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RANKING OF GEOTHERMAL SITES FOR BIODIVERSITY MANAGEMENT IN THE WAIKATO REGION

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RANKING OF GEOTHERMAL SITES FOR BIODIVERSITY MANAGEMENT IN THE WAIKATO REGION

Contract Report No. 2756a

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1. INTRODUCTION

Waikato Regional Council commissioned Wildland Consultants to revise the criteria set used for the ranking of geothermal habitats in the Waikato Region. The criteria set was based on the method for ranking terrestrial ecosystems in the Waikato Region (WRC 2011), the use of which was resulting in inconsistencies or errors when applied to geothermal habitats. Key requirements of the Regional Council are that the review is to address the removal of criteria not relevant for geothermal habitats, the removal of any potential "double-dipping" with regards to site scoring, and simplification, to ensure that the scoring system can be applied both efficiently and accurately. A key objective of the revision was to also design a single worksheet that includes all of the criteria, to enable the calculation of an overall site score.

This report provides:

- An overview of the wider regional ranking criteria set.
- A brief review of the wider regional ranking criteria set, to identify the criteria relevant to ranking geothermal sites.
- Identification of additional or newly-formulated criteria relevant to the ranking of geothermal sites.

It is important that the Regional Council is able to soundly prioritise potential biodiversity management effort in geothermal areas. These habitats are of very limited extent, occur at more than 60 sites, and many are degraded and/or under considerable threat.

2. WIDER CONTEXT

Geothermal sites in the Waikato Region have been well documented in the following reports: Wildland Consultants 2000, 2003, 2004c, 2006, 2007a&b, 2012, and 2014. These inventories, and others done elsewhere, particularly in the Bay of Plenty Region, clearly show that only relatively limited areas of geothermal habitat remain on a national basis. The condition of sites in the Waikato Region is also well documented, including management requirements to maintain and/or improve condition.

Geothermal habitats are also recognised as being an 'originally rare' ecosystem at a national level by Williams *et al*. (2007) who include dry hydrothermally-heated ground, hydrothermally-altered ground that has cooled, acid rain systems, fumaroles, and geothermal stream-sides in their definition of geothermal systems. Holdaway *et al*. (2012), in their list of naturally uncommon ecosystems in New Zealand, list the following geothermal features as being Threatened-Critically Endangered: fumaroles, geothermal streamsides, geothermal heated ground, geothermal hydrothermally altered ground (now cool). This list can be expanded to include other geothermal habitat types which are clearly 'historically rare' and 'naturally uncommon': hydrothermally-heated ground that is wet or moist, geothermal wetlands and lake margins (e.g. Lake Orotu, Waiotapu), steam-induced vegetation, and hot springs.

It is also relevant to consider national-level frameworks such as Lee *et al*. (2005), who grouped seven ecological integrity indicators within three primary elements: native dominance (native vegetation cover, non-native plant and animal dominance, water quality, and ecosystem disruption), species occupancy (composition - plants, composition - animals), and environmental representation (climate change).

While not directly applicable to geothermal habitats as a system for the ranking of management priorities, this approach nevertheless has some relevance to aspects of a ranking system.

It also needs to be recognised that the Waikato Regional Policy Statement contains a set of criteria for the evaluation of indigenous vegetation and the habitats of indigenous fauna. A non-statutory guideline is also available, to assist with the application of that criteria set.

3. REGIONAL CRITERIA FOR MANAGEMENT PRIORITIES

The original Waikato Regional Council criteria set used to assess geothermal habitats comprised the following:

- National Priorities for Biodiversity Protection;
- Threatened Land Classification;
- Ecosystem Condition;
- Regional Representativeness;
- Region's "Land Priority" with regards to Land Environments of New Zealand;
- Vulnerability;
- Extinction Threat;
- Outcome Objectives for Long Term Council Plan;
- Funding and Management Input;
- Restoration Potential.

The above criteria set, as noted, was designed and previously used for the ranking of significant natural areas across the Region. As such, it has been applied (WRC 2011) to the following ecosystem types:

- Terrestrial
- Wetland
- Sand Dune
- Shingle Beach
- Offshore Islands

For various reasons, geothermal vegetation and habitats don't fit particularly well into the above categories, leading to the need for this review.

