixture of cobbles, gravel and sediment, and riparian vegetation includes a variety of native and exotic species (App. I, Fig. xvi).

2.2.3 Physical description of the Northern Flow Channel

Photographs of this channel are provided in Appendix II.

This forms a grassed depression across the grazed paddocks with no visible botanical zonation between the paddock and the swale cross-section (App. II, Figs. i, ii). The lack of any form of aquatic or even ephemeral vegetation extends eastwards, and the ground is dry and compacted (App. II, Fig. iii). The flora is composed of a sward of dryland weeds (fat hen, plantain), with a similar exotic species composition as the Cam headwater channel. We also noted an outbreak of Old Man’s Beard invading the poplar tree line (App. II, Fig. iv). There was no facultative or obligate aquatic vegetation along the channel invert.

3 Field methods and results

There was some anecdotal evidence (landowner, pers. comm.) that while only one perennial (ornamental) pond was located in the Site Area, during a flood event, the Cam/Ruataniwha River channel could connect to the pond and provide ecological passage for fish (eels and trout) along the stream corridor. Due to this ecological link, the aquatic ecology in the perennial reach of the Cam/Ruataniwha River headwaters, downstream of the property, was therefore assessed. Sampling locations are presented in Fig. 4.

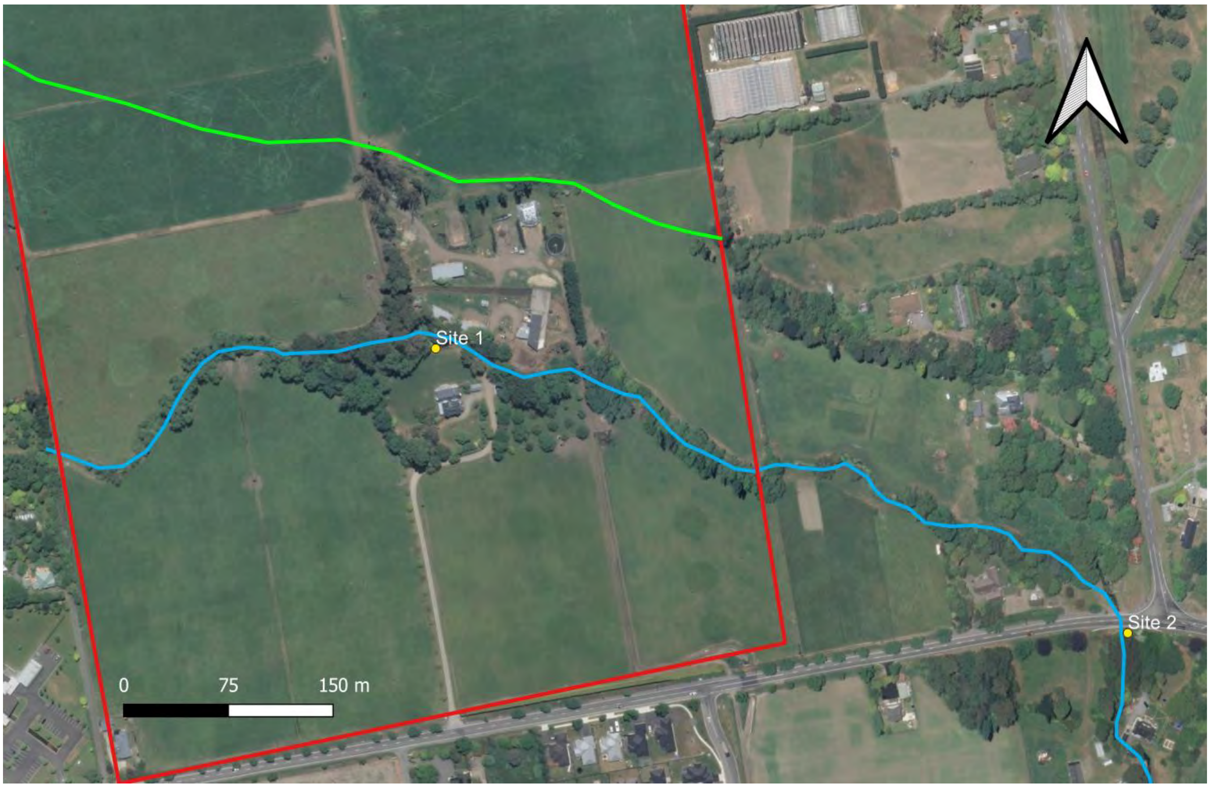


Figure 4. Map showing the boundary of the residential development (red), Cam/Ruataniwha River (blue, dry within development boundaries), and the Northern Flow Channel (green, also dry within property boundaries), and the locations of fish and invertebrate surveys (yellow markers).

3.1 Macroinvertebrate Survey

The macroinvertebrate collection method used was a semi-quantitative collection technique called "protocol C1", appropriate for riffle habitat in stony streams (Stark *et al.* 2001). This methodology is consistent with data collection for compliance monitoring for AEE (Assessment of Environmental Effects) and SOE (State of the Environment) reporting. Stream invertebrates are affected by flood flows, and published protocols advise that sampling should not be undertaken within 3-4 weeks of floods. In this instance, no significant rainfall events occurred in the three weeks prior to collection.

The mechanics of collecting macroinvertebrates using Protocol C1 are detailed in Stark et al. (2001), and it is not necessary to provide further detail here. One macroinvertebrate composite sample was collected from Site 2, composed of eight kick-net sub-samples with a combined habitat area of approximately 0.72 m2 (8 x 0.3 m x 0.3 m). Kick net samples were collected across the stream transect, working upstream in a zigzag manner. To supplement this, approximately 3 m of woody debris collected from within the stream was washed through the kick net. Samples were field-preserved in ethyl alcohol, and the aquatic macroinvertebrates for the drain branches were transported to the Christchurch laboratory for identification using the standard identification keys (Chapman *et al.* 2011; Winterbourn 1973; Winterbourn *et al.* 2006).

The invertebrate sample identified an abundance of the New Zealand mud snail (*Potamopyrgus antipodarum*) in Cam River (Table 1). This native species is common throughout New Zealand and is not sensitive to pollutants (MCI-hb = 4). However, other abundant species identified in this sample were the mayfly *Deleatidium* (MCI-hb = 8) and the caddisfly *Pycnocentria* (MCI-hb = 7). These species are significantly more sensitive to pollutants, and are only present in healthy waterways. A number of other native caddisfly species were also identified in this sample. One of these species, *Olinga*, has an MCI-hb score of 9 and is therefore very sensitive to poor stream health.

Table 1. Invertebrate data from a sample at Site 2, downstream of the Plan Change Area.

