

Assessment of ecological information available for geothermal sites in the Waikato region

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ASSESSMENT OF ECOLOGICAL INFORMATION AVAILABLE FOR GEOTHERMAL SITES IN THE WAIKATO REGION



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1. INTRODUCTION

Geothermal ecosystems are some of the most threatened in the Waikato Region, having undergone significant reductions in extent and condition. Five geothermal ecosystem types have been recognised in New Zealand and these are all considered to have been naturally rare prior to human colonisation of New Zealand (Williams *et al.* 2007). Additionally, these are all identified as Critically Endangered in Holdaway *et al.* (2012). Waikato Regional Council (WRC) has an inventory of geothermal sites in the Waikato Region, which contains a summary of ecological information and assessments of ecological significance and relative significance level (Wildland Consultants 2014a; also see Wildland Consultants 2014b&c).

WRC updates this inventory around every four to five years, when new aerial photographs are flown, processed and made available.

WRC recently developed and applied simple and accurate indicators to assess the extent, condition, and protection level of geothermal vegetation and habitats in the Region (Wildland Consultants 2015). This project identified that there were gaps in some of the existing ecological information available for each site. WRC currently requires a summary of the type, details, scale, and date of existing information available for each site described by Wildland Consultants (2014). Priority rankings are also required for the future collection of information, to address any gaps identified.

2. METHODS

All of the sites assessed in Wildland Consultants (2014a) are listed in an Excel spreadsheet. Sites in the spreadsheet are listed by geothermal field, generally ordered from north to south, which is also consistent with Wildland Consultants (2014a). Information has been summarised for each site, including vegetation descriptions and mapping, geophysical assessment, information on plants (vascular and non-vascular), animal presence and abundances, pest plant threats, monitoring (plots/transects, photopoints, temperatures of substrates and water features), and whether a restoration or management plan had been prepared for each of these sites.

A literature review - including an internet search for available literature - for each site was undertaken to search for any additional publicly-available literature on these sites. Herpetofauna, aquatic fauna¹, invertebrate fauna¹, and detailed pest animal assessments.

¹ Surveys on some of these features have been undertaken; for example, NIWA has undertaken surveys on aquatic fauna and there have been some limited surveys of invertebrates undertaken.

3. FUTURE SURVEYS

3.1 Vegetation and mapping

The extent and composition of almost all geothermal vegetation and habitat in the Waikato Region has been mapped and at least broadly described on at least one occasion since 2007. There are exceptions: Hipaua and Ketetahi have not been surveyed in previous studies. The vegetation at these two sites has never been mapped in the field and has only been assessed as a desktop exercise, using aerial photography. These are important sites that - if described and mapped in more detail - would help to determine the full range and extent and composition of geothermal vegetation and habitats in the Taupo Volcanic Zone, facilitating improved assessments of significance and the state of the geothermal resource. There may also be other areas of geothermal vegetation present on hill slopes south of Tokaanu that have not been mapped previously. It is also possible that new areas of geothermal vegetation will be discovered during field visits to these sites. Other areas of geothermal habitat may be present but currently undocumented in the Waikato Region, but any undocumented sites are likely to be less than one hectare in extent.

Changes to the condition and extent of geothermal sites are known to occur for both natural and human-induced reasons. Regular monitoring (e.g. five yearly) is required to assess changes to site condition and this should be timed to coincide with the WRAPS updates. The following four types of relative priorities have been identified:

Category 1

- Sites that are at greater risk of human-induced change. This includes sites of any size:
 - Within or near residential areas.
 - Within or near commercial or industrial areas.
 - Located in geothermal fields subject to geothermal energy extraction.

Category 2

- Sites that are known to be undergoing natural change. The Te Maari site is an example of natural change following an eruption in 2012.
- Large sites, or sites with rare features. Inspections of key parts of sites larger than 10 hectares should be undertaken more regularly than smaller sites. An appropriate time frame for these sites may be five yearly.
- A desktop exercise could help to further prioritise site assessments within this category.

Category 3

- Sites that have not been previously field surveyed and mapped due to lack of land access (e.g. Hipaua and Ketetahi) and other non-documented sites. Remote evaluation, say every five years, may be adequate (e.g. Hipaua) unless there is a significant change or the landowners request further evaluation.