4. GEOTHERMAL-SPECIFIC CRITERIA

4.1 Overview

The wider regional criteria set above was reviewed and each criterion was critiqued for their applicability to geothermal ecosystems. Criteria were either retained with modifications, or omitted.

4.2 Original criteria to be retained, with modifications

The following criteria are considered to be appropriate and useful for the ranking management priorities for geothermal habitats, and should continue to be used for that purpose:

- Size of Area;
- National Priorities for Biodiversity Protection (except Priority 1, see below);
- Threatened Species;
- Representativeness;
- Proximity to Natural Areas (Buffering);
- Vulnerability;
- Restoration Potential;Outcome Objectives;
- Funding and Management Input.

Discussion

Size is an important criteria for geothermal areas as larger sites tend to have greater habitat diversity, and the largest sites are, without exception of very considerable value.

National Priorities: Geothermal habitats are of very limited extent on a national basis, and national-level priorities are important.

Threatened Species: Various threatened species only occur in geothermal habitats, so the threatened species criterion is important.

Representativeness: The retention (and enhancement) of the full representative range of geothermal habitats is important, although it can be validly argued, due to the limited overall area remaining, that all geothermal areas are important, although extent, diversity, and quality may vary markedly. It is still nevertheless useful, for ranking purposes, to determine which sites have higher values for this criterion.

Representativeness, as a general concept, has been used widely in New Zealand and can be defined as comprising indigenous vegetation or habitats of indigenous fauna that contain associations of indigenous species representative, typical, or characteristic of the natural diversity of the region or the relevant ecological district(s).

In relation to geothermal sites, representativeness is based on the character of habitats present at a site and can take account of ecological sequences, and diversity. This

criterion can also take account of the condition or quality of the vegetation/habitat, in terms of the degree of physical modification to ecological processes, as well as community structure, species composition, and the degree of invasion by exotic species.

Irreplaceability is also an important consideration. Various unique combinations of geological and hydrological processes have, in places, led to the formation of irreplaceable geothermal features (i.e. those that are the only example, or a high proportion of what remains of their type), which should be taken into account when the representation of features at geothermal sites is considered. Particular importance needs to be assigned to sites with high irreplaceability when rankings are applied.

The 'traditional' application of the representativeness criterion in New Zealand context is for it to be assessed within relevant ecological districts. This framework is perhaps less relevant to geothermal habitats although it can still be used. Geothermal fields provide a suitable evaluation framework as they determine key processes which drive the extent and character of geothermal surface feature expressions. Altitude is also a relevant consideration, say within relevant bio-climatic zones.

Proximity to natural areas (buffering): This is important as better sites tend to be larger and also tend to be part of larger complexes that include non-geothermal vegetation. Proximity to other geothermal sites is also an important consideration, particularly if connected by non-geothermal indigenous vegetation (or a mixture of indigenous and exotic vegetation, such as stands of wilding exotic trees).

Vulnerability: A key criterion as vulnerability to modification is a key consideration for the prioritistion of management effort, to avoid loss or serious degradation of a site.

The criteria to be retained were divided into two groups: the first relating to ecological value, and the second relating to prioritisation of management.

Ecological value:

- National priority;
- Size;
- Representativeness;
- Proximity to natural areas;
- Threatened or At Risk species.

Management priorities:

- Vulnerability;
- Outcome objectives;
- Fudning and management;
- Restoration potential.

These criteria sets are set out in more detail in Sections 4 and 5 respectively.

Criteria were given different weightings depending on the relative importance of the criterion. Representativeness was given the highest weighting among the criteria for assessment of ecological value, due to its importance for all classes of geothermal vegetation and habitat. Size and taxon threat status were also weighted relatively highly. Vulnerability and restoration potential have the highest weighting for assessment of management priority.

Likewise, restoration potential is important as there is little point in putting considerable effort into degraded sites where there is little potential gain to be achieved. This also has a bearing on the outcome objectives and the levels of funding and management input required.