		No.	MCI-hb	QMCI-hb
ANNELIDA				
Oligochaeta		1	1	1
Hirudinea		2	3	6
MOLLUSCA				
Gastropoda				
Hydrobiidae	*Potamopyrgus antipodarum*	316	4	1264
INSECTA				
Diptera				
Chironomidae indet		2	2	4
Dixidae	*Paradixa*	2	4	8
Ephemeroptera				
Leptophlebiidae	*Deleatidium*	19	8	152
Trichoptera				
Leptoceridae	*Hudsonema amabile*	1	6	6
	Hudsonema alienum	2	6	12
	Triplectides	4	5	20
	Oecetis	1	6	6
Hydrobiosidae	*Psilochorema*	1	8	8
Conoesucidae	*Olinga*	1	9	9
	Pycnocentria	23	7	161
Coleoptera				
Dytiscidae		1	5	5
No. Scoring taxa		14		
TOTAL No. of animals		376		
MCI-hb		105.7		
QMCI-hb		4.4		
% EPT taxa		13.8		

Overall, the presence of these EPT species resulted in an MCI score of 105.7. Based on the interpretation of MCI-type biotic indices, a score of between 100 – 119 is considered to represent “Good” stream ecological health (Stark & Maxted 2007).

3.2 Fish Survey

To assess the fish community in the vicinity of the proposed development, electric fishing was conducted, under AEL’s electric fishing permits (MPI Permit 749, DOC 70754-FAU and under authority from NCFGC). In combination, these reaches encompassed all hydrological habitat types in the area, including: pool, riffle and run habitats. The total sample time (i.e., the total time that the machine was actively electrifying the water) for these reaches was 17 minutes. Captured fish were then anaesthetised, identified, measured, and upon recovery from anaesthesia, released back into their resident habitats.

Both Sites 1 and 2 (see Fig. 4) were electro-fished on 21st April 2021 using a conventional Kainga EFM300 electric fishing machine at an operating voltage of 200 V. D.C. This voltage provided a sufficient electrical field size to prevent escapement. Electric fishing serves to briefly (approx. 3 seconds) render fish unconscious to facilitate their capture in nets for identification. The machine incorporates a timer, allowing the effective fishing time to be recorded. Overall conditions for fish capture using electric fishing were adequate, with low, but acceptable, water conductivity and excellent water clarity.

Despite 4 minutes of effective fishing effort, no fish were identified in the ornamental pond (Site 1). The waterbody at this location is man-made, lined with plastic, and contains significant amounts of organic debris. It is likely very difficult for fish to inhabit due to a lack of open water and limited macroinvertebrate population.

After 13 minutes of active fishing effort at Site 2 two fish species were identified (Table 2). These were the brown trout (*Salmo trutta*, Fig. 5) and the common smelt (*Retropinna retropinna*, Fig. 6).

Table 2. Fish catch data from Cam River in the vicinity of 52 Kippenberger Ave.

	Brown trout	Common smelt	Total
Site 1	0	0	0
Site 2	5	1	6

Figure 5. Juvenile brown trout from Cam River (Coldstream) downstream of Kippenberger Avenue.

Figure 6. A common smelt from Cam River (Coldstream) downstream of Kippenberger Avenue. This fish was photographed while recovering from anaesthetic. The identification of this normally coastal fish was surprising.

The common smelt can be distinguished from the closely related Stokell's Smelt by the common smelt possessing larger, but fewer, scales along the lateral line (c. 60 *in* McDowall 1990). Stokell's smelt has smaller scales, approximately 100, along the lateral line.

The common smelt is native to New Zealand but is considered "Not Threatened" (Dunn *et al.* 2017). The brown trout is an introduced species. The presence of common smelt, but to a lesser extent the brown trout, indicate fair stream health. The lack of eels and bullies, but also the surprising presence of smelt, very much a coastal species, is a highly unusual fish community. There may be an anthrogenic reason or reasons for this, but this is not known with confidence.

4 Discussion

4.1 Previous Work by AEL in the upper Cam reach

AEL has been involved with mapping trout spawning grounds in the upper Cam River area for Waimakariri District Council in 2005 (Taylor 2005) , 2012 ((Taylor *et al.* 2012)) and 2017 (Taylor & Marshall 2017). On all three occasions, winter baseflow surface water rose at a perennial spring east of the Plan Change Area, within the property of 7/8 Golf Links Road (Fig. 2).

4.2 Ecological stream health

Both the invertebrate and fish composition are suggestive of "good" stream health, with the high diversity and abundance of caddisflies and mayflies, and the presence of the physiologically sensitive common smelt being particular indicators. Our earlier trout spawning surveys have always revealed trout spawning downstream of Kippenberger Ave, also an indicator of at least reasonable oxygen levels and water quality.

The unusual fish composition is noteworthy. In one respect it reflects poor fish access from the sea, but the presence of common smelt indicates good sea access (or introduction by man) at some point in the past, and smelt may have formed a land-locked population, which they have been known to do naturally or deliberately (McDowall 1990; Ward *et al.* 2005). Possibly migratory fish access may have been denied by instream structures associated with "The Mill" further downstream, but the reason is currently unknown. However, a possible perched culvert along the upper course may prevent access to many fish species with a sea lifestage (e.g., eels, whitebait).

4.3 Buffer Strip Width for the Cam River

Three ecological studies have indicated that in recent past, there has not been permanent surface water within the site. The lined pond on the property is a relatively recent water feature, and did not contain fish at the time of survey. It is possible, under heavy rain, eels may reach the pond, but this has not occurred in the recent past. There is no aquatic habitat, even ephemeral, upstream of the ornamental pond. Rain does puddle and flow at times upstream of the pond, but of insufficient permanence to sustain wetland plants or support aquatic life. The channel has a sward of small trees and shrubs, but all the species we observed were exotic dryland species. Some of the species were similar to those we saw in the Northern Flow Channel, and may have been planted for ornamental purposes. In many respects the morphology and ecology of the Cam/Ruataniwha River resembled that of the Northern Flow Channel.

Because the local habitat lacks any aquatic ecology, any buffer strip within the site does not require a width of a size to provide significant local ecological function, but requires a width sufficient to support the banks during flood flows, to reduce nutrient inputs, and trap sediment from overland sheet flow. At the time of survey, the banks appeared eroded in places, and sediment washed down into the ephemeral channel during rain is likely to be transported into the quality aquatic habitat downstream, including the trout spawning reaches. Sediment can detrimentally clog trout spawning gravels, but would also have a detrimental impact on the habitat where caddisflies and mayflies are present in some number.

Effective and significant removal of phosphorous and nitrate, if sufficiently planted for nutrient absorption, can take place over a 10 m buffer strip. For this discussion, this width can be taken as at the water's edge when the channel flows. At 10 m width, nitrate removal can exceed 70% (Parkyn 2004), and in a flat catchment, this width is considered of sufficient width to trap fine sediment (Main 2003). This may require a sward of soft *Carex* spp. or grass which facilitate biofiltration (Parkyn 2004).

However, while a 10 m buffer could not provide ecological function to support local ecological life in the channel, it would provide utility in supporting the aquatic ecology downstream of the perennial springs, particularly the habitat downstream of Kippenberger Ave. Specifically the buffer strip would provide a flight path and roosting/feeding habitat for the winged lifestages of mayfly and caddisfly species further downstream. Such a buffer strip would also serve as a corridor for native bush birds

The proposed Waimakariri District Plan, like the operative requires a 20 m buffer zone on both sides of the Cam/Ruataniwha River, which seems excessive given the lack of any aquatic value in this reach. The current proposed minimum width between properties and the riparian zone is 7 m (App. III, Fig. ii).

