ECOLOGICAL ASSESSMENT OF THE TAUPO COMMERCIAL AND INDUSTRIAL STRUCTURE PLAN

NOVEMBER 2008

Report No. 2019

Prepared for:

TAUPO DISTRICT COUNCIL
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CONTENTS

PROJECT TEAM

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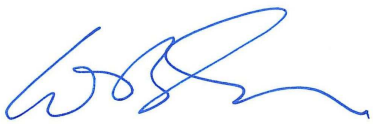

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1. INTRODUCTION

Taupo District Council (TDC) is currently leading the preparation of a structure plan for Taupo Township titled "The Taupo Town Commercial and Industrial Structure Plan". Wildland Consultants Ltd have been commissioned to assess the ecological values and opportunities of parts of the plan designated as "proposed industrial business land areas", but not including the town centre or existing commercial areas, which the Structure Plan will cover.

The Taupo District Council adopted its growth management strategy, Taupo District 2050 (TD2050), in June 2006. The strategy outlines the Council's vision for the management of future urban growth within the District. Although the strategy focuses on a settlement pattern for the initial 20 year period, the strategy also provides direction for a 50 year perspective. The guidance given in TD2050 in relation to commercial and industrial land was based primarily on previous planning processes, including the Taupo Urban Structure Plan 2004 and the Taupo Town Centre Structure Plan 2004. The Taupo Town Commercial and Industrial Structure Plan was identified as part of the implementation of TD2050. The Eastern Taupo Arterial (ETA) has also provided a catalyst for this Structure Plan and a focus for commercial and industrial development within Taupo. As well as opening up land on the inside of the ETA, which has been identified as having potential for commercial or industrial purposes, it also provides some unique opportunities for the CBD to improve its connection with the lakefront once the existing State Highway 1 becomes a local road.

The Eastern Taupo Arterial will provide an alternative route around Taupo Township to the existing State Highway 1, which uses Lake Terrace, and forms a logical boundary to development to the east of Taupo township. The ETA provides significant a opportunity in regards to the undeveloped land inside the road, which will need to be considered as part of the structure plan. Another major opportunity is the improvement of linkages between Taupo township, the Tongariro Domain, the Lake, and the boat harbour, once the existing State Highway becomes a local road.

Initially the land areas to be covered by the Taupo Town Commercial and Industrial Structure Plan include the existing areas zoned as Town Centre and Industrial Environment by the District Plan, and the areas identified as potential Industrial/Business in the Taupo Urban Structure Plan 2004 and Taupo District 2050. The structure plan will also need to be cognisant of areas currently zoned residential, high density residential, or rural where commercial or industrial activities have established (e.g. Spa Road and Rangatira E).

The study areas shown in Figure 1 have been identified, by TDC, as "proposed industrial business land". They comprise five separate areas, covering *c*.740 ha, adjacent to Taupo township, with an altitude range of *c*.360-480 m a.s.l.:

- Rangatira E Block;
- Centennial Drive to Broadlands Road;
- Broadlands Road to Crown Road;
- Crown Road/Napier-Taupo Road Junction;
- Taupo Airport Blocks.

This report provides descriptions of the vegetation and habitats, and ecological values and constraints within the project area. Potential effects have been identified, along with opportunities to protect and enhance ecological features. A selection of site photos is provided in Appendix 2.

2. PROJECT BRIEF

- Compile and review relevant hard copy information and digital data on vegetation, habitats, and indigenous fauna.
- Undertake field survey of the study area to inspect, describe, and evaluate vegetation and habitats, flora, and fauna.
- Identify ecological values in and adjacent to the project area and any potential ecological constraints.
- Evaluate opportunities to avoid, minimise, or to mitigate for potential negative effects.
- Identify opportunities for ecological restoration, particularly associated with gullies and geothermal features.

It was also requested that the following aspects related to the Catchment Management Plan requirements set by Taupo District Council's comprehensive consent conditions were assessed.

- Receiving water sediment and water quality.
- Receiving water habitat, ecology and ecosystem health.
- The natural and amenity values of receiving waters.
- Receiving water riparian vegetation.
- The extent and quality of open stream channels (including ephemeral water courses).
- Erosion and sedimentation of receiving waters.

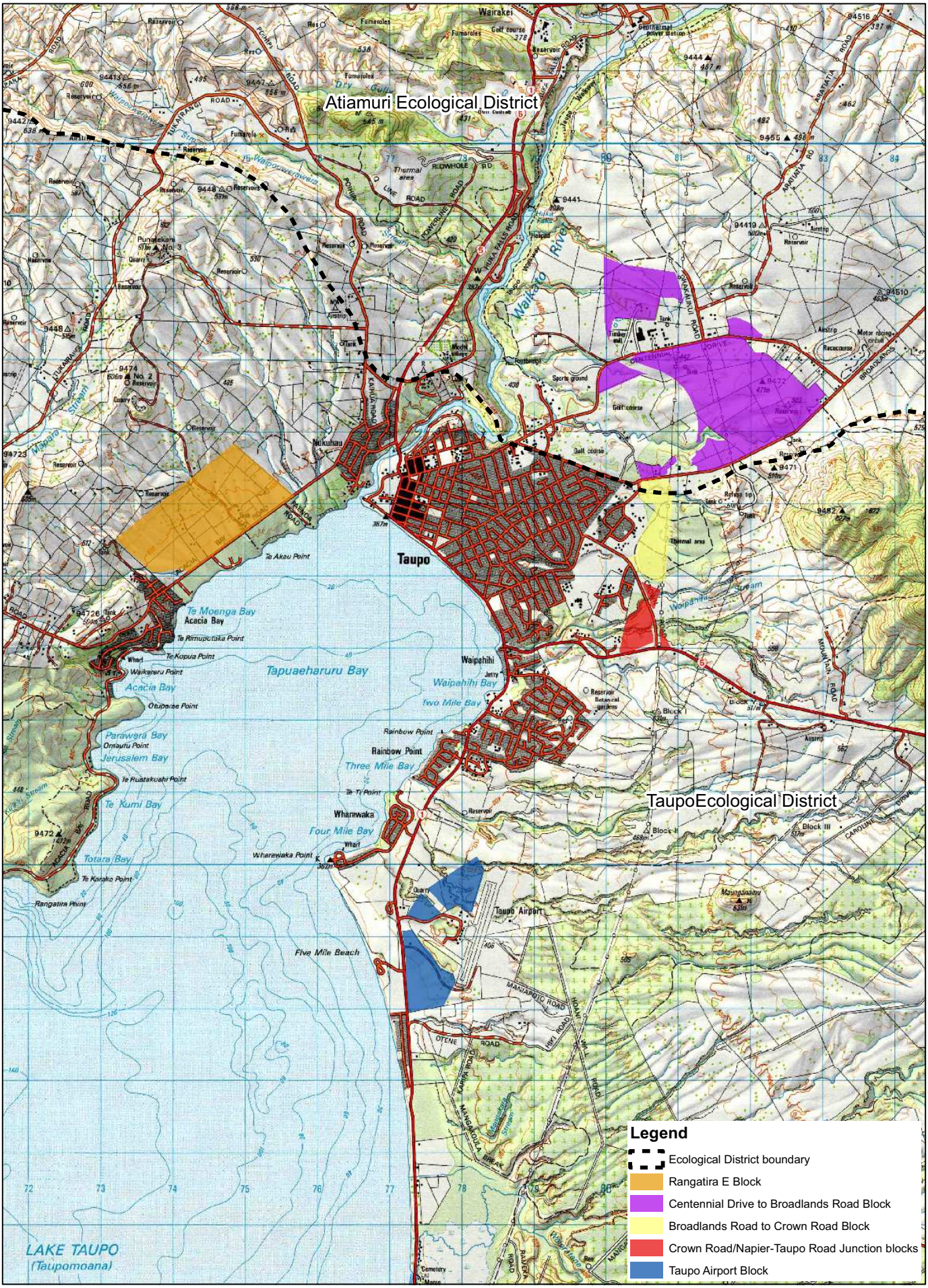

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Figure 1. Location of Taupo Commercial and Industrial Structure Plan

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3. METHODS

Boundaries of the project area were identified by Taupo District Council. The following information requirements were identified to undertake the project:

- A current map of the vegetation and habitat pattern;
- Information on the current biodiversity present and its condition within the site.

Field inspections of the project area were undertaken on 5 and 6 August, and 8 October 2008. Parts of the site were viewed from a distance, while other areas were walked through, and descriptions were compiled of the vegetation and habitats present. Vegetation and habitats were recorded onto aerial photographs, at a scale of 1:5,000. Each broad vegetation unit was described using the methods of Atkinson (1985). Other areas with land uses such as roads, farm buildings, plant nursery, and residential properties already present were identified separately. Pasture grassland was identified and described as a broad type. The status of vegetation units that were not walked through, or viewed from a distance was assigned according to visual similarity to other vegetation units on aerial photographs. Much of the vegetation present at the site is highly variable in composition, therefore broad vegetation classes were used to identify classes.

All vascular plants seen in the field survey were recorded, along with all fauna species seen or heard. Additional species that are likely to be present were also identified.

4. ECOLOGICAL AND LAND USE CONTEXT

4.1 General

The project area lies within two Ecological Districts - Taupo and Atiamuri - which are located within the Central Volcanic Plateau Ecological Region (see Figure 1 for the boundary of these ecological districts and McEwen 1987 for a description of these ecological districts).

4.2 Geology, soils and landforms

The project area ranges from *c.*360-480 m in altitude, all within the lowland bioclimatic zone, adjacent to Taupo Township.

The area is also within the area identified as the 'Taupo Basin' within the Tongariro-Taupo Conservation Management Strategy produced by the Department of Conservation (2002). This is one of four management areas recognised within the Tongariro-Taupo conservancy. The Taupo Basin is a huge subsided caldera complex formed during many catastrophic volcanic eruptions. The major landforms in the project area are gently-sloping landscapes of rhyolitic ignimbrite and pumice alluvium formed during and after eruptions from Taupo and northern volcanic centres between 1.3 million and 1,800 years ago. These landscapes are broken by valleys and cliffs formed by rivers. Yellow-brown pumice soils have developed on Taupo pumice over most of the area. There is also an andesitic ash component in the Taupo Basin as well as pockets of organic loam. Geothermal areas are a significant feature of the Taupo

Basin, but have been heavily influenced by human activity (Department of Conservation 2002). See Section 5.7 for details of geothermal vegetation.

4.3 Climate

The Taupo Basin lies mainly in a cool temperate zone, with a relatively short growing season. Frosts can be expected in many years in the months between December and March. Snow falls to lake level in most years, but seldom settles there. Rainfall is in the range of 1,000-1,600 mm, and is fairly evenly spread throughout the year. The prevailing winds are from the west and southwest (Department of Conservation 2002).

4.4 Vegetation

Prior to human settlement, most of the Taupo and Atiamuri Ecological Districts would have been covered almost entirely in forest, with local areas of wetlands and geothermal areas (Department of Conservation 2002). Since this time, the vegetation has undergone intensive modification with most areas being burned or logged/or burnt for cultivation. Most geothermal areas have also been affected by development; refer to Section 5.7 for details (Department of Conservation 2002, Leathwick *et al.* 1995).

4.5 Threatened Land Environments

Landcare Research, with funding from the Ministry for the Environment, has developed an environmental classification of New Zealand designed to provide a framework for a range of conservation and resource management issues: Land Environments of New Zealand or LENZ (Leathwick *et al*. 2002). Walker *et al.* (2005) and Walker *et al.* (2007) have analysed and identified threatened land environments, based on past habitat loss and current levels of legal protection. This framework (LENZ environments in Leathwick *et al.*2002, Walker *et al.* 2005, and Walker *et al.* 2006) was used to help indicate where important environmental features may be located on the project area (Figure 2). Using this classification most - *c.*572 ha; 77% - of the project areas falls within the 'Acutely Threatened' category - the highest threat category - while a smaller area (*c.*168 ha; 23%) occurs within the 'At Risk' category.

4.6 Hydrology

The entire project area is within the Lake Taupo catchment. Only one permanently-flowing waterway was recorded in the study area, but many gullies with ephemeral streams are present. These gullies may contain very large water flows following storm events. This is evident from the steep sides and rapid erosion of pumice tephra following the Taupo eruption nearly 2000 years ago.

The River Environment Classification system (REC) was produced for the Ministry for the Environment by the National Institute of Water and Atmospheric Research (NIWA). It organises and maps information about the physical characteristics of New Zealand's rivers, including catchment climate, topography, geology, and land cover. Information is mapped by individual river segment for New Zealand's entire river network (Snelder *et al.* 2004).

