



OHAAKI

Area:	Geothermal Habitat: c.18.1 ha Geothermal Vegetation: c.18.0 ha
Geothermal Field:	Ohaaki
Site Description:	<p>Ohaaki is an amalgamation of two sites assessed in Wildland Consultants (2014a), Ohaaki East and Ohaaki West.</p> <p>The Ohaaki site comprises a relatively large area of geothermal vegetation and habitat, located near the Ohaaki Geothermal Power Plant. Substantial changes to the vegetation and landform within this site have occurred over several years due to land subsidence as a result of draw-off associated with the geothermal power station. Pest plants are a major issue at the site, and pest animals are also adversely affecting vegetation and habitats. Geothermal features comprise a large boiling pool in the northeast of the site (Ohaaki Ngāwhā), sinter, geothermally-influenced clays, sinter terraces, steaming fumaroles, fissures, and geothermally-influenced bare ground. 31.2% (5.6 ha) of the site is legally protected by a QEII National Trust covenant, the rest is on unprotected private land. Access to much of the site is restricted as it is within the power station grounds. The site includes nationally uncommon ecosystem types: geothermally heated ground (dry), fumaroles; geothermal streamsides, and hydrothermally altered ground (now cool) (Williams <i>et al.</i> 2007, Holdaway <i>et al.</i> 2012). The site includes a large population of geothermal kānuka (At Risk-Naturally Uncommon) and <i>Dicranopteris linearis</i> (5-10 plants) (At Risk-Naturally Uncommon). Geothermal extraction for electricity generation has resulted in significance land subsidence at this site. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Ohaaki Geothermal Field for energy production is having any effects on these values. Cody (2007) lists three features and geothermal characteristics present at or near this site.</p>
Ecosystem Services:	<p>Provisioning services present include honey production, conservatively valued at \$200 annually as there is limited area of mānuka and other species suitable for honey production. Wilding pines have been removed or killed on site, although it is unknown if any economic value has been gained from trees extracted from the site.</p> <p>The site provides regulation and maintenance services of bioremediation, mass stabilisation and control of erosion rates, and sequestration of carbon (4,284 tC annually) and potentially other climate change gases. The site provides some cultural services, although the extent of many of these is not well known. Visitor use of the site is low, with restrictions to many parts of the site for public safety around geothermal power plant and bores. Some parts of the site are visible from nearby highways. The site is not currently known to be used for bathing, but has the potential to be used for this service in the future. The site is of scientific interest, with 1,880 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).</p>