Based on the available literature, AEL believes a 10 m native-planted buffer zone area from the water's edge will protect the clear aquatic values further downstream from the development impacts.

While the landscape plan does not provide for a vegetated buffer strip of this width continuously along the channel, the 10 m development setback is achieved by a combination of planted riparian buffer and setback widths, with a combined minimum total of 11 m west of cross-section A-AA but mitigated with planting near the property boundary (App. II, Fig. ii). Other cross-sections (B-BB & D-DD) exhibit significantly wider setbacks.

4.4 Realignment of the Cam/Ruataniwha River

The Developer proposes to re-align the upper channel of the Cam headwaters west of the homestead. This will involve 'flattening' the existing curved path into a gentler meander (App. III, Fig. i), but with the course still flowing through the man-made pond near the homestead, and waterway features downstream of that point.

I have seen the draft landscape designs for the Cam/Ruataniwha River and Northern Flow Channel prepared by Rough & Milne Ltd prepared by Fraser Miller. For the Cam River headwaters west of the homestead we recommend an ecologically functional buffer strip of 10 m width from the channel edge. The buffer strip will be composed of native trees and shrubs, including cabbage trees and lancewoods, but may include within its width a pervious grassed walking path on the true left (north) bank. Ecological linkages will benefit from a native riparian and wetland plant-out, beneficial for waterbirds and winged aquatic insect life-stages. This would represent a significant ecological improvement from the current community of introduced plants and weeds along its existing course (App. I, Figs. vi, vii). To affect the ecological enhancement, we would recommend a wetland specialist be engaged to prepare and help implement a wetland restoration plan, and that an indigenous plant-out is monitored/weeded for 5 years to ensure wetland plants establish and retain dominance.

Where possible, existing exotic tall trees, possibly only 4 specimens, will be retained. These will strengthen the banks around the new channel alignment to counter the erosive forces associated with flood flows which occur from time to time (landowner pers. comm). Landscaping will reduce the soil erosion, which is evident in some locations in both channels, and will enhance and protect significant ecological values further downstream. We note that as most of the channel does not contain permanent water, shading of the channel is not an environmental requirement, although the tall-tree shading will be maintained around the permanent pond (Site 1). If the riparian zone develops a dense sward of vegetation, this will support biofiltration of floodwaters, advantageous to the perennial reaches downstream (east) of the site.

Based on recent development designs, two box culverts have been incorporated into the Cam/Ruataniwha River channel realignment. While the invert cannot be buried into the substrate, and the builds are not therefore compliant with the recent NES-F (New Zealand Government 2020), the inverts will be flush with the bed. We consider this arrangement satisfactory, given that fish passage this far upstream of the natural fish distribution will be extremely rare.

Due to the low habitat permanence, this waterway exhibits a higher chance of water stagnation. This could result in increased algal growth and high densities of chironomids (midges). It is recommended that waterway stagnation be prevented through constant gradients across the site, and that pools are not constructed. Eels, and possibly other fish, will migrate upstream into ephemeral reaches to feed opportunistically during heavy rain. Therefore, pools are not recommended for this reason as well, as they may trap fish when flow recedes. Constructive feedback from MKT recommends the incorporation of riffles, which, when water is present, aerates the water through turbulence, and provides refuge for small fish.

4.5 Notes on the Northern Flow Channel

The Northern Channel lacks any value for aquatic life. However, it is clear from aerial photography that the channel is an old fluvial channel from the Ashley River when it flowed further south towards the sea. Currently, the Northern Flow channel, under high flows, may connect to the upper Taranaki Stream catchment.

In our opinion, in respect to the definition of a natural wetland, the Northern Flow Channel is not a wetland as it specifically excluded from that definition as it represents an “area of pasture that, at the commencement date, is dominated by (that is more than 50% of) exotic pasture species and is subject to temporary rain-derived water pooling” (Ministry for the Environment 2021). Moreover, the dry soils in the invert of the channel (App. II, Figs i-iii) were not indicative of wetland soils, indicated prolonged periods of wetland conditions, as described in Fraser *et al.* (2018). We therefore consider that is no need to set an esplanade reserve on either side of the Northern Channel, certainly in terms of preserving function for aquatic ecology. However, there will be some requirement for weed control at some stage, in particular the control of Old Man’s Beard. This will require a maintenance lane for weed control.

Under the current conditions, the Northern Flow Channel will not support aquatic life, or even water bird habitat. For these reasons, we do not consider that the Northern Flow Channel represents a wetland (ephemeral or otherwise), and only requires the minimum setback around the northern swale. The northern flow channel does have a distant ephemeral connection to the headwaters of Taranaki Stream, but permanent aquatic habitat is a long way downstream, with a winter rising point near Smarts Road, approximately 1.3 km downstream (Taylor *et al.* 2012). We recommend that the construction of pools are not attempted in this channel as there is a chance of water stagnation, and that the invert follow a uniform gradient similar to the Cam / Ruataniwha River.

The development plan proposes that excessive stormwater in the Northern Flow Channel, which receives stormwater from beyond the development, is redirected in part, into the Cam /Ruataniwha River. This is unlikely to change the ephemeral status of either stormwater flow path.

Landscaping cross-sections and plans (Rough & Milne Drawing No. L 1.9, Rev. A)indicate a riparian planting of trees, shrubs and rushes, or which at least some are native, which will enhance flight corridors for birds and insects. This corridor is linked to its Cam River counterpart, enhancing the habitat as a whole as a fly-way, even when surface water is not present.

4.6 Construction Effects

While the directly impacted reach of the Cam/Ruataniwha River is currently dry, erosion and sediment control measures are still considered important. Loose dirt and silt in the channel is liable to become suspended during rainfall, significantly increasing turbidity in downstream reaches. For this reason, it is recommended that a buffer zone be retained on both sides of the Cam / Ruataniwha River during works. Similarly, airborne dust can collect in the channel and become suspended in the waterway during rainfall. Dust from hall roads and heavy machinery should therefore be minimised where practicable.

All works in and near the channel must also comply with the Environment Canterbury erosion and sediment control guidelines and online toolbox. Sediment fences should be utilised when working near the waterway, aiding in the prevention of loose dirt collecting in the channel. These fences should be checked on a regular basis, as the movement of earth can induce strains on the fences and potentially force the buried fence toe toward the surface. The toe of the fence must remain buried to prevent loose sediment entering the channel.

The wetland area should be encircled by a filter fence, and dirty run-on water arising from up-gradient sources diverted around the wetland during the construction phase. If the wetland begins to dry due to the bypass, clean water could be added to replenish the wetland.

To minimise erosion caused by rainfall, geotextiles or erosion control blankets should be utilised when working in the buffer and riparian zones around both the Cam / Ruataniwha River and the Northern Flow Channel. This will prevent excess turbidity in the waterways, and retain bank shape during rainfall events. The protocol for use of these blankets is detailed in the Environment Canterbury erosion and sediment control toolbox.