4.3 Original criteria to be omitted

The following criteria should not be used for the ranking of geothermal habitats:

- Threatened Environment Classification;
- Region's Land Priority;
- Ecosystem Condition;
- Extinction Protection.

Neither of the criteria for **Threatened Environment Classification** or the Region's **Land Priority** are applicable to geothermal ecosystems as the mapping systems on which they are based do not include geothermal ecosystems. The significance of a geothermal site is better addressed through assessment of its size, ecosystem condition, and representativeness.

Ecosystem condition can be considered under Representativeness as the condition of vegetation and habitats can be accommodated under that criterion.

The **Extinction Protection** criterion has aspects relevant to geothermal ecosystems, but these are now covered in detail under the revised and expanded criterion for "Threatened or At Risk Species". This criterion encompasses all Threatened or At Risk taxa found at a site, and whether a site constitutes a national or regional stronghold for any of these.

5. ECOLOGICAL VALUE CRITERIA SET

5.1 Overview

As noted above, the criteria set to rank overall ecological value contains four elements:

- National priority
- Size
- Representativeness
- Proximity to natural areas.

Each criterion is outlined and discussed below.

5.2 National priority (24 points)

The national priority of a site can be assessed using two sub-criteria below which contribute points cumulatively, i.e. scores are added for each sub-criterion. Habitat for Threatened or At Risk species is also a National Priority (National Priority 4) but this has been addressed within a separate criterion: Threatened or At Risk Species (Section 5.6 below).

Sub-criteria for the evaluation of National Priority are as follows:

- Site supports indigenous vegetation in an ecological district with 20% or less remaining in indigenous cover;
- Site contains an "originally rare' ecosystem type at a national level, as defined by Williams *et al*. (2007) and Holdaway *et al*. (2012).

If a site supports indigenous vegetation in an ecological district with 20% or less remaining in indigenous cover, a score of 6 would be applied. If one or more 'originally rare ecosystem types' are present, a score of 6 is also applied. The combined scores for National Priority are then multiplied by 2, to obtain a maximum possible score of 24.

Justification

List the site characteristics that trigger each of the two sub-criteria.

5.3 Size (40 points)

The size of a geothermal site contributes towards its ecological value, with larger sites generally having greater diversity and long-term viability, and having greater importance for the conservation of geothermal habitats in the Region.

Size can be assessed for each site as follows:

- >50 ha High. Score 20
- 10 to 50 ha Medium. Score 15
- 1 to <10 ha Medium-Low. Score 10.
- <1 ha Low. Score 1.

Size has been assigned a weighting of 2, to attain a maximum possible score of 40. Further explanation of the size scores is provided below.

- **High (20):** The ecosystem being assessed is >50 ha in area. Geothermal ecosystems that comprise separate areas, but cumulatively sum to >50 ha, should be included here if they are part of a contiguous natural landscape and are part of the same Geothermal Field.

- **Medium (15):** The ecosystem being assessed is 10-50 ha in area. Geothermal ecosystems that comprise separate areas, but cumulatively sum to 10-50 ha, should be included here if they are part of a contiguous natural landscape and are part of the same Geothermal Field.

- **Medium-Low (10):** The ecosystem being assessed is relatively small, 1-10 ha. Geothermal ecosystems that comprise separate areas, but cumulatively sum to 1-10 ha, should be included here if they are part of a contiguous natural landscape and are part of the same Geothermal Field.

- **Low (1):** The total area of geothermal ecosystem that is being assessed is very small (<1 ha).

Justification

State which of the "High", "Medium", "Medium-Low", or "Low" categories above the site fits most closely.

5.4 Representativeness (75 points)

To assess representativeness, the following should be taken into account:

- The type and extent of geothermal habitats present at a site, e.g. create a list of habitats and their areas.
- The relative state (i.e. condition) of those habitats.
- Irreplaceability.

Representation of particular habitat types at a site is an important consideration, along with condition. Irreplaceability can be considered within the relevant geothermal field or ecological district (or both), and is also an important consideration.