Category 4

- Smaller sites <10 hectares with no obvious threats from adjacent land use activities.

As all sites with indigenous geothermal vegetation are significant, appropriate timeframes need to be determined for field survey to check current condition and to update descriptions. Relative priorities for future information gathering should take account of:

- Threats, known or potential.
- Likelihood of significant modification.
- Likelihood of loss, of part(s) or all of a geothermal site.

Obvious known threats are all human-induced, and include energy extraction, farming (e.g. grazing), earthworks, rubbish dumping, fire, wetland drainage, recreation and tourism, plantation forestry, and spray drift from topdressing and herbicide application. Other serious threats include pest plants, particularly species such as wilding conifers, which, over time, can significantly alter vegetation character. Pest animals are also an issue (e.g. damage to vegetation by introduced mammals has been noted at some sites) but are less likely to result in major changes to structural character.

Relative priorities for future monitoring and information gathering are set out in Table 1.

Table 1: Relative priorities for future monitoring and information gathering at geothermal sites in the Waikato Region.

Site Category ¹	Type of Information ²	Frequency ³ (Years)	Comments
Category 1			
Sites within or close to residential areas.	Extent Character Threats	3	These sites are often small and highly modified, and subject to many threats.
Sites within or near commercial or industrial land uses.	Extent Character Threats	3	As for above.
Sites within geothermal fields subject to energy extraction.	Extent Character Threats	3	Potential for significant changes in substrate temperature.
Category 2			
Sites undergoing natural change.	Extent Character Threats	5	Large sites can be quite dynamic, with heating and/or cooling of local areas.
Large sites.	Extent Character Threats	5	As above.
Sites with rare features.	Extent Character Threats	5	The degree of threat will depend on the type(s) of features present.
Category 3			
Sites not previously field surveyed.	Extent Character Threats	Now, and then 5 yearly	Five-yearly or as opportunities arise.

Site Category ¹	Type of Information ²	Frequency ³ (Years)	Comments
Other undocumented sites.	Extent Character Threats	Now, and then 5 yearly	As above.
Category 4			
Small sites (<1 ha) not within the above categories.	Extent Character Threats	5	Relatively stable small sites not subject to obvious threats.

¹ Refer to text above for further discussion of Categories 1-4.

² To be collected during each monitoring round.

³ Suggested frequency of site checking/information gathering. Note that this should not be applied rigidly as situations will change.

Most small sites have been mapped in detail. Due to health and safety reasons, detailed mapping is often difficult for larger and more active sites. Opportunities exist to describe and map some of these areas using remote sensing (e.g. using a helicopter or drone) where ground-based survey is not feasible.

3.2 Geothermal features

Detailed survey of the geophysical characteristics of the geothermal features have been undertaken of most sites by GNS and its predecessors. Most of this data is unpublished, but there are published reports on Orakeikorako and Waiotapu, for example. Much of this work was undertaken 20 or more years ago. In recent times about 14 sites have been subject to detailed descriptions of most geophysical features. Most of these are small sites, although for some of the larger sites, geophysical characteristics have been partly described, e.g. Waiotapu South (the largest site), Waiotapu North, and Orakeikorako.

3.3 Priorities for 2016/2017 field survey

Table 1 above and personal knowledge of the sites has been used to identify priorities for field survey in 2017. Sites have been assigned to one of five priorities, with Priority 1 being the highest priority for field survey. These are presented in Appendix 1. However, these priorities should be reviewed prior to field survey, based on personal knowledge and by overlaying the current site extents over 2016/2017 aerial imagery to identify whether there has been any noticeable change in composition or extent of sites since the last survey.

3.4 Plants

Vascular Plants

Vascular plant species lists have been prepared for 11 of the 64 sites, including one site for which there is a species list with relative abundances. There is also a species list for all sites within the Mokai Geothermal Field combined, a list for the Tauhara Geothermal Field, and a combined species list for several sites within Wairakei-Tauhara Geothermal System. A list has also been compiled for the Maungakaramea/Rainbow Mountain Scenic Reserve, but it is not exclusive to geothermal vegetation. Coarse abundance levels should be specified for all future floristic surveys.