Work on the waterways and riparian zones should not take place during or immediately after rainfall. If surface water connectivity due to rainfall is maintained following significant rainfall, fish that have entered the impacted reaches of both the Cam / Ruataniwha River and Northern Flow Channel should be removed by a qualified ecologist before work commences.

4.7 Proposed Waimakariri District Plan Waterway Overlays

The Waimakariri District Council has recently notified a proposed Waimakariri District Plan. This plan includes overlays pertaining to the Cam / Ruataniwha River and Northern Flow Channel.

Within the plan, both channels through the site at 52 Kippenberger Ave are classified as Nga Wai (Sites and Areas of Significance to Māori). The proposed plans should therefore encompass Māori values, and have minimal impacts on the natural character values of the waterbody and margins. These criteria have been met by the proposed development, as the channel and riparian zones will be retained and naturalized, and the existing introduced riparian plants replaced with native species.

The proposed Waimakariri District Plan would also enforce a 20 m minimum setback. Based on the stormwater filtration study referred to in the above section titled “Buffer strip width for the Cam River”, the minimum 10 m setback consistent with the current site landscape plan would cause no adverse impacts on the waterway. The proviso for a reduced setback for ephemeral habitats is that the riparian strip is not required to support local aquatic life but provide an ecological pathway to aquatic habitats further downstream.

4.8 Aquatic Habitat Permanence

The following section is in response to a query from the Ministry for the Environment dated 20 October 2021 on the Belgrove Referral application seeking confirmation as to whether there are any wetlands existing within the project area.

Aquatic Ecology Limited (AEL) has surveyed the Bellgrove development site on several occasions this year: 15 March, 21 April, 26 May 2001, and more recently 21st January 2022. These trips were to specifically identify aquatic habitats, either permanent or temporary, existing within the development area.

Additionally, AEL approached the eastern boundary of the site during the winter months, as part of trout spawning surveys being completed on behalf of the Waimakariri District Council in 2005 (Taylor 2005), 2012 (Taylor *et al.* 2012), and 2017 (Taylor & Marshall 2017).

All of these studies, even at winter baseflow, have confirmed that, at least in the recent past, there is no perennial natural aquatic habitat present within the Bellgrove site. The most upstream permanent spring is on the neighbouring property to the east (7/8 Golf Links Road).

There are two ephemeral channels traversing the development area; an up-gradient swale form for the Cam/Ruataniwha River which has a form towards the perennial springs further east and described above, and a Northern Flow Channel, a dry gully which appears to lead to the Taranaki Stream headwaters at Smarts Road. The Northern Flow Channel conveys high flows from the East Belt area north of Rangiora.

4.8.1 Cam / Ruataniwha River

Up-gradient (west) of the homestead pond, the swale invert is dry and contains no wetland vegetation (facultive or obligate *in* Clarkson *et al.* 2021), nor wetland soils.

The Cam / Ruataniwha River swale contains an artificial, constructed and lined ornamental pond near the Homestead. This pond is a relatively recent constructed feature (landowner pers. comm.), and now contains a natural wetland community and therefore would be defined as a wetland under the RMA. However, it is not a natural one so the National Policy Statement-Freshwater Management (NPS-FM) does not apply (page 23 *in* Ministry for the Environment 2020a).

The area directly east of the pond, lacked surface water, but was ringed with *C. secta* which have probably dispersed from planted specimens around the pond, or had been deliberately planted (Figs. 7a, b). In the vicinity of the wetland there is a canopy and sub-canopy of both exotic and native trees and shrubs. These include totara, lancewood, karamu, coprosmas, and cabbage tree.

A survey of the area was undertaken using the recent wetland status assessment (page 11 *in* Ministry for the Environment 2021). The data forms, completed in the field are provided in App. IV. For this damp area, the botanical survey "passed" both a wetland plant dominance test, and prevalence test. It was clear that there were a number of common "facultative wetland" and "obligate" wetland species (e.g. floating sweetgrass, willow weed, water pepper, and chickweed) that had naturally colonised the area, even if the tussock sedge (*Carex secta*) is assumed to be planted and ignored. Both of two soil cores were damp in this location, were pale grey, pasty and plastic to the touch. Neither had reductive mottling (indicative of anaerobic conditions) as per Fraser *et al.* (2018). There was no apparent soil horizons with a layer of rounded river gravels present 25 cm below the ground surface. At the lowest point in the habitat, groundwater seeped into our inspection pit 25 cm below ground level. In summary, I regarded the soil as non- hydric, and possibly of recent origin (Fraser *et al.* 2018), but it passed the hydrology test for wetland habitats. Overall, the indication was the habitat was a recent wetland from a historical perennial riverine form. The habitat is considered an 'induced wetland' (Ministry for the Environment 2021), under the NPS-FM because the wetland may incur overflow from the lined pond, especially under heavy rain, or if the lined pond is re-filled with hose water. Using the wetland assessment guide, an induced wetland has the same status under the NPS-FM as a 'natural wetland'. The habitat edge of the induced wetland has been recently pegged and the margin is in agreement with the opinion of Dr. Philip Grove (ECan scientist).

The value of the wetland is currently low, with few indigenous species, however its value lies in its potential as it is surrounded by a riparian zone containing a number of mature native trees and shrubs, which would enhance the value of the wetland should it be retained and restored.

With rain, the downstream swale can fill and flow east with rainwater, but it drains away to the neighbouring property. Water does puddle in one excavated location near the eastern boundary as a result of rainfall, even when there is no surface water inflow, suggesting its excavated invert connects to the shallow groundwater level. There are no wetland plants or soils at this location (Fig. 8), and consequently it also does not qualify as a 'natural wetland' as defined by the NPS-FM (Ministry for the Environment 2020a).

Figure 7a. Looking down gradient (east) of ornamental pond. Mature C. secta, like those in the pond.

Figure 7b. Looking up gradient (west) towards ornamental pond. The invert contained broad-leaf plantain (*Plantago major),* but was dominated by willow weed, chickweed, and floating sweetgrass.

Figure 8. Ponding area which fills during heavy rain (AEL wpt 98, 15/3/2021). Area dug out, so potentially constructed. The invert had no vegetation.

4.8.2 Northern Flow Channel

The northern flood channel, an old fluvial channel of the Ashley River, is completely dry along its full length, but presumably temporarily conveys floodwater during significant storm events. It contains no wetland plants, nor does it contain wetland hydric soils (Fraser *et al.* 2018) as indicated in our ecological report included with the referral application. Therefore, it does not qualify as a wetland, natural or otherwise, as defined by the NPS-FM (Ministry for the Environment 2020a) or wetland delineation protocols (Ministry for the Environment 2020b).

4.9 Riparian Plant Recommendations

4.9.1 Riparian habitat

When planted close to the banks of a waterway, overhanging native grass and rush species such as *Carex virgata* or *Juncus edgariae* will create shade, fish refuge and feeding habitat. Shade is important in the moderating water temperature and limiting algal growth. This could be important post-flood before the waters drain away from the channel. It is possible that some fish could enter the flooded channel and feed opportunistically, a common trait for native fish, like the upland bully identified downstream.