For each site, representativeness can be ranked as being Very High, High, Medium, or Low, and scored as follows:

- **Very High (15):** One of the best *OR* relatively large *OR* good quality example of vegetation and habitat/habitat mosaic/ecological sequence in the relevant geothermal field/ecological district. Key ecological and hydrological processes are intact.

  No evidence that threats (e.g. drainage, fluid extraction, pest plants, pest animals, geothermal power generation) are having marked detrimental effects on key elements of habitat quality. Wilding trees or other exotic plants may be present, but have not significantly degraded key geothermal processes or character. Example sites are Ketatahi Hot Springs, which is virtually unmodified by anthrogenic influences, and Te Kopia.

- **High (10)**: Often good quality, but may be smaller and similar to other areas that occur elsewhere in the relevant geothermal field/ecological district. Ecological and hydrological processes are only slightly affected.

Little evidence that threats (e.g. drainage, fluid extraction, pest plants, pest animals, geothermal power generation) are affecting habitat quality.

Exotic plant species may be present but have not significantly degraded key geothermal processes or character. Example sites are Red Hills and Waiotapu South which are dominated by indigenous vegetation.

- **Medium (5)**: Degraded and/or small; better quality examples exist elsewhere in the relevant geothermal field/ecological district. Ecological and hydrological processes are obviously modified.

  Some impacts from threats (e.g. drainage, fluid extraction, pest plants, pest animals, geothermal power generation) are evident. Exotic plant species cover up to 30% of the site. Example sites include Ohaaki West and Te Kiri o Hine Kai Stream catchment/Wairoa Hill, due to the considerable presence of wilding pines.

- **Low (1)**: Very degraded, one of the lowest quality examples of a habitat type in the relevant geothermal field/ecological district.

  Ecological and hydrological processes are severely affected by threats (drainage, fluid extraction, pest plants, pest animals, or geothermal power generation). Site is dominated by exotic species, or is likely to become so in the long-term. Example site is Horohoro, which is dominated by exotic species.

The score for representativeness was multiplied by 5, to obtain a maximum possible weighted score of 75.

Justification

Identify the site characteristics that resulted in its score for representativeness, e.g. best example of geothermal vegetation in the relevant geothermal field/ ecological district.

5.5 Proximity to other natural areas (15 points)

Sites that are contiguous with other indigenous habitat types (e.g. indigenous forest) are likely to have greater buffering against other land uses (e.g. farming or forestry). Proximity to other geothermal sites is also an important consideration, as a complex of geothermal sites may occur within a larger tract of linking indigenous vegetation, or mixtures of indigenous and exotic (e.g. wilding trees) vegetation. Examples include: Waiotapu North-Waiotapu South, and Maungakakaramea (Rainbow Mountain), and Lake Rotokawa and Rotokawa North.

Proximity to natural areas was scored as follows:

- **High (15)**: Site predominantly located within a larger tract of indigenous vegetation or habitat.

- **Medium (10)**: Site contiguous with, but not entirely surrounded by, indigenous vegetation or habitat types.

- **Low (5)**: Site isolated from other indigenous vegetation or habitat types.

This criterion was multiplied by 1, to obtain a maximum possible score of 15.

Justification

Identify the characteristics of the site that triggered the score for proximity to natural areas e.g. site surrounded by indigenous vegetation.

5.6 Threatened or At Risk Species (40 points)

Geothermal areas provide habitats for vascular plants, avifauna, bats, invertebrates, lichens, fungi, thermophiles, and other biota. Various threatened taxa may be present but indigenous vascular plants are prominent at most geothermal sites. Threatened vascular plant species comprise the groups of threatened species most easily evaluated under this criterion. As such, this criterion is currently based on the assessment of that group.

Geothermal habitats are critical for the survival of plant species that are restricted to geothermal habitats (e.g. prostate kānuka - *Kunzea ericoides* var. *microflora*[1]) or maintain their greatest abundance within geothermal habitats in New Zealand (e.g. *Christella* aff. *dentata* 'thermal'). This criterion assesses the importance of a site for the conservation of Threatened or At Risk geothermal plant species. Various sub-criteria set out below can be used to address the presence or absence of Threatened or At Risk plant species, and the relative importance of these populations for the conservation of these species, on a local, regional, and national basis.