Bryophytes and Lichens

A list of common non-vascular plant species has been prepared for three sites. No sites have detailed lists of non-vascular plant species. Comprehensive surveys of bryophytes and lichens are justified for all geothermal sites, and could be undertaken progressively over time. Indigenous bryophytes and lichens have had their threat status classified, and better knowledge of bryophyte and lichen communities would help to inform assessments of geothermal significance.

3.5 Pest plants

An overview of pest plant distribution has been prepared for almost all (62) sites, and more detailed weed distribution maps have been prepared for four of these sites. Two sites - Te Maari Crater and Red Crater - where relatively detailed field inspections have been undertaken have no pest plants; both sites are amongst the highest altitude sites in the North Island.

Two sites - Ketetahi and Hipaua - have very limited information on pest plant distribution, although pest plants are unlikely to be present at Ketetahi.

The largest sites of good to high quality geothermal vegetation are also the highest priority for pest plant distribution mapping: Waikite, Maungaongaonga, Waiotapu North, Maungakaramea (Rainbow Mountain), Te Kopia, Waihunuhunu, Orakeikorako, Red Hills, Orokonui, Crown Road, Te Kiri O Hine Kai Stream Catchment/Wairoa Hill, Rotokawa North, Lake Rotokawa, and Tokaanu Thermal Park.

Some sites with older information on pest plant distribution, such as Craters of the Moon, which were last mapped nearly ten years ago, would benefit from updated mapping. Management decisions for small sites with populations of Threatened and At Risk plant species would be informed by monitoring of pest plants where populations of key indigenous plant species are likely to be threatened by pest plant invasion, e.g. Waipapa Stream and Whangapoa Springs.

3.6 Fauna

Avifauna

Fifty-three sites have incidental records of avifauna, while the remaining eleven sites have no data on avifauna. Some sites have limited avifauna information due to the limited time spent at the site during field survey, where the primary goal was to describe and map the vegetation present. Avifauna survey is not a high priority for management at most geothermal sites in the Waikato Region, because most do not provide significant habitat for avifauna.

The most significant values for avifauna at geothermal sites in the Waikato Region are the sites with wetland and lake margin habitat (e.g. Tokaanu Lakeshore wetland, the wetlands at the southern end of Waiotapu South, Lake Rotokawa, Waikite, and Tokaanu Thermal Park), which support Threatened and At Risk bird species. Sites with mātātā/North Island fernbird (*Bowdleria punctata vealeae*), pūweto/spotless crane

(*Porzana tabuensis tabuensis*), and pīhoihoi/New Zealand pipit (*Anthus novaeseelandiae novaeseelandiae*) would also warrant regular monitoring as fernbird may be an indicator of overall site health.

Sites surrounded by higher quality indigenous forest habitat, such as Maungakaramea and Te Kopia, may also warrant collection of more comprehensive avifauna information, as they would better illustrate the characteristic avifauna of geothermal sites. In future surveys bird information collected from geothermal sites could be captured in eBird (<https://ebird.org/home>).

Other Fauna Information Gaps

Most geothermal sites have limited or no information on herpetofauna, fish, invertebrates, and fungi, with some information on micro-organisms captured by GNS Science. Each of these gaps should be filled progressively by targeted surveys. Sites where these surveys should be prioritised include the larger, more intact, sites and those with more habitat diversity, such as Waikite, Te Kopia, Maungakaramea, Waiotapu South, Orakeikorako, Lake Rotokawa, Hipaua, and sites on Mt Tongariro.

Baseline assessments of pest animal densities, and ongoing monitoring of pest animal abundance, may be needed where Threatened or At Risk indigenous fauna are vulnerable to predation from pest animals, or where pest animals are having significant effects on geothermal vegetation and habitat. Examples include Waiotapu South, where pigs are a problem, and Waikite, where dama wallaby have been present for some time.