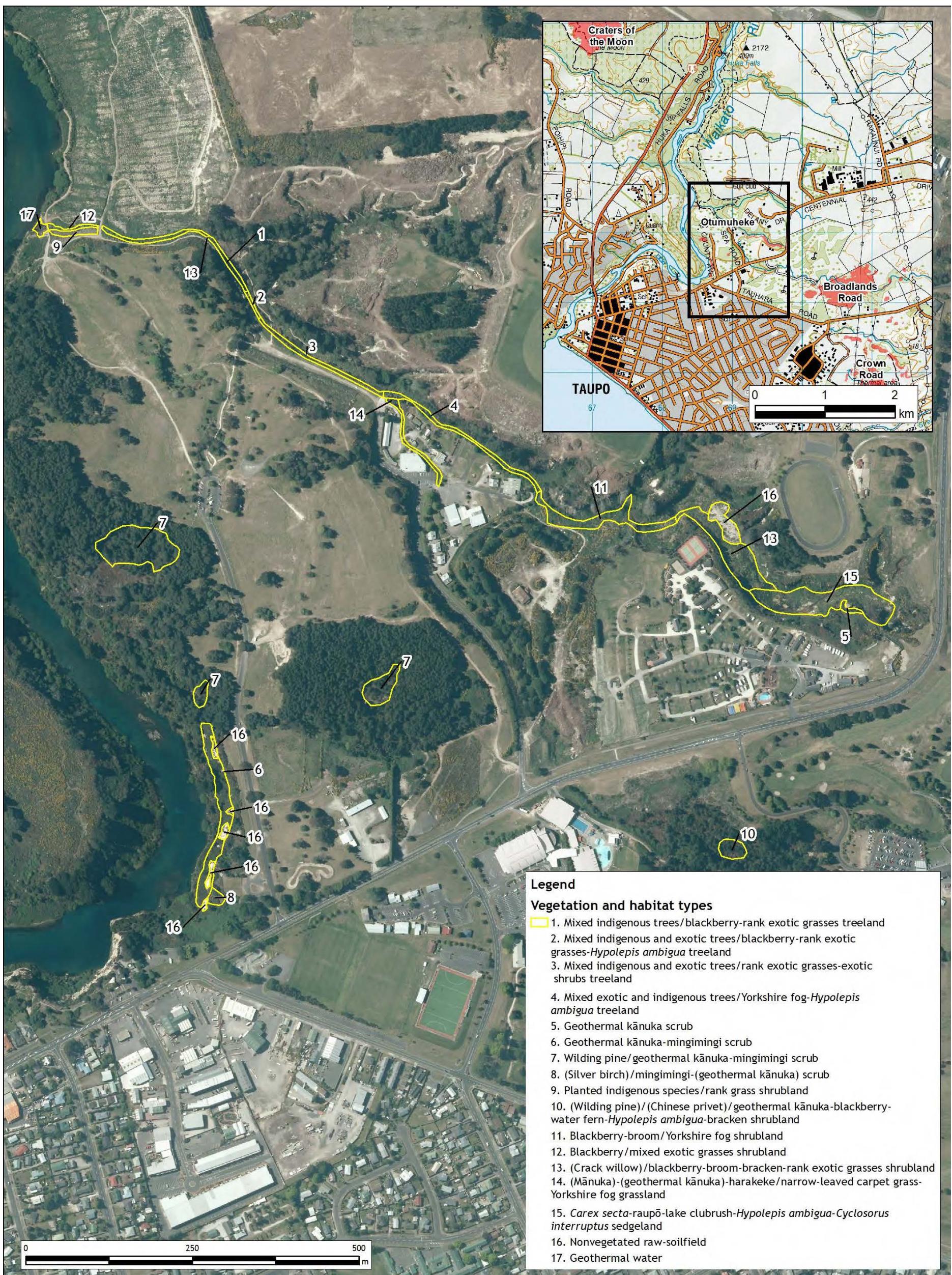


Large areas of a naturally rare ecosystem, hydrothermally altered ground (now cool), are present at Ohaaki and many of these areas are being threatened by pest plant invasion. (January 2011)



The most famous feature is the Ngawha or geothermal pool near Ohaaki Marae. The natural flow of this pool ceased soon after the commissioning of the Ohaaki Power Station in 1989 and the pool is now fed by bore water. (April 2017)





Data Acknowledgment
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Service (WRAPS) 2012
Report: 4363
Client: WRC
Ref: 01 1769
Path: E:\gis\EW_Geothermal_Sites_2003\2017\mxd\June2017\
File: Otumuheke.mxd

Otumuheke

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Date: 28/02/2018
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OTUMUHEKE

Area:	Geothermal Habitat: c.3.8 ha Geothermal Vegetation: c.3.8 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	<p>Otumuheke is an amalgamation of three sites assessed in Wildland Consultants (2014a), Otumuheke, Spa Thermal Park, and Kathleen Springs.</p> <p>Otumuheke is on the northeastern side of Taupō township and located within the site is the recreational area ‘Spa Park’ which attracts local, regional and international visitors for swimming, walking and other leisure activities. Most of the site is on unprotected private land, but 2% of the site is protected (Patuiwi Marginal Strip and Taupō District Council Reserve). Geothermal features including springs, geothermal wetlands, bare geothermal soils, sinter, and hot seepages are present in the Otumuheke Stream and Waikato River. The geothermal wetland in the north of the site is in relatively good condition, and is one of few areas of sinter wetland remaining around Taupō. The remainder of the stream gully is highly modified and is dominated by invasive exotic plants. The site supports populations of five At Risk plant species, <i>Nephrolepis flexuosa</i> (At Risk-Declining), <i>Cyclosorus interruptus</i> (At Risk-Declining), <i>Christella aff. dentata</i> (“thermal”) (At Risk-Naturally Uncommon), <i>Hypolepis dicksonioides</i> (At Risk-Naturally Uncommon), and geothermal kānuka (At Risk-Naturally Uncommon). Otumuheke occurs in the Tauhara Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for extracting energy for generation, domestic, commercial and other uses¹. Some geothermal features within the site have become quiescent due to the continued drawdown from the field for geothermal power generation. The AC baths complex discharges water into a channel, downstream of the former springs. In some areas, lowered soil temperatures have enabled the establishment of invasive pest plant species, particularly wilding pines and blackberry. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Tauhara Geothermal Field for energy production is having any effects on these values.</p> <p>Cody (2007) lists six features and geothermal characteristics present at or near this site. This site is of regional significance for its ecological values (Wildland Consultants 2014a).</p>
Ecosystem Services:	<p>Provisioning services the Otumuheke site provides include energy extraction and supplies of wood. Some other services such as food and fibre resources may also be provided. Some of the species present are a potential resource for honey production (e.g. mānuka, geothermal kānuka and other species), conservatively estimated at a value of \$40 annually. In recent years, some wilding pine control has been undertaken in the Otumuheke Valley and in Spa Park. Some of the extracted timber has been sold, or been utilised for firewood and other commercial gain.</p> <p>The site provides regulation and maintenance services of bioremediation in wetland habitat and riparian vegetation (unknown value). The vegetation provides mass stabilisation and control of erosion rates, and sequestration</p>

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.

of carbon (904.4 tC) and potentially other climate change gases.

The site provides a number of cultural services, with the site being well visited as it is located on the edge of a major New Zealand urban centre (Taupō township), and some features of the site are regularly visited by international and New Zealand tourists. Spa Park receives around 29,500 visitors annually (25,600 domestic and 3,900 international tourists) (Burns and Luketina 2011). Other visitors drive by the site and visit other features. Walking and cycling tracks near parts of the site are well used. Taupo District Council has recently undertaken a \$1.5 million development of the Spa Park swimming area to improve amenity while protecting the geothermal vegetation. Other recreational facilities are nearby, including playgrounds, skate parks, dog parks and a commercial campground. Many visit Spa Park for the purposes of swimming in the geothermal springs on the edge of the Waikato River. Safety services include hand rails on bridges over geothermal streams, warning signs, fencing, and formed walkways to control people movements. The site is of scientific interest, with 1,939 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).



