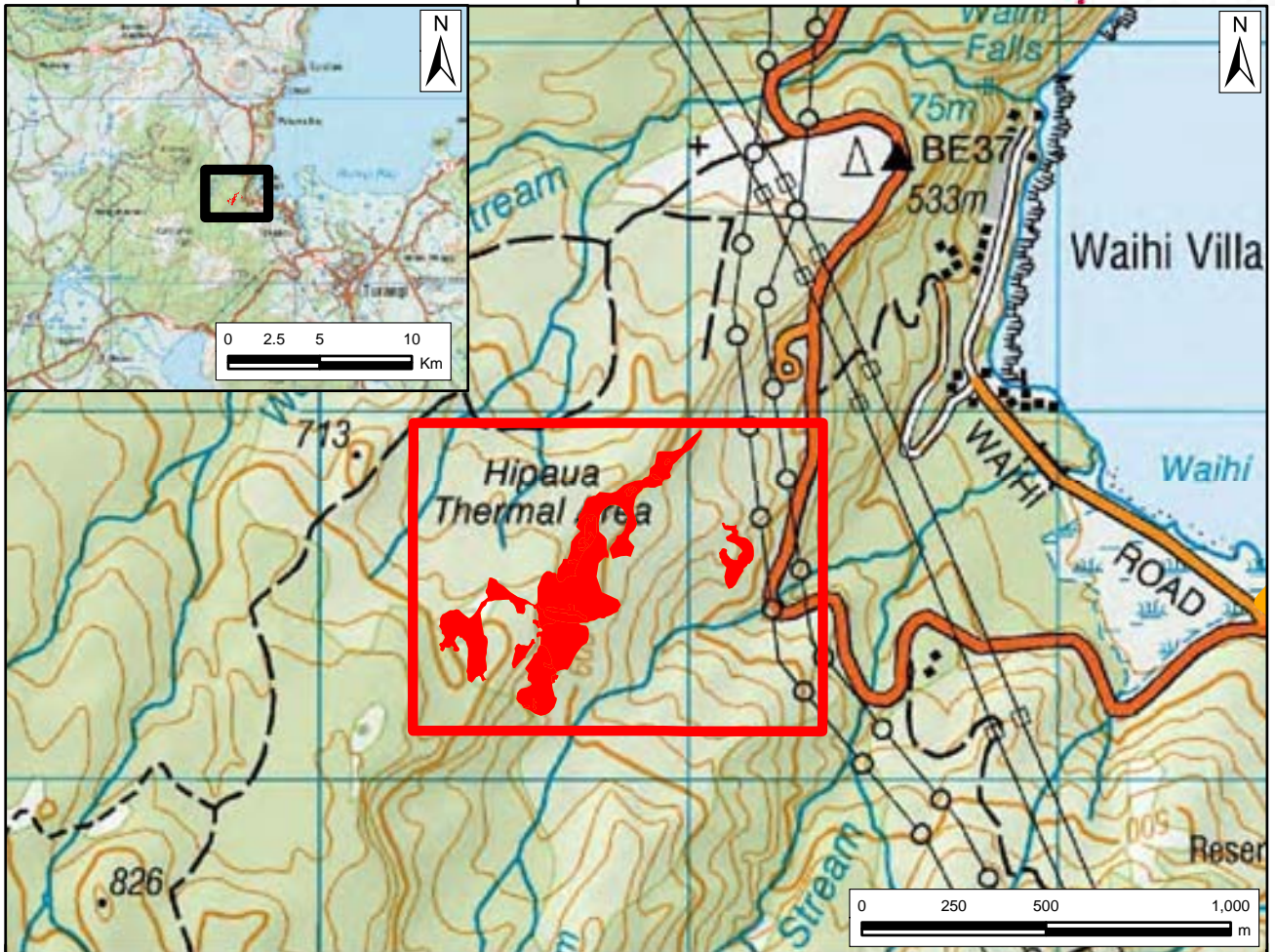


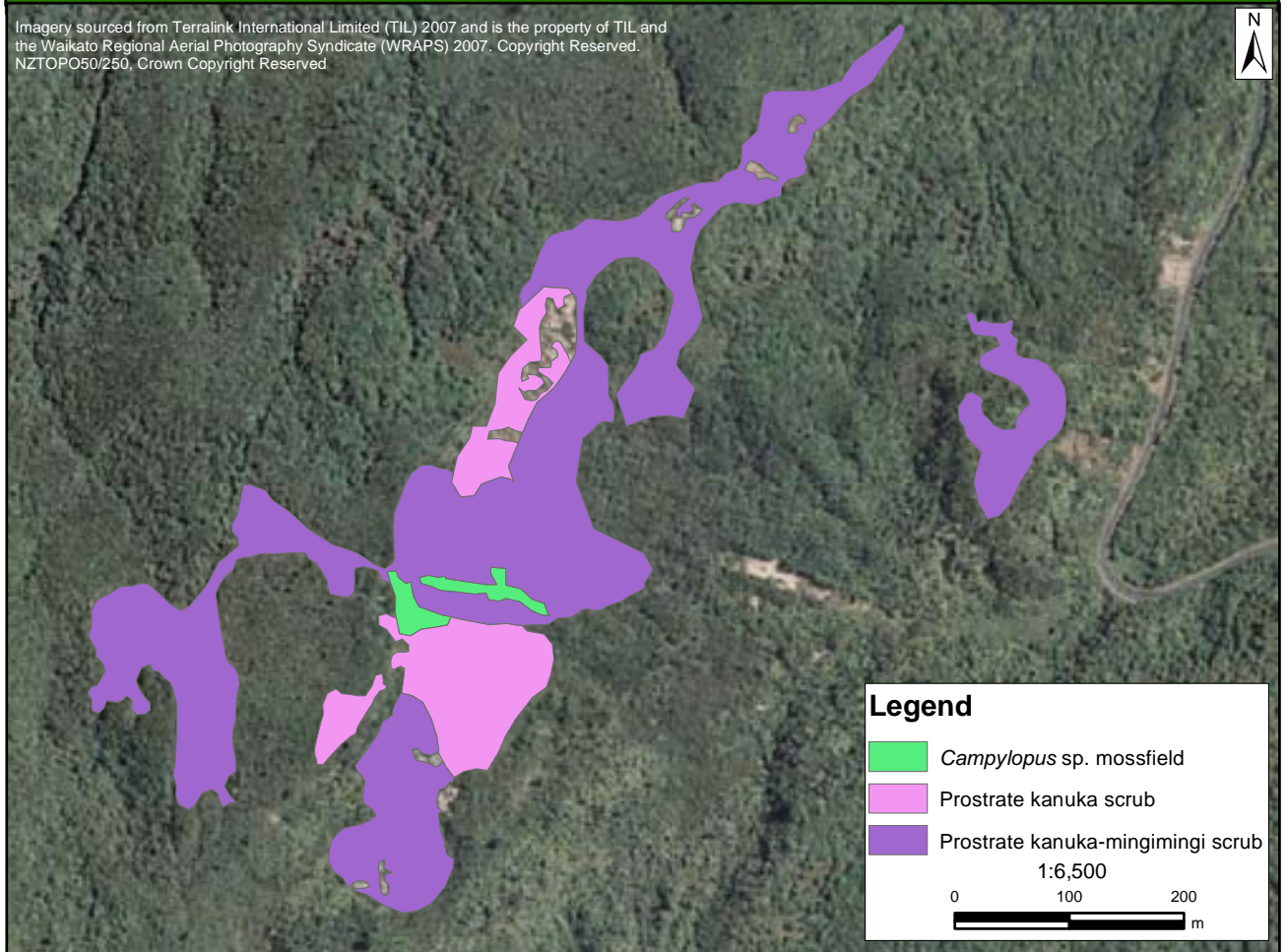
1.14 TOKAANU-WAIHI-HIPAUA GEOTHERMAL FIELD

List of Geothermal Sites

TOV02	Hipaua
TOV03/TOV04/	
TOV05/TOV06	Tokaanu Lakeshore Wetland
TOV07	Maunganamu West
TOV08	Tokaanu Thermal Park
TOV09	Tokaanu Urupa Mud Pools
TOV10	Maunganamu East
TOV11	Maunganamu North Wetland
TOV14	Tokaanu Tailrace Canal



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HIPAUA

Site Number: TOV02¹
Grid Reference: NZTopo50 BH35 368 845
GPS reference: NZTM E1836790 N5684476
Local Authority: Taupo
Ecological District: Tongariro
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 550-700 m
Extent of Geothermal Habitat: c.11.4 ha
Extent of Geothermal Vegetation: c.11.4 ha
Date of Field Survey: No survey. Observed from main road on 19 October 1999.

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
04.01 04.01.01	Prostrate kanuka-dominant scrub Prostrate kanuka scrub A dense cover of prostrate kanuka and local patches of <i>Campylopus</i> moss amongst scattered steaming fissures.	Hillslope	c.2.0 ha
04.01.02	Prostrate kanuka-mingimingi scrub Prostrate kanuka and mingimingi form a dense cover with occasional fumaroles. Karamu and whauwhaupaku occur locally, particularly at the margins of this type where the prostrate kanuka-mingimingi scrub merges with whauwhaupaku-karamu-kamahi/tutu scrub (outside of site). (Source: Given 1995)	Hillslope, shallow gullies	c.8.7 ha
14.02 14.02.02	<i>Campylopus</i>-dominant mossfield <i>Campylopus</i> sp. mossfield <i>Campylopus</i> sp. occurs in patches amongst steaming fissures.	Hillslope	c.0.3 ha
28.01 28.01.01	Nonvegetated raw-soilfield (not mapped) Nonvegetated raw-soilfield Heated bare soil (estimated from aerial photographs). Appears to be geothermal clays in site photographs, but should be assessed in the field.		c.0.4 ha

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009) and *Campylopus* sp., which are both restricted to geothermal areas (Given, 1995), are present. Other „At Risk’ geothermal plant species may be present.

Fauna: Unknown common indigenous and introduced bird species typical of the habitat are likely to be present.

Current Condition (1999 Assessment): A relatively unmodified site well buffered by indigenous vegetation. It contains a good example of a mosaic of geothermal vegetation zones

¹ Previously identified as T19/1 in Wildland Consultants (2004).

corresponding to soil temperatures (Given 1995).

**Threats/Modification/
Vulnerability:**

Invasive pest plants: Unknown. There appears to be some pampas visible on photographs (taken from a helicopter), provided by Waikato Regional Council (July 2002).

Human impacts: Human impacts are currently very low, and the site is virtually unaltered by human interference (Given 1995).

Grazing: Livestock have no access to this area.

Adjoining land use: Surrounded by indigenous vegetation on unprotected private land.

Site Change:

Recent change: Any change in site boundaries is primarily based on improved 2007 aerial photographs.

Historical: Photographs from 1941 (Historical photo: SN 178 Run 207 Photos 27, 1941) were assessed. The site has probably changed little since 1941, although boundaries between the different vegetation types present, particularly the boundary between geothermal scrub and non-geothermal scrub, are difficult to determine.

**Management
Requirements:**

The current low levels of human impact should be maintained and the site should be monitored regularly to ensure that it remains in good condition. If pampas is present, as indicated by photographs, then it should be controlled.