Scoring of Threatened or At Plant Risk species has been capped at three or more species in the same category and would be calculated as shown in Table 1.

Table 1: Scoring of threatened species criteria based on the number of species in each threat class. Weightings of threat classes are set out below in Table 2.

Number of Species in Each Threat Category	Score Calculation
1	1 x weighting of threat class
2-3	2 x weighting of threat class
>3	3 x weighting of threat class

[1] Recent revision of *Kunzea* taxonomy (de Lange 2014) was not adopted in this iteration because field work was completed prior to the publication of the revision.

Weighting of threat classes are as follows:

Table 2: Weighting of threat classes.

Threat Category		Weighting
Threatened	Nationally Critical	6
	Nationally Endangered	5
	Nationally Vulnerable	4
At Risk	Declining	3
	Recovering	2
	Relict/Naturally Uncommon/Sparse/ Range Restricted	1
Other	Data Deficient	1

A worked example of the above system is shown in Table 3.

Table 3: Threatened or At Risk species at a site and how to calculate the overall score for the 'threatened plant species' criterion

Species in Each Threat Category	Score Calculation (Number of Species × Weighting of Threat Class)	Score
At Risk-Naturally Uncommon *Thelypteris confluens, Kunzea ericoides* var. *microflora**	2 x 1	2
At Risk-Declining *Cyclosorus interruptus*	1 x 3	3
Total		**5**

* Recent revision of *Kunzea* taxonomy (de Lange 2014) was not adopted in this iteration because field work was completed prior to the publication of the revision.

Twelve Threatened or At Risk plant species that occur in geothermal habitats are listed below. A hypothetical site that had all of these species would score 9, comprising $2 \times 3 = 6$ for At Risk-Declining species plus $3 \times 1 = 3$ for Naturally Uncommon species. An additional five points is assigned for each species that has a recognised national or regional stronghold[1] at a site, with a cap of up to three strongholds.

- *Cyclosorus interruptus* At Risk-Declining
- *Thelypteris confluens* At Risk-Naturally Uncommon
- *Christella* aff. *dentata* 'thermal' At Risk-Naturally Uncommon
- *Nephrolepis flexuosa* At Risk-Declining
- *Dicranopteris linearis* At Risk-Naturally Uncommon
- *Kunzea ericoides* var. *microflora* At Risk-Naturally Uncommon
- *Hypolepis dicksonioides* At Risk-Naturally Uncommon
- *Schizaea dichotoma* J.E.Sm. At Risk-Naturally Uncommon
- *Fimbristylis velata* At Risk-Naturally Uncommon
- *Calochilus paludosus* At Risk-Naturally Uncommon

[1] A stronghold is defined as a site that supports the largest, or one of the largest, populations of a Threatened or At Risk species, either regionally or nationally.

- *Calochilus robertsonii* At Risk-Naturally Uncommon
- *Caladenia alata* At Risk-Naturally Uncommon

Additional species may be added to this criterion in time due to increased knowledge of geothermal habitats, or taxonomic revisions.

No site is likely to score more than 24 points for this criterion: three Naturally Uncommon species (3 points), two At Risk-Declining (6 points), and three strongholds (15 points). The score is unweighted.

6. CRITERIA SET FOR MANAGEMENT PRIORITIES

6.1 Overview

As noted in Section 3 above, four criteria are used to rank sites with respect to priority for active management:

- Vulnerability
- Outcome objectives
- Funding and management
- Restoration potential

Each criterion is discussed further below.

6.2 Vulnerability (24 points)

Vulnerability is the susceptibility of a site or habitats at a site to modification or degradation from human and/or pest impacts. Vulnerability was classed as High, Medium, or Low, and scored as follows.

- **High (4):** Geothermal areas that are deteriorating (or have a high probability of deteriorating) in the short-term as a result of adverse effects from a threat mechanism that is operating, e.g. clearance and drainage of geothermal vegetation and conversion to other land uses, e.g. industrial land.

- **Medium (3):** Ecosystems that have the potential to deteriorate in the medium term as a result of a low intensity threat, e.g. wilding pines are establishing on the margins and have the potential to spread further within the site.