The large area of sinter in the upper main spring in the main Otumuheke Valley. This area has the largest *Cyclosorus interruptus* population near Taupō. (December 2012)



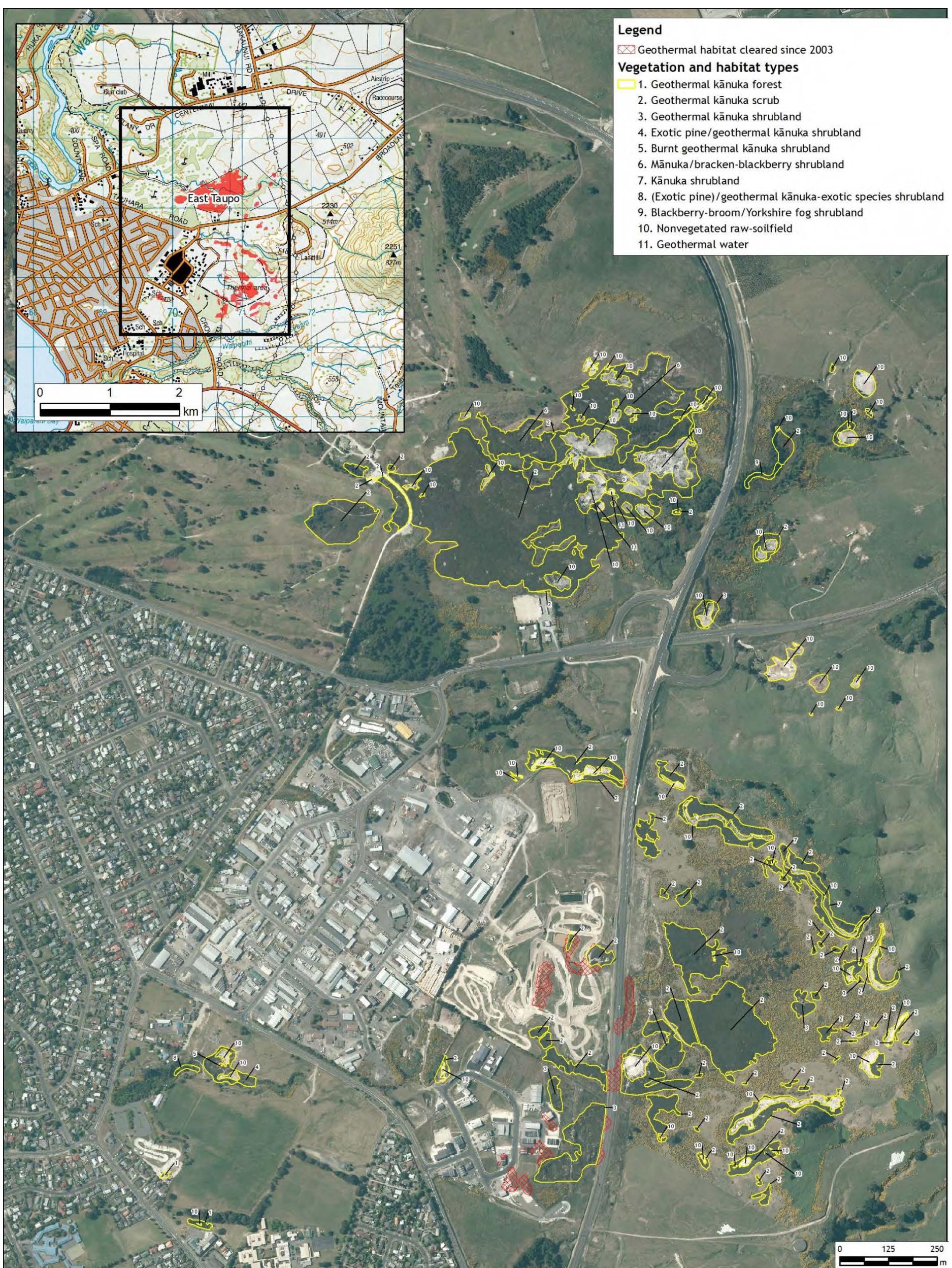
Pines have recently been removed off cliffs on valley sides of Otumuheke Stream Valley (December 2012)



Otumuheke Stream outlet into the Waikato River is a popular bathing site. (December 2012)



Geothermal bare ground and geothermal kānuka above the Waikato River in the Spa Park part of the Otumuheke site. (July 2014)



EAST TAUPŌ

Area:	Geothermal Habitat: c.51.5 ha Geothermal Vegetation: c.51.4 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	<p>East Taupō is an amalgamation of three sites assessed in Wildland Consultants (2014a): Broadlands Road, Crown Road, and Crown Park.</p> <p>The East Taupō site is mixture of unprotected private land, and protected land, with 46.0% (23.7 ha) of the site being legally protected (Broadlands Road Geothermal Scenic Reserve and Taupō District Council Reserve). The site is located on the eastern edge of Taupō Township, some of it within the urban zone and some in rural areas. The geothermal features comprise steaming ground, mud pools, explosion craters, geothermal ponds, heated soils and fumaroles. Three At Risk species are present at the site including geothermal kānuka (At Risk-Naturally Uncommon), <i>Dicranopteris linearis</i> (At Risk-Naturally Uncommon), and New Zealand pipit (At Risk-Declining). The site comprises a relatively large example of geothermal habitat, which includes nationally uncommon habitat types: geothermally heated dry ground, fumaroles; and hydrothermally altered ground (now cool) (Williams <i>et al.</i> 2007; Holdaway <i>et al.</i> 2012). Cody (2007) lists four features and geothermal characteristics present at or near this site. Some pest plant control has been undertaken by the Waikato Regional Council in parts of the site. The ecological condition of the site ranges from good to poor, with a large number of pest plants present. Ongoing pest plant invasion, stock access, fires and clearance for other activities such as motocross, have resulted in a reduction in the extent and/or quality of geothermal vegetation in parts of this site. The East Taupō geothermal site is located in the Tauhara Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for extracting energy for energy generation, domestic, commercial, and other uses¹. In some areas, lowered soil temperatures have enabled the establishment of invasive pest plant species, particularly wilding pines and blackberry. Occasional wildfires have been detrimental to ecological integrity on occasion. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Tauhara Geothermal Field for energy production is having any effects on the features.</p>
Ecosystem Services:	<p>Provisioning services at East Taupō include honey production (conservatively valued at \$2,320 annually). In recent years, some wilding pine control has been undertaken in Crown Park and other parts of the site and extracted trees may have been utilised for firewood or other commercial gains.</p> <p>The site provides regulation and maintenance services of bioremediation (unknown value). The vegetation provides mass stabilisation and control of erosion rates, and sequestration of carbon (12,233 tC annually) and potentially other climate change gases.</p> <p>The site provides a number of cultural services, with the site receiving high visitor numbers due to its location on the edge of a major New Zealand urban centre (Taupō township). Walking paths and cycle tracks go through some features. A motocross park, golf course, and horse riding</p>