Significance Level: Regional (Table 1 - Criteria 1, 3, 5, 7, 9, 10; Table 2 - Factors 12, 14).

**Significance/
Justification:**

This site is of regional significance because it is an important habitat for an „At Risk’ species (prostrate kanuka) and is a relatively large area of a nationally uncommon habitat type, and is thus representative of the ecological character of the Waikato Region. It is likely to have significant ecological values, however these are unknown as it has not been possible to assess the site. The vegetation is highly intact, displaying good zonation and high indigenous component (Given 1995), and it is well buffered.

The site is part of an extensive natural area extending from the shores of Lake Taupo to the summit of Kakaramea, Tihia and Pihanga and including Lake Rotopounamu and Lake Rotoaira.

Notes:

Access to this site was not granted, and the descriptions and assessments have been compiled from existing literature, digital aerial photographs (2007) and a visual inspection from SH 41 using binoculars during the 1999-2000 survey.

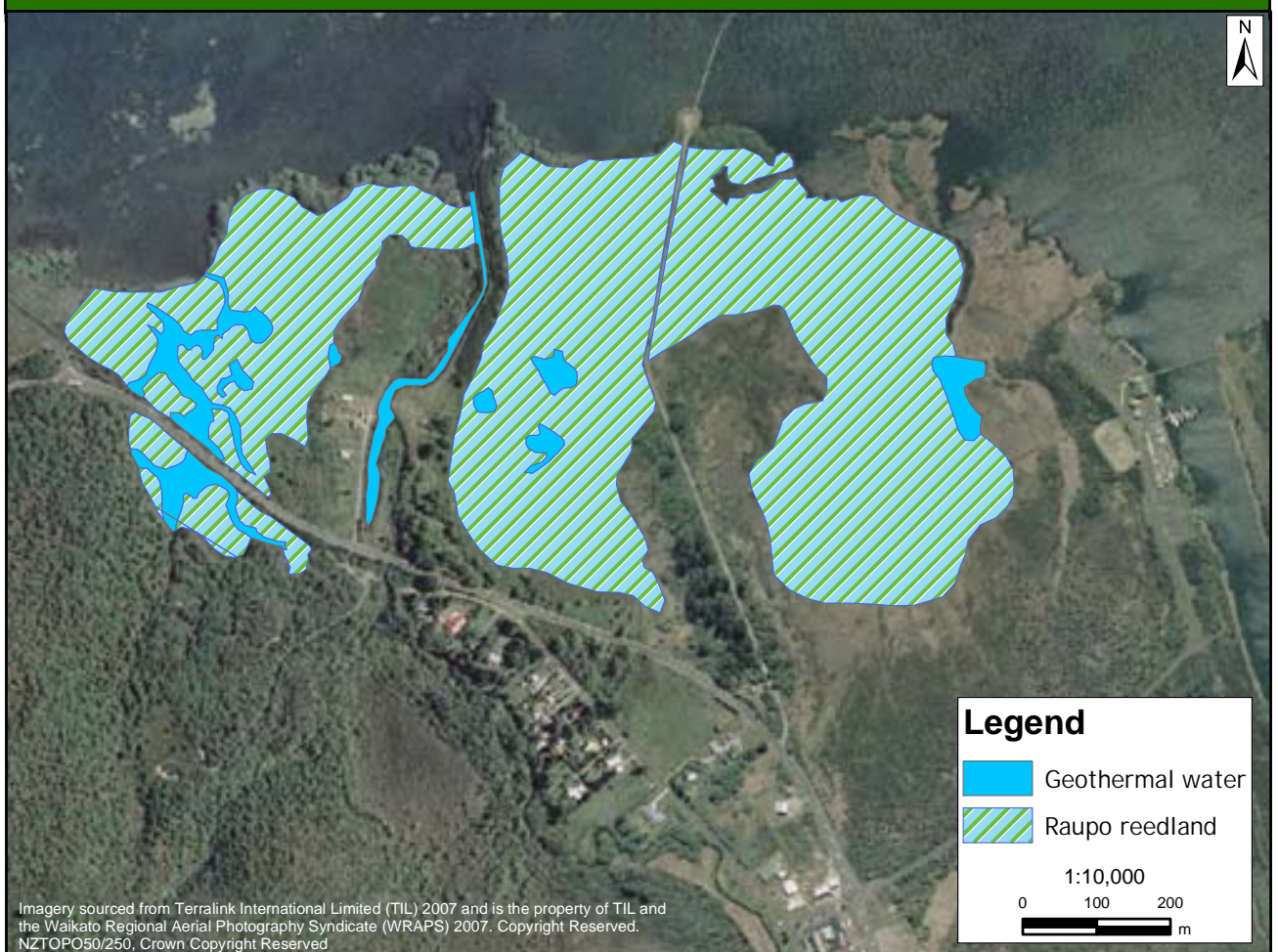
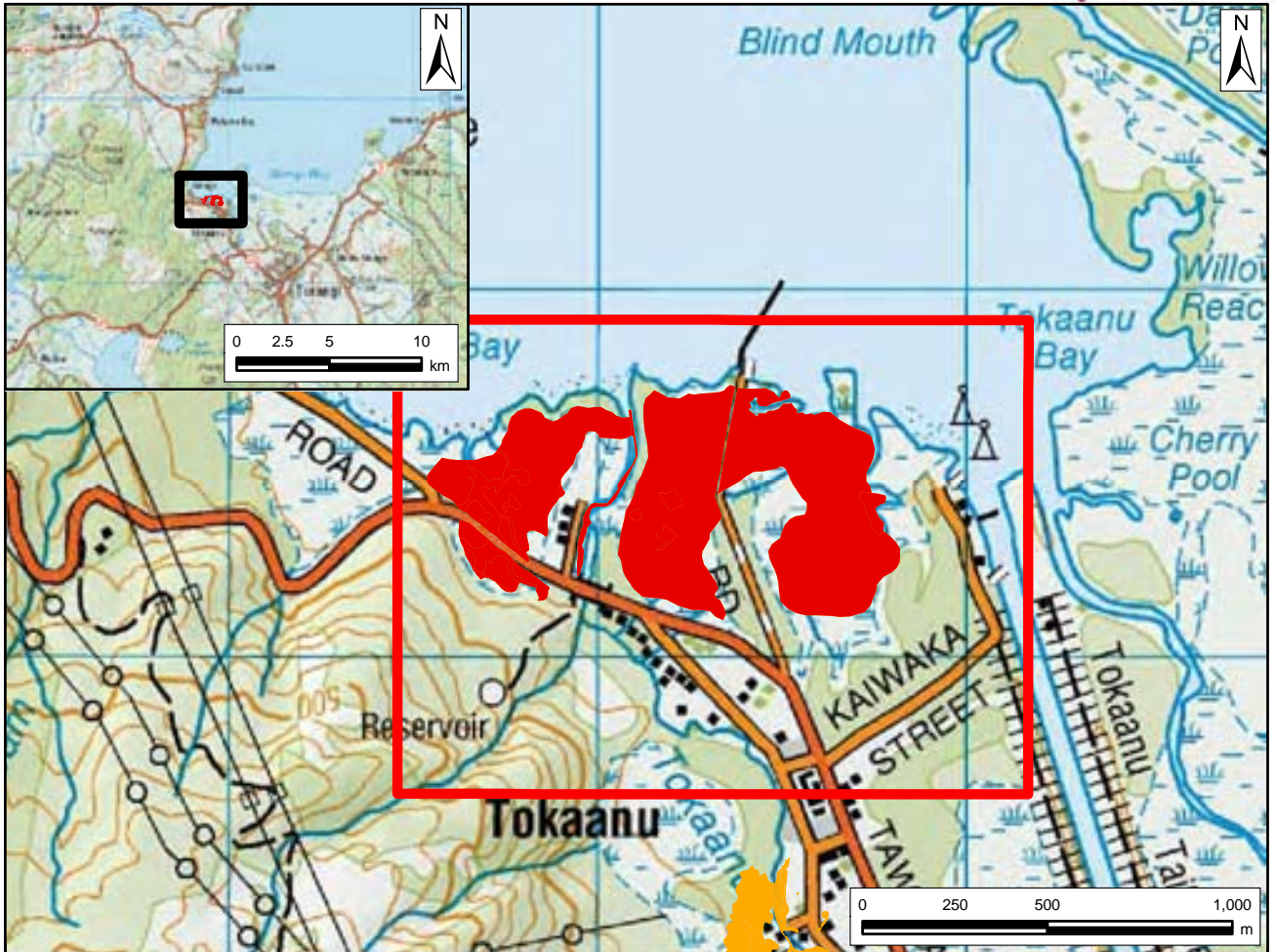
The 2007 aerial photographs used for this report are of considerably higher quality than those used in the 2004 report on geothermal vegetation in the Region (Wildland Consultants 2004), and as a result, additional areas were

added to the site. However, if site access is granted in the future, the boundaries should be reassessed, and the site should be inspected in detail for all features.

Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region and this site was classed as Category A - the highest category.

References:

Department of Conservation 1998; Given 1995 & 1996; Wildland Consultants 2004.



TOKAANU LAKE SHORE WETLAND

Site Number: TOV03/TOV04/TOV05/TOV06¹
Grid Reference: NZTopo50 BG35 394 024
GPS reference: NZTM E1839400 N5702400
Local Authority: Taupo
Ecological District: Taupo; Tongariro
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Unprotected private land and Protected (Tokaanu Recreation Reserve)
Altitude: c.340 - 360 m
Extent of Geothermal Vegetation: c.42.4 ha
Date of Field Survey: 13 February 2007

Code	Type	Landform	Extent
11.01 11.01.01	Raupo-dominant reedland Raupo reedland An extensive area of raupo reedland. A small population of arrow grass was viewed from the road on 13 February 2007. Crack willow and grey willow were recorded in this wetland, particularly on the margins of Lake Taupo and recently reclaimed wetland. Steam could be seen rising from the wetland at some locations, but access to most sites is very difficult.	Lake margin wetland	c.39.1 ha
22.01 22.01.01	Geothermal water Geothermal water (occurs within 11.01.01, not mapped) Geothermally-influenced water. Steam was viewed rising from this water on 13 February 2011.		

Indigenous Flora: No „Threatened’ or „At Risk’ species were noted during the 2007 survey; however a full field survey has not been carried out due to the difficulty of accessing most of this site.

Fauna: One „Threatened’ and two „At Risk’ (Miskelly *et al.* 2008) bird species were recorded in this wetland; New Zealand dabchick („Threatened-Nationally Vulnerable’), spotless crake („At Risk-Relict’), and North Island fernbird („At Risk-Declining’). Australasian bittern („Threatened-Nationally Critical’ in Miskelly *et al.* 2008) are also present in the area (W. Shaw, Wildland Consultants, pers. comm. 2009).

Current Condition (2007 Assessment): This wetland is in excellent ecological condition. Pest plants are relatively rare in most of this site, with willow species (crack willow and grey willow) noted, particularly on site margins. Some land has been reclaimed for road construction, pasture development, and canal construction.

**Threats/Modification/
Vulnerability:**

Invasive pest plants (2007 Assessment): Grey willow and crack willow were recorded in the wetland. These species should be controlled.