An appropriately planted riparian zone will serve as a buffer against weather events and contaminated runoff, especially nutrients like nitrogen and phosphorus present in the soil prior to land use change. Native grasses at the edge of the waterway, followed by larger shrubs such as *Hebe salicifolia* further up the bank, and finally large trees such as lemonwood (*Pittosporum eugenioides*) at the top of the bank, could combine to create a strong barrier. This barrier blocks both wind and sunlight, effectively regulating the water temperature within the waterway (Collier *et al.* 1995). Many native aquatic fish and invertebrate species are highly susceptible to significant variation in water temperature, therefore regulation of the temperature in the vicinity of a waterway is important.

Thus, while both waterways within the proposed boundaries are currently ephemeral, this planting plan would significantly increase aquatic values within the impacted reaches, when the waterway is watered.

4.9.2 Wetland habitat

The constructed wetland (lined pond), and the induced wetland just east of it, have potential for native wetland plant-out and restoration. Currently both habitats, other than the conspicuous endemic tussock sedge (*Carex secta*), have largely been filled with introduced herbs and grasses.

The wetland planting plan is best undertaken with the landscape architect in conjunction with a wetland specialist. Such a plant-out would enhance any existing ecological links with the existing tall-tree canopy and native shrub strata. The planting plan would form part of a wetland management plan, The wetland is small, and a number of invasive introduced weeds are present in the wetland (e.g. willow weed, water pepper, forget-me-not, common chickweed App. IV). Therefore, weed invasion from the wetland periphery could be significant, so for this reason we recommend that any native plant-out is monitored and/or weeded for 5 years, until native herbs and shrubs have asserted ecological dominance.

The wetland planting will enhance and synergise existing ecological links with indigenous vegetation around the wetland margins. Aquatic life, but especially invertebrates, have close ecological links with native trees and shrubs, largely because NZ aquatic invertebrates are almost completely indigenous as well.

4.9.3 Flighted aquatic macroinvertebrates

A number of EPT species exhibit both aquatic nymph and winged adult life-cycle stages. The winged stage is used as a method of dispersal, as an individual can travel further before depositing eggs. It is therefore important to ensure high connectivity along both the waterway and riparian zones of the Cam / Ruataniwha River and Northern Flow Channel. Plants in the riparian zone provide these species with both food and shelter, and the correct choice of plants is imperative in enabling the survival and dispersal of these native species. This is detailed below.

Riparian plants as food

The input of leaf detritus into the channel requires taller canopy plants such as lemonwood, totara and narrow-leaved lacebark. But the semi-deciduous South Island kowhai (*Sophora microphylla*) would also be important for detrital inputs. Detrital material will accumulate in the dry channel for the majority of the year, and some will be washed into perennial sections of waterway during rainfall, providing carbon input into waterway ecosystems downstream of the proposed development area.

The invertebrate sample taken in the upper Cam / Ruataniwha River (i.e., near Kippenberger Ave) identified a number of detrital feeders which would directly benefit from the dead woody material (i.e. detritus). These include *Pycnocentria sp.*, the most abundant caddisfly downstream, and the woody-case caddisfly *Triplectides*, a native detrital shredder. The larvae of *Hudsonema* sp. Are in part detrital feeders, but they are also active predators of the abundant snail *Potamopyrgus* sp.

The larval stage of all other invertebrate species, for example the mayfly *Deleatidium*, and the snail *Potamopyrgus*, both common downstream of the development area, are algae/diatom scrapers and grazers. However, they have an indirect link to continual detrital inputs from the planted margins in the proposed development area, as the nutrients released from the detritus support algal growth.

Many native macroinvertebrates do not consume food during their flighted adult life-cycle stages. They therefore spend a limited time period in this stage, and use it only for dispersal and reproduction. This is relevant for *Deleatidium* and other mayflies, which have only vestigial mouthparts (Wisely 1965). Due to their lack of feeding, the lifespan is short, between 3 and 72 hours during the terrestrial adult stage.

However, caddisfly species exhibit mouthparts adapted to feed on water and nectar during their adult life-cycle stage (Collier & Scarsbrook 2000). This allows them to survive for a longer period in this stage, assisting in the development of eggs. Some Diptera (fly) species, such as Chironomidae (i.e. non-biting midges), also have the ability to consume nectar during their adult stage. Due to the high number of Trichoptera taxa in the upper Cam / Ruataniwha River, and the presence of Chironomidae, it is recommended to place emphasis on native plant species that produce nectar when planning the riparian planting of the Cam River and Northern Flow Channel. Based on the above research, it is recommended that an emphasis be placed on nectar producing plants in both the wet and dry plain areas. In the case of the Dry Plains, plant on the supplied plant list that produce nectar include the cabbage tree (*Cordyline australis*), South Island kowhai (*Sophora microphylla*), five finger (*Pseudopanax arboreus*) and mountain flax (*Phormium cookianum*). Other native nectar-producing species that have not been included in the plant list are kakabeak (*Clianthus* sp.) and common flax (*Phormium tenax*). It would be considered beneficial to incorporate these species into the design.

It is also known that a number of stonefly species have a broad diet during the flighted adult stage, including but not limited to pollen, spores, fungi and detritus (Collier & Scarsbrook 2000). While no stonefly species were recorded in the Cam / Ruataniwha River at the time of survey, the presence of spore-producing plants such as tree ferns, as well as bark and leaf detritus, will increase the chances of this macroinvertebrate order inhabiting the Cam / Ruataniwha River in the future.

Riparian plants as shelter

Plants in the riparian zone also provide shelter and protection for the afore-mentioned adult macroinvertebrate species. Winged macroinvertebrates are highly susceptible to adverse effects from predation, and weather events such as high wind or rainfall. Plants with dense foliage, such as the native red mapau (*Myrsine australis*) and koromiko (*Hebe salicifolia*), are critical in protecting these native invertebrates from predation by birds. Larger tree species such as totara (*Podocarpus totara*) and Tarata or lemonwood (*P. eugenioides*) provide dense canopies to block strong wind and rainfall from entering the riparian zone.

Rakiura vernale, a species of caddisfly, has also been observed to swarm near stands of manuka (*Leptospermum scoparium*) and kanuka (*Kunzea robusta*) (Michaelis 1973). While the nymph of this species was not identified in the Cam River macroinvertebrate sample, other caddisfly species may exhibit similar behaviours. It is therefore worthwhile to include these plant species in the riparian zones of the Cam / Ruataniwha River and Northern Flow Channel, within the development boundary.

5 Conclusions

Following extensive field surveys, AEL can confirm that no natural wetlands have been identified within the site.

The proposed alignment plans, stormwater plans, layout plans and landscape plans for both the Cam / Ruataniwha River and Northern Flow channel will effectively improve ecological values and minimise all adverse effects. Providing all plans and ideas outlined in this report are considered, AEL endorses naturalisation of both channels through the proposed methods.