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.

area are present in parts of the site. A recreational sports field is located within Crown Park, with a school adjacent. Heated ground at Crown Park and Broadlands Rd are used for cooking. Public safety is a key aspect of management in the area, with warning signs and fencing to control people movements. The site is of scientific interest, with 927 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).



East Taupō, Broadlands Road Scenic Reserve. Extensive areas of geothermal kānuka are present. (March 2017)



East Taupō, Broadlands Road Scenic Reserve. Note the nearby golf course and the recent fire at the site. (February 2016)



Crown Road part of the East Taupō Site. Some parts of this area are farmed. (February 2016)



WAIPAHIHI VALLEY

Area:	Geothermal Habitat: c.0.3 ha Geothermal Vegetation: c.0.2 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	<p>Waipahihi Valley geothermal area is located towards the southern end of Taupō Township in Waipahihi Valley, with a few geothermal features on the edge of Lake Taupō. The Waipahihi Stream feeds into the geothermal Onekeneke Stream, which rises in the valley, fed by geothermal springs. Approximately 71.5% (0.2 ha) of the site is legally protected (Waipahihi Stream Conservation Area) and the rest is on unprotected private land. Geothermal features comprise geothermal springs, sinter depositing springs, a geothermal stream and ponds. The hot stream provides bathing opportunities for visitors via the De Bretts Thermal Park (hot pools, camping ground and hotel complex). The Waipahihi Valley is of regional significance for its ecological values (Wildland Consultants 2014a) because parts of the site are protected as a Conservation Area and it contains geothermal kānuka (At Risk-Naturally Uncommon), <i>Cyclosorus interruptus</i> (At Risk-Declining), <i>Hypolepis dicksonioides</i> (At Risk-Naturally Uncommon), and <i>Christella aff. dentata</i> (“thermal”) (At Risk-Naturally Uncommon). The Waipahihi Stream has been diverted and partially channelised within the de Bretts outdoor pool area, but is more natural in the eastern part of the site. Vegetation clearance and other site modifications (surface water draw off, pool complex development) have altered natural geothermal expressions and vegetation composition. Lawn mowing may reduce the likelihood of natural regeneration of geothermal kānuka and <i>Cyclosorus interruptus</i> populations, although it has also suppressed blackberry growth. The spring and small pool on the margin of Lake Taupō are used on a regular basis by bathers. Waipahihi Valley is located in the Tauhara Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for extracting energy for energy generation, domestic, commercial and other uses¹. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Tauhara Geothermal Field for energy production is having any effects on these values. Cody (2007) lists one feature and geothermal characteristic present at or near this site.</p>
Ecosystem Services:	<p>Waipahihi Valley is a small site, and no values were able to be given to any provisioning services. A heat exchanger is present within the natural areas present at Waipahihi Valley (unknown value).</p> <p>The site provides regulation and maintenance services of bioremediation (unknown value). The vegetation provides mass stabilisation and control of erosion rates, and sequestration of carbon (47.6 tC annually) and potentially other climate change gases.</p> <p>The site provides a number of cultural services, with the site being well visited as it is located on the edge of a major New Zealand urban centre (Taupō township). The de Bretts Pool area is a fee-paying tourist attraction with up to 740,000 visitors per year (Barns and Luketina 2011), with additional local, national and international visitors experiencing the geothermal springs at the lake front (estimated visitor number of 7,700 annually (Barns and Luketina 2011). The facilities at de Bretts include</p>

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.

hotels, camping site, and heated swimming pools (\$22 entry fee per person in 2017). To enhance public safety, walking paths, fences, bridges and safety warning signs have been constructed. The site is of scientific interest, with 183 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).



Waipahihi spring in the upper parts of the Waipahihi Valley. (August 2011)