¹ Previously identified as T19/9, T19/10, T19/11, T19/12 in Wildland Consultants (2007).

Human impacts (2007 Assessment): Drains have been constructed through parts of the wetland. Parts of the wetland have been converted to pasture and residential housing, and roads have been constructed to access the lake.

Grazing (2007 Assessment): No grazing is known to occur within the remaining wetland.

Adjoining land use (2007 Assessment): Farming; roads; Lake Taupo; wetland; residential.

Site Change:

Recent change: Not assessed. No significant change is known to have taken place in this wetland in the last ten years.

Historical: An inspection was undertaken of 1941 aerial photographs of this site (Historical photos: SN 178 Run 207 Photos 29-31, 1941). While little evidence of change is seen when 1941 and 2007 aerial photographs are compared, a canal (Tokaanu Tailrace Canal) that has been constructed through the eastern part of the wetland is likely to have changed the character of parts of the wetland. Land has been reclaimed on each side of the canal. An area that was in pasture in 1941, to the east of the road that leads to the boat ramp and jetty (Wharf Road), has now reverted to wetland. Willows have become established alongside this road since 1941. No willows are obvious in 1941 aerials, but are common on lake margins in 2007 aerial photographs.

Management Requirements: Control of willows and any other pest plants should be undertaken in this wetland.

Significance Level: National (Table 1 -, Criteria 3, 5, 6, 7, 9, 10, 11; Table 2 -, Factors 7, 8).

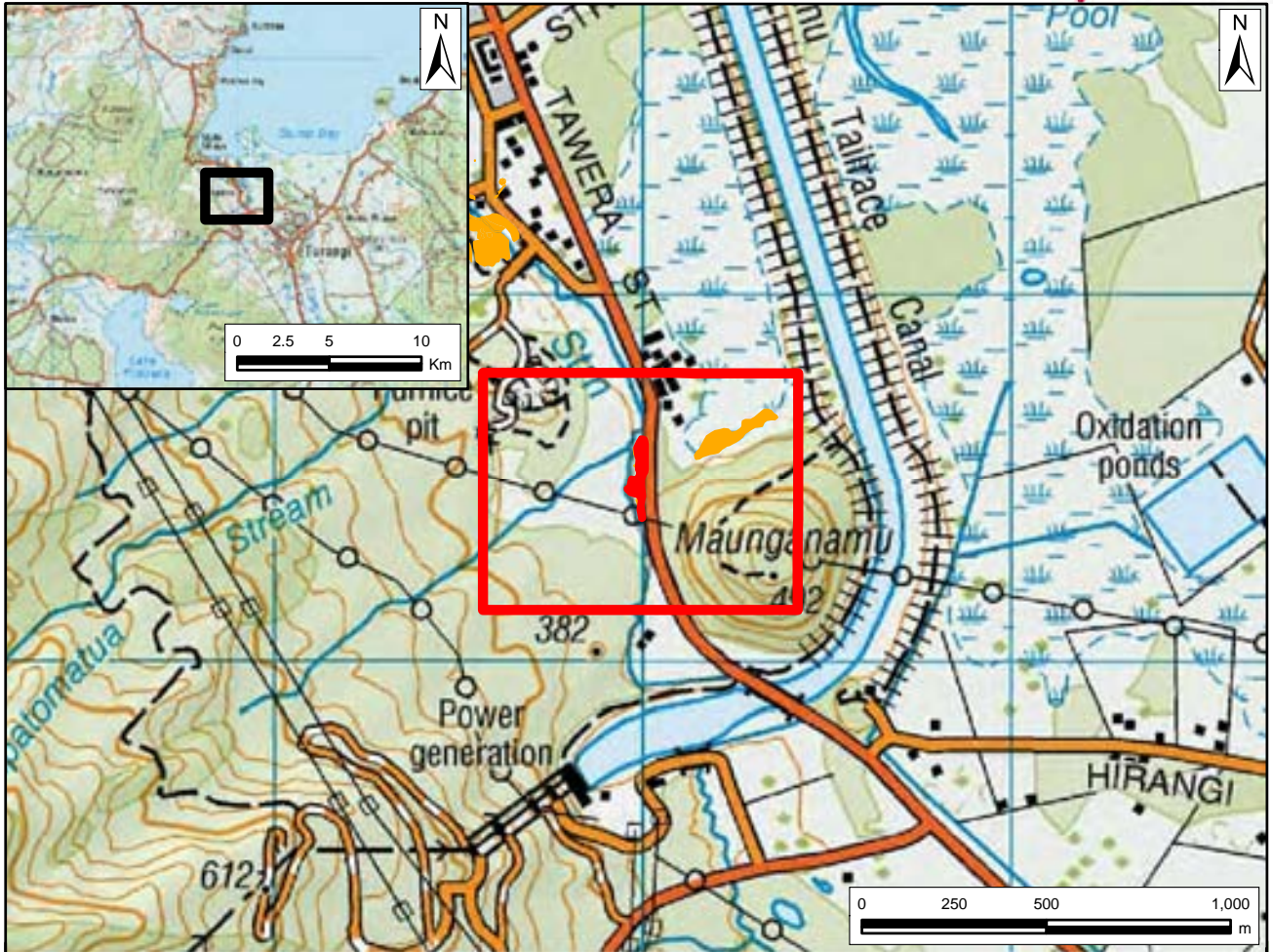
Significance Justification: The site is of national significance because it provides habitat for a „Threatened’ species (Australasian bittern), and because it is a good quality example of a nationally uncommon habitat type (i.e. geothermal). It is one of the best examples of a wetland-geothermal sequence in Taupo Ecological District and is part of a large freshwater wetland in which is in excellent ecological condition.

Notes: The temperature of the substrate was measured in many locations in the eastern part of the site, but no evidence of geothermal vegetation was found with temperatures ranging from 17-19°C. However, extensive areas of geothermal vegetation were found further inland.

Part of the area of raupo reedland was viewed from the road and entered by kayak on 13 February 2007. This is an extensive area of wetland vegetation and it is likely geothermal habitat is scattered throughout the site. The site was also viewed from State Highway 41 on 16 February 2007. Steam was seen rising from open water at several locations within this site. Based on these observations, it is therefore considered that extensive areas of geothermal water and geothermal wetland are present.

This site was not assessed in Wildland Consultants (2004 & 2007).

References: Bromley & Mongillo 1991; Hochstein 2007; Wildland Consultants 2007.



MAUNGANAMU WEST

Site Number: TOV07¹
Grid Reference: NZTopo50 BH35 400 825
GPS Reference: NZTM E1839981 N5682478
Local Authority: Taupo
Ecological District: Taupo; Tongariro
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Protected (Tokaanu Public Garden Reserve) and unprotected private land
Altitude: 360 m
Extent of Geothermal Habitat: c.0.6 ha
Extent of Geothermal Vegetation: c.0.6 ha
Date of Field Survey: 13 February 2007

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
11.01	Raupo-dominant reedland	Wetland	c.0.6 ha
11.01.01	Raupo reedland Occasional crack willow occurs over raupo reedland in association with <i>Baumea rubiginosa</i> , <i>Schoenoplectus tabernaemontani</i> , <i>Eleocharis acuta</i> , pohue, lotus, and creeping bent. Blackberry and Japanese honeysuckle are common on margins. Soil temperatures at 10 cm depth were around 22.5° and 25.4°C (measured with the thermocouple probe). At 1 m depth temperatures were recorded up to 49.1 °C.		

Geophysical Assessment: Several airborne IR anomalies were recorded to occur along the eastern banks of the Tokaanu Stream along a c.200 m long stretch to the north of 6 244 000 m N. Thermal springs and minor mud pools were mapped by Healy (1942) within this stretch.

Indigenous Flora: No „Threatened’ or „At Risk’ species as listed in de Lange *et al.* (2009) are known from this site.

Fauna: Common indigenous and introduced species typical of the habitats were present. The wetland vegetation is likely to provide habitat for fernbird and spotless crane (classed as „At Risk-Declining’ and „At Risk-Relict’ respectively in Miskelly *et al.* 2008), in conjunction with the adjacent large area of wetland habitat.

Current Condition (2007 Assessment): Weeds are present on the margins, and occasional crack willow is present in the wetland.

¹ Previously identified as T19/6 in Wildland Consultants (2004 and 2007a).

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2007 Assessment):* Blackberry (1-5% cover); Japanese honeysuckle (1-5% cover); and crack willow (1-5% cover).

*Human impacts
(2007 Assessment):* There is a road within 10 m of the site. A culvert is also present.

*Grazing
(2007 Assessment):* This site is not grazed by stock.

*Adjoining land use
(2007 Assessment):* Tokaanu Stream and State Highway.

Site Change:

Recent change: Not assessed. Any change not likely to be significant.

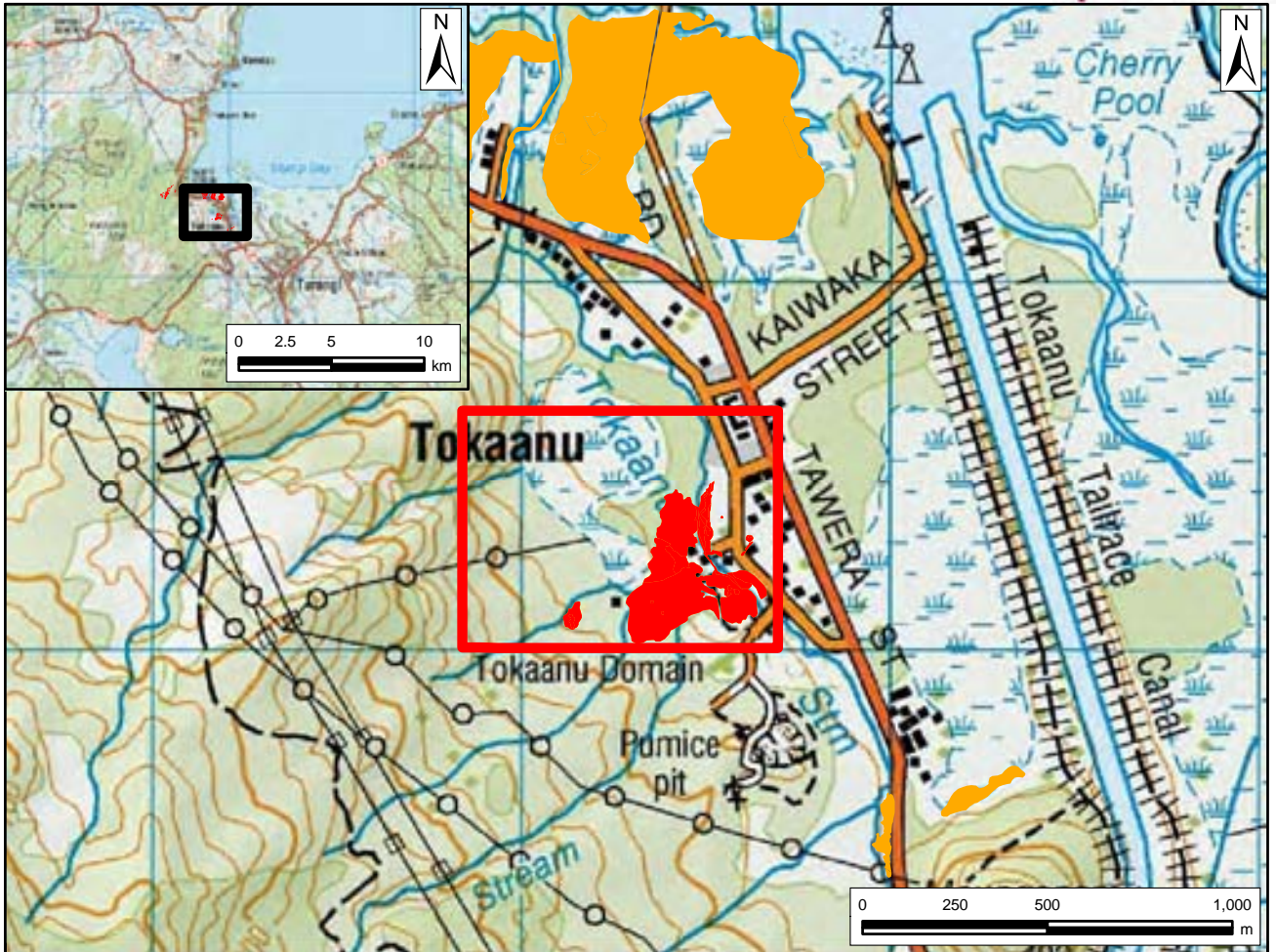
Historical: This site is too small to see any evidence of change since 1941 (Historical photos: SN 178 Run 207 Photos 29-31, 1941).