From the REC data we have determined that there is approximately 10.1 km of recognisable gully systems within the project area (Figure 3). Twenty-six percent are high-gradient gullies: steep gullies with potentially high water velocities with substrates that tend to be coarse relative to the lower gradient valley landform classes. Another 46% are middle-order gullies. These are typically broad and shallow with some meander pattern, resulting in a varied morphology. The remainder (28%) of the gully system is considered to be low gradient (as per Snelder *et al.* 2004).

The Lake Taupo catchment is underlain largely by rhyolitic tephras and in the northern part of the catchment, including the industrial sites of this project, overlain by relatively thick Taupo imbrignite, which in turn sits atop an older rhyolitic imbrignite, the Oruanui imbrignite of *c.*26,500 years old. The thick layer of Taupo imbrignite extends well below the current lake level, allowing most groundwater to enter the lake through seepage. It is thought that there is a large groundwater storage reservoir and that only 20 percent of water reaches the lake via overland streams. (Morgenstern 2007).

Environment Waikato has proposed a variation to the Waikato Regional Plan (Variation 5) to manage the water quality and clarity of the Lake Taupo Catchment. Lake Taupo is known to be building up increasing levels of nitrates, which come from water ways in its catchment. Environment Waikato has proposed capping nitrogen levels in the lake and reducing manageable discharges in the lake's catchment by 20 percent by 2020. Scientists regard this reduction as the minimum required in order to maintain the present level of water quality in the lake. The majority of manageable nitrogen discharges come from the agricultural sector (Environment Waikato 2005).

4.7 Geothermal

Geothermal systems are specifically identified in National Priority Three in the guidelines on National Priorities for Protecting Rare and Threatened Biodiversity on Private Land (MfE and DOC 2007). National Priority Three deals with originally rare terrestrial ecosystem types such as geothermal systems. These are ecosystem types which have always been of limited extent and naturally rare, even in New Zealand's pre-human landscapes. Subsequent land development and the use of geothermal systems for electricity generation has heavily affected geothermal vegetation, much of which has been cleared or damaged, often through local small-scale incremental impacts which, collectively, have resulted in considerable loss and degradation.

Three geothermal sites are known to occur near the project area: Broadlands Road, Crown Park, and Waipahihi Valley (Wildland Consultants 2004 & 2006). These three sites occur in the Tauhara Geothermal Field (Cave *et al.* 1993), which extends across the boundary of Taupo and Atiamuri Ecological Districts. Ecological districts are commonly used for the assessment of representativeness and relative ecological significance, for which they provide a very useful framework. For geothermal vegetation and habitats, however, which is a heavily reduced and nationally rare ecosystem type, ecological district boundaries are of less relevance. It is particularly important to consider the total extent of geothermal vegetation and, especially, the extent of prostrate kanuka-dominant communities. The most up-to-date information on this matter is provided by Bycroft *et al.* (2006), including the following key points:

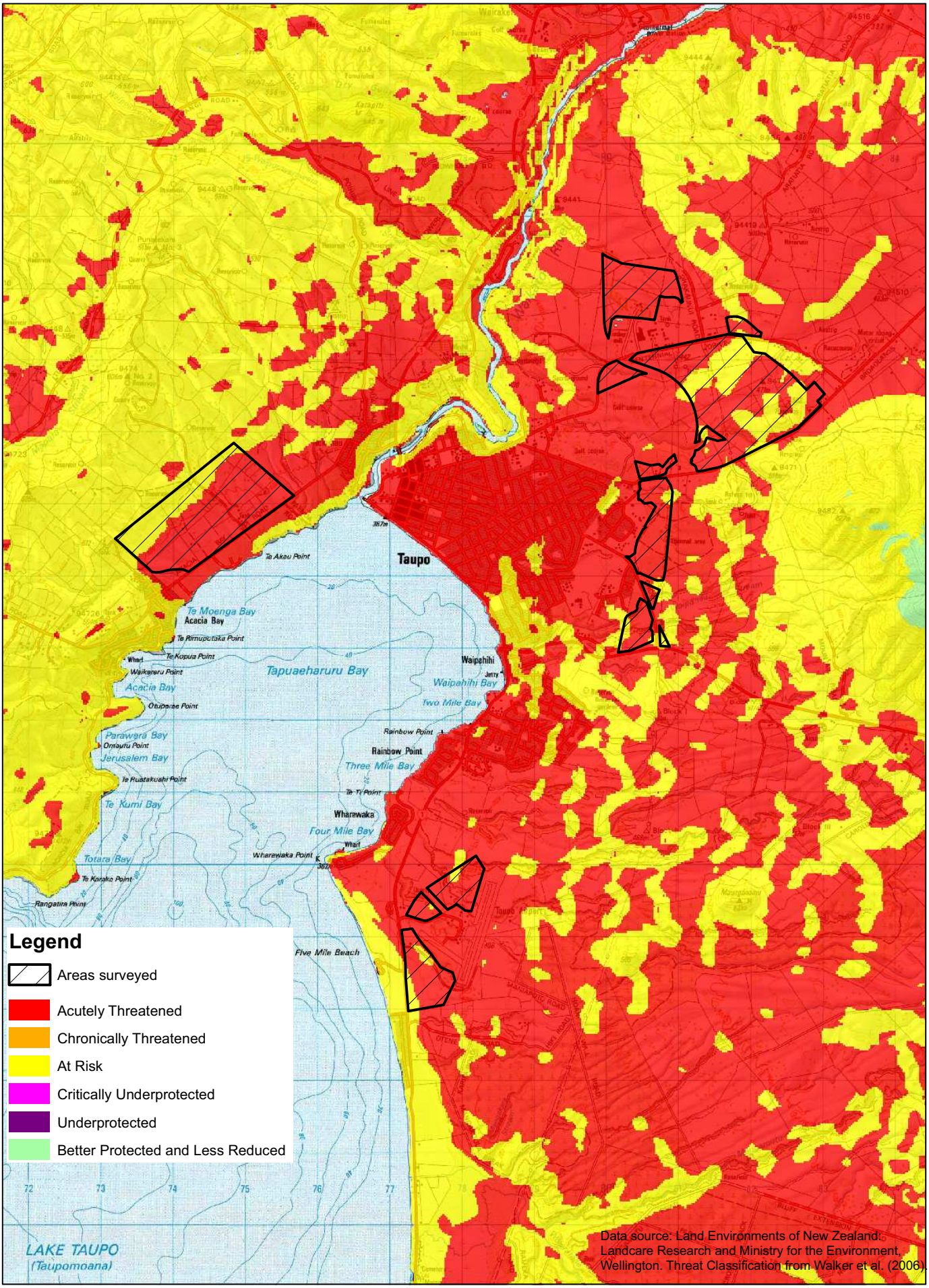

Figure 2. Land Environments of New Zealand. Threat categories in and adjacent to Taupo Commercial and Industrial Structure Plan

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0 1.5 3 km

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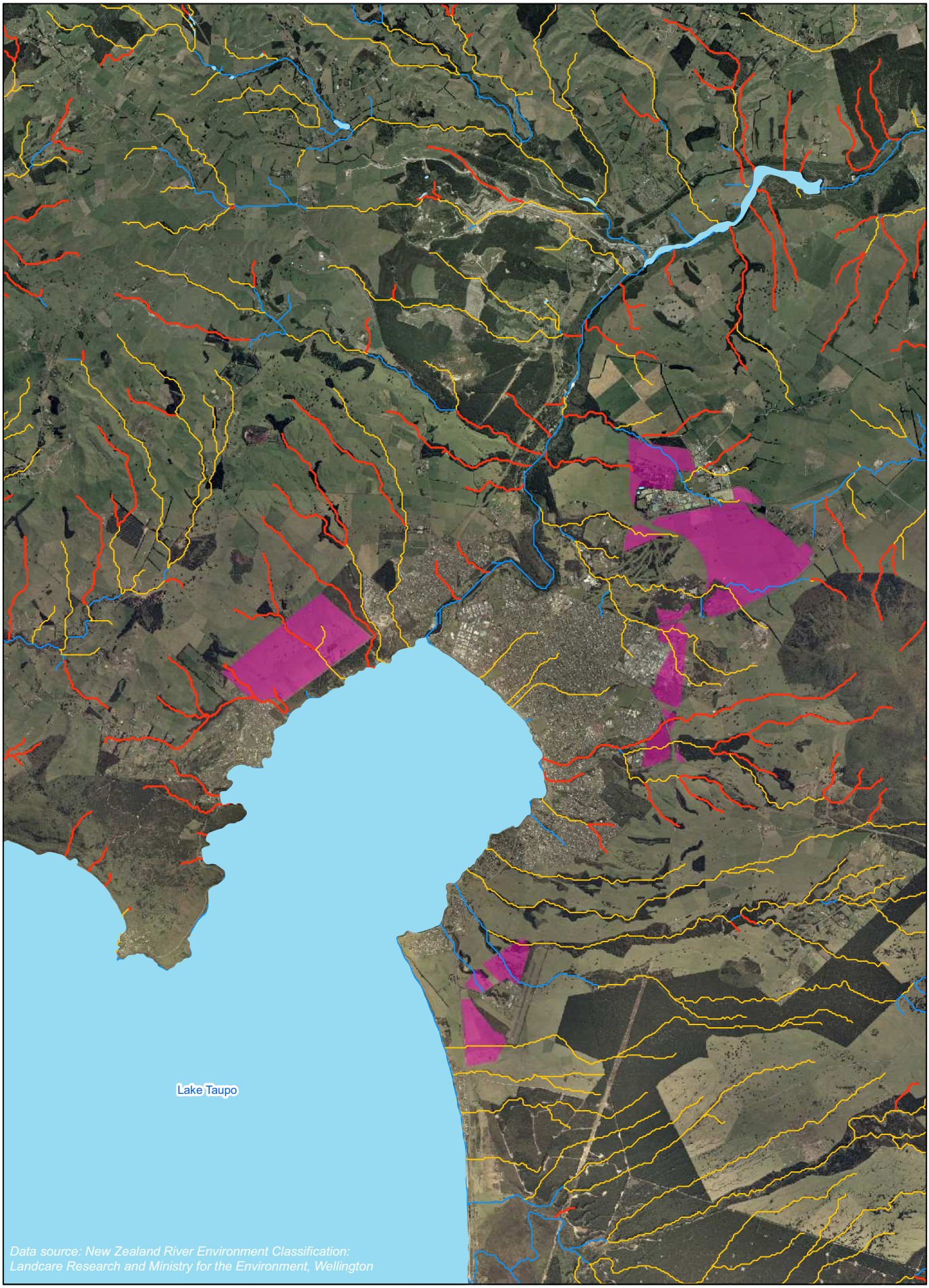

Legend

Valley Landform

- High-Gradient (>0.04)
- Medium-Gradient (0.02 - 0.04)
- Low-Gradient (<0.02)
- Area surveyed

N

0 2 4 km

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Figure 3. River Environments Classification (and gradients) in and adjacent to Taupo Commercial and Industrial Structure Plan

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- The total area (in New Zealand) of prostrate kanuka-dominant scrub and shrubland is only *c.*363 ha, of which *c.*312 ha (*c.*86 percent) is in the Taupo and Atiamuri Ecological Districts.

- About *c.*60 percent of prostrate kanuka-dominant scrub and scrubland has some level of formal protection (i.e. *c.*40 percent is not protected).

- The total area of terrestrial geothermal vegetation and habitats in New Zealand is only *c.*850 ha.

- About *c.*80 percent of the geothermal vegetation and habitats in New Zealand are located in the Waikato Region (Wildland Consultants 2004).

The Tauhara field is a shallow steam-heated aquifer that underlies part of the Taupo Township. It has been exploited for electricity generation (New Zealand Geothermal Association website[1]: accessed 16 August 2007). Crown Park, Kathleen Springs, Spa Thermal Park, and Otumuheke Stream (Wildland Consultants 2004). The sites in this geothermal field comprise a total of *c.*53 ha of geothermal vegetation and habitats.