6 Recommendations

AEL recommends the following that:

- Water stagnation, and possible fish entrapment, should be prevented in both channels by ensuring the re-aligned channel has a uniform gradient, so stormwater recedes in a uniform manner.

- That an ecological buffer of at least 10 m is maintained on the Cam / Ruataniwha River. A minimum development setback is only required on the Northern Bypass Channel.

- That the induced wetland to the east is included in the waterway setback area, and subject to a native wetland-plant-out which will enhance the existing native-tree canopy already present.

- That a wetland specialist be engaged to prepare a wetland restoration plan, which will included the selection of indigenous wetland and riparian plants and monitoring the subsequent ecological establishment. Its is probable that some monitoring, and possibly weeding, will be required during the establishment phase of indigenous plants.

6.1 Riparian Planting Recommendations

Overall, all species listed in the plant guide, based on the Di Lucas Associates ecosystem maps, will be effective in creating a strong corridor of indigenous vegetation, with benefits for aquatic invertebrates and the overall waterway health. The following recommendations should be considered when designing a planting plan for this vicinity.

- Low, overhanging plants should be placed close to the waterway (e.g. *Carex virgata*, *Juncus edgariae* (if soil is sufficiently damp), *Austroderia richardii*). *Carex* sp. should also be added to the riparian zone of the dry plains area, with the species choice corresponding to the soil moisture.

- Shrub, scrambler and small tree species should be planted in the middle section of riparian zone.

- Tall, shade producing trees (e.g lemonwood, narrow-leaved lacebark, totara) should be planted in the upper section of the riparian zone.

- Within the margin of the pegged induced wetland, a specific planting plan is required.

- An emphasis should be placed on nectar-producing plants. Examples of these plants are listed below.
    - Cabbage tree (*Cordyline australis*)
    - Mountain flax (*Phormium cookianum*)
    - South Island kowhai (*Sophora microphylla*)
    - Five finger (*Pseudopanax arboreus*)
    - Manuka (*Leptospermum scoparium*)
    - Kanuka (*Kunzea robusta*)
    - Kakabeak* (*Cleanthus* sp.)
    - Harakeke* (*Phormium tenax*)

* Not currently on the Cam / Ruataniwha River Plant List

6.1.1 Additional notes regarding Cam / Ruataniwha River Plant list

- *Olearia paniculata* is not mapau, however it is an ecologically significant and nectar producing species that could be incorporated into the landscape design.

- The *Coprosma* sp. family provides a strong habitat for lizards. Lizards have not been incorporated into this survey to my knowledge, however the use of these plants will encourage the presence of lizards, which is considered beneficial.
- The kowhai tree (*Sophora microphylla*), and leaves of the Ngaio tree (*Myoporum laetum*) are poisonous if ingested.

7 Acknowledgements

We thank the land owner for orientation around the site area, discussions about the wetland, and Michelle Ruske-Anderson and Helen Caley for reading earlier drafts.

8 References

Chapman, D. W.; Lewis, M. H.; Winterbourn, M., J. 2011: Guide to the freshwater Crustecea of New Zealand. Christchurch, New Zealand Freshwater Sciences Society. 188 p.

Clarkson, B., R.; Fitzgerald, N. B.; Champion, P.; Forester, L.; Rance, B. D. 2021. New Zealand Wetland Plant List 2021. Manaaki Whenua - Landcare Research, *LC3975*. 58 p.

Collier, K. J.; Cooper, A. B.; Davies-Colley, R. J.; Rutherford, J. C.; Smith, C. M.; Williamson, B. R. 1995. Managing Riparian Zones: A contribution to protecting New Zealand's rivers and streams; Volume 1: Concepts Department of Conservation, Wellington. p.

Collier, K. J.; Scarsbrook, M. R. 2000: Use of riparian and hyporheic habitats.179-206 *In:* Collier, K. J.; Winterbourn, M., J. *eds*: New Zealand Stream invertebrates: Ecology and Implications for Management. New Zealand Limnological Society. Christchurch.

Dunn, N. R.; Allibone, R. M.; Closs, G. P.; Crow, S.; David, B. O.; Goodman, J. M.; Griffiths, M.; Jack, D.; Ling, N.; Waters, J. M.; Rolfe, J. R. 2017. Conservation Status of New Zealand freshwater fishes, 2017. Department of Conservation, Wellington. 15 p.

Fraser, S.; Singleton, P.; Clarkson, B., R. 2018. Hydric soils – field identification guide. LandCare Research, Wellington. 83 p.

Main, M. R. 2003. Review of streamside buffer distances in Discussion Draft NRRP Water Quality Chapter 7, between land applications of contaminants and surface waters. Environment Canterbury, Christchurch. *Environment Canterbury Technical Report No. R03/28*. 76 p.

McDowall, R. M. 1990: New Zealand Freshwater Fishes: A Natural History and Guide. Auckland, Heinemann Reed. 553 p.

Michaelis, F. B. 1973: The distribution and life history of Rakiura vernale (Trichoptera: Helicopsychidae). *Journal of the Royal Society of New Zealand 3* (*2*): 295-304.

Ministry for the Environment 2020a. National Policy Statement for Freshwater Management, pp. 70 (*Issue*): 70.

Ministry for the Environment 2020b. Wetland delineation protocols. Ministry for the Environment, Wellington. 10 p.

Ministry for the Environment 2021. Defining 'natural wetlands' and 'natural inland wetlands'. Wellington. *ME 1590*. 25 p.

New Zealand Government 2020. Resource Management (National Environmental Standards for Freshwater). New Zealand Government, Wellington. 60 p.

Parkyn, S. M. 2004. Review of Riparian Buffer Zone Effectiveness. Ministry of Agriculture and Forestry, Wellington. *MAF Technical Paper No: 2004/05 No. 2004/05*. 31 p.

Stark, J. D.; Boothroyd, I. K. G.; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R. 2001. Protocols for sampling macroinvertebrates in wadeable streams. Ministry for the Environment, Wellington. *Macroinvertebrate Working Group Report No. 1*. 65 p.

Stark, J. D.; Maxted, J. R. 2007. A User Guide for the Macroinvertebrate Community Index. Cawthron Institute, Nelson. *Cawthron Report No. 1166*.p.

Taylor, M. J. 2005. An update of trout spawning in the Cam River. Aquatic Ecology Limited, Christchurch. *AEL Report No. 33*. 36 p.

Taylor, M. J.; Blair, W.; McCaughan, H. 2012. Brown Trout Spawning Surveys of the Cam, Taranaki and Waikuku catchments. Aquatic Ecology Limited, *No. 101*. 56 p.

Taylor, M. J.; Marshall, W. 2017. Ecological values in the Waimakariri District; and their sensitivities to minor works in waterways. Aquatic Ecology Limited, Christchurch. *AEL Report 151*. 63 p.

Ward, F.; Northcote, T.; Boubee, J. 2005: The New Zealand common smelt: biology and ecology. *Journal of Fish Biology 66* (*1*): 1-32.

Winterbourn, M., J. 1973: A guide to the freshwater mollusca of New Zealand. *Tuatara 20* (*3*): 141-159.