Management Requirements: Control of pest plants (particularly crack willow) will maintain the ecological values of the site.










Significance Level: Regional (Table 1 - Criteria 5, 6, 10; Table 2 - Factor 9).

Significance Justification: This site is of regional significance because it is protected and managed by the Department of Conservation and it forms a small part of an extensive ecological sequence that extends from the shores of Lake Taupo to the summit of Kakaramea, Tihia and Pihanga and includes Lake Rotopounamu and Lake Rotoaira. This ecological sequence includes extensive areas of geothermal habitat.

References: Bromley & Mongillo 1991; Wildland Consultants 2004 & 2007a.

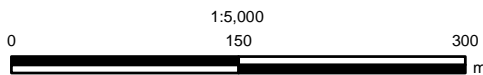


Legend

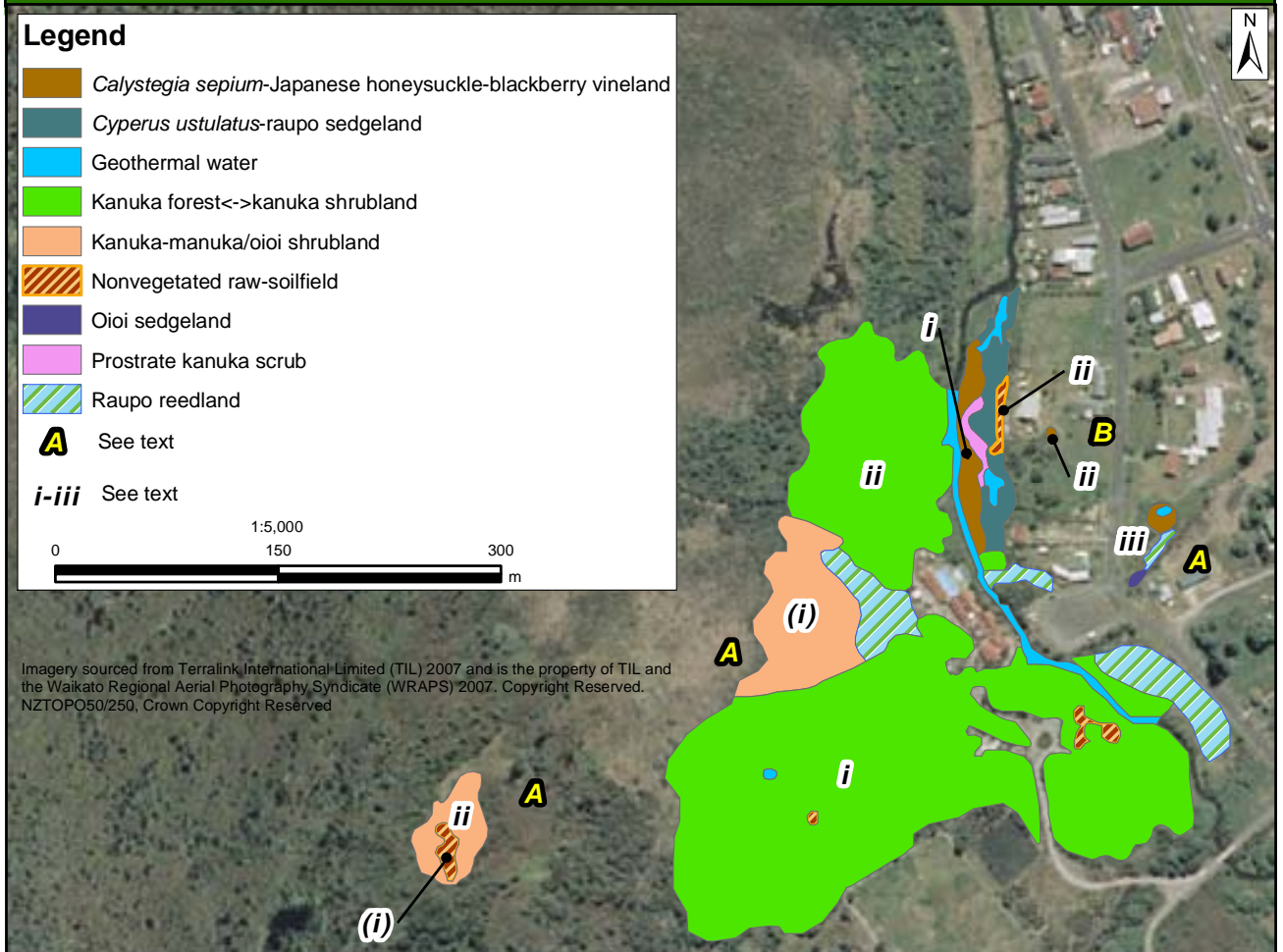
-  *Calystegia sepium*-Japanese honeysuckle-blackberry vineland
-  *Cyperus ustulatus*-raupo sedgeland
-  Geothermal water
-  Kanuka forest<->kanuka shrubland
-  Kanuka-manuka/oioi shrubland
-  Nonvegetated raw-soilfield
-  Oioi sedgeland
-  Prostrate kanuka scrub
-  Raupo reedland

A See text

i-iii See text



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TOKAANU THERMAL PARK

Site Number: TOV08¹
Grid Reference: NZTopo50 BH35 364 833
GPS reference: NZTM E1839472 N5683151
Local Authority: Taupo
Ecological District: Taupo
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Protected (Tokaanu Thermal Park Recreation Reserve administered by DOC)
Altitude: c.360 m
Extent of Geothermal Habitat: c.7.8 ha
Extent of Geothermal Vegetation: c.7.6 ha
Date of Field Survey: 23 August 2004 (partly updated in February 2007)

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
01.04 01.04.11	<p>Kanuka forest</p> <p>Kanuka forest ↔ kanuka shrubland</p> <p>(i) Kanuka forest forms the vegetation cover over c.80% of this vegetation unit. Kanuka up to c.7 m high with a diameter at breast height of c.10-15 cm comprises the canopy, with an understorey of kanuka, mingimingi and oioi, with scattered turutu, hound's tongue fern, <i>Cyperus ustulatus</i> and manuka. Mud pools and hot water pools are common beneath the kanuka canopy. Kanuka shrubland forms the vegetation cover over the remaining c.20% of this area and generally occurs around the site margins. Kanuka shrubs are common with local <i>Cyperus ustulatus</i> and narrow-leaved carpet grass. Moss (including <i>Wijkia extenuata</i> and <i>Ptychomnion aciculare</i>) often form a dense groundcover. Manuka and mingimingi are abundant in both vegetation types. Around cooking sites and disturbed areas, weeds, e.g. Japanese honeysuckle, yucca (<i>Yucca</i> sp.), blackberry, broom, and various ornamental trees such as rhododendron (<i>Rhododendron</i> sp. (unidentified)), are present. Other common species present include kohuhu, whauwhaupaku, turutu, karamu, wheki, swamp kiokio and <i>Paesia scaberula</i>.</p> <p>(ii) Kanuka forest to 4 m tall. Mud pools and hot springs are common throughout with several patches of nonvegetated raw-soilfield. Soil temperatures of up to 90.5°C were recorded at 50 cm depth with a fluke and soil probe in this vegetation type. Ivy, blackberry, <i>Microsorium pustulatum</i>, turutu, Japanese honeysuckle and mingimingi are common in places. Atakororeke</p>	Flat	c.5.7 ha

¹ Previously identified as T19/3 in Wildland Consultants (2004 and 2007a).

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
	Stream, a geothermal stream, passes through this vegetation type. The approximate location of this stream is shown on the site map. The surface temperature of water in the stream was 23.0°C, but temperatures increased to 58.1°C (fluke thermocouple) at 10 cm depth in substrate. <i>Cyperus ustulatus</i> and kiokio are common along stream margins beneath a kanuka canopy. Blackberry becomes thick around stream margins c.100 m upstream of where the stream flows into the Tokaanu River. Prostrate kanuka was common, particularly towards the northern portion of this site near stream margins.		
03.03 03.03.01	Mixed exotic vineland Pohue-Japanese honeysuckle-blackberry vineland (i) A dense vineland comprising pohue and Japanese honeysuckle growing over blackberry. Patches of tall fescue are common. Mud pools and hot springs are scattered throughout this vegetation type. (ii) A small mud pool hole has a small bubbling spring (temperature recorded of 88°C). (iii) Vineland surrounding a hot spring.	River margins; mud pool; hot spring	c.0.2 ha
04.01 04.01.01	Prostrate kanuka-dominant scrub Prostrate kanuka scrub Prostrate kanuka shrubland with a canopy height of 1-2 m. Pohue, Japanese honeysuckle and blackberry are common on margins.	Flat	<0.1 ha
05.04 05.04.07	Kanuka-dominant shrubland Kanuka-manuka/oioi shrubland (i) Emergent kanuka is common in association with scattered manuka over a dense cover of oioi. Small patches of nonvegetated raw-soilfield are also present in places. (ii) A canopy dominant with manuka (height of 3 m), with occasional kanuka and mingimingi, over an understorey of oioi and sinter. The site is surrounded by dense blackberry scrub.	Hillslope	c.0.8 ha
09.02 09.02.06	<i>Cyperus ustulatus</i>-dominant sedgeland <i>Cyperus ustulatus</i>-raupo sedgeland Dense <i>Cyperus ustulatus</i> and raupo to 2.5 m. Japanese honeysuckle and blackberry common on margins. Patches of sinter and nonvegetated raw-soilfield are common.	Wetland	c.0.2 ha
09.08 09.08.01	Oioi-dominant sedgeland Oioi sedgeland Oioi is dominant, with local <i>Eleocharis acuta</i> , <i>Schoenus maschalinus</i> and adventive grasses, including creeping bent and Yorkshire fog.	Wetland	<0.1 ha
11.01 11.01.01	Raupo-dominant reedland Raupo reedland Raupo forms a dense reedland, with scattered <i>Carex virgata</i> and <i>Schoenoplectus tabernaemontani</i> , and a few saplings of grey willow and crack willow. <i>Cyperus</i>	Flat	c.0.5 ha