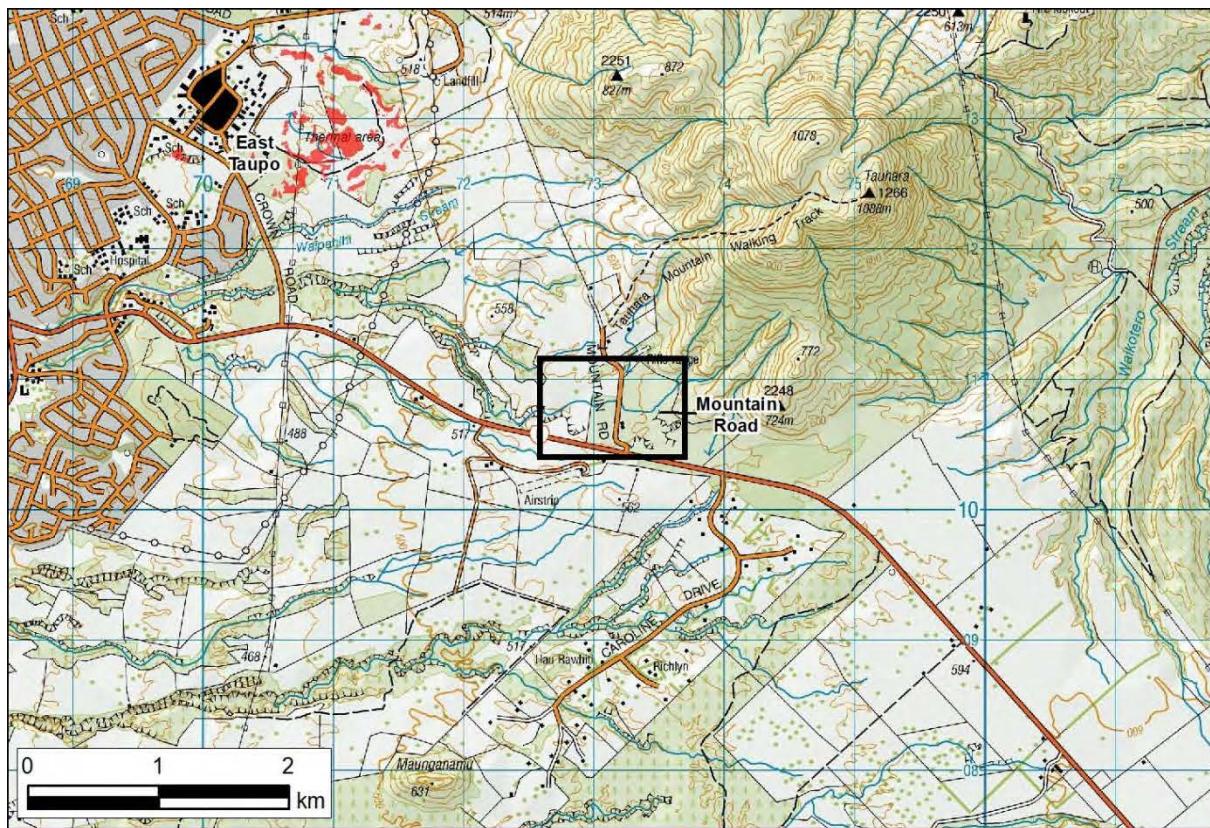


Illegal clearance of vegetation has occurred at Waipahihi Valley in the past. (August 2011)



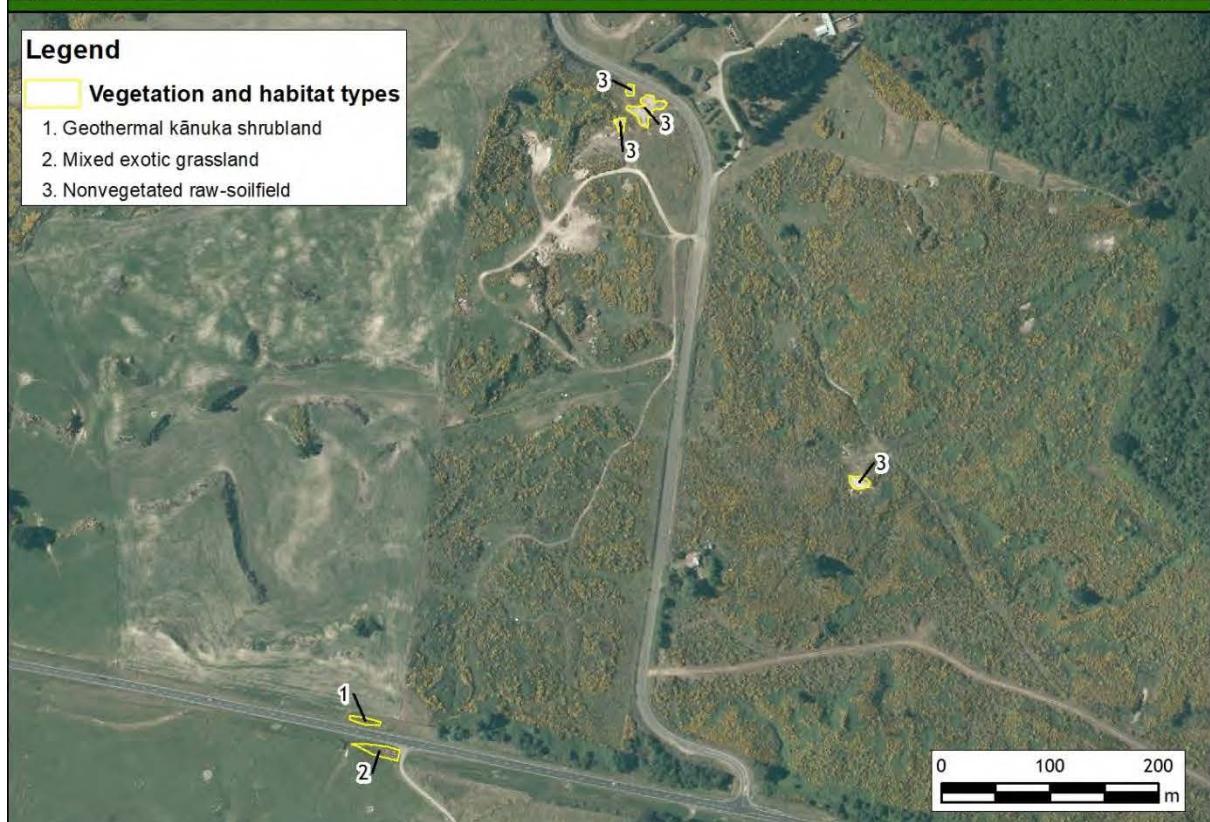
A large number of springs occur on the edge of Lake Taupō near the outlet of the stream from the Waipahihi Valley. (July 2014)