Winterbourn, M. J.; Gregson, K. L. D.; Dolphin, C. H. 2006. Guide to the aquatic invertebrates of New Zealand; Bulletin of the entomological society of New Zealand. 102 p.

Wisely, B. 1965: Studies on Ephemeroptera III. *New Zealand Journal of Science 8* (*3*).

9 Appendix I. Site photographs from Cam / Ruataniwha River

Fig. i, Wpt 53 . Looking west along the Cam / Ruataniwha River, at the western boundary hedgerow

Fig. ii, Wpt 53 . Looking east along the Cam / Ruataniwha River, near the western boundary hedgerow

Fig. iii. Wpt 52. Fenced, but mixture of dryland shrubs and trees.

Figure iv. Wpt 51. Small trees and shrubs predominate, with no aquatic plants or surface water.

Figure v. Wpt. 49 . A stock crossing west of the homestead.

Figure vi. Wpt 47 Looking west at dry swale west of the homestead's ornamental pond.

Figure vii. Wpt 47 Looking east at the dry swale bed upgradient of the ornamental pond

Figure viii. Wpt. 46, looking west at dryland swale

Figure ix. Wpt. 46, looking east towards the ornamental pond. An old fluvial channel is perceptible at this location.

Figure x. The ornamental pond at the base of the homestead lawn.

Figure xi. Carex secta growing in the ornamental pond.

Figure xii. The swale east and downgradient of the pond. Largely lined with *C .secta* and a riparian border of introduced and native shrubs and small trees.

Figure xiii. An excavated depression where rainwater ponds.

Figure xiv. The perennial spring on the property of 6/7 Kippenberger Avenue.

Figure xv. The Cam / Ruataniwha River headwaters immediately upstream of the Kippenberger Ave bridge. In the sunlit perennial reach of Coldwater Stream the channel was obscured by a ratft of exotic introduced aquatic weeds.

Figure xvi. The shaded shallow riffle habitat downstream of Kippenberger Avenue.

10 Appendix II. Site photographs from Northern Flow Channel

Figure i. Looking west along the Northern Flow Channel.

Figure ii. Looking east along the Northern Channel.

Figure iii. The soil in the thalweg is dry and compacted, and did not appear mottled or smell like a hydric soil.

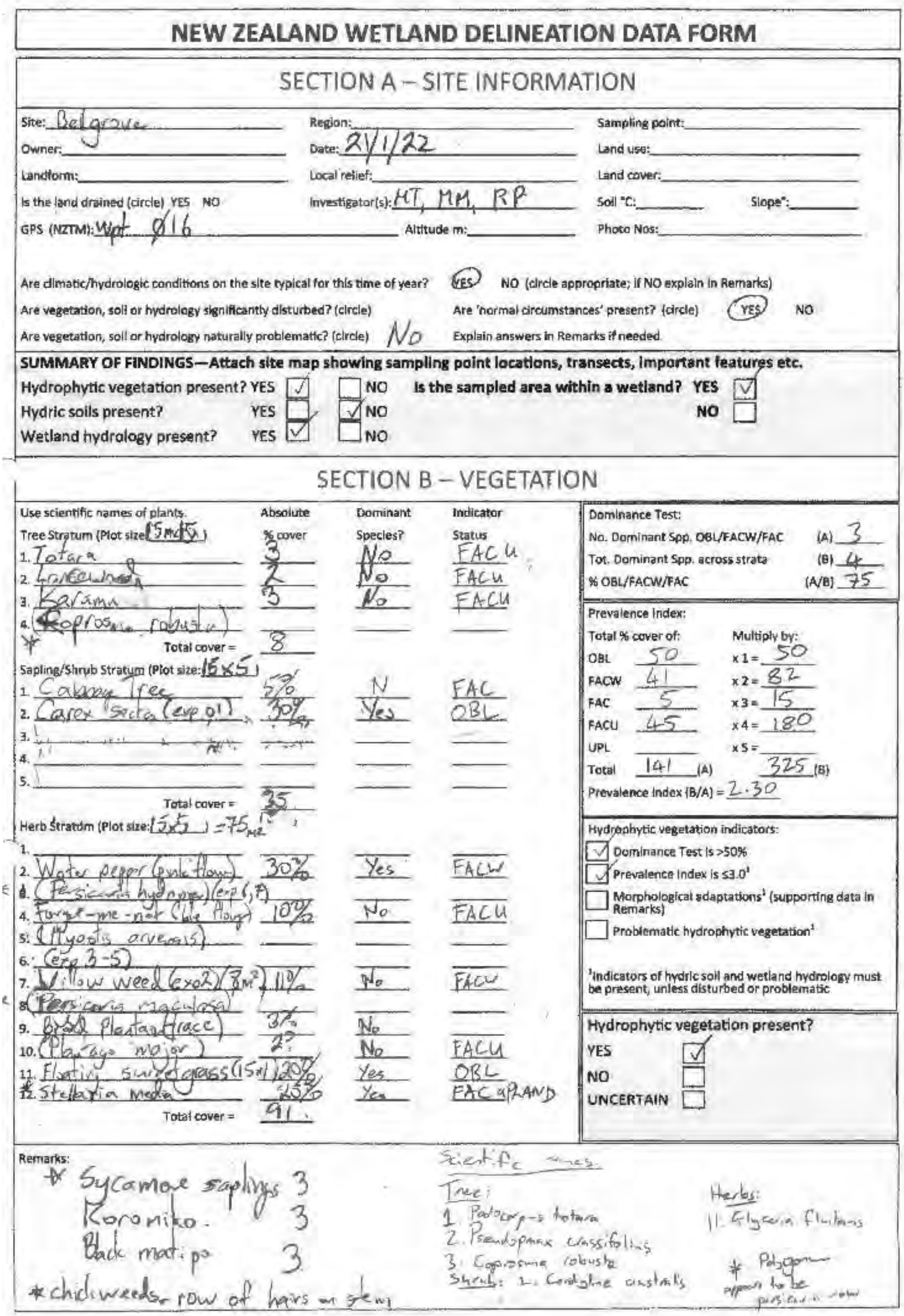
Figure iv. An outbreak of Old Man's Beard is invading the poplar tree line at one point.

11 Appendix III. Proposed re-alignment of the Cam / Ruataniwha River

Figure i. Proposed re-alignment of the Cam / Ruataniwha River headwaters (red line), with existing course (blue line). The lot numbers are old and have been superseded.

Figure ii. Proposed minimum setback widths (7 m plus vegetated buffer) in the October landscape plans for the Cam / Ruataniwha River.

12 Appendix IV. Wetland delineation form completed in the field



NEW ZEALAND WETLAND DELINEATION DATA FORM

SECTION A – SITE INFORMATION

Site: Belgrove
Region:
Sampling point:
Owner:
Date: 21/1/22
Land use:
Landform:
Local relief:
Land cover:
Is the land drained (circle) YES NO
Investigator(s): MT, MM, RP
Soil °C:
Slope°:
GPS (NZTM): Wpt 016
Altitude m:
Photo Nos:

Are climatic/hydrologic conditions on the site typical for this time of year? (YES) NO (circle appropriate; if NO explain in Remarks)
Are vegetation, soil or hydrology significantly disturbed? (circle)
Are 'normal circumstances' present? (circle) (YES) NO
Are vegetation, soil or hydrology naturally problematic? (circle) No
Explain answers in Remarks if needed

SUMMARY OF FINDINGS—Attach site map showing sampling point locations, transects, important features etc.