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
	<i>ustulatus</i> is locally dominant and blackberry is common along the road margin. Grey willow is present.		
14.02 14.02.02	<i>Campylopus</i>-dominant mossfield (not mapped) <i>Campylopus</i> sp. mossfield	Pools; sinter terraces	
22.01 22.01.01	Geothermal water Geothermal water Hot stream and hot springs. Site was viewed from a distance and geothermal habitat was estimated from aerial photography.	Stream; hot springs; open water	c.0.2 ha
28.01 28.01.01	Nonvegetated raw-soilfield Nonvegetated raw-soilfield Boiling water, sinter terraces, hot pools, and boiling mud. Scattered exotic grasses (e.g. narrow-leaved carpet grass, annual poa) and herbs (e.g. wild portulaca) were present. <ul style="list-style-type: none"> • A sinter terrace with oioi common on margins. • Nonvegetated raw-soilfield (thermally altered soils) with common raupo and prostrate kanuka and <i>Cyperus ustulatus</i> on margins. Hot springs and mud pools are common. Temperatures of up to 96.7°C (fluke thermocouple) were recorded. 	Flat; gently sloping; hillslope	c.0.1 ha

Geophysical Assessment¹:

Overview of field work and background:

Several poorly-known thermal manifestations of the Tokaanu geothermal field were visited on Wednesday 7 February 2007. This was a hot, sunny day with the air temperature increasing from c.23°C at 10.00 am to almost 30°C at 2.00 p.m.

During the second half of the day selected manifestations in the Tokaanu Domain were inspected, along with the old discharging bore to the west of the Domain (BH2).

Visit of two selected manifestations in the Tokaanu Domain:

Manifestations in the Tokaanu Domain which discharged water at boiling temperature in July 2005 were revisited. The first one was the old Taumatapuhipuhi geyser where geysering activity had ceased in 1966 shortly after commissioning of the first bath house well. The discharge changed then to some periodic ebullient discharge of boiling water as seen by the author on 14 July 2005. When revisited on 7 February 2007, the ebullient cycle had not changed - the temperature (98.5°C) of the discharged hot water is still close to local boiling point.

However, a previously boiling spring, located halfway between Taumatapuhi and the bath Admin. Building, and which discharged at c.100°C in July 2005 (see Hochstein 2005), had cooled down and discharged hot water at 72.6°C when visited on 7 February 2007.

Visit of the old 'Healy Bore (BH 2):

This c.97 m deep well lies at the western boundary of the Department of Conservation-administered Tokaanu Thermal Park. The well was drilled in 1942 and was sited by Mr. J. Healy. It freely discharges some deep thermal

¹ Hochstein 2007

water (probably since 1951) which has created impressive, c.600 m² large silica sinter flats at E1839134 N5683066, covered in part by yellow algae. The site was visited to assess its thermal vegetation. Boiling water is discharged at the top of a sinter mound (c.3 m diameter). The discharge rate of the thermal water was found to be c.1-1.5 kg/s. A similar rate had been reported by previous studies, summarized in Hochstein (2005), a summary which includes a short history of this manifestation. The recent growth of shrubs, blackberry, and bracken has made BH 2 an almost inaccessible but still a spectacular site.

Indigenous Flora:

A moderate sized population of *Korthalsella salicornioides* occurs at this site (Beadel & Bill 2000). *Korthalsella salicornioides* is a semi-parasitic mistletoe classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* (2009). *Schizaea dichotoma* (also classed as an „At Risk-Naturally Uncommon’ species in de Lange *et al.* 2009) known from kauri forests of Northland and South Auckland, and locally at geothermal sites, is also present (Beadel & Bill 2000). This is the southern limit of distribution for this species. (Note no plants of *Korthalsella salicornioides* or *Schizaea dichotoma* were recorded in the 2004 or 2007 survey.

A good sized population of prostrate kanuka (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009) is present.

Given (1995) recorded *Christella* aff. *dentata* (“thermal”) (classed as „At Risk-Declining’ in de Lange *et al.* 2009) from this site, but it is now considered extinct at this site. *Nephrolepis flexuosa* (classed as „At Risk-Declining’ in de Lange *et al.* 2009) was recorded from this site in 1987 (de Lange *et al.* 2009), but has not been recorded in subsequent surveys and is also presumed extinct at this site.

Fauna:

North Island fernbird (classed as „At Risk-Declining’ in Miskelly *et al.* 2008) are present at this site. Other birds present include tui, bellbird and grey warbler.

**Current Condition
(2007 Assessment):**

Historical photographs held at the tourism complex show that much of the present vegetation cover has developed over the last few decades. The dynamics of this site are not well understood and it is likely that the current vegetation will continue to evolve and change as the thermal activity changes. Continuing draw-off of heat or hot water from the site is likely to have ongoing impacts. However the vegetation is of relatively good quality, and is contiguous with an extensive wetland to the west. Pest plants are common in surrounding vegetation and geothermal margins. The site is highly dissected by formed walking tracks.

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2007 Assessment):*

This site is vulnerable to pest plant invasion along track margins. The main weed species are Japanese honeysuckle (1-5% cover), ivy (<1-5 % cover), exotic grasses (1-5% cover), grey willow (1-5%) and bamboo (<1% cover). Several ornamental species have been planted around a geyser and bathing area. The spread of these species should be regularly monitored and control implemented as required.

Human impacts (2007 Assessment): Human impacts relate to the draw-off of heat or hot water which is likely to have ongoing impacts and high use from walkers; however the tracks appear to be generally adhered to. Indigenous species have been planted in parts of this reserve.

Grazing (2007 Assessment): Livestock are not a threat to this area.

Adjoining land use (2007 Assessment): Indigenous vegetation; blackberry scrub; residential; farm land; recreation facilities (swimming baths, tracks).

Site Change:

Recent change: Any changes to the extent of geothermal vegetation are likely to be minor. Additional areas were added to this site in 2007, based on additional information on geothermal vegetation. However, this does not represent real change. The site has not been re-assessed in the field.

Historical: An inspection was made of black and white aerial photographs (Historical photo: SN 178 Run 207 Photos 29-31, 1941). The Healy Bore to the south of the site, and its associated geothermal vegetation, was not evident on aerial photographs in 1941, as this was drilled in the 1950s (see Geophysical notes above). The boundary of geothermal surface manifestations at Tokaanu are difficult to determine on historical photos, as much of the site boundary is masked by wetlands. However, it is evident that some geothermal vegetation has been cleared for conversion to pasture, and the establishment of a network of walking tracks is evident on the geothermal site. There also appears to be significantly more bare ground around the main tourist part of the geothermal site in 1941 than there is today, indicating that the character of this site has changed since the 1940s, and may be less active than in the recent past.

Management Requirements: The site should be kept weed free.

Significance Level: A: Regional (Table 1 - Criteria 1, 3, 5; 6, 7, 9, 10; Table 2 - Factors 12, 14).
B: Local (Table 1 - Criterion 5; Table 2 - Factor 19)

Significance Justification: Most of the site is ranked as being of Regional Significance (marked as A on map). The site contains populations of three species ranked as „At Risk’ (*Korthalsella salicornioides*, prostrate kanuka, and *Schizaea dichotoma*). The site is protected under the Reserves Act (1977) and comprises a relatively large example of geothermal vegetation, including a wide diversity of habitat types.

This site is also part of an extensive natural area extending from the shores of Lake Taupo to the summit of Kakaramea, Tihia and Pihanga and including Lake Rotopounamu and Lake Rotoaira.

A small part of the site (marked as B on map) is of local significance because it contains geothermal habitat, a nationally uncommon habitat type, however it is very small and highly modified with no indigenous plant species recorded.