- **Low (2):** Sites with low vulnerability are frequently of either very low or very high quality. High quality sites with low vulnerability include natural areas that are largely unmodified, have low levels of introduced plants and animals, and are either large in size or well-buffered by adjacent natural areas. Many sites that are ranked as 'Unmodified' (refer to Section 4, above) will be of low vulnerability, assuming that current levels of management continue. Many sites that are ranked as 'Extremely Degraded' will also have a low level of vulnerability. This is because they are already very highly degraded and are unlikely to experience further deterioration in condition unless they are completely destroyed.

The score for vulnerability was multiplied by 6, to obtain a maximum possible weighted score of 24.

Justification

Identify and list the site characteristics relevant to vulnerability, e.g. small highly modified site.

6.3 Restoration potential (20 points)

This criterion is an assessment of the level of restoration that could be achieved at a site based on the funding input, measured in dollars invested per hectare per year.

- **High (4):** Less than $1,000/ha/year for a minimum of three years would make significant improvements at a site, including recovery of habitats and reduction of threats.
- **Medium (2):** between $1,000 to $2,000/ha/year for a minimum of three years would make significant improvements at a site.
- **Low (1):** greater than $10,000/ha/year for a minimum of three years would be required to make significant improvements at a site.

This criterion was multiplied by five, to obtain a maximum possible weighted score of 20.

Justification

Briefly describe or suggest restoration work or other management efforts (if any) that could potentially be achieved depending on the funding value assigned to the site (as indicated above).

6.4 Outcome objectives (14 points)

This criterion has two components:

- Community involvement.
- Updating of ecosystem inventories.

Outcome objectives are scored cumulatively for each sub-criterion met, as outlined below:

- **Community Involvement (4):** Community involvement can contribute greatly to the enhancement of biodiversity, and up-to-date ecosystem inventories are essential in ensuring that resources are channelled to the best outcomes. If a community is undertaking biodiversity or ecological enhancement activities at the site, the site would be assigned a score of 4.

  Justification: For community involvement, identify the relevant community group that is committing resources to the site, and/or the project name.

- **Updating of Ecosystem Inventories (3):** Refer to the site identification information or attributes/maps that have been added to the Waikato Regional Council's information systems (name of data set, e.g. Biodiversity GIS vegetation mapping, WERI). If a site meets this sub-criterion it is assigned a score of 3.

  Justification: For updating of ecosystem inventories state how management is contributing to knowledge of the site.

Overall

The sub-criteria for community involvement (maximum score 4) and ecosystem inventories (maximum score 3), are summed, and multiplied by 2 to obtain a maximum possible weighted score of 14.

6.5 Funding and management input (10 points)

This criterion is an assessment of the level of funding or support - from sources other than Waikato Regional Council - for activities such as pest control, fencing, threatened species protection and/or habitat restoration within a site. This criterion seeks to identify where resources are currently being currently applied, and sites achieve a higher score if there is little or no existing funding or management.

Possible Values

- **Unknown (5):** There is no information available that indicates any funding and/or management input.
- **Unresourced and unmanaged (5):** It is known that there is no funding or management input at a site.
- **Intermittently resourced and managed (4):** There is limited funding and management input from one or two sources (for example a local community group).
- **Moderately resourced and managed (3):** There is funding and management input (for example from a local District Council, trust or conservation organisation).
- **Adequately resourced and managed (2):** There is a high level of funding and management input (for example from central government (e.g. Department of Conservation) or national trusts or conservation organisations such as QEII, Landcare Trust, Forest & Bird).

This criterion is multiplied by 2, to obtain a maximum possible weighted score of 10.

Justification Content

List and briefly describe any funding and/or management (if known) occurring within the site.

7. TRIAL SCORING OF SITES

7.1 Overview

There are 83 geothermal sites in the Waikato Region and the revised criteria sets above - for ecological values and management priorities - were applied to 64 of these. A site could achieve a maximum total site score of 274. Sixty-four sites were assessed, and site scores ranged from 55 to 232. Results from these evaluations are summarised below.