3.7 Monitoring

3.7.1 Vegetation plots or transects

Quantitative monitoring of geothermal sites in the Waikato Region using plots or transects is currently relatively scarce, occurring at 12 of 64 sites. Most long-term monitoring has been set up within the last ten years. Nine of these monitoring projects have associated soil/water temperature monitoring.^{1,2}

3.7.2 Photopoints

Photopoints have been established at 15 of 64 sites. Photopoints could easily be established at all sites, when inventory studies of vegetation and habitat are being undertaken in the field.

It should be noted that some of the larger sites that do have established photopoints have only a very limited number of photopoints, which do not represent the variation

¹ Note that GNS (and their predecessors) have measured water temperature of many features (some are part of ongoing quarterly or annual monitoring programmes either by WRC or GNS) and WRC holds this information in a database.

² As part of the current assessment, temperature records have only been included in the supporting Microsoft Excel spreadsheet where they have been undertaken as part of ongoing, repeatable, vegetation monitoring. As substrate temperature is informative for vegetation monitoring, substrate monitoring should always be undertaken in conjunction with vegetation monitoring.

of vegetation and habitats present at these sites. For example, Te Kiro O Hine Kai Stream Catchment/Wairoa Hill and Craters of the Moon each only have two permanent photopoints. Additional photopoints are necessary at these sites, to better represent the vegetation and habitats present.

3.7.3 Threatened or At Risk plants

Forty-eight of 64 geothermal sites in the Waikato Region are known to have populations of Threatened and/or At Risk plants (as per the classifications in de Lange 2013). To meet the criterion of monitoring of Threatened and At Risk plants, in the supporting spreadsheet the abundance of the species must have been assessed and information collected on condition, threats, and/or population structure. Of the 48 sites where Threatened and At Risk plant species are known, monitoring of Threatened and/or At Risk species has been undertaken at 13 sites. Further assessments of these populations have occurred at ten of these sites. Monitoring has been comprehensive for the entire assemblage of At Risk and Threatened species at one site only (Orokonui).

A greater emphasis on monitoring has been applied to geothermal ferns, three species of which have been monitored at all sites (Wildland Consultants 2007). Targeted monitoring of geothermal kānuka (*Kunzea tenuicaulis*) population has only been undertaken one site, but it has been surveyed within transects and plots at various sites, e.g. Crown Road, Broadlands Road, Orokonui, Te Kopia, and Craters of the Moon. At Risk orchids, such as *Calochilus robertsonii* at Lake Rotokawa, may be good indicators of site health and could also be targeted for more regular monitoring. Future monitoring could be undertaken at times of the year where orchids are more conspicuous. Some orchid species are only present at certain times of the year, e.g. late spring.

3.8 Restoration/management plan

Detailed restoration and management plans have been prepared for three of 64 sites: Broadland Road, Craters of the Moon, and Otumuheke. One site - Orakeikorako - has a plan for the control of wilding pines. Preparation of management plans should be a high priority for sites where ecological restoration or weed control is needed. Sites where restoration has taken place require regular follow up to assess the success of restoration works, and to update restoration plans as required.

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PRIORITIES FOR 2016/2017 FIELD SURVEY

Priorities for field survey, survey of surrounding areas using a drone, increase in definition of aerial photographs, are included below. Actions identified as Priority 1 are of the highest priority, followed in numerical order through to 5. However, these priorities should be reassessed once the 2016/17 aerial photographs are available by overlaying the 2014 GIS layer to identify any large discrepancies in vegetation/habitat extent or composition between 2016/17 photographs and 2011/12 photographs. The full suite of tasks can be undertaken at each site, however high priority actions for each site are identified.

Legend

V	=	Vegetation mapping and description
GF	=	Geothermal features
P	=	Plant list (including abundance estimates)
W	=	Pest plant mapping
RP	=	Restoration/management plan
SIS	=	Update site information sheet and map as per 2014 report (Wildland Consultants 2014)
PP	=	Establish photopoints

PRIORITY 1

Site Name	Key Work Required ¹	Notes
Hipaua (TOV02)	SIS, P, V, PP	
Ketetehi (TGV02)	SIS, P, V, PP	Also survey Emerald Lakes, Red Crater at the same time.
Tokaanu	SIS, P, V, PP	Combination of aerial survey using a drone, followed by ground based survey of potential sites with geothermal vegetation or habitat.
Te Maari Craters (TGV01)	SIS, P, V, PP	

PRIORITY 2

Survey surrounding area for previously unknown small areas of geothermal vegetation/habitats. (Use drone or similar to undertake this work.)