Notes: Given (1996) assessed the botanical value of many of the geothermal sites

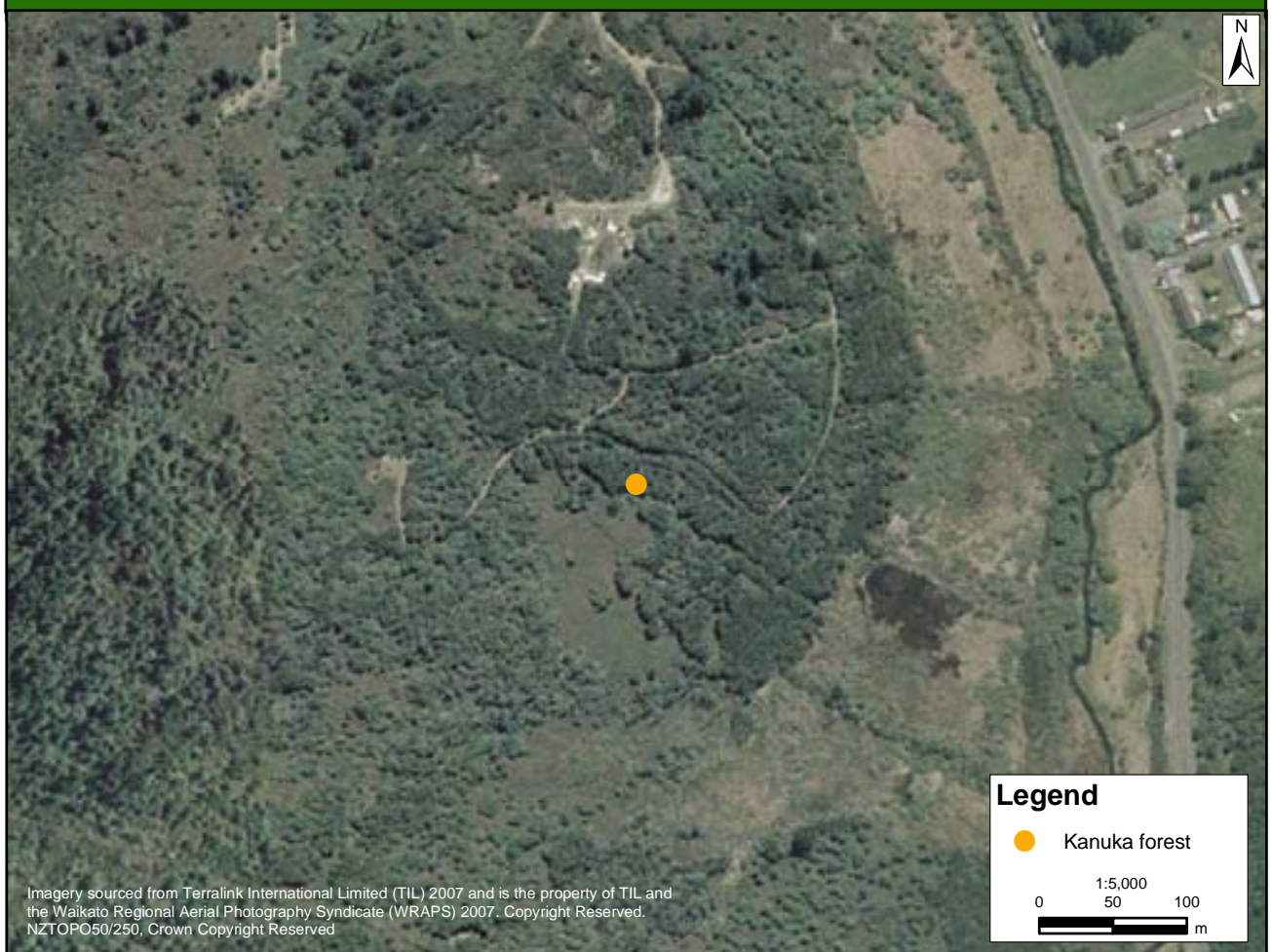
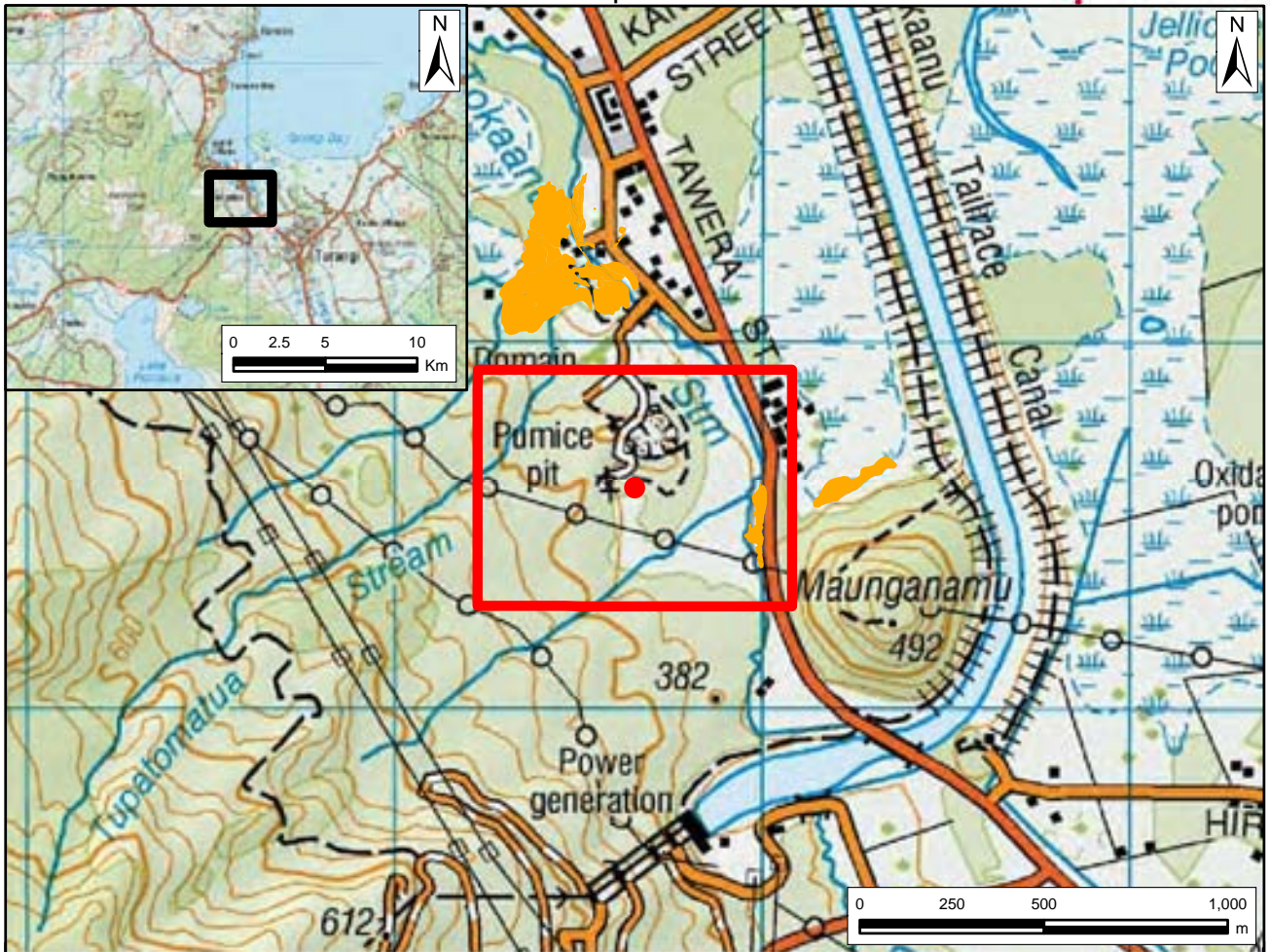
in the Waikato Region and in this study, this site was classed as Category B - the second highest category.

It is difficult to safely undertake a detailed inspection of the site because of the geothermal activity which makes it difficult to determine the exact boundary of geothermal activity in the wetland. However, the geothermal area mapped in this report is similar to the area shown in IR anomalies in Bromley & Mongillo 1991, and Hochstein 2007, Figure 3.2, Page 73).

Two pools within this site are listed in Waikato Regional Council (unpublished) as Taumatapuhipuhi spring (an unfenced pool of *c.*75°C, which periodically erupts hot water) and Takarea No. 5 (a fenced pool of *c.*75°C).

References:

Anon. no date; Beadel & Bill 2000; Department of Conservation 1997; Given 1995 & 1996; Healy 1942; Hochstein 2007; Waikato Regional Council (unpublished); Wildland Consultants 2004 & 2007a.



Legend

- Kanuka forest

1:5,000

0 50 100 m

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TOKAANU URUPA MUD POOLS

Site Number: TOV09¹
Grid Reference: NZTopo50 BH35 397 826
GPS Reference: NZTM E1839651 N5682603
Local Authority: Taupo
Ecological District: Tongariro
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Protected (Tokaanu Hot-Springs Reserve)
Altitude: c.380 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 7 February 2007

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
01.04	Kanuka-dominant forest	Mud pool	<0.1 ha
01.04.03	Kanuka forest Kanuka forest to c.7 m tall overhangs two mud pools. There is occasional whauwhaupaku and mapou present in the canopy. There is scattered turutu, mingimingi, and blackberry around the mud pools (one 5 × 5 m and the other 4 × 4 m).		

Geophysical Assessment²:

These pools are shown on a map in a 1942 paper (see Figure 2 in Healy 1942) where they are listed as „two larger mud pots’. The mud pools were visited late afternoon on 7 February 2007 and were found to lie close to E1839752 N5682555, a position which is similar to that shown in the 1942 map by Healy. The pools are within kanuka forest, c.30 m to the east of a track and about 250 m to the southeast of the cemetery; the pools can be located by the sound of their bubbles. The western „mud pot’ has a diameter of c.4 m; the one adjacent to the east is c.5 m wide. The level of the larger pool is c.0.5 m below that of the smaller one. A maximum temperature of 87.4°C was measured with a thermocouple device in a breached „mud volcano crater’ near the northeast rim of the smaller eastern pool; the temperature of upwelling liquid mud in other „bubbles’ in both pools varied between 74° and 84°C (IR gun). Since little steam was visible, it can be inferred that almost all vapour is condensed by the liquid mud and that the driving agent of the „bubbles’ is gas, most likely CO₂ gas. There was no H₂S smell. The pH of the liquid mud was found to be close to neutral (assessed with a pH paper strip).

Indigenous Flora:

Kanuka, turutu, and mingimingi are species typical of geothermal habitat.

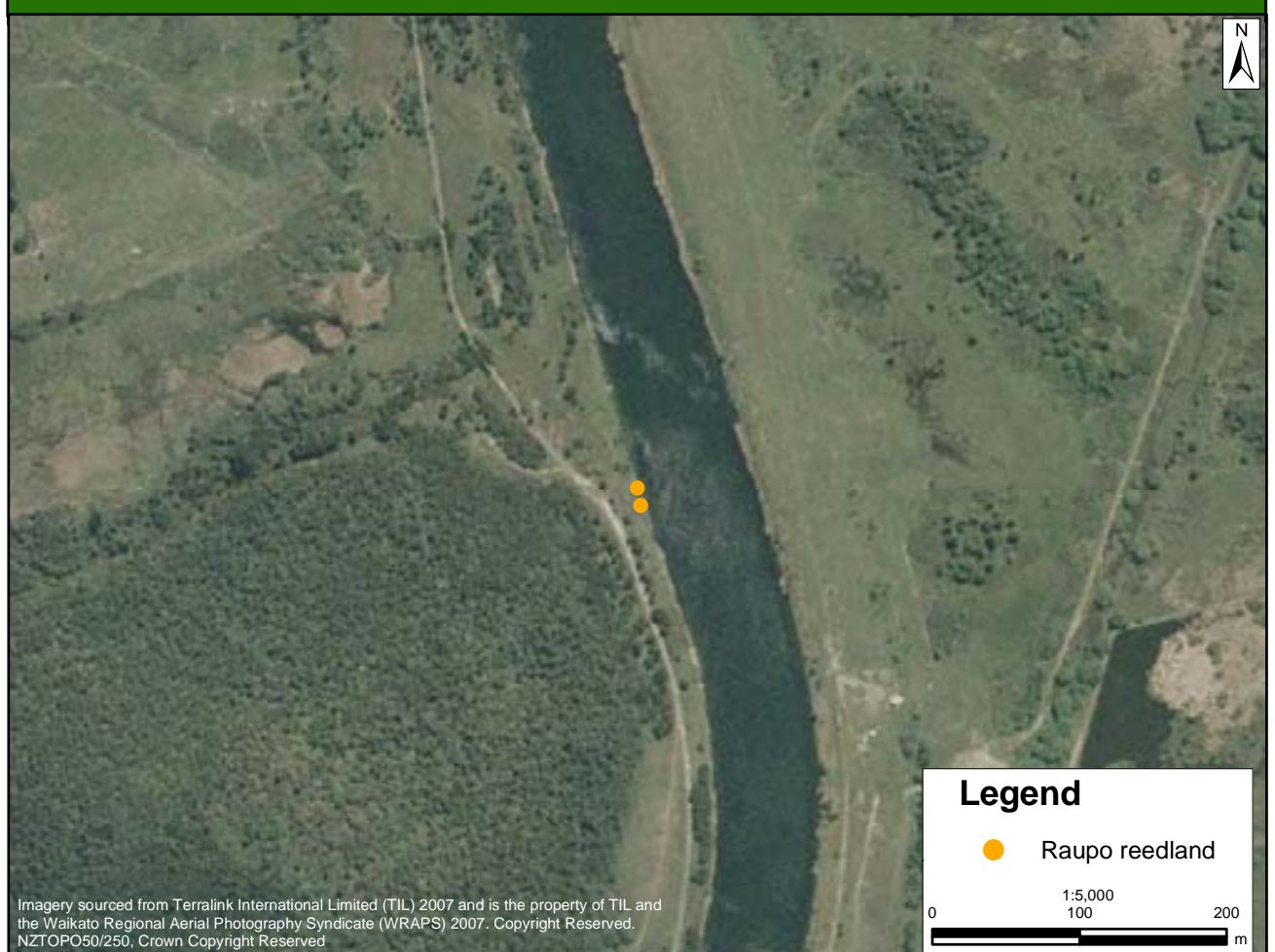
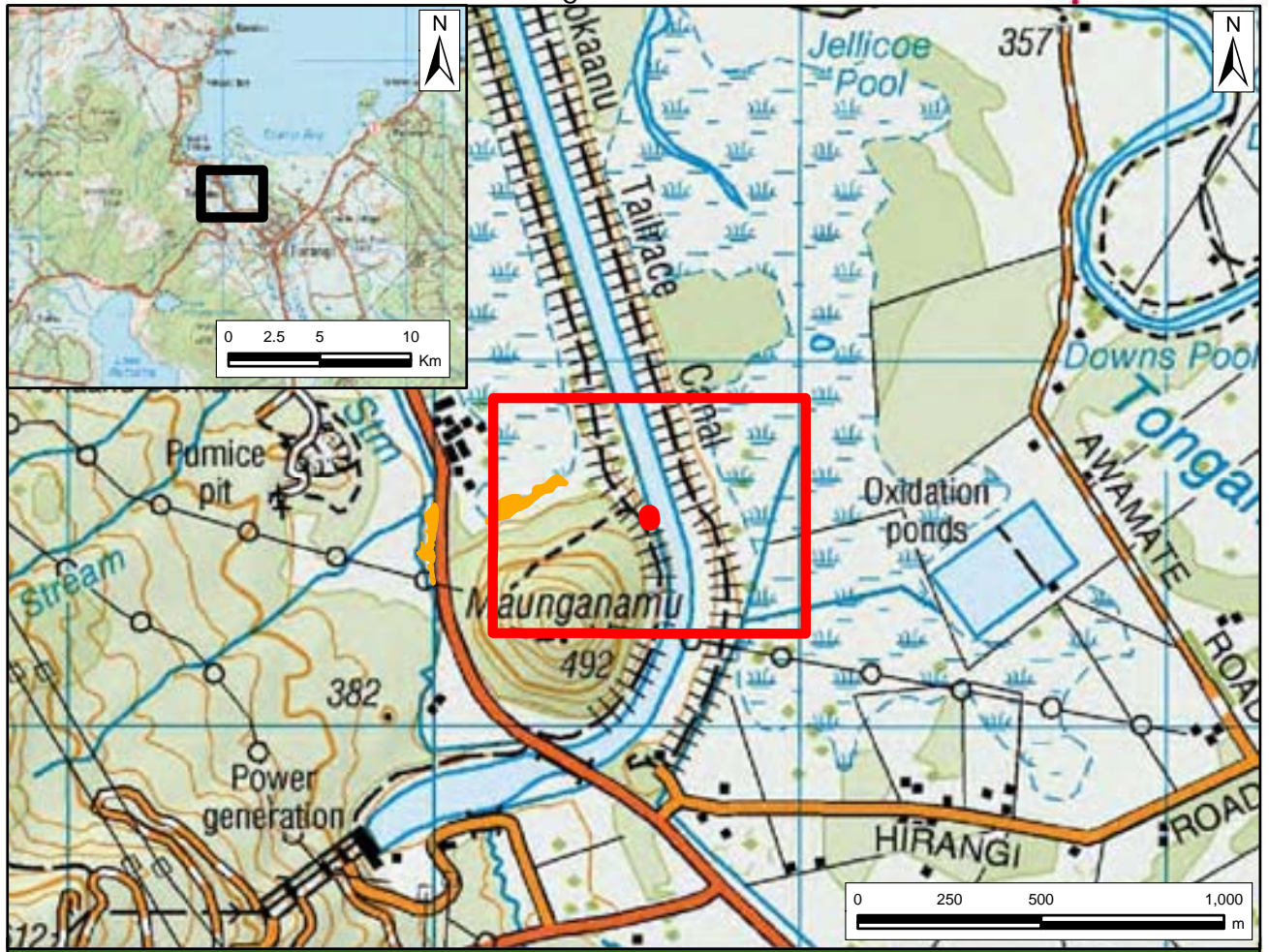
Fauna:

Common cicadas were audible during the field survey. Common indigenous and introduced bird species typical of the habitats are likely to be present.

¹ Previously identified as T19/5 in Wildland Consultants (2004 and 2007a).

² Hochstein 2007.

Current Condition (2007 Assessment):	The site is in excellent condition with only scattered blackberry present.
Threats/Modification/Vulnerability:	
<i>Invasive pest plants (2007 Assessment):</i>	Blackberry (1-5% cover).
<i>Human impacts (2007 Assessment):</i>	A small unformed track leads to the site.
<i>Grazing (2007 Assessment):</i>	Horses have been taken to the site, but there were no signs of horse grazing in the area.
<i>Adjoining land use (2007 Assessment):</i>	Indigenous forest and vehicle track.
Site Change:	
<i>Recent change:</i>	Not assessed. Any changes are not likely to be significant.
<i>Historical:</i>	This site is too small to see any evidence of change since 1941 (Historical photo: SN 178 Run 207 Photo 30, 1941). The pools are shown on a map in a 1942 paper (see Figure 2 in Healy 1942) where they are listed as „two larger mud pots’.
Management Requirements:	Maintain cover of indigenous vegetation around the mud pools.
Significance Level:	Regional (Table 1 - Criteria 5, 10; Table 2 - Factor 16).
Significance Justification:	The mud pools are within an extensive natural area that is of regional significance as it forms part of an extensive ecological sequence extending from the shores of Lake Taupo to the summit of Kakaramea, Tihia, and Pihanga, and including Lake Rotopounamu and Lake Rotoaira. The ecological sequence includes extensive areas of geothermal habitat.
References:	Healy 1942; Hochstein 2007; Wildland Consultants 2004 & 2007a.



Legend

- Raupo reedland

0 100 200 m

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MAUNGANAMU EAST

Site Number: TOV10¹
Grid Reference: NZTopo50 BH35 405 826
GPS Reference: NZTM E1840588 N5682576
Local Authority: Taupo
Ecological District: Taupo
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.360 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 7 February 2007

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
11.01	Raupo reedland	Canal margins	<0.1 ha
11.01.01	Raupo reedland with abundant creeping bent and occasional pohue. Geothermal seepages are also present in the open canal water.		

Geophysical Assessment²:

Overview of field work and background:

Several poorly known thermal manifestations of the Tokaanu geothermal field were visited on 07 February 2007. This was a hot, sunny day with the air temperature of c.23°C at 10:00 am. The water temperature of the outflow of the 240MW Tokaanu hydro-power station in the tailrace canal had a range of c.14⁰ and 17°C.

Manifestations below the bridge alongside the tailrace canal (locations inferred from an old infra-red (IR) survey of the field (Bromley & Mongillo 1991)) were inspected. These IR anomalies were located on the west bank of the tailrace canal, c.0.6-0.7 km downstream from the SH 41 road bridge.

IR anomalies along the tailrace bank, downstream from the SH 41 bridge:

Three IR anomalies are shown in the Bromley & Mongillo (1991) study to occur along the western bank of the tailrace canal, c.600-700 m downstream from the SH 41 bridge. For most part, the banks are steep and lined by a strip of raupo reedland.

Close to the inferred northern-most site of one of the three IR anomalies, we found a stretch of shore water with surface temperatures of up to 24°C (IR gun); the ambient water temperatures outside the stretch were c.18°C. Probing with the thermocouple probe, temperatures between 52° and 60°C were found at the first site at 0.3 m depth. The site (E1840593 N5682576), is distinguished by algae and subsurface plant growth which points to some zonation based on temperature gradients. The thermal water discharge occurred over a stretch along the shore at least c.10 m long; surface (water)

¹ Previously identified as T19/7 in Wildland Consultants (2004 and 2007a)

² Undertaken by Hochstein in 2007

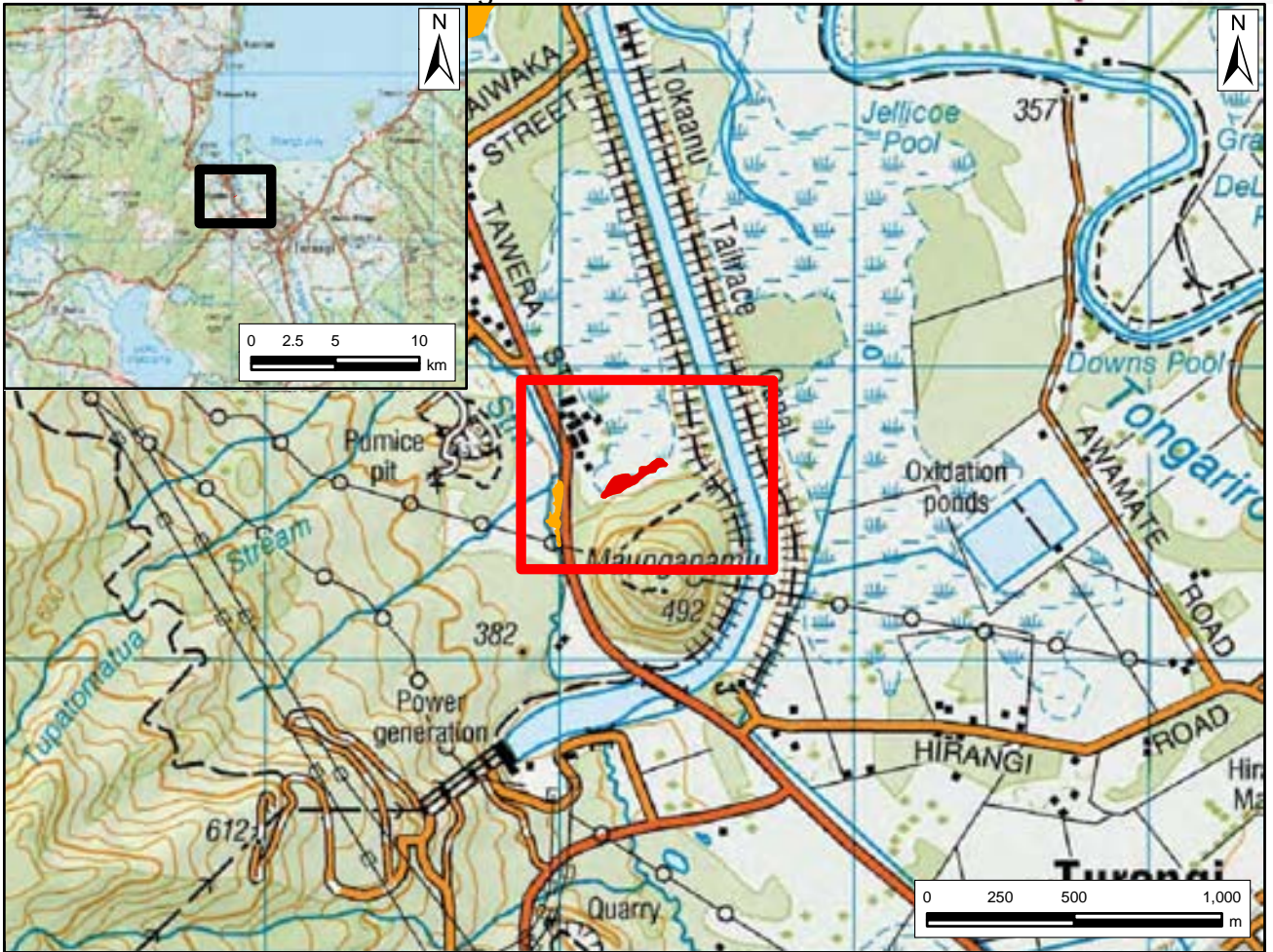
temperatures of 20° and 23°C in this area were observed using the IR gun. At the second site a maximum temperature of 62.1°C was observed at c.0.3 m depth; the lake bottom also exhibited a growth of brown-grey algae. Smaller seeps of thermal water occurred on land, c.0.2 m above the stream margins, with temperatures of up to 44°C were observed in one seep.