Hydrophytic vegetation present?	YES ☑	NO ☐
Hydric soils present?	YES ☐	NO ☑
Wetland hydrology present?	YES ☑	NO ☐
Is the sampled area within a wetland?	YES ☑	NO ☐

SECTION B – VEGETATION

Use scientific names of plants.

Tree Stratum (Plot size: 5mx5)	Absolute % cover	Dominant Species?	Indicator Status
1. Totara	3	No	FACU
2. Lancewood	2	No	FACU
3. Karamu	3	No	FACU
4. (Coprosma robusta)			
* Total cover =	8		

Sapling/Shrub Stratum (Plot size: 15x5)	Absolute % cover	Dominant Species?	Indicator Status
1. Cabbage Tree	5%	N	FAC
2. Carex secta (esp 01)	30%	Yes	OBL
3.			
4.			
5.			
Total cover =	35		

Herb Stratum (Plot size: 15x5) = 75m²	Absolute % cover	Dominant Species?	Indicator Status
1.			
2. Water pepper (pink flower)	30%	Yes	FACW
3. (Persicaria hydropiper) (esp 6, 7)			
4. Forget-me-not (blue flower)	10%	No	FACU
5. (Myosotis arvensis)			
6. (esp 3-5)			
7. Willow weed (exo2) (8m²)	11%	No	FACW
8. (Persicaria maculosa)			
9. Broad Plantain (race)	3%	No	
10. (Plantago major)	2?	No	FACU
11. Floating sweet grass (15m²)	20%	Yes	OBL
12. Stellaria media	25%	Yes	FAC upLAND
Total cover =	91		

Dominance Test:
No. Dominant Spp. OBL/FACW/FAC (A) 3
Tot. Dominant Spp. across strata (B) 4
% OBL/FACW/FAC (A/B) 75

Prevalence Index:

Total % cover of:		Multiply by:
OBL	50	x 1 = 50
FACW	41	x 2 = 82
FAC	5	x 3 = 15
FACU	45	x 4 = 180
UPL		x 5 =
Total	141 (A)	325 (B)

Prevalence Index (B/A) = 2.30

Hydrophytic vegetation indicators:
☑ Dominance Test is >50%
☑ Prevalence Index is ≤3.0[1]
☐ Morphological adaptations[1] (supporting data in Remarks)
☐ Problematic hydrophytic vegetation[1]

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic

Hydrophytic vegetation present?
YES ☑
NO ☐
UNCERTAIN ☐

Remarks:
* Sycamore saplings 3
Koromiko 3
Black matipo 3
* chickweeds row of hairs on stem

Scientific names:
Tree:
1. Podocarpus totara
2. Pseudopanax crassifolius
3. Coprosma robusta
Shrub: 1. Cordyline australis

Herbs:
11. Glyceria fluitans
* Polygonum appears to be persicaria now

Figure i. Wetland delineation data form, page 1.

SECTION C – SOIL AND HYDROLOGY

Profile description: (Describe to the depth needed to confirm indicator presence/absence, 30 cm default)

Depth (cm)	Matrix colour (moist)	Mottles colour (moist)	Mottles %[1]	Mottles Size[2]	Mottle location[3]	Material[4]	Remarks
25cm					No mottles	stones	

[1]Use % area charts; [2]Use size classes; [3]Ped face, pore, within ped along roots, within matrix; [4]Organic (peaty), humic, mineral soil

Hydric soil indicators: 11-13

Soil drainage (circle) W MW I P VP

Organic layers:
- [x] Organic soil material
- [x] Litter
- [x] Fibric
- [x] Mesic
- [x] Humic
- [x] Peaty topsoil
- [x] Peaty subsoil

Concretions:
- [x] Iron concretions
- [x] Manganese concretions
- [x] Nodular

Consistence:
- [x] Plastic
- [x] Sticky
- [x] Fluid

Colours: profile form either:
- [x] Gley OR
- [x] Mottled

Horizon:
- [x] Reductimorphic
- [x] Redox mottled
- [x] Redox segregations
- [x] Perch-gley features

Cause of wetness (circle appropriate):

Location (Depression) Flat Valley Gully Slope

(Water table): Depth (cm) ____

High GW Perched Seepage Tidal Lithic

Pans: Depth (cm) ____

Pan Humus Fe-pan Densi- Duri- Fragi Ortstein

Layers: Depth (cm) ____

Slow perm argillic

- [x] Pugged

Hydric soils present? YES [ ] NO [ ] UNCERTAIN [ ] NZSC subgroup ____________

Primary hydrology indicators; minimum of 1 required; check all boxes that apply (wpt 18 / 2nd)

- [x] Surface water (1A) ✗
- [x] Groundwater <30 cm (1B) ✓
- [x] Soil saturation <30 cm (1C) ✓
- [x] Water marks (2A) ✗
- [x] Sediment deposits (2B) ✗
- [x] Drift deposits (2C) ✗
- [x] Algal mat/crust (2D) ✗
- [x] Iron deposits (2E) ✗
- [x] Surface soil cracks (2F) ✗
- [ ] Inundation on aerial imagery (2G)
- [x] Sparsely vegetated concave surface (2H) ✓
- [x] Salt crust (2I) ✗
- [x] Aquatic invertebrates (2J) ✗
- [x] Hydrogen sulphide odour (3A) ✗
- [x] Oxidised rhizosphere on roots (3B) ✗
- [x] Reduced iron (3C) ✗
- [x] Reduced iron in tilled soil (3D) ✗
- [x] High water table stunted/stressed plants (4A) ✗

Secondary hydrology indicators: minimum of 2 required; check all boxes that apply

- [x] Water-stained leaves (2K) ✗
- [x] Drainage patterns (2L) ✓
- [x] Dry-season water table (3E) ✓
- [ ] Saturation in aerial imagery (3F)
- [x] Geomorphic position (4B) ✓
- [?] Shallow aquitard (4C) ?
- [ ] FAC-neutral test (4D)
- [x] Frost-heave hummocks (4E) ✗

FAC-neutral test (4D); refer to Section B: Vegetation
1. No. OBL & FACW dominant species ____(A)
2. No. FACU & UPL dominant species ____(B)
3. Total ____(A+B)
4. FAC-neutral (>50%) ____(A/A+B)*100

Wetland hydrology present? YES [ ] First sample: (NO) [ ] Second sample: (Yes)

Sketch of site/soil:

recent gley soil over gravel?

wpt 17 * wpt 18 * (pond)

g.l. at wpt 017 ~ c. 10cm lower the wpt 08

Remarks:

* wp 017 (exp 15)

mossies present at wpt 18 – clear recent stagnant ponded water

Figure ii. Wetland delineation data form, page 2.