The Broadlands Road geothermal site is mostly administered by the Department of Conservation as Broadlands Road Scenic Reserve, with several geothermal manifestations on adjoining private land also considered to be part of this site. It is located to the north of Broadlands Road. The geothermal vegetation of Broadlands Road has been surveyed/assessed for ecological values previously by Given (1989), Burns (1996), Beadel and Bill (2000), and Wildland Consultants (2004 & 2006). This geothermal vegetation, with some additional adjacent areas of geothermal vegetation outside the reserve, was mapped as 'Broadlands Road' in Wildland Consultants (2006). This area was ranked as being of 'Regional Significance' because it contains a large area of scrub dominated by the 'At Risk' species prostrate kanuka, and it also contains a large area of geothermal habitat, a nationally uncommon vegetation type. The Broadlands Road site comprises *c.*30.3 ha of geothermal vegetation and habitats, of which *c.*19.4 ha is prostate kanuka scrub and 4.6 ha of nonvegetated raw-soilfield. It also contains indigenous non-geothermal habitats, including scrub, shrubland and forest vegetation.

Crown Road occurs to the south of Broadlands Road, but has been more heavily affected by farming, industrial development, fire, and a motorcycle course. It is currently private and District Council land. The geothermal vegetation at Crown Road has been surveyed/assessed for ecological values previously by Given (1989), Beadel and Bill (2000), and Wildland Consultants (2004). Further reductions of geothermal vegetation have taken place since the most recent of these surveys in 2003, following an industrial subdivision at Ashwood Park. In 2004, *c.*19.0 ha of geothermal vegetation was mapped at this site with *c.*15.3 ha of prostrate kanuka present (Wildland Consultants 2004). A few plants of *Dicranopteris linearis* were recorded from the site in 2004. The site was ranked as being of 'regional' significance because it contains a good quality and relatively large example of prostrate kanuka scrub and shrubland, and being a relatively large example of vegetation influenced by

[1] http://www.nzgeothermal.org.nz/geothermal_energy/nz_geothermal_fields.asp

geothermal activity; a nationally uncommon habitat type (Wildland Consultants 2004).

A small unit of geothermal vegetation is present to the west of the units of the current study areas referred to in this report as "Crown Road/Napier-Taupo Road Junction Blocks". The project area is in stormwater gullies at the head of the Waipahihi Valley, but upstream of this geothermal site. This site was ranked by Wildland Consultants (2004) as being of 'regional' significance because it contains a small population of three species listed in Hitchmough *et al.* 2007; *Cyclosorus interruptus* (Chronically Threatened - Gradual Decline) prostrate kanuka, and *Hypolepis dicksonioides* (At Risk - Sparse). The geothermal site is administered by the Department of Conservation as a Conservation Area.

5. VEGETATION AND HABITATS

Vegetation and habitats and land use patterns for the project area - the five blocks shown in Figure 1 - are mapped in Figures 4-8 and descriptions are provided below.

5.1 Rangatira E Block (*c.*241.1 ha)

1. Pasture (*c.*207.0 ha)

   Pasture includes grassland vegetation which is utilised for pastoral farming. The most common species were sweet vernal (*Anthoxanthum odoratum*), browntop (*Agrostis capillaris*), catsear (*Hypochoeris radicata*), yarrow (*Achillea millefolium*), annual poa (*Poa annua*), Yorkshire fog (*Holcus lanatus*), ryegrass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*), sheep's sorrel (*Rumex acetosella*), serradella (*Ornithopus perpusillus*), white clover (*Trifolium repens*), dock (*Rumex obtusifolius*), Scotch thistle (*Cirsium vulgare*), marsh thistle (*Cirsium palustre*), and nettle (*Urtica urens*). Scattered shrubs of broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*), as well as trees of maritime pine (*Pinus pinaster*), radiata pine (*Pinus radiata*), poplar (*Populus* sp.), flowering cherry (*Prunus* sp.), eucalyptus (*Eucalyptus* sp.), and oak (*Quercus ilex*) are also present.

2. Riparian vegetation and associated steep banks (*c.*0.5 ha)

   The valley floor is dominated with rank exotic grasses with scattered planted harakeke (*Phormium tenax*), silver birch (*Betula pendula*), and manuka (*Leptospermum scoparium*). Valley sides have common harakeke (flax), lupin (*Lupinus arboreus*), manuka, and deciduous exotic trees.

3a. Existing small business, residential, farm buildings, gardens, lawns (*c.*0.1 ha)

3b. Camping ground (*c.*2.0 ha)

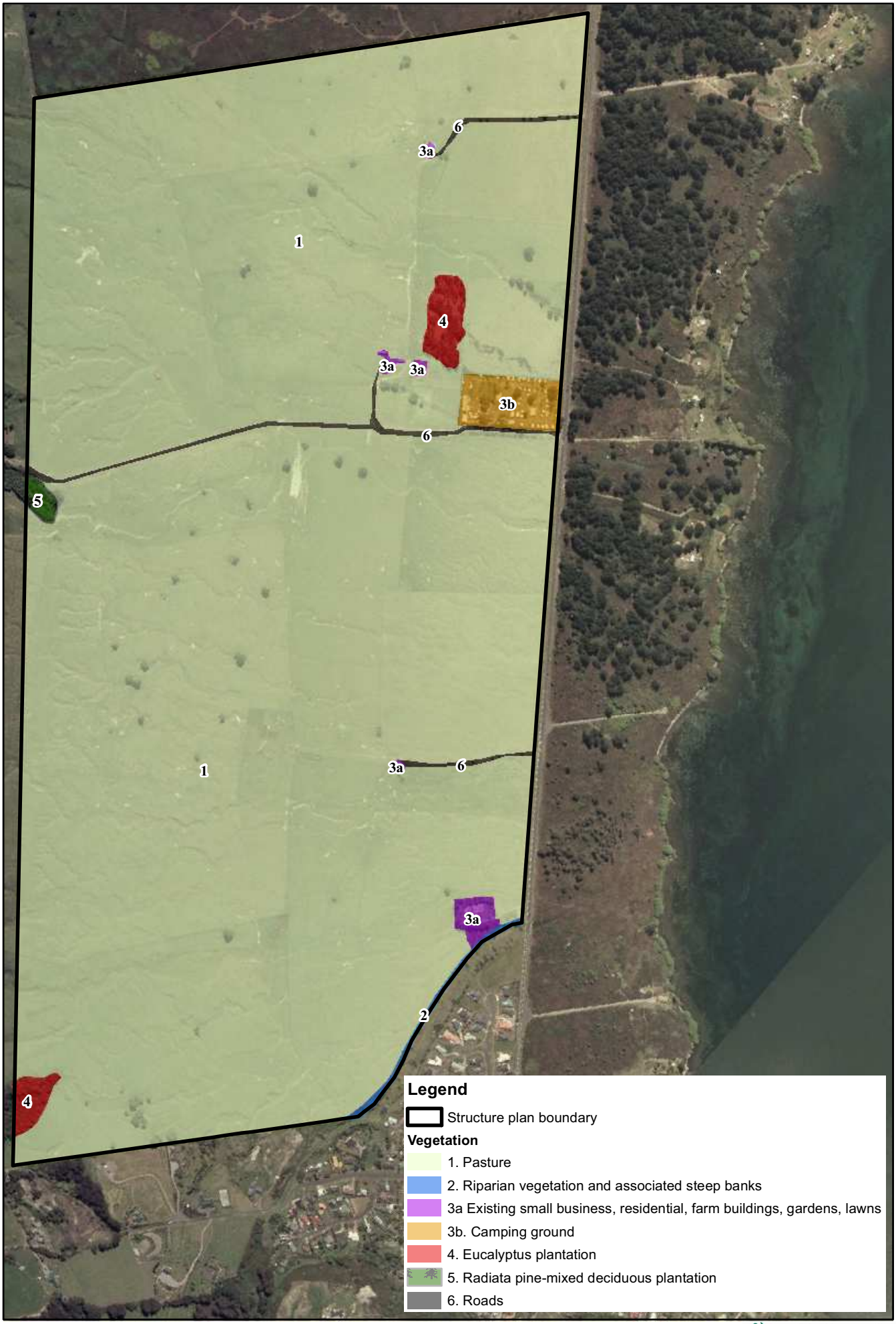

Figure 4. Vegetation/habitat types and land use, Rangatira E Block

0 250 500 m

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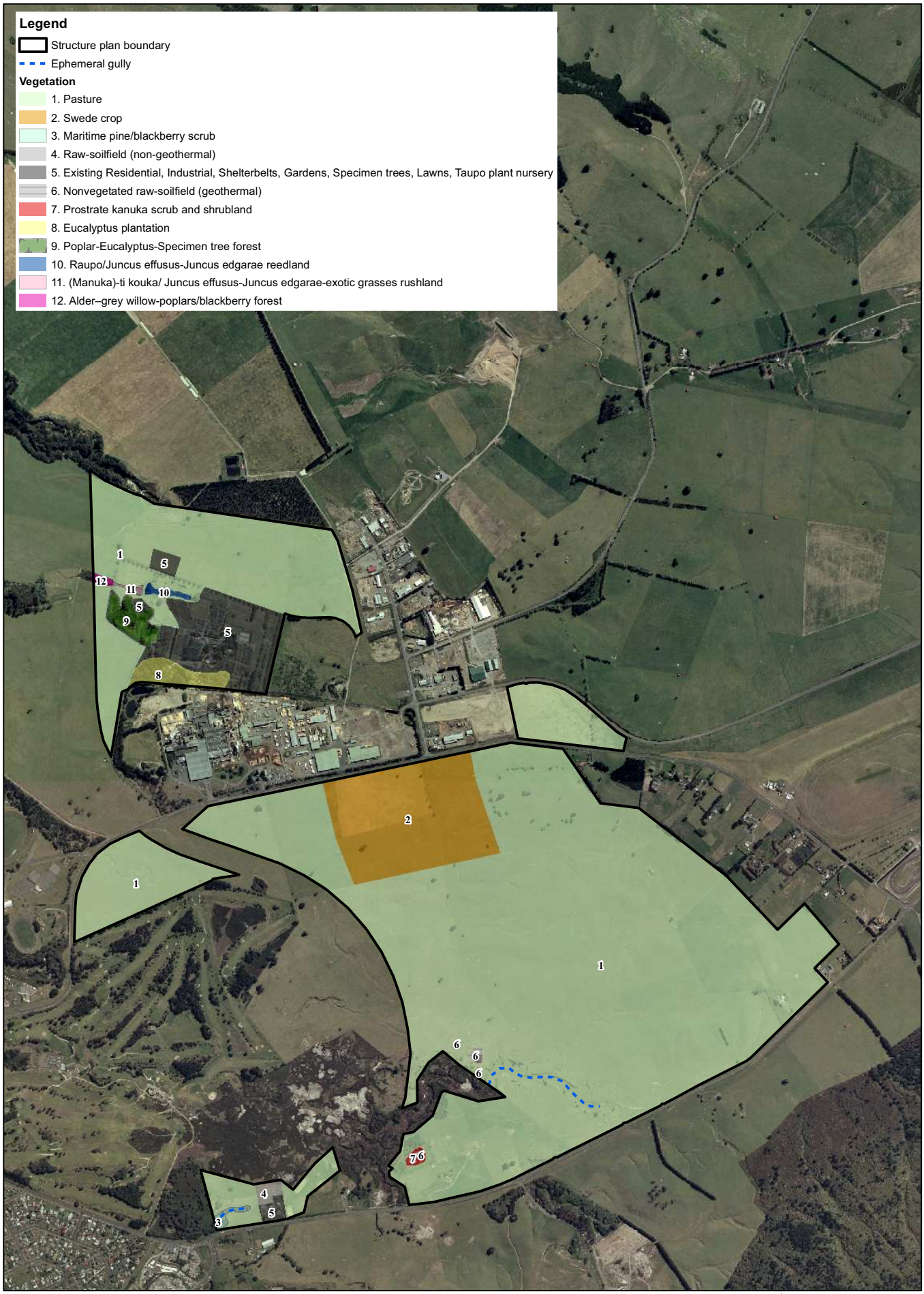

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Figure 5. Vegetation/habitat types and land use, Centennial Drive to Broadlands Road