Legend

- Vegetation and habitat types
1. Geothermal kānuka shrubland
 2. Mixed exotic grassland
 3. Nonvegetated raw-soilfield



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Report: 4363	Scale: 1:6,000
Client: WRC	Date: 28/02/2018
Ref: 011769	Cartographer: JO
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Mountain Road

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Date: 28/02/2018
Cartographer: JO
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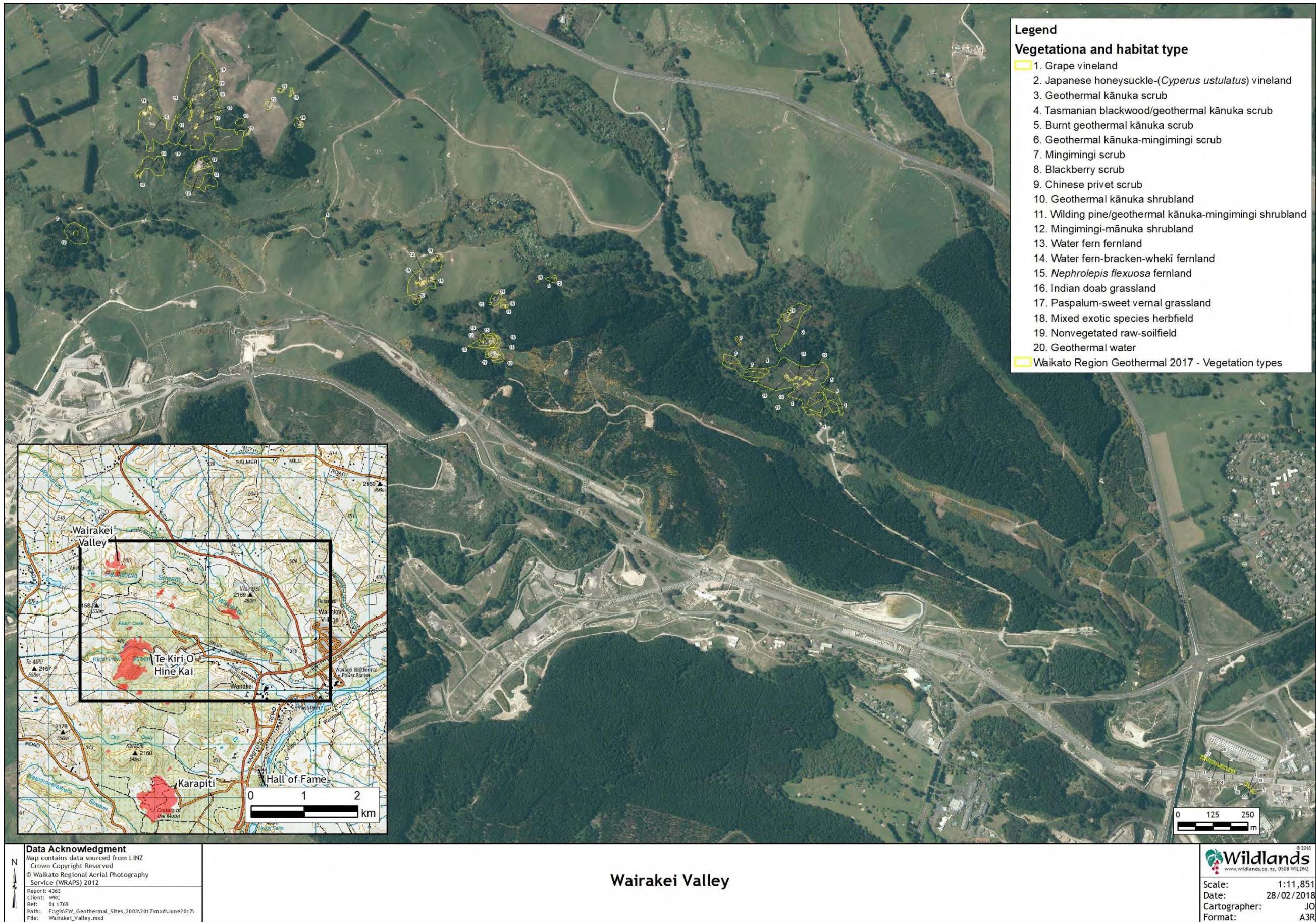
MOUNTAIN ROAD

Area:	Geothermal Habitat: c.0.1 ha Geothermal Vegetation: c.0.1 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	The Mountain Road site comprises at least four small areas of geothermal habitat on unprotected private land and includes geothermally heated soils and steam vents. They are located southwest of the dacite dome of Tauhara, with features on each side of State Highway 5 (Napier-Taupō Road) and two features in developed land to the north of this (all about 1.5-2.5 km east of Taupō Township). This small site has been degraded by human use, trampling by domestic stock, and invasion by exotic plant species. It contains a small area of a naturally uncommon habitat type (geothermally heated dry ground; Williams <i>et al.</i> 2007; Holdaway <i>et al.</i> 2012). The site also includes a small population of an At Risk indigenous plant species (geothermal kānuka). The Mountain Road sites are located in the Tauhara Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for extracting energy for energy generation, domestic, commercial and other uses ¹ . The impacts of exploitation on geothermal features is unknown.
Ecosystem Services:	This is a very small area of geothermal habitat and as such provision of ecosystem services is presumed to be minor. The site is also mostly on private land, or immediately adjacent to State Highway 5, and visitor use is low due to this. The geothermal habitats and vegetation have intrinsic value because they are a very small example of a unique ecosystem type, but the ecosystem services provided by this site are difficult to assess due its small size. The vegetation provides some sequestration of carbon (23.8t C annually) and potentially other climate change gases. One of the fumaroles present is used for cooking. For the purposes of the ecosystem services study, very small sites such as this one should be assessed as part of other sites to create a larger area for assessment or removed from the study and assigned a generic value, based on size.