Site Name	Key Work Required ¹
Maunganamu West (TOV07)	Map and describe any previously unknown small areas of geothermal vegetation. Prepare plant species lists for all areas inspected on the ground (c.f. viewed from a distance through binoculars). Tokaanu Thermal Park and Waikite Valley are also a high priority for pest plant mapping.
Tokaanu Lake Shore Wetland (TOV05)	
Tokaanu Thermal Park (TOV08)	
Waikite Valley (WAV01))	

¹ The full suite of tasks can be undertaken for each site, however, high priority actions for each site are identified.

PRIORITY 3

These are generally High Value sites for which there is recent high-quality information available, however, the quality of information could be greatly improved if higher resolution aerial photographs were available (and utilised). This may be achieved via the 2016/2017 RDAM (Regional Digital Aerial Mosaic) photographs or the use of a drone to obtain high quality imagery (including infrared). Annotated plant lists should be prepared (or updated where they already exist) for any of these sites that are field inspected on the ground.

Site Name	Notes
Maungaongaonga (WTV01)	High priority for pest plant mapping.
Ngapouri (WTV02)	
Waiotapu North (WTV03)	High priority for pest plant mapping.
Maungakarama (Rainbow Mountain) (WTV04)	High priority for pest plant mapping.
Waiotapu South (WTV05)	
Te Kopia (TKV01)	High priority for pest plant mapping.
Orakeikorako (OKV03)	High priority for pest plant mapping.
Red Hills (OKV04)	High priority for pest plant mapping.
Te Rautehuia (WKV01)	
Te Rautehuia Stream (WKV02)	
Upper Wairakei Stream (Geyser Valley) (WKV03)	
Craters of the Moon (WKV10)	
Rotokawa North (RKV01)	High priority for pest plant mapping.
Lake Rotokawa (RKV02)	High priority for pest plant mapping.

PRIORITY 4

Require field work to determine full range of current threats to the site.

Site Name	Notes
Waipapa Stream (MKV02)	High priority for pest plant mapping.
Tirohanga Road (MKV03)	
Paerata Road (MKV04)	
Whangapoa Springs (ATV02)	High priority for pest plant mapping.
Murphy's Springs (TKV02)	
Western Te Kopia (TKV03)	
Waihunuhunu (OKV01)	High priority for pest plant mapping.
Longview Road (RPV01)	
Ohaaki Steamfield West (OHV01)	
Ohaaki Steamfield East (OHV02)	
Otumuheke Stream (THV01)	
Spa Thermal Park (THV03)	
Broadlands Road (THV04)	
Crown Road (THV06)	High priority for pest plant mapping.
Waipahihi Valley (THV07)	
Te Kiri O Hine Kai Stream Catchment/ Wairoa Hill (WKV05)	High priority for pest plant mapping.
Tokaanu Urupā Mud Pools (TOV09)	
Maunganamu North Wetland (TOV11)	

PRIORITY 5

There is generally recent high quality information available for these sites, which are generally of relatively lower value or are relatively small.

Site Name	Notes
Horohoro (HHV01)	
Northern Paeroa Range (WAV02)	
Whakamaru (MKV01)	
Upper Atiamuri West (ATV01)	
Matapan Road (ATV03)	
Mangamingi Station (TKV06)	
Akatarewa Stream (OKV02)	
Akatarewa East (OKV05)	
Waikato River Springs (NMV01)	
Orokonui (NMV02)	High priority for pest plant mapping.
Whangairorohea (WGV01)	
Wharepapa Road (RPV02)	
Golden Springs (RPV03)	
Crown Park (THV05)	
Mountain Road (THV08)	
Kathleen Springs (THV09)	
WairakeiBorefield (WKV04)	
Lower Wairakei Stream (WKV06)	
Karapiti Forest (WKV07)	
Hall of Fame Stream (WKV08)	
Waipouwerawera Stream/Tukairangi (WKV09)	
Maunganamu East (TOV10)	
Tokaanu Tailrace Canal (TOV14)	



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