0 500 1,000 m

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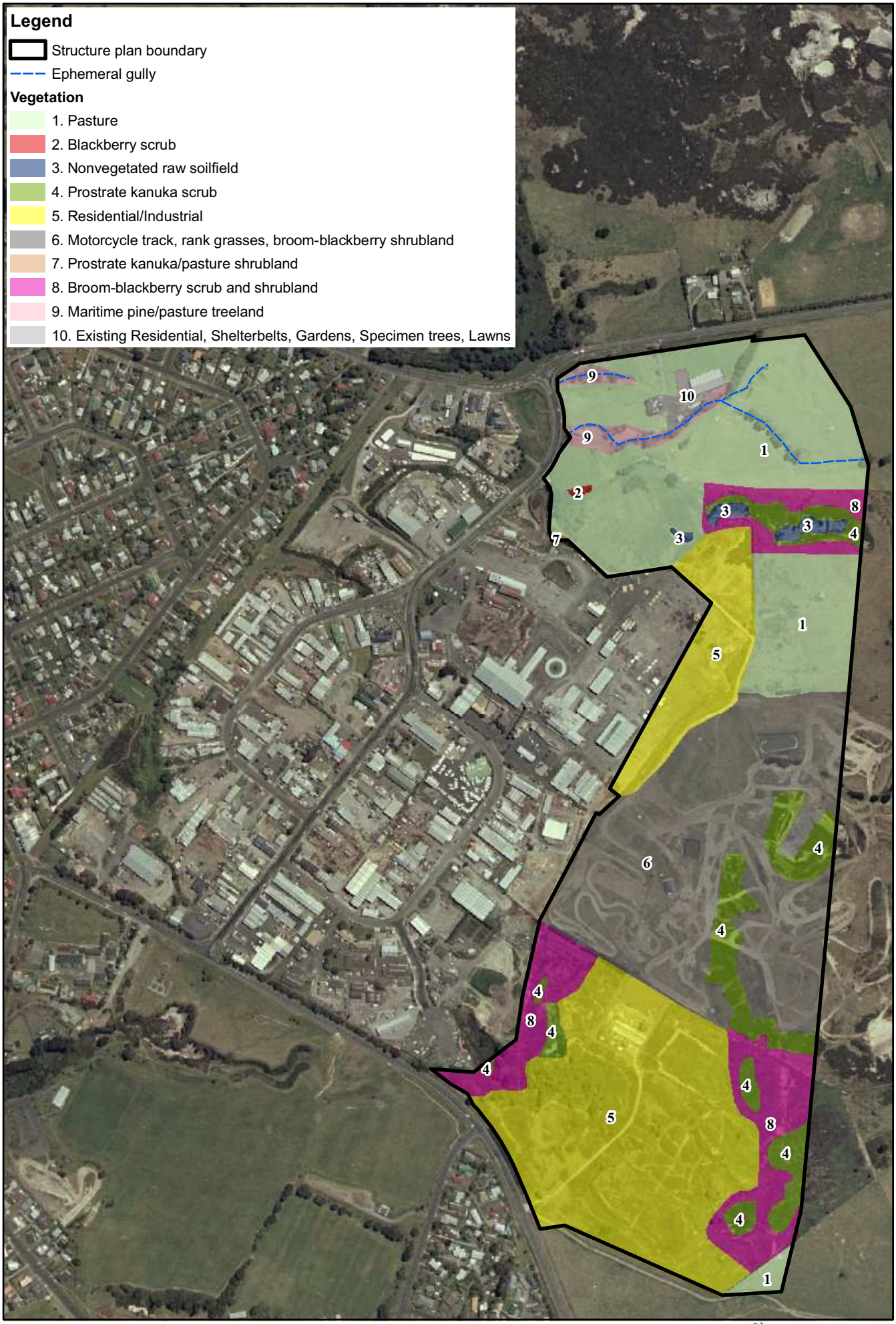

Figure 6. Vegetation/habitat types and land use, Broadlands Road to Crown Road

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0 100 200 m

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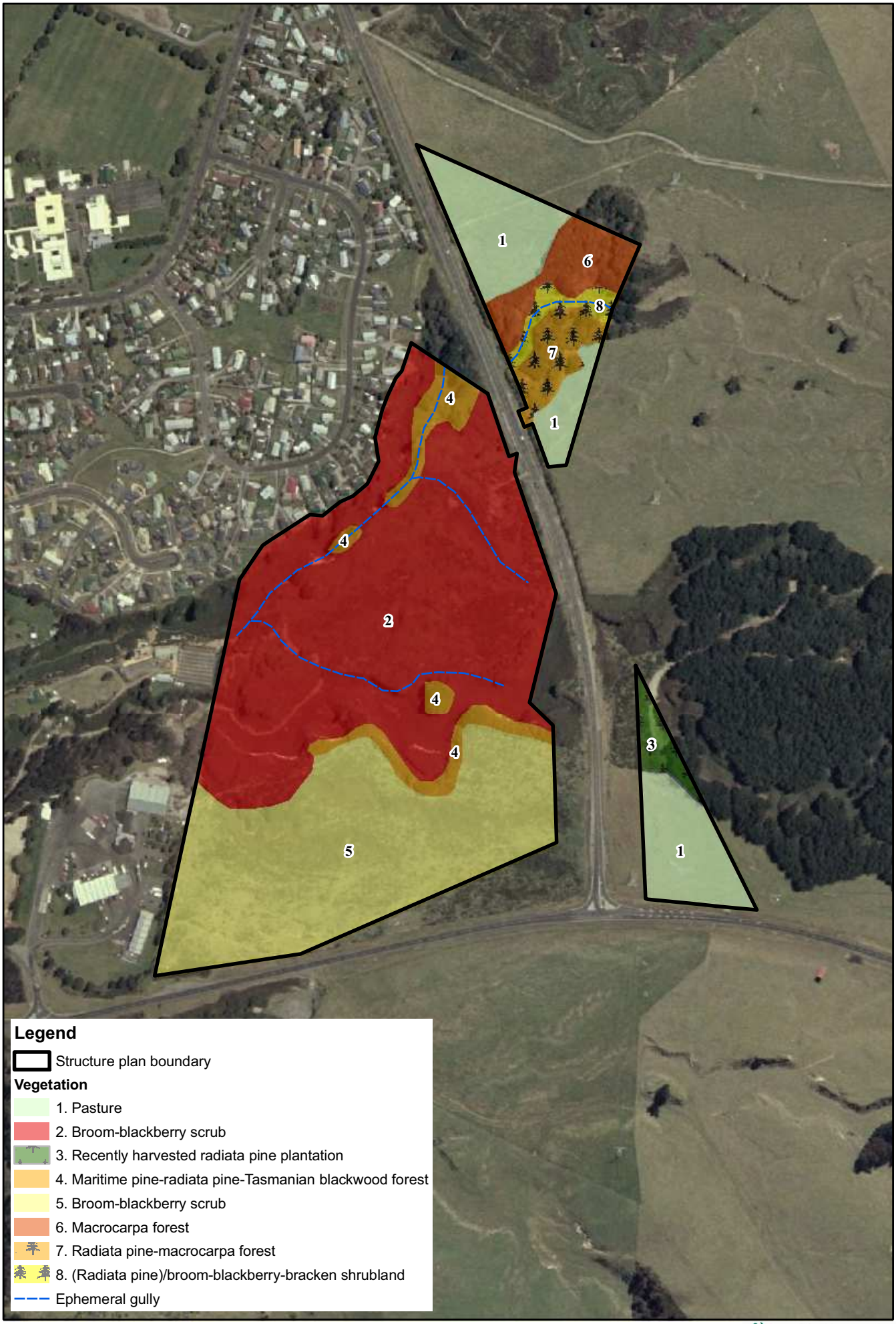

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Figure 7. Vegetation/habitat types and land use, Crown Road/Napier-Taupo Road Junction

0 100 200 m

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Wildlands

Scale: 1:6,000
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Figure 8. Vegetation/habitat types and land use, Taupo Airport Block

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Wildlands

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4. Eucalyptus plantation (*c.*1.88 ha)

5. Radiata pine-mixed deciduous plantation (*c.*0.4 ha)

6. Roads (*c.*1.5 ha)

5.2 Centennial Drive to Broadlands Road Blocks (*c.*350.8 ha)

1. Pasture (*c.*297.2 ha)

   Pasture includes grassland vegetation which is utilised for pastoral farming. The most common species were sweet vernal, browntop, catsear, yarrow, narrow-leaved plantain, annual poa, Yorkshire fog, ryegrass, cocksfoot, sheep's sorrel, serradella, white clover, dock, Scotch thistle, and marsh thistle. Narrow-leaved carpet grass (*Axonopus fissifolius*) and Indian doab (*Cynodon dactylis*) are common near geothermal sites. Scattered patches of shrubs of broom and gorse, as well as trees of maritime pine, are also common. This also includes recently-installed pipelines and infrastructure associated with geothermal energy extraction, but this has not been mapped separately.

2. Swede crop (*c.*27.0ha)

3. Maritime pine/blackberry scrub (*c.*0.5 ha)

   Scattered maritime pines are present over dense blackberry scrub with common broom. Several manuka are emergent over the blackberry. Bracken is common in places.

4. Raw-soilfield (non-geothermal) (*c.*0.8 ha)

   Recently cleared and levelled pasture.

5. Existing Residential, Industrial, Shelterbelts, Gardens, Specimen trees, Lawns, Taupo plant nursery (*c.*17.5 ha)

6. Nonvegetated raw-soilfield (geothermal) (*c.*0.5 ha)

   Geothermally influenced bare ground largely devoid of vegetation.

7. Prostrate kanuka scrub and shrubland (*c.*0.3 ha)

   A dense canopy of prostrate kanuka (often *c.*1 m tall) with occasional monoao and mingimingi. The groundcover is often a mix of lichens, mosses, liverworts and occasional *Lycopodiella cernua*.

8. Eucalyptus plantation (*c.*3.3 ha)

9. Poplar-Eucalyptus-specimen tree forest (*c.*2.6 ha)

10. Raupo/Juncus effusus-Juncus edgarae reedland (*c.*0.5 ha)

A degraded wetland, with margins currently grazed by domestic stock, with common raupo and mixed rushes.

11. (Manuka)-ti kouka/ Juncus effusus-Juncus edgarae-exotic grasses rushland (*c.*0.5 ha)

A small degraded wetland, currently grazed by domestic stock

12. Alder–grey willow-poplars/blackberry forest (*c.*0.3 ha)

Common alder (*Alnus glutinosa*), grey willow and poplars are present over an understorey with common blackberry and wheki. *Carex secta* is common on stream margins as well as watercress in a flowing stream. *Phormium tenax* has been planted on margins between farmland and this vegetation type. The stream is *c.*1 m wide and 20 cm deep, with flow rates of *c.*1 m/sec on the day of the site visit.

5.3 Broadlands Road to Crown Road Blocks (*c.*53.5 ha)

1. Pasture (13.4 ha)

See Vegetation Type 1 for Centennial Drive to Broadlands Road Block.

2. Blackberry scrub (0.1 ha)

A dense stand of blackberry to 3 m tall.

3. Nonvegetated raw-soilfield (0.4 ha)

Geothermally-influenced ground devoid of vegetation comprising heated soils, chemically altered soils, and fumaroles.

4. Prostrate kanuka scrub (4.0 ha)

A dense canopy of prostrate kanuka (often *c.*1 m tall) with occasional monoao (*Dracophyllum subulatum*) and mingimingi (*Leucopogon fasciculatus*). Blackberry (*Rubus fruticosus*), broom, and Indian doab become more common on margins. The groundcover is often a mix of lichens, mosses, liverworts and occasional *Lycopodiella cernua*. Emergent maritime pines are common.

5. Residential/industrial (15.6 ha)

6. Motorcycle track, rank grasses, broom-blackberry shrubland (13.6 ha)

7. Prostrate kanuka/pasture shrubland (4.0 ha)

A small unit of prostrate kanuka shrubs to *c.*1m tall over grazed pasture.

8. Broom-blackberry scrub and shrubland (5.1 ha)

   Extensive areas are dominated by broom and blackberry, with isolated open areas of rank grassland.

9. Maritime pine/pasture treeland (0.9 ha)

   Common maritime pine in ephemeral gullies with scattered broom and blackberry, and occasional *Cotoneaster glaucophyllus* and karamu. Pasture dominates the understorey.

10. Existing residential, shelterbelts, gardens, specimen trees, lawns (0.5 ha)

5.4 Crown Road/Napier-Taupo Road Junction Blocks

1. Pasture (3.5 ha)

   Pasture includes grassland vegetation which is utilised for pastoral farming. The most common species were sweet vernal, browntop, catsear, yarrow, narrow-leaved plantain (*Plantago lanceolatum*), annual poa, mouse-eared chickweed (*Cerastium fontanum*), Yorkshire fog, ryegrass, cocksfoot, sheep's sorrel, serradella, white clover, dock, and Scotch thistle.

2. Broom-blackberry scrub (20.7 ha)

   Deeply-incised gully vegetation. The valley floor comprises rank exotic grassland and broom scrub and occasional patch of blackberry and bracken (*Pteridium esculentum*). The valley sides comprise dense blackberry scrub with occasional patches of bracken and broom.