7.2 Ecological value

Sixty-four sites were scored. Site scores for ecological values ranged from 24 to 182.

Using the criteria and scoring set out above (Section 4), a site can achieve a maximum possible score of 206 for relative ecological value. However no site scored more than 182 due to the wide range of criteria considered for each site, and the low likelihood that any one site will score highly for all criteria.

All sites scoring 120 or more can be considered to be a high priority for management. All sites of National or International significance scored at least 120 points.

7.3 Management priority

A site could achieve a maximum of 68 points for management priority. Sixty-four sites were assessed, and site scores ranged from 27 to 60.

High values for management priority are obtained for sites that are vulnerable but for which cost-effective restoration actions are readily available. Ecological value and priority for management are not always related, as sites that score highly for criteria such as representativeness and condition will often score poorly for criteria such as vulnerability (as the largest, most intact sites are often the least vulnerable), or restoration potential (as the sites with the best ecological condition may be a low priority for restoration efforts).

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APPENDIX 1: SPECIES LISTED BY WAIKATO REGION COUNCIL AS QUALIFYING FOR THE "EXTINCTION PROTECTION" CRITERION (FROM WRC 2011)

Common Name	Scientific Name
North Island brown kiwi	*Apteryx mantelli*
Blue duck	*Hymenolaimus malachorhynchos*
Awaroa koromiko	*Hebe scopulorum*
Northern New Zealand dotterel	*Charadrius obscurus aquilonius*
Brown teal	*Anas chlorotis* "North Island"
Swamp helmet orchid	*Anzybas carsei*
	Thermophilic archaea
Maui's dolphin	*Cephalorhynchus hectori maui*
Cooks scurvy grass	*Lepidium oleraceum*
Mistletoe species:	*Korthalsella salicornioides* *Peraxilla tetrapetala* *Tupeia antarctica* *Alepis flavida* *Peraxilla colensoi*
Epacris shrub	*Epacris sinclairii*
Sneezeweed	*Centipeda minima* subsp. *minima*
Christella	*Christella* "thermal" (unnamed c.f. *C. dentata*)

APPENDIX 2: SITE RANKINGS

An MS Excel spreadsheet DM 3292678 of the full ranking scores is available from WRC on request.

Site name	Total weighted score
Te Kopia	232
Waiotapu South	227
Maungakakaramea (Rainbow Mountain)	222
Waikite Valley	201
Waihunuhunu	193
Orakeikorako	192
Red Hills	182
Lake Rotokawa	173
Rotokawa North	170
Tokaanu Lake Shore Wetland	168
Maungaonaonga	167
Craters of the Moon	165
Emerald Lakes	159
Otumuheke	158
Ketetahi (Tongariro)	153
Te Maari Craters	149
Te Kiri o Hine Kai Stream catchment	149
Hipaua	147
Ohaaki West	146
Crown Road	145
Waiotapu North	143
Upper Wairakei Valley (Geyser Valley)	142
Waipapa Stream	138
Orakonui	137
Akatarewa Stream	137
Te Rautehuia Stream	137
Tokaanu Thermal Park	136
Te Rautehuia	133
Broadlands Road	131
Red Crater	131
Ohaaki East	123
Murphy's Springs	117
Longview Road	116
Western Te Kopia	114
Spa thermal park	112
Paerata Road	107
Waikato River Springs	105
Wharepapa Road	105
Ngapouri	101
Maunganamu North Wetland	98
Tirohanga Road	95
Whangapoa	94
Golden Springs	94
Akatarewa East	92
Lower Wairakei Stream	92
Mangaminigi Station	92
Karapiti	91
Northern Paeroa Range	87
Waipouwerawera	85
Maunganamu West	85
Wairakei Borefield	83
Whakamaru	79
Kathleen Springs	75
Hall of Fame Stream	74
Crown Park	71
Waipahihi Valley	71
Upper Atiamuri West	70
Mountain Road	69
Matapan Road	69
Maunganamu East	69
Tokaanu tailrace canal	69
Tokaanu urupa mud pools	67
Horohoro	57
Whangairorohea	55

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