We did not search for the exact location of the other two IR anomalies located between 50-100 m upstream on the same bank because the manifestations are likely to be very small and possibly in the canal. These could be searched for and located using a boat with the approval of the canal managers.

Indigenous Flora:	Species typical of geothermal wetland are present.
Fauna:	None recorded. Common indigenous and introduced bird species typical of the habitats are likely to be present.
Current Condition (2007 Assessment):	Good condition.
Threats/Modification/Vulnerability:	
<i>Invasive pest plants (2007 Assessment):</i>	Blackberry (1-5% cover)
<i>Human impacts (2007 Assessment):</i>	The site is part of an artificial canal that is utilised for hydro-electricity.
<i>Grazing (2007 Assessment):</i>	This site is not grazed by stock.
<i>Adjoining land use (2007 Assessment):</i>	Tokaanu Stream and State Highway.
Site Change:	
<i>Recent change:</i>	Not assessed. Any changes not likely to be significant.
<i>Historical:</i>	In 1941 there was bare ground in the vicinity of the site (which may be indicative of the presence of a greater extent of geothermal vegetation and habitat in the area at that time) and it appears that construction of the Tokaanu Tailrace Canal (constructed in conjunction with the Tokaanu Power Station, commissioned in 1973) resulted in a reduction of the extent of this site (Historical photos: SN 178 Run 207 Photos 29-31, 1941; SN 1099 Run A Photo 2, 1958).
Management Requirements:	None noted.
Significance Level:	Local (Table 1, Criterion 5; Table 2, Factor 19).
Significance Justification:	The site is of local significance as it is a small example of geothermal wetland, a habitat that is nationally uncommon.

Notes: Further surveys are likely to result in the discovery of further examples of geothermal habitat in the vicinity of this site, particularly when water levels in the canal are low.

References: Bromley & Mongillo 1991; Hochstein 2007; Wildland Consultants 2004 & 2007a.



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MAUNGANAMU NORTH WETLAND

Site Number:	TOV11 ¹
Grid Reference:	NZTopo50 BH35 403 826
GPS Reference:	NZTM E1840178 N5682636
Local Authority:	Taupo
Ecological District:	Taupo
Geothermal Field:	Tokaanu-Waihi-Hipaua
Bioclimatic Zone:	Submontane
Tenure:	Unprotected private land and protected (Tokaanu Thermal Park Recreation Reserve).
Altitude:	c.440 m
Extent of Geothermal Habitat:	c.0.9 ha
Extent of Geothermal Vegetation:	c.0.9 ha
Date of Field Survey:	February 2007

Code	Type	Landform	Extent
11.01	Raupo-dominant reedland	Wetland	c.0.9 ha
11.01.01	Raupo reedland The site was viewed from the distance and appeared to be a raupo reedland with common emergent crack willow. This site is included as geothermal based on geothermal presence found near site at Oasis Motel, and evidence of Hochstein (2007) and Bromley & Mongillo (1991).		

Geophysical Properties²:	We began the search for the manifestations with a visit of the Oasis Motel (owner M.R. Foxall) who showed us his 28 m deep thermal bore (present exit temperature was 68°C in February 2007). Mr Foxall also pointed out the general area (to the east) behind his property where warm ground had been found in the past. As an example we were shown a 2 m deep soak hole (c.1 m diameter, concrete lining) at E1840218 N5682776 where a temperature of 30.5°C was measured at the water-covered bottom, pointing to the presence of steam-heated, perched groundwater. We could not find the spring sampled by Healy and stopped our search at the western edge of the raupo reedland wetland (near E1840178 N5682636), which is near the property boundary. Further searching would require permission for access from another landowner and possibly some preparatory shrub cutting.
Indigenous Flora:	No „Threatened’ or „At Risk’ flora species were noted during the 2007 survey.
Fauna:	No „Threatened’ or „At Risk’ fauna species were noted during the 2007 survey. However, the site is likely to provide habitat for wetland bird species, including spotless crane (classed as „At Risk-Relict’ in Miskelly <i>et al.</i> 2008).
Current Condition (2007 Assessment):	A full detailed site inspection has not been undertaken. Fences were poorly maintained near the site in 2007, however because the site was surrounded by blackberry, stock access was probably minimal. The wetland is in a moderate condition with common emergent crack willow.

¹ Previously identified as T19/8 in Wildland Consultants (2007).

² Hochstein 2007

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2007 Assessment):* Crack willow (5-25% cover) is present in the wetland. This should be controlled.

*Human impacts
(2007 Assessment):* The wetland is farmed near to its edges.

*Grazing
(2007 Assessment):* The wetland has been farmed until recently, and stock may have access to margins.

*Adjoining land use
(2007 Assessment):* Farming and Department of Conservation Reserve. Fences were over-run by blackberry in 2007.

Site Change:

Recent change: Unknown. Probably no significant change.

Historical: In the 1958 photograph there appears to be bare ground in the vicinity of the site, of which only a small portion of this is likely to be geothermal (Historical photo: SN 1099 Run A Photo 2, 1958).

Management Requirements: Willow control should be undertaken, and the site should be fenced to exclude stock.

Significance Level: Local (Table 1 - Criteria 5, 6; Table 2 - Factor 19)

Significance Justification: This site is locally significant because it is an example of a nationally uncommon habitat type (geothermal wetland). A very small portion of the site is legally protected.

Notes: Small groups of hot springs were reported by Healy (1942) to occur in a stretch of swampy ground over the north region of Mt Maunganamu. One hot spring (77°C) discharged c.100 m to the east of the main road and was sampled by Healy who apparently did not visit other manifestations in the same area. The same or an adjacent spring (Nr.52) was sampled and analyzed by Mahon & Klyen (1968); its temperature was 66°C. It is likely that thermal springs in the swampy area were detected by their IR signature in 1991; other recorded IR signals (Bromley & Mongillo 1991) are associated with thermal ground in paddocks to the east of the Oasis Motel. A short summary of the thermal manifestations in the North Maunganamu sector has been given by Hochstein (2005).

A neighbouring landowner has reported geothermal steam coming from this site. It is currently a raupo reedland wetland with common crack willow. As we did not have permission to access this site at the time of field survey in 2007, we have only examined this site from the road and neighbouring property.

This site has not been assessed in any previous assessment of ecological values of geothermal sites.

References: Bromley & Mongillo 1991; Healy 1942; Hochstein 2005 & 2007; Mahon & Klyen 1968; Wildland Consultants 2007.



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TOKAANU TAILRACE CANAL

Site Number: TOV14¹
Grid Reference: NZTopo50 BH35 400 819
GPS Reference: NZTM E1840064 N5681876
Local Authority: Taupo
Ecological District: Taupo
Geothermal Field: Tokaanu-Waihi-Hipaua
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.360 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 7 February 2007

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
11.01 11.01.13	Raupo-dominant reedland (Crack willow)/raupo reedland Occasional crack willow occurs over a raupo reedland with patches of <i>Baumea rubiginosa</i> , swamp kiokio, <i>Juncus edgariae</i> , and creeping bent. Other species present include Yorkshire fog, harakeke, <i>Carex virgata</i> and tall fescue.	Wetland	<0.1 ha

Geophysical Assessment:²

Overview of field work and background:

Several poorly known thermal manifestations of the Tokaanu geothermal field were visited on 07 February 2007. This was a hot, sunny day with an air temperature of c.23°C at 10:00 am. The water temperature of the outflow of the 240 MWe Tokaanu hydro-power station in the tailrace canal had a range of c.14° to 17°C.

Manifestations above the bridge alongside the tailrace canal were visited for which locations were inferred from an old infra-red (IR) survey of the field (Bromley & Mongillo 1991).

Infra-red anomalies along the tailrace shores, close to the power station outlet:

An IR anomaly was observed during the 1991 airborne survey close to the southern shore of the tailrace canal, c.100-150 m downstream from the station outlet. Using an IR gun, a c.40 m long stretch of the shore line was searched without finding any temperature anomaly in the shallow water. We also searched for a thermal anomaly at the opposite site along the north bank where, according to Mr A. Hema (Tokaanu Power Station), some minor thermal activity had been noticed in the past c.100 m downstream from the outlet at low outflow level. However, no thermal anomaly was found near that site.

Another IR anomaly located by the 1991 survey points to a thermal site

¹ Previously identified as T19/4 in Wildland Consultants (2004 and 2007a).

² Undertaken by Hochstein in 2007.

along the northern bank, c.275 m downstream from the power house outlet. The site is near a basic boat launching pad. This time a minor thermal anomaly was found as indicated by near-shore water temperatures of c.18°C along a c.10 m long stretch; it was surrounded by water with ambient temperatures of c.15.5°C. In the centre of the anomalous stretch (approximately at E1840049 N5681375), water temperatures between 28° and 29°C were found at 0.3 m depth using a thermocouple device. The anomalous temperatures were reproducible when the site was re-occupied. The site lies close to the northeast corner of an old test pond dredged in 1969 to assess the danger of hydrothermal eruptions during excavation of the tailrace canal. The pond covered hot ground with boiling temperatures at shallow depths (Hochstein and Prebble 2006).

Indigenous Flora:	Species typical of geothermal wetland are present.
Fauna:	None recorded. Common indigenous and introduced bird species typical of the habitats are likely to be present.
Current Condition (2007 Assessment):	Site is in a moderate condition and indigenous habitat has formed alongside artificial tailrace canal.
Threats/Modification/Vulnerability:	
<i>Invasive pest plants (2007 Assessment):</i>	Crack willow (5-25% cover) is present near the site.
<i>Human impacts (2007 Assessment):</i>	The site occurs beside an artificial canal.
<i>Grazing (2007 Assessment):</i>	The site is not grazed by stock.
<i>Adjoining land use (2007 Assessment):</i>	Canal; roads.
Site Change:	
<i>Recent change:</i>	Not assessed as site is too small.
<i>Historical:</i>	In 1958 there was bare ground in the vicinity of the site (only a small portion of this is likely to be geothermal). However the Tokaanu Tailrace Canal (constructed in conjunction with the Tokaanu Power Station, commissioned in 1973) is likely to have flooded part of this site (Historical photo: SN 1099 Run A Photos 3, 1958), but it is not possible to determine the extent of loss.
Management Requirements:	Control of crack willow would enhance the ecological values of the site.
Significance Level:	Local (Table 1, Criterion 5; Table 2, Factor 19).
Significance Justification:	The site is of local significance as it comprises a small example of a habitat that is nationally uncommon.

Notes: More geothermal sites may be found alongside the canal if the site was surveyed by boat, particularly when water levels are low.

References: Bromley & Mongillo 1991; Hochstein & Prebble 2006; Hochstein 2007; Wildland Consultants 2004 & 2007a.