3. Recently harvested radiata pine plantation (0.4 ha)

4. Maritime pine-radiata pine-Tasmanian blackwood forest (1.4 ha)

   The upper edge of steeply-incised stream gullies are planted with common Tasmanian blackwood (*Acacia melanoxylon*), maritime pine, and radiata pine (*Pinus radiata*). Broom and blackberry are common

5. Broom-blackberry scrub (20.7 ha)

   Broom and blackberry to 3 m tall are common over pasture (see Type 1 above).

6. Macrocarpa forest (1.1 ha)

   Macrocarpa plantation forest over an understorey of scattered *Asplenium polyodon* and *Microsorum pustulatum* and litter (90%cover).

7. Radiata pine-macrocarpa forest (0.8 ha)

Small plantation stand and scattered trees on valley sides, comprising radiata pine and occasional macrocarpa.

8. (Radiata pine)/broom-blackberry-bracken shrubland (0.4 ha)

Ephemeral gully with scattered radiata pine over broom, blackberry, and bracken shrubland with patches of rank exotic grassland species common.

5.5 Taupo Airport Block

1. Pasture (81.7 ha)

Pasture includes grassland vegetation which is utilised for pastoral farming. The most common species were browntop, sweet vernal, woolly mullein, catsear, yarrow, narrow-leaved plantain, annual poa, mouse-eared chickweed, Yorkshire fog, ryegrass, cocksfoot, sheep's sorrel, white clover, dock (*Rumex obtusifolius*), and Scotch thistle. Isolated patches of broom and gorse are common throughout. Scattered maritime pine trees are also present.

2. (Scattered radiata and maritime pine)/bracken-blackberry-broom fernland (2.2 ha)

Deeply-incised ephemeral gully with scattered maritime pine and radiata pine over an understorey of dense bracken, blackberry and broom.

3. Maritime pine forest (3.9 ha)

Deeply-incised ephemeral stream gully with a valley sides dominated with a maritime pine forest. The valley floor is dominated by rank grasses. The remainder of the understorey is dominated with dense bracken, blackberry, broom with occasional wheki (*Dicksonia squarrosa*). Alder (*Alnus glutinosa*) is common on margins.

4. Broom-gorse/pasture shrubland (6.1 ha)

Gullies more shallow than Type 3 described above, comprising broom and gorse shrubland over pasture (see Type 1 above). Scattered maritime pines are present.

6. FLORA

Thirty-two indigenous species and 69 exotic species were recorded (refer to Appendix 1) although this will not be a complete list for the site. Most species recorded are common, typical of the habitats present and none are rare or threatened, as per Hitchmough *et al*. (2007). Two 'At Risk' species are known from the project area: prostrate kanuka and *Dicranopteris linearis*.

7. FAUNA

7.1 Avifauna

A list of avifauna recorded from, or likely to occur in, the study area, is presented in Table 1. A total of 16 indigenous and 16 exotic bird species are present or are likely to be present in the project area.

Table 1: Bird species recorded or likely to utilise habitats in the parts of the Taupo Commercial and Industrial Structure Plan investigated in this study. Species in bold were recorded in the current survey. Threat status is given for indigenous species, as per Hitchmough *et al.*2007.

Common Name	Scientific Name	Status	Notes
Herons, bitterns and egrets (ardeidae)			
White-faced heron	*Ardea novaehollandiae*	Not threatened	Likely to utilise pasture and ephemeral wetland habitat.
Waterfowl (anatidae)			
Paradise shelduck (putangitangi)	*Tadorna variegata*	Not threatened	Likely to utilise pasture, farm ponds and ephemeral wetland habitat.
Mallard	*Anas platyrhynchos*	Introduced	Likely to utilise pasture, farm ponds and ephemeral wetland habitat.
Raptors (accipteridae and falconidae)			
Australasian harrier (kahu)	*Circus approximans*	Not threatened	Likely to utilise open pasture habitat.
Gamebirds (phasianidae)			
California quail	*Callipepla californica*	Introduced	Likely to utilise habitats throughout the site.
Ring-necked pheasant	*Phasianus colchicus*	Introduced	Likely to utilise habitats throughout the site.
Rails, gallinules and coots (rallidae)			
Pukeko	*Porphyrio porphyrio*	Not threatened	Present in pasture, ephemeral wetland habitats.
Plovers, dotterels and lapwings (charadriidae)			
Spur-winged plover	*Vanellus miles*	Not threatened	Likely to utilise open pasture habitat.
Gulls, terns and noddies (laridae)			
Southern black-backed gull (karoro)	*Larus dominicanus*	Not threatened	Likely to utilise pasture and ephemeral wetland habitat.
Cuckoos (cuculidae)			
Shining cuckoo (pipiwharauroa)	*Chrysococcyx lucidus*	Not threatened	Utilises forest habitats when present between spring and autumn.
Typical owls (strigidae)			
Morepork (ruru)	*Ninox novaeseelandiae*	Not threatened	Likely to utilise habitats throughout the site.
Kingfishers (alcedinidae)			
Sacred kingfisher (kotare)	*Todiramphus sanctus*	Not threatened	Likely to utilise habitats throughout the site.
Larks (alaudidae)			
Skylark	*Alauda arvensis*	Introduced	Likely to utilise open pasture habitat.
Swallows and martins (hirundinidae)			
Welcome swallow	*Hirundo tahitica*	Not threatened	Likely to utilise habitats throughout the site.

Common Name	Scientific Name	Status	Notes
Pipits (moticillidae)			
New Zealand pipit	*Anthus novaeseelandiae*	Not threatened	Likely to utilise open pasture and scrub habitat.
Accentors (prunellidae)			
Dunnock	*Prunella modularis*	Not threatened	Likely to utilise habitats throughout the site.
Thrushes (muscicapidae)			
Blackbird	*Turdus merula*	Introduced	Likely to utilise habitats throughout the site.
Song thrush	*Turdus philomelos*	Introduced	Likely to utilise habitats throughout the site.
Australasian warblers (acanthizidae)			
Grey warbler (rirorirо)	*Gerygone igata*	Not threatened	Likely to utilise habitats throughout the site.
Monarch flycatchers (monarchidae)			
North Island fantail (piwakawaka)	*Rhipidura fuliginosa placabilis*	Not threatened	Likely to utilise habitats throughout the site.
White-eyes (zosteropidae)			
Silvereye (tauhou)	*Zosterops lateralis*	Not threatened	Likely to utilise habitats throughout the site.
Honeyeaters (meliphagidae)			
Bellbird (korimako, makomako)	*Anthornis melanura*	Not threatened	Utilises forest and scrub habitats
Tui	*Prosthemadera novaeseelandiae*	Not threatened	Utilises forest and scrub habitats
Buntings, cardinals, and tanagers (emberizidae)			
Yellowhammer	*Emberiza citrinella*	Introduced	Likely to utilise open pasture and scrub habitat.
Finches (fringillidae)			
Chaffinch	*Fringilla coelebs*	Introduced	Likely to utilise habitats throughout the site.
Greenfinch	*Carduelis chloris*	Introduced	Likely to utilise open pasture and scrub habitat.
Goldfinch	*Carduelis carduelis*	Introduced	Likely to utilise open pasture and scrub habitat.
Redpoll	*Carduelis flammea*	Introduced	Likely to utilise open pasture and scrub habitat.
Sparrows and weavers (ploceidae)			
House sparrow	*Passer domesticus*	Introduced	Likely to utilise habitats throughout the site.
Starlings and mynas (sturnidae)			
Starling	*Sturnus vulgaris*	Introduced	Likely to utilise habitats throughout the site.
Indian myna	*Acridotheres tristis*	Introduced	Likely to utilise habitats throughout the site.
Bell magpies (cracticidae)			
Australian magpie	*Gymnorhina tibicen*	Introduced	Likely to utilise habitats throughout the site.

No threatened species, as listed in Hitchmough *et al*. (2007), were recorded during this survey.

7.2 Aquatic species

Only one small waterway is present in the project area, and it does not provide significant habitat for aquatic species.

7.3 Other species

Much of the area is farmed, with stock all being either cattle (*Bos taurus*) or sheep (*Ovis aries*). European rabbits (*Oryctolagus cuniculus*) were common. Other exotic animals are likely to be common including possums (*Trichosurus vulpecula*) feral and domestic cat (*Felis catus*), ferrets (*Mustela furo*), stoats (*Mustela erminea*), weasels (*Mustela nivalis vulgaris*), brown hare (*Lepus europaeus*), Norway rats (*Rattus norvegicus*), ship rat (*Rattus rattus*), mice (*Mus musculus*), and hedgehogs (*Erinaceus europaeus*).

An invertebrate survey was not undertaken for this study. Small remnants of indigenous forest in urban areas are important in providing habitat for a diverse range of invertebrate species. Kuschel (1990) reported that even small remnants of indigenous forest in suburban environments can provide significant habitat for a diverse range of indigenous beetles. This can also be presumed to be the case for many other terrestrial and aquatic invertebrate groups (e.g. other insects, snails, and spiders). The gully systems currently have a cover of exotic forest, but with an understorey which includes a number of indigenous species.

8. LANDFORM ASSESSMENT

The landforms within most parts of the project area are gently-sloping plateaus, although a few sections of gently-rolling hill country are also present, particularly at the eastern end of the Centennial Drive and extending into the Broadlands Road Block. Deeply-incised gullies are present at the far-western end of the 'Rangatira E Block', the middle of the 'Centennial Drive to Broadlands Road Block', The northern part of the 'Crown Road to Napier Taupo Road Junction Block', and northern part of the Taupo Airport Blocks. These gullies typically have steeply-sided walls with relatively wide flat beds. The valley floors, while normally dry, can be expected to carry significant volumes of stormwater during large rainfall events.

Geothermal features are present in two of the blocks, as described in Section 5 above. Landforms and habitats in these areas include geothermal nonvegetated raw-soilfield, steaming ground, and small craters and fumaroles.

9. ECOLOGICAL VALUES

Most of the project area has been developed for farming and is currently dominated by exotic species. However, examples of significant geothermal vegetation are known from two of the blocks on the property. Many of the gully systems have a mixed cover of forest and scrub which provides habitat for indigenous fauna. There is the potential to greatly enhance the sites of these values for indigenous fauna. Areas identified as having ecological constraints are shown in Figures 9-13.

The geothermal vegetation in Broadlands Road Scenic Reserve, and prostrate kanuka and associated geothermal habitat at Crown Road, is of very high ecological and conservation value. It was ranked as being of 'Regional Significance' in Wildland Consultants (2004 & 2006) because it contains a large area of prostrate kanuka scrub

(an 'At Risk' species), and comprises a relatively large area of geothermal habitat, which is a nationally uncommon habitat type. Broadlands Road Scenic Reserve is also protected under the Reserves Act 1977, as a Scenic Reserve (See Section 6 for more details).

One small wetland with a small stream, which eventually flows outside of the study area and into the Waikato River, was present in the Contact Energy-owned land to the north of the Timber Mill on Centennial Drive (west of the Taupo Native Plant Nursery). It is recommended that this wetland is protected and fenced to exclude domestic stock, and the stream margins should be fenced with a 5-10 m riparian buffer.

10. POTENTIAL ECOLOGICAL EFFECTS AND OPPORTUNITIES

10.1 Geothermal

From an ecological perspective, the greatest potential ecological effect of land development at these sites is the potential for adverse effects on geothermal vegetation and habitats at Crown Road and the neighbouring Broadlands Road Scenic Reserve. The following issues and threats will need to be addressed:

- A buffer is suggested for the protection of geothermal vegetation, as shown in Figures 9 and 10. These areas are all worthy of formal protection.

- For parts of the project above the Waipahihi Stream geothermal site, future management needs to address the potential effects that any development could have on stormwater flows into the Waipahihi Valley.

The following issues have been identified as being relevant to the Crown Road and Broadlands Road Scenic Reserve sites:

- **Accessibility to People and Vehicles**

  Broadlands Road Scenic Reserve

  Threat: The reserve is currently relatively inaccessible to the general public, which has limited the damage caused by people trampling on vegetation. Geothermal vegetation is particularly vulnerable to trampling damage. Informal tracking is evident at many other geothermal locations, where people have walked though geothermal vegetation, particularly in prostrate kanuka scrub and shrubland. Trampling can also cause compaction of geothermal soils.

  Management: Establish a barrier (fence) and buffer between any development and the reserve to prevent access by people on foot and in vehicles.