Mountain Road. (July 2014)

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.



WAIRAKEI VALLEY

Area:	Geothermal Habitat: c.14.8 ha Geothermal Vegetation: c.14.7 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	<p>Wairakei Valley is an amalgamation of four sites assessed in Wildland Consultants (2014a): Te Rautehuia, Te Rautehuia Stream, Upper Wairakei Valley (Geyser Valley), and Lower Wairakei Stream.</p> <p>Wairakei Valley, located c.8 km north of Taupō, comprises geothermal features such as springs, pools, heated soils and clays, fumaroles, mud pools, geothermal craters, areas of old and recent sinter, dried mud pools, and geothermal streams. One part of the site (Wairakei Natural Thermal Valley) is run as a tourism venture, although some geothermal features described as part of the tourist venture (and for which this valley was once renowned) have become dormant due to the continued field drawdown for geothermal power generation by the Wairakei Power Station (Given 1989a). Ongoing pest plant invasion, stock access, and a fire in late 2012 have resulted in a reduction in the extent and/or quality of geothermal vegetation in parts of this site. This site is of regional ecological significance (Wildland Consultants 2014a) because it is a relatively large example of geothermal habitat, which includes nationally uncommon ecosystem types: heated ground (dry); fumaroles; geothermal streamsides and hydrothermally altered ground (now cool) (Williams <i>et al.</i> 2007; Holdaway <i>et al.</i> 2012). It is also an important habitat for populations of eight At Risk species, including geothermal kānuka (At Risk-Naturally Uncommon), <i>Dicranopteris linearis</i> (At Risk-Naturally Uncommon), <i>Christella aff. dentata</i> (“thermal”) (At Risk-Naturally Uncommon), <i>Hypolepis dicksonioides</i> (At Risk-Naturally Uncommon), <i>Nephrolepis flexuosa</i> (At Risk-Declining), New Zealand pipit (At Risk-Declining), and North Island robin (At Risk-Declining). This site is located in the Wairakei Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for extracting energy for energy generation, domestic, commercial and other uses¹. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Wairakei Geothermal Field for energy production is having any effects on these values. Cody (2007) lists 33 features and geothermal characteristics present at or near this site (or other nearby sites in the Wairakei Geothermal Field).</p>
Ecosystem Services:	<p>Provisioning services provided at the Wairakei Valley site include honey production (conservatively valued at \$80 annually). There is the potential for wilding pines (and other exotic trees) to be utilised for firewood or other commercial gain.</p> <p>The site provides regulation and maintenance services of bioremediation, mass stabilisation and control of erosion rates, and sequestration of carbon (3,522tC annually) and potentially other climate change gases.</p> <p>The site provides a number of cultural services, with parts of the site being well visited as a tourist attraction, while other parts are on private land and are only seen by workers at the geothermal power plant, at forestry sites, or on farms. Tourists currently pay a fee of \$10 per person to visit the</p>

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.

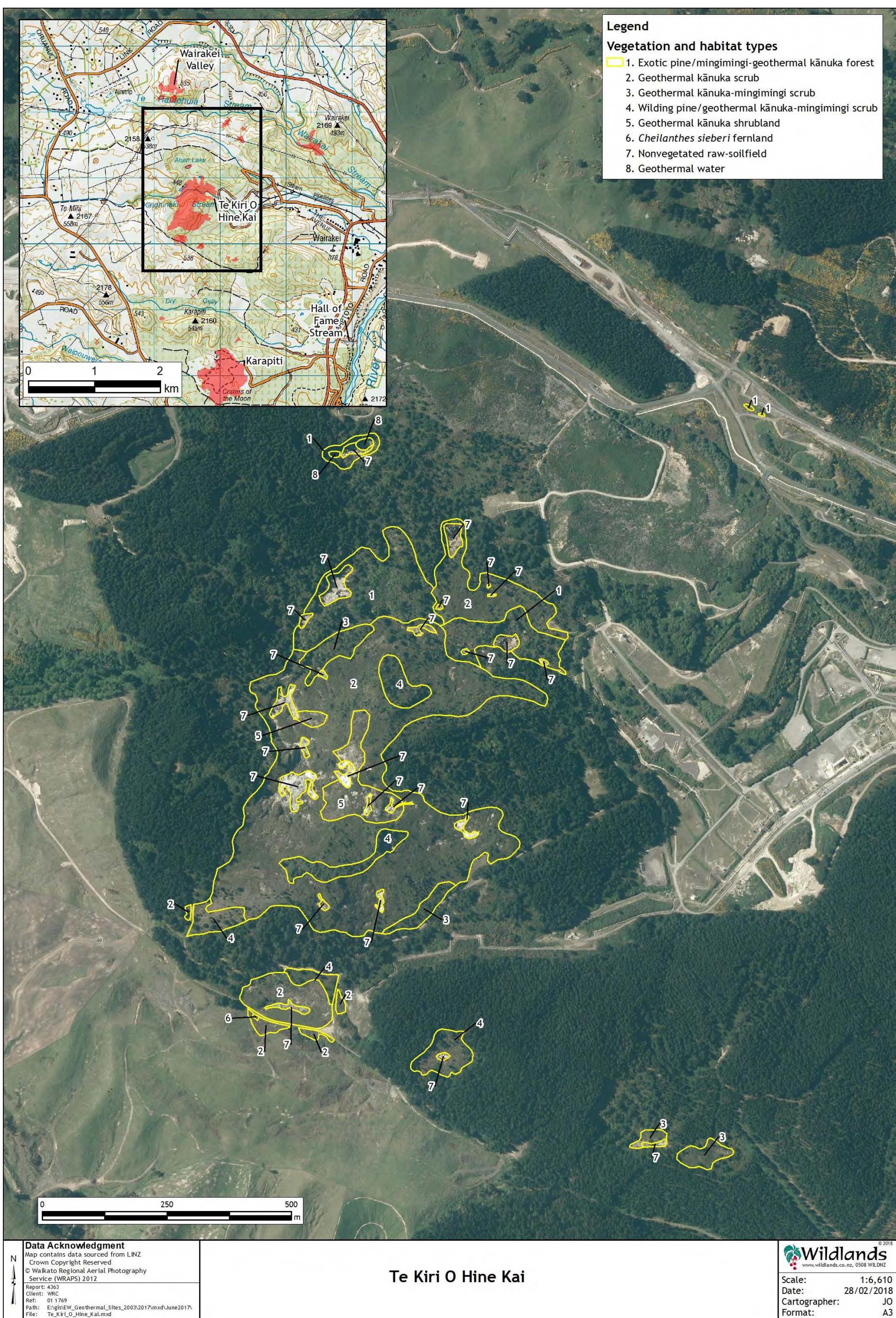
Wairakei Natural Thermal Valley site. Camping facilities and a café are also present at this tourist site. Safety is a key aspect of management of the tourist areas, with hand rails on bridges over geothermal streams, warning signs, fencing, and formed walkways to control people movements. The site is of high scientific interest, with 2,636 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).