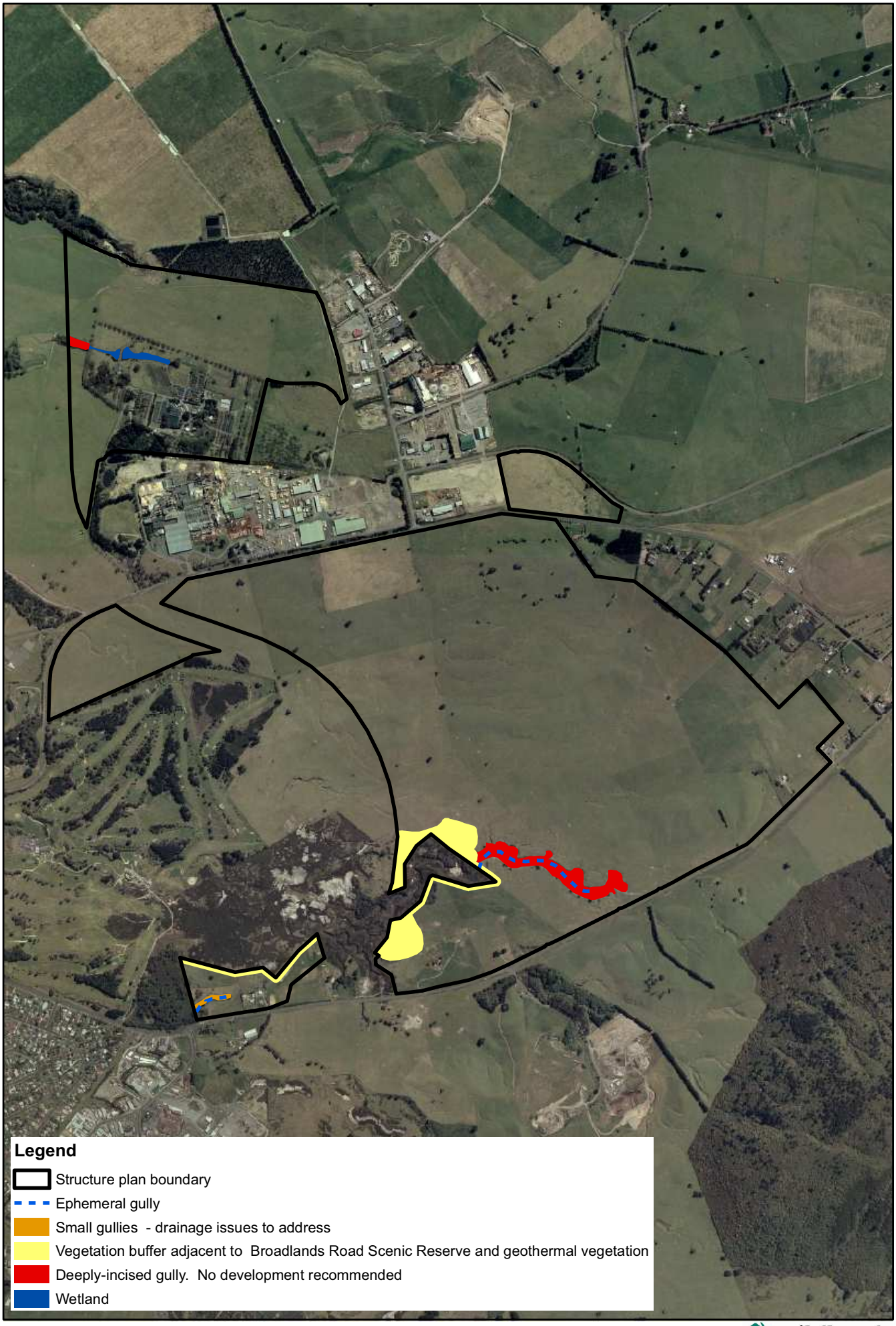
Figure 9. Ecological Constraints at Rangatira E Block

0 250 500 m

E:\gis\Taupo_structure\Taupo_Structure - Rangatira E Block Constraints.mxd

Wildlands

Scale: 1:10,000
Date: 21/11/08
Cartographer: RPB
Format: A4



N

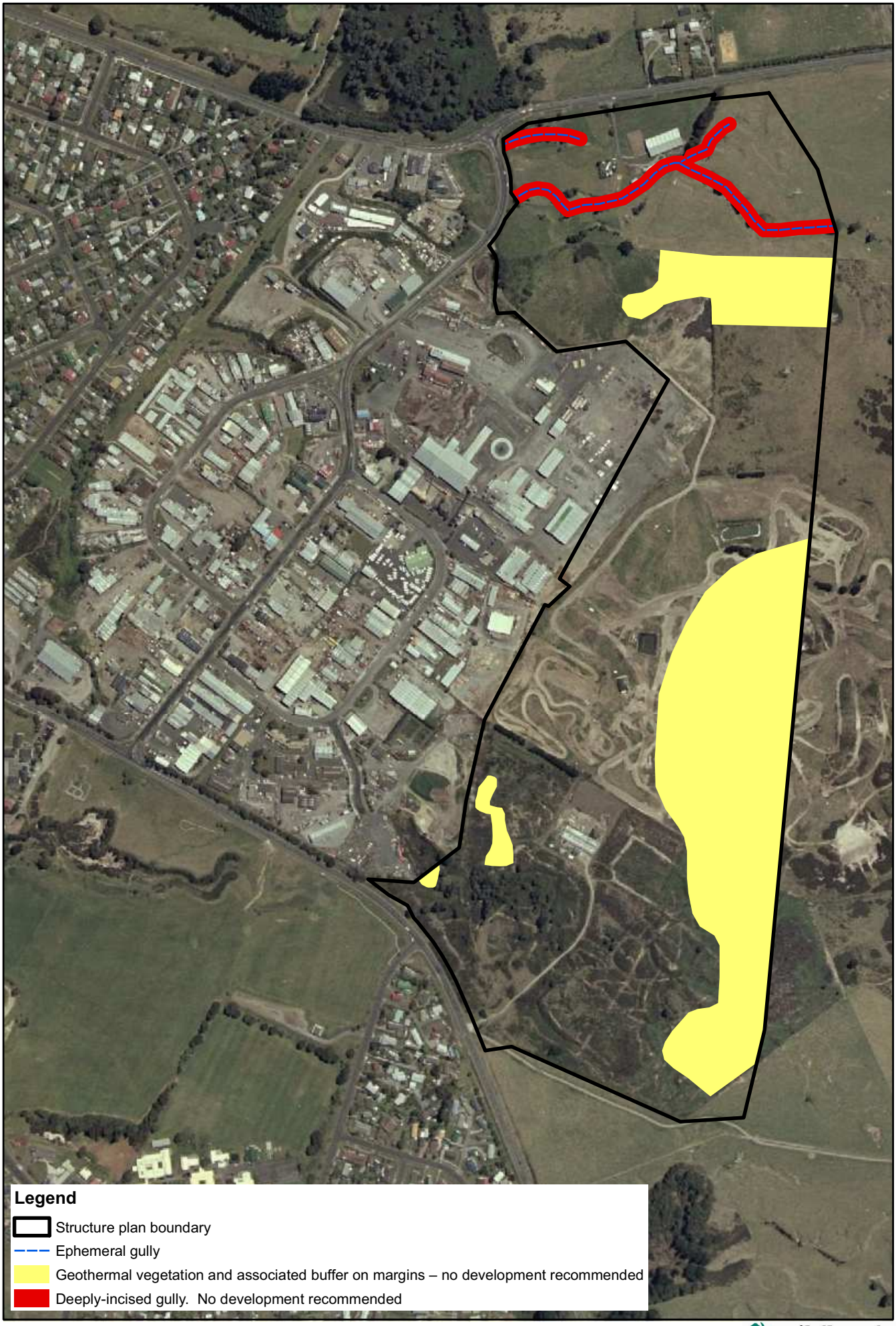
Figure 10. Ecological Constraints, Centennial Drive to Broadlands Road

0 500 1,000 m

E:\gis\Taupo_structure\Taupo_Structure - Centennial Drive to Broadlands Road Block Constraints.mxd

Wildlands

Scale: 1:20,000
Date: 21/11/08
Cartographer: RPB
Format A4



N

Figure 11. Ecological Constraints, Broadlands Road to Crown Road

0 100 200 m

E:\gis\Taupo_structure\Taupo_Structure - Broadlands Road to Crown Road Block Constraints.mxd

Wildlands

Scale: 1:7,000
Date: 21/11/08
Cartographer: RPB
Format A4

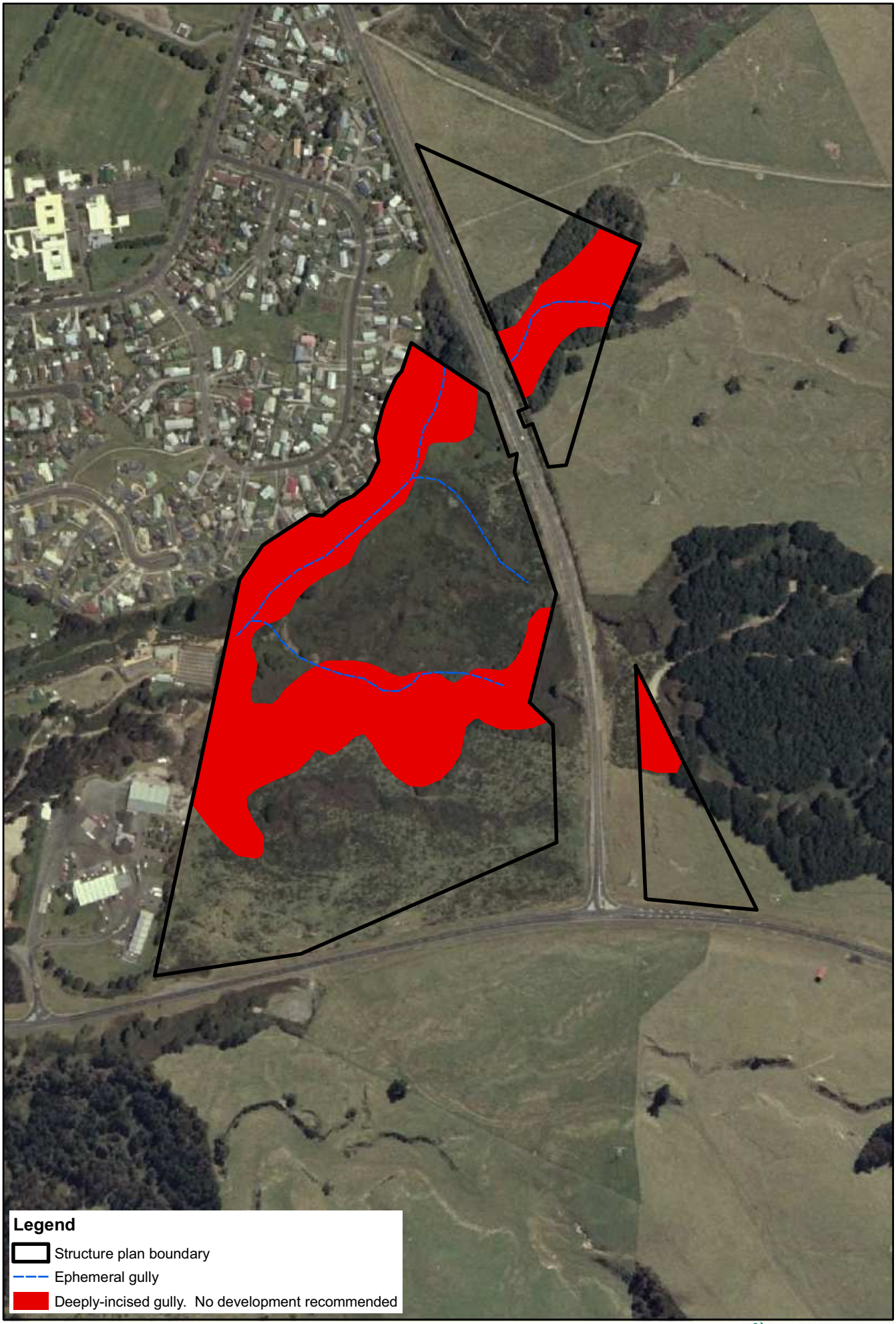


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Figure 12. Ecological Constraints, Crown Road/Napier-Taupo Road Junction

0 100 200 m

E:\gis\Taupo_structure\Taupo_Structure - Crown Road-Napier-Taupo Road Junction blocks Constraints.mxd

Wildlands

Scale: 1:6,000
Date: 15/08/08
Cartographer: RPB
Format A4

Figure 13. Ecological Constraints, Taupo Airport Block

0 250 500 m

E:\gis\Taupo_structure\Taupo_Structure - Taupo Airport Block Constraints.mxd

Wildlands

Scale: 1:10,000
Date: 12/11/08
Cartographer: RPB
Format A4

- **Fire**

  Crown Road and Broadlands Road Scenic Reserve

  Threat: Geothermal vegetation - particularly species such as prostrate kanuka and monoao - is especially vulnerable to fire. There is a risk of wild fire caused by discarded cigarette butts thrown by people constructing or utilising the industrial development site. Fire has recently been a problem at part of the Crown Road site.