Upper Wairakei stream in the Wairakei Natural Thermal Valley tourist site. (January 2011)



Te Rautehuia part of the Wairakei Valley site. Parts of the Te Rautehuia geothermal site are farmed. (January 2011)



TE KIRI O HINE KAI

Area:	Geothermal Habitat: c.35.8 ha Geothermal Vegetation: c.35.7 ha
Geothermal Field:	Wairakei-Tauhara
Site Description:	<p>Te Kiri O Hine Kai is an amalgamation of two sites assessed in Wildland Consultants (2014a): Te Kiri O Hine Kai Stream Catchment/Wairoa Hill and Wairakei Borefield.</p> <p>Te Kiri O Hine Kai is located c.7 km north of Taupō. It comprises a geothermally active gully and hill slopes with geothermal clays, mud pools, fumaroles, hot water and mud lakes. It is a large and mostly connected area of geothermal features and vegetation surrounded by pine plantation and geothermal electricity generation operations. Several small isolated geothermal areas are scattered outside this core geothermal area. The largest of these includes Alum Lakes and the surrounding vegetation in deep sided craters to the north of this site. The site interior contains extensive areas of geothermal kānuka scrub and other geothermal vegetation types, but it is vulnerable to, and is being compromised by, pest plant invasion, particularly wilding pines. Weeds are common on the margins of the site and the geothermal vegetation condition is probably being altered by geothermal energy extraction from the Wairakei Geothermal Field.</p> <p>Most of this site is of regional significance for its ecological values (Wildland Consultants 2014a) because it comprises a relatively large area of geothermal vegetation, which includes nationally uncommon habitat types: fumaroles, geothermally heated dry ground; hydrothermally altered soils (now cool) (Williams <i>et al.</i> 2007, Holdaway <i>et al.</i> 2012). The site also contains populations of five At Risk species, including geothermal kānuka (At Risk-Naturally Uncommon), <i>Dicranopteris linearis</i> (At Risk-Naturally Uncommon), <i>Christella aff. dentata</i> (“thermal”) (At Risk-Naturally uncommon), <i>Nephrolepis flexuosa</i> (At Risk-Declining), and New Zealand pipit (At Risk-Declining). This site occurs within the Wairakei Geothermal Field, which is part of the Wairakei-Tauhara Geothermal System. This field has been exploited for energy generation, domestic, commercial and other uses¹. Vegetation and geophysical monitoring of the features is undertaken - partly to assess if using the Wairakei Geothermal Field for energy production is having any effects on the features. Cody (2007) lists 12 features and geothermal characteristics present at this site, one of these was ranked as being of national significance.</p>
Ecosystem Services:	<p>Few provisioning services are provided at the Te Kiri O Hine Kai site. There is some potential for wilding pines (and other exotic trees) to be utilised for firewood or other commercial gain.</p> <p>The site provides regulation and maintenance including mass stabilisation and control of erosion rates, and sequestration of carbon (8,496 tC annually) and potentially other climate change gases.</p> <p>The site provides limited cultural services. Most of the site is on private land and is located almost entirely behind the fences containing</p>

¹ http://nzgeothermal.org.nz/nz_geo_fields: Accessed 14 February 2018.

geothermal power plant infrastructure and thus is not accessible to the general public. Some health and safety warning signs are present in parts of the site. The site is of scientific interest, with 239 research papers published on the geophysical characteristics of the site, its geothermal field and other scientific values (Google Scholar search).



Geothermal kānuka scrub and shrubland dominate much of the Te Kiri O Hine Kai site.
(January 2011)

Scattered wilding pines are present at the Te Kiri O Hine Kai site.
(January 2011)