  Management: Establish a buffer between any development and geothermal development. For Broadlands Road Scenic Reserve it recommended that a barrier is created that will reduce the likelihood of people entering the reserve.

- **Stormwater and Drainage**

  Crown Road and Broadlands Road Scenic Reserve

  Threat: Any drainage and stormwater overflows into significant geothermal vegetation and habitats are likely to cause significant changes to geothermal vegetation habitats currently present.

  Management: Manage stormwater and drains at the site so that water is channelled away from geothermal vegetation and habitats (particularly those in Broadlands Road Scenic Reserve).

- **Buffers around Significant Geothermal Vegetation**

  Crown Road and Broadlands Road Scenic Reserve

  Issue: Protective buffers around natural areas generally enhance their viability. They buffer sensitive ecosystems from external modifying influences such as wind and weed invasion. All geothermal areas would have originally been surrounded by larger areas of indigenous non-geothermal vegetation, which previously provided connective links or corridors to other geothermal sites. Connections need to be protected or enhanced wherever possible.

  The presence of surface geothermal activity can fluctuate at a particular location and across the landscape. A buffer of reasonable size is desirable around many geothermal sites, to allow for this variability.

  Management: Establish a buffer between any development and significant geothermal vegetation. Consider establishing a planted strip of ecologically appropriate locally-sourced indigenous species between any future development and geothermal vegetation.

- **Pest Plants**

  Crown Road and Broadlands Road Scenic Reserve

  Threat: Increased levels of human activity on the reserve boundary could increase the likelihood of pest plants becoming established in significant geothermal vegetation. Pest plants may also spread from the industrial site into the reserve. Increased access to the site (this is mostly an issue for Broadlands Road Scenic Reserve) may increase the chances of the dumping of garden refuse, which in turn increases the vulnerability of the site to weed invasion.

  Management: Establish a buffer between future development and significant geothermal vegetation.

  If industrial development occurs on the margins of Broadlands Road Scenic Reserve then it is recommended that a monitoring programme, in association with the Department of Conservation, is established to survey and control the spread of any weed species into the reserve that may have arrived as a result of activities the development.

  Have a qualified ecologist familiar with pest plant threats in natural areas and geothermal vegetation assess any planting plan within the industrial site within 100 m of the significant geothermal area, to ensure that potentially invasive weed species are not planted.

- **Litter (Rubbish)**

  Crown Road and Broadlands Road Scenic Reserve

  Threat: Litter (rubbish) blown in by wind from site development (or from people following retail development), and deliberate dumping of rubbish by people can make the appearance of geothermal vegetation unsightly. It can also bring in weed species.

  Management: Establish a buffer (20 m) between the development and any geothermal vegetation.

10.2 Management of stream gullies with flowing waterways

Part of the project brief required that the following aspects related to the 'Catchment Management Plan' requirements established by Taupo District Council's comprehensive consent conditions were assessed. This section relates specifically to the one small permanently flowing waterway (and associated wetland) in the study area for the project: the stream that flows west of the Taupo Native Plant Nursery into the Waikato River.

The following aspects were required to be assessed:

- Receiving water sediment and water quality;
- Receiving water habitat, ecology and ecosystem health;
- the natural and amenity values of receiving waters;
- Receiving water riparian vegetation;
- The extent and quality of open stream channels (including ephemeral water courses);
- Erosion and sedimentation of receiving waters.

Further details are provided in Wildland Consultants (2008), based on a study for the proposed Mapara Structure Plan. The stream flows out of a somewhat degraded wetland, which includes an area of raupo reedland. The wetland and stream are currently grazed by cattle. A short section flows through grazed pasture (this section is not fenced and has stock regularly trample stream margin vegetation) and the stream gully is then fenced to outside of the project area.

It is recommended that the best approach to protect and enhance water quality, sediment control and controlling erosion of this stream and its margins would be to fence the entire length of the stream and associated wetland to exclude farm stock. A minimum of a 5 m-wide buffer, which should be planted with locally-sourced indigenous species (see section below for suitable species) should be established along each side of this stream. The downstream area that is currently fenced is a suitable buffer, but pest plant species could be controlled (e.g. grey willow, alder, and blackberry) and indigenous plant species planted on margins (see section below for suitable species) if resources are available.

10.3 Management of gullies for stormwater management

The larger gully systems, many with steep sides and all with ephemeral streams are shown in Figures 9 to 13. Each individual steeply-sided stormwater gully will need to be assessed separately to enable the best management options for stormwater management, ecological values, recreation use. General guidelines for stormwater management are presented below.

10.3.1 Revegetation goals

The revegetation goals aim to improve the water management, recreational values, aesthetics and ecological values of the gullies, as outlined below:

- stormwater management (e.g. increase infiltration, filtration of runoff, and control of water flow);

- create a dense vegetation cover on the gully floors to prevent exposure of soil to ephemeral water flow and potential accelerated soil erosion;

- prevent shading of the gully floors by only establishing lower growing trees and shrubs on the gully sides;

- aesthetics (e.g. remove weeds and create a pleasant backdrop to a residential area);

- soil conservation and recovery (e.g. decrease sedimentation, reduce soil erosion, reduce soil compaction, and stabilise steep slopes);

- wildlife habitat (e.g. provide nesting sites, nectar and fruit);

- weed suppression (e.g. create a dense cover of indigenous vegetation on the gully sides that is resistant to weed invasion);

- recreation (provide grassed areas and a shared walkway/bike track).

10.3.2 Management requirements

The general management requirements set out below relate to all areas to be revegetated:

- Remove exotic vegetation;
- Remove rubbish;
- Site preparation prior to planting (including pest control, if required);
- Plant indigenous species;
- Monitor plantings and maintain as required;
- Monitor for weed invasion; and
- Undertake weed control if required.

10.3.3 Revegetation approach

Water Management Specifications

The requirements specified by Environment Waikato (Document No. 1135481) for vegetation in soil conservation compartments at Taupo are:

- "*gully floors should be maintained in a vigorous sward of long pasture grasses*";

- "ideally no trees should occur on the gully floors…however consideration will be given to widely spaced trees that do not prevent or restrict ground cover vegetation";

A report on the revegetation and soil management of Taupo ephemeral gullies (Simcock and Smale 2005) recommends:

- "*Open planted trees at 5 to 10 m spacing along the valley floors with a groundcover of grasses, sedges or ferns*";

- "*Trees for these areas* [valley floors] *should have single trunks and tolerate pruning to 1.5 to 2.5 m height to ensure enough light reaches the valley floor to sustain a dense sward of well-anchored, low-maintenance groundcover to filter sediment from stormwater and physically protect the soil* "[For valley floors] *…suitable moderately-sized trees (to about 10m height) with moderate to fast growth rates include kowhai, cabbage tree, kanuka, lancewood, ribbonwood and lacebark. With suitable nursery stock and a higher pruning effort tarata, five-*

finger and kohuhu would be suitable. In the deepest gullies tall trees can be planted: totara, rewarewa, silver and red beech, kahikatea and tanekaha";

- "The primary aim of managing gully sides is preventing erosion of loose pumice into the valley floor and suppressing weeds". Species listed as suitable for revegetation of gully walls include flax, toetoe, *Olearia furfuracea*, *Corokia cotoneaster*, tutu, kanuka, kohuhu, tarata, five-finger, kowhai, ribbonwood, koromiko, broadleaf and prickly mingimingi.

Note: Some of the species listed above do not naturally occur in gully systems at Taupo, e.g. lacebark, silver beech, and red beech.

Indigenous Species for Use in Revegetation

On an ecological basis, the species selected for planting at a restoration site should be naturally occurring either at or in close proximity to the site. A list of recommended species is provided in Table 1, grouped by suitable planting habitats (i.e. gully floor or gully wall).

Other issues that have been considered during species selection include the overall appearance of the site, maintenance requirements, and provision of habitat and seasonal food sources for indigenous fauna. Adequate screening of housing/industrial sites on the other side of gullies should be obtained, as the plantings develop, from tall trees planted on gully floors and walls.

Gully Walls

It is recommended that most of the species that are planted are fast-growing shrubs or small trees (e.g. kohuhu (*Pittosporum tenuifolium*), manuka, kanuka, *Phormium cookianum*, karamu, koromiko, *Hebe parviflora*, ti kouka (cabbage tree), five finger, and wineberry) that will rapidly create a closed canopy with lesser amounts of kowhai and ribbonwood. Lower growing species should be planted near the base of the gully walls (e.g. toetoe, whaririki, and harakeke) so that the gully floor is not shaded. Where there are existing populations of indigenous ferns, these should be left undisturbed during site preparation, if possible. Plants should be planted at 1.1 m spacings. The total planting density will be 8,000 plants/ha. On very steep/vertical slopes, species which only grow to a maximum of 3-4 m will be planted, e.g. *Phormium cookianum*, *Coprosma lucida*, *Hebe stricta*, *Cortaderia fulvida*, and kiokio.

Gully Floors

The focus of vegetation cover in the gully floors should be recreation and stormwater management. This can be achieved by establishing dense swards of grass in the wider section of the gully (40-80 m long) with scattered specimen large trees 20-25 m apart. The large specimen trees should be limbed (see Section 6 below) to ensure that the grassy sward stays dense and continuous without bare soil being exposed. Where the gully narrows (i.e. pinch points) a groundcover of sedges (0.6-0.7 m apart) and toetoe (1 m spacings) with small groups of small trees (3-5 m apart) and a few scattered large trees (10-15 m apart) can be established. Small groves of trees and sedges could be

established. These larger specimen trees would be species such as totara, rimu, and kahikatea and smaller trees planted in groupings at 3-5 m spacings (e.g. kohuhu, five finger, kowhai, wheki ponga, and ribbonwood) with a groundcover of *Carex virgata, Carex secta*, toetoe, and kiokio. The trees would all be limbed to ensure adequate light reaches the groundcover to enable a dense groundcover to be maintained.

Table 1: Plant species suitable for steeply-sided gullies (non geothermal areas) associated with proposed industrial land at Taupo.

Species (Common Name)	Planting Densities (plants/ha)	
	Gully Walls[1]	Gully Floors[2]
Indigenous Species		
Aristotelia serrata (makomako; wineberry)	✓	
Blechnum novae-zelandiae (kiokio)		✓
Carex virgata (purei)		✓
Carpodetus serratus (putaputaweta)	✓	
Coprosma grandifolia (kanono)	✓	
Coprosma lucida	✓	
Coprosma robusta (karamu)	✓	
Cordyline australis (ti kouka, cabbage tree)	✓	✓
Coriaria arborea var. *arborea* (tutu)	✓	
Cortaderia fulvida (toetoe)	✓	✓
Dacrydium cupressinum (rimu)	✓	✓
Dacrycarpus dacrydioides (kahikatea)	✓	✓
Dicksonia fibrosa (wheki ponga)		✓
Fuchsia excorticata (kotukutuku)	✓	
Hebe parviflora	✓	
Hebe stricta var. *stricta* (koromiko)	✓	
Hedcarya arborea (porokaiwhiri, pigeonwood)	✓	
Knightia excelsa (rewarewa)	✓	✓
Kunzea ericoides (kanuka)	✓	✓
Leptospermum scoparium (manuka)	✓	✓
Melicytus ramiflorus (mahoe)	✓	
Myrsine australis (mapou)	✓	
Olearia rani (heketara)	✓	
Phormium cookianum (whaririki)	✓	
Phormium tenax	✓	✓
Pittosporum eugenioides (tarata)	✓	
Pittosporum tenuifolium subsp. *tenuifolium* (kohuhu)	✓	
Plagianthus regius (ribbonwood)	✓	✓
Podocarpus totara (totara)	✓	✓
Prumnopitys ferruginea (miro)	✓	✓
Pseudopanax arboreus (whauwhaupaku, five-finger)	✓	
Pseudopanax crassifolius (horoeka, lancewood)	✓	✓
Schefflera digitata (pate)	✓	
Sophora tetraptera (kowhai)	✓	✓
Exotic Species		
Dactylis glomerata (cocksfoot)		seeded
Holcus lanatus (Yorkshire fog)		seeded

10.3.4 Other infrastructure and recreation use issues that should be addressed in gully design

Issues that should be addressed for any gully design include the following:

- Location of stormwater infrastructure
- Potential for walking/cycleway tracks.
- Crime prevention through environmental design.
- Mowing and maintenance of plantings

10.4 Hydrology and stormwater runoff

Other than steeply-sided stream gullies, which have been discussed in the previous section (and one other small stream and wetland) the other main hydrological issue to be addressed is the impact of new subdivisions, roads and industrial sites which usually alter land surfaces to make them less permeable to water. This is by both compaction of land surface and making them impervious to water (e.g. roads and new buildings). This can result in increased stormwater runoff and catchment scale erosion and flooding impacts. Topsoil is commonly compacted or destroyed, washed away in storms, or disposed of offsite which subsequently increases the need for irrigation (Eason *et al.* 2003). Issues specific to the proposed industrial sites assessed in this study relate to the easily erodible pumice soil, alternating drought and heavy rain periods, and seepage of contaminants into groundwater systems.

Some of the shallow ephemeral gullies are shown in Figures 9 to 13, as sites where stormwater management will need to be addressed. Elsewhere, the landscapes on these properties are gently-undulating and many very shallow gullies, that are 1-2 m deep and only 10-20 m wide occur repeatedly across the landscape and were too small to map separately. Stormwater management on these sites will also need to be considered when any new development is being planned.

10.4.1 Low impact development

Issues with developing an area can be mitigated by using Low Impact Development (LID), which is a set of tools to better manage stormwater from areas appropriately designated for growth (Wulkan *et al.* 2003). Key elements include working with nature to avoid or minimise impervious surfaces, utilising vegetation to assist in trapping pollutants and sediment, limiting earthworks, incorporating design features that reduce impacts, and enhancing biodiversity (Eason *et al.* 2003). Examples from around the world are proving that a minimal discharge of stormwater is possible without infiltration to the ground. The following examples are sourced from Eason *et al.*(2003) and Wulkan *et al.* (2003);

- Various types of permeable pavement (e.g. concrete lattice pavers with grass growing through them, pervious concrete).

- Open road sections with vegetated swales (e.g. vegetated waterways and cascades rather than pipes, which also eliminates the need for kerbs, ponds and drainage structures).

- Bioretention areas (e.g. soil filtration and planted evotranspiration areas parallel to major roads or adjacent to car-parks to filter contaminants and reduce road runoff).

- Soil amendments (e.g. adding compost or other soil conditioning material into topsoil before spreading it back over the site - improves water retention and soil characteristics).

- Rooftop rainwater collection systems (e.g. using rainwater to flush toilets and water gardens).

- Green roofs (e.g. using vegetation swales on the roof to hold and evotranspirate water).

- Innovative building foundations (e.g. sections of foundation wall are poured and "pinned" into the ground using heavy-duty steel pins that extend deep enough to support the structure and prevent uplift. No heavy machinery required to dig foundations, which prevents compaction).

- Homemade bog garden (e.g. back filled pond with impermeable liner prevents infiltration into the soil, water is disposed of via plant evapotranspiration).

10.4.2 Issues

Pumice soils are easily erodible both by water and, when exposed, by wind. Hence it is important to maintain vegetation along overland water flow pathways and to maintain vegetation as cover or windbreaks over the entire area.

During the site visits all of the stream tributaries and gullies in the study area were dry, and yet the deeply-incised gullies indicate that at other times of the year overland flow is significant. Increases in impervious surfaces such as concrete and asphalt may exacerbate this issue (Wulkan *et al.* 2003).

It will be challenging to maintain and enhance the vegetation and habitat qualities of overland flow riparian margins during both wet and drought periods. Creation of more shallow open water bodies fringed with native riparian vegetation, preferably using existing flow-channels, may help modulate the extremes between drought and severe flow. Shallow open water bodies are also likely to attract bird and other animal species which can enhance the living and working experience in a subdivision.

Increased habitation and development is also likely to increase the concentration of contaminants within the stormwater flow. As indicated earlier, it is thought that only 20 percent of water reaches Lake Taupo by the way of overland flow, the remainder reaches the lake via aquifers (Morgenstern 2007). This posses a real risk of contamination filtering into the aquifer. Reducing stormwater runoff and improving filtration with an LID approach may assist with the mitigation of this issue.

11. CONCLUSIONS

Taupo District Council is leading the preparation of a commercial and industrial structure plan for Taupo Township. Wildland Consultants were commissioned to assess ecological values and opportunities of parts of the plan designated as "proposed industrial business land areas, as identified by Taupo District Council. The area was considered in five broad blocks, as the areas of proposed business land are quite distinct from each other.

A field survey was undertaken and the vegetation and habitats and land uses were mapped. Most of the project area is in pasture and is currently farmed and has low ecological values. Significant habitat types include the geothermal vegetation at Crown Road and Broadlands Road, which have been previously identified as being of 'Regional Significance' by Wildland Consultants (2004). No threatened fauna species were recorded from the project area. Two plant species classified as 'At Risk' are known from the project area: prostrate kanuka and *Dicranopteris linearis.*

Sites of ecological significance were identified and should be considered as constraints to future land development. The most significant habitat type is geothermal habitat, and appropriate buffers for this vegetation is discussed in the report. One small stream and small wetland system was recorded as part of this study, near the Taupo Native Plant Nursery. If any industrial development is to be undertaken in this area, it is recommended that this stream and wetland is fenced to exclude stock, and that margins are planted with locally-sourced indigenous plant species.

Other significant ecological issues relate to management of steeply-incised gullies and stormwater management. Development planning will need to take account of these gullies and stormwater management requirements, to ensure that sediment and other contaminants are not discharged to the lake. As such, it will be necessary to design and install water and sediment management structures in the gullies. The gullies also represent a significant opportunity for ecological restoration of indigenous vegetation and habitats. If this is done to a high standard, these gullies will become a significant ecological asset for Taupo. They can also be utilised as part of an extended network of walking tracks and cycle ways in and adjacent to the township.

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LIST OF VASCULAR PLANT SPECIES
(excludes planted species in gardens and
planted species at the Taupo Plant Nursery)

INDIGENOUS SPECIES

Gymnosperms

Podocarpus totara	totara

Monocot. trees and shrubs

Cordyline australis	ti kouka
Phormium tenax	harakeke, flax

Dicot. trees and shrubs

Brachyglottis repanda s.s.	rangiora
Coprosma robusta	karamu
Hebe stricta var. *macroura*	koromiko
Kunzea ericoides	kanuka
Kunzea ericoides var. *microflora*	prostrate kanuka
Leptecophylla juniperina	prickly mingimingi
Pittosporum eugenioides	tarata
Pittosporum tenuifolium subsp. *tenuifolium*	kohuhu
Pseudopanax arboreus var. *arboreus*	whauwhaupaku, five finger
Solanum aviculare var. *aviculare* (incl. *S. a.* var. *albiflorum* and *S. cheesemanii*)	poroporo
Sophora tetraptera	kowhai

Dicot. lianes

Muehlenbeckia australis	puka

Lycopods and psilopsids

Psilotum nudum

Ferns

Asplenium flaccidum s.s.	makawe
Asplenium oblongifolium	huruhuruwhenua
Asplenium polyodon	petako
Blechnum novae-zelandiae s.s.	kiokio
Cyathea dealbata	ponga
Dicksonia fibrosa	wheki-ponga

Dicksonia squarrosa	wheki
Dicranopteris linearis[1]	
Hypolepis ambigua	
Microsorum pustulatum	kowaowao, hounds tongue fern
Pellaea rotundifolia	tarawera, button fern
Pneumatopteris pennigera	pakau
Polystichum vestitum	puniu, shield fern
Pteridium esculentum	bracken, rarahu

Rushes

Juncus edgariae	wi

Monocot. herbs (other than orchids, grasses, sedges and rushes)

Typha orientalis	raupo

ADVENTIVE SPECIES

Gymnosperms

Cryptomeria japonica	Japanese cedar
Larix decidua	larch
Pinus pinaster	maritime pine
Pinus radiata	radiata pine
Pseudotsuga menziesii	Douglas fir
Cupressus macrocarpa	Macrocarpa

Dicot. trees and shrubs

Acacia melanoxylon	Tasmanian blackwood
Alnus glutinosa	alder
Betula pendula	silver birch
Chamaecytisus palmensis	tree lucerne
Cotoneaster simonsii	
Cytisus scoparius	broom
Erica lusitanica	Spanish heath
Eucalyptus sp.	eucalyptus
Leycesteria formosa	Himalayan honeysuckle
Ligustrum sinense	Chinese privet
Lupinus arboreus	lupin
Populus sp.	poplar
Prunus sp.	ornamental cherry
Rubus sp. (*R. fruticosus* agg.)	blackberry
Salix cinerea	grey willow

[1] Willie Shaw pers. comm. 2004.

Ulex europaeus	gorse
Ulmus sp.	elm

Dicot. lianes

Lonicera japonica	Japanese honeysuckle

Grasses

Agrostis capillaris	browntop
Agrostis stolonifera	creeping bent
Anthoxanthum odoratum	sweet vernal
Cortaderia selloana	pampas
Cynosurus cristatus	crested dogstail
Dactylis glomerata	cocksfoot
Holcus lanatus	Yorkshire fog
Lolium perenne	rye grass
Poa annua	annual poa
Schedonorus phoenix	tall fescue

Rushes

Juncus effusus	soft rush

Composite herbs

Achillea millefolium	yarrow
Cirsium arvense	California thistle
Cirsium palustre	marsh thistle
Cirsium vulgare	Scotch thistle
Conyza albida	fleabane
Crepis capillaris	hawksbeard
Gamochaeta spicata	cudweed
Hypochoeris radicata	catsear
Lactuca serriola	prickly lettuce
Mycelis muralis	wall lettuce
Senecio jacobaea	ragwort

Dicot. herbs (other than composites)

Brassica rapa subsp. *sylvestris*	wild turnip
Cerastium fontanum	mouse-ear chickweed
Digitalis purpurea	foxglove
Galium aparine	cleavers
Geranium robertianum	herb Robert
Lotus pedunculatus	lotus
Malva sp.	mallow
Ornithopus perpusillus	serradella
Oxalis sp.	oxalis
Plantago lanceolata	narrow-leaved plantain

Ranunculus repens	creeping buttercup
Rumex acetosella	sheep's sorrel
Rumex obtusifolius	dock
Solanum nigrum	black nightshade
Stellaria media	chickweed
Trifolium dubium	suckling clover
Trifolium repens	white clover
Urtica urens	nettle
Verbena bonariensis	purple-top
Veronica arvensis	field speedwell

SITE PHOTOGRAPHS

Plate 1: Prostrate kanuka scrub and wilding pine tree near Ashwood Park.

Plate 2: Ashwood Park subdivision. Prostrate kanuka scrub sites were destroyed at this site when this development was undertaken.

Plate 3: Pasture and shallow ephemeral gully near Centennial Drive.

Plate 4: Pasture, currently grazed by horses on the northern side of Broadlands Road, near boundary of the geothermal habitat of Broadlands Road Scenic Reserve. Prostrate kanuka scrub is present to the left of fence.

Plate 5: A gully with an ephemeral waterway drains from east to west to the north of Broadlands Road. The vegetation is (maritime pine)/blackberry-broom scrub, adjoining grazed pasture.

Plate 6: Broadlands Road Scenic Reserve contains an extensive area of prostrate kanuka scrub, a vegetation type characteristic of geothermal habitat.

Plate 7: Deeply-incised gully in Taupo Airport Block, with maritime pine forest in background and bracken-blackberry scrub in foreground. These gullies are surrounded by pasture.

Plate 8: Floor of gully shown in Plate 7, contains rank exotic grasses.

Plate 9: Pasture typical of most of the Taupo Airport block, with many ephemeral flow gullies surrounded by broom and gorse scrub and shrubland. Note the scattered maritime pines.

Plate 10: Overview of southern part of the Taupo Airport Block, which is mostly pasture with broom and gorse common.

Plate 11: Pasture and broom shrubland and scrub near junction of Napier-Taupo Road and Crown Road.

Plate 12: Gully on far western side of the Rangatira E Block. The valley floor contains rank grasses, with mixed plantings of harakeke and silver birch.

Plate 13: Numerous shallow gullies occur across the Rangatira E Block.

Plate 14: Repeated pattern of shallow gullies at the Rangatira E Block.

Plate 15: An ephemeral gully system to the south of Broadlands Road.

Plate 16: Prostrate kanuka scrub at motorcycle track at Crown Road.