

# Mapping significant natural areas of the Waikato region: the physical basis for the identification of karst ecosystem sites

Updated methodology report

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# Mapping Significant Natural Areas of the Waikato Region: the Physical Basis for the Identification of Karst Ecosystem Sites

## Updated Methodology Report

Bruce W Hayward

June 2019



*Waikawau Valley surface karst.*

For information on the management of karst landscapes in the Waikato Region go to:  
[Management of karst landscapes in the Waikato \(arcgis.com\)](http://arcgis.com)

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*Rakaunui coastal karst*

## 1.0 Abstract

In 2017, Waikato Regional Council hosted a Karst Workshop of local experts on karst, caves and their biota and nominated 58 sites as potentially meeting the needs for protection of significant karst ecosystems in the region. This report outlines the way these nominated sites have been assessed for their geoh heritage values and diversity and then mapped. This exercise resulted in the deletion or merging of several nominated sites and addition of several others that were already included and mapped in the New Zealand Geopreservation Inventory and four caves that were known to have particular biotic values. The resulting sites meet the criteria for significance under sections 6 (b) and (c) in the RMA, and their protection will maintain and enhance the best examples of 'originally rare' ecosystem types at a national level.

The following criteria were used to assess and document the geoh heritage values of all sites:

- a. The extent to which the landform or cave contributes to the understanding of the geology.
- b. The rarity or unusual nature of the site or feature.
- c. The extent to which the feature is an outstanding representative example of the diversity of Waikato Region's karst landforms and caves.
- d. The extent to which the feature is part of the Waikato SNA karst group of features.
- e. The extent to which the feature contributes to the aesthetic values of the wider landscape.
- f. The extent of community association with, or public appreciation of, the values of the feature or site.
- g. The potential value of the feature or site for public education.
- h. The potential value of the site to provide additional understanding of the geological or biotic history.
- i. The state of preservation of the feature or site.
- j. The extent to which the feature is associated with a historically important natural or human event.
- k. The importance of the site to Mana Whenua was not assessed here, as this is more appropriately undertaken by local iwi.

GIS mapping was undertaken at a scale of 1:10 000 using the same GIS aerial photography base map (WRAPS 2012) as used by Waikato Regional Council maps. The preliminary GIS mapping from the NZ Geopreservation Inventory and Waitomo District proposed ONF mapping project were used as a starting point for many sites. Other sites were mapped from scratch in a desk-top exercise using published cave maps, topographic contours, Google Earth satellite images and oblique aerial photographs supplied by Waikato Regional Council. A total of 58 sites are now included, documented and mapped and five catchment areas that are particularly sensitive for the protection of the biota in caves have also been mapped. Data on all these sites is summarised in this report with more detailed information available for each site in digital spreadsheet format.

## 2.0 Introduction

This report is for information purposes only and describes the protocol of karst mapping and ranking in terms of geological significance.

### 2.1 Advice and acknowledgments

To assist the author with information on the location and values of certain sites in the region, assistance and advice was obtained from experts in their fields:

- a. Experienced speleologist and cave mapper Peter Crossley, editor of NZ Speleological Society's New Zealand Cave Atlas, North Island, 1980s-present.
- b. Experienced speleologist, cave mapper and karst management expert Dave Smith (DoC, Auckland).
- c. Internationally-renowned karst geomorphologist Prof. Paul Williams (Auckland University).
- d. Waitomo cave specialist John Ash (Waitomo Cave Museum Society and Discovery Centre).
- e. Experienced rare plants botanist and speleological enthusiast Assoc. Prof. Peter de Lange (Unitec; formerly DOC, Auckland).
- f. Geomorphologist/geologist Dr Jill Kenny who undertook a national review of karst in the NZ Geopreservation Inventory a decade ago and produced an initial set of maps of important sites.

- g. Local northern Coromandel geologist Johnny Irons who provided information on the location of caves at Torehina. This assistance is gratefully acknowledged.

## 2.2 GIS layers

After discussions with the Waikato Regional Council karst team it was agreed that three separate GIS layers would be produced containing:

- a. Surface karst sites – areas with karst and limestone at and close to the surface.
- b. Caves – an area on the surface that overlies a cave or cave system with an accuracy of c. +/- 100 m.
- c. Cave catchments – areas upstream of significant caves where deleterious water quality changes including increased sediment erosion could impact caves downstream.



*Grand Canyon cave entrance*

## 3.0 Background

### 3.1 History of this project

Regional and District Councils are required by the Resource Management Act to recognise and provide protection for areas of significant indigenous vegetation and significant habitats of indigenous fauna. Waikato Regional Council is currently undertaking a process of identifying and prioritising significant natural areas in the Waikato Region, using criteria developed within the framework of the Regional Policy Statement.

In 2008/2009 the University of Waikato was engaged to identify karst areas of potential ecological significance within the Waikato and to prioritise karst areas for biodiversity management. A preliminary assessment was prepared (Floyd and Clarkson, 2009) which identified the likely extent of karst within the Waikato. In 2017 a further report was prepared by Environmental Research Institute University of Waikato (Clark et al., 2017) that incorporated and updated the 2009 output, and included an assessment of identified karst SNA sites in terms of both their geomorphological and ecological significance. This report also provided a record of sites containing karst-associated threatened species, together with an assessment of each site for the presence of four karst-associated ecosystem types that are recognised

as naturally uncommon in New Zealand (Landcare, 2014). The Clark et al. (2017) exercise used GIS techniques based on data layers such as the GNS QMap outcrop of limestone and calcareous sedimentary rocks, TOPO 2009 records of cliff lines, cave entrances and sinkholes and MfE land cover data and herbarium records of threatened species. Using an automated scoring system the top scoring 50 or so sites in the region and top sites in districts were determined. The authors however had major concerns about the broad-brush nature and lack of detail of their data sets and recommended that every identified site needed to be field checked.

Waikato Regional Council organised a Karst Workshop in July 2017 to discuss the question of where to from here? The consensus was that a different approach to identify and map the top 50 karst ecosystem sites in the region would be far more efficient and reap results much sooner than proceeding to field check all the sites identified by the GIS assessment exercise. The karst and cave experts (e.g. Bruce Clarkson, Kessels Ecology, Wildlands, and Dave Smith) in the Karst Workshop proceeded to nominate the best sites that they were aware of and this was later supplemented by sites in the New Zealand Geopreservation Inventory (Worthy, 1990; Kenny & Hayward, 1996, 2009).

In 2018 a report was prepared by the University of Waikato (Lewis, 2018) providing additional background information of the biological and geomorphic values of the original top 57 selected sites based on an extensive literature and web search.

### 3.2 Geomorphic environments of karst-related, naturally-uncommon ecosystems

A 2007 study, conducted for the Ministry for the Environment, identified 72 New Zealand ecosystems that were considered to be historically rare (Williams et al., 2007). These ecosystems typically arise due to unusual environmental conditions, are mostly small, often support unique biodiversity, and commonly have an ecological importance disproportionate to their size (Landcare Research, 2014).

The four relevant, naturally-rare, karst-related ecosystems are given as (Landcare Research, 2014):

**Cave entrances:** “This ecosystem comprises the opening of a cave, extending just to the furthest limit of light penetration. Sites typically are shaded and may be either wet or dry. They may include cave walls and associated rockfalls and the cavern floor. Implicit in this definition is that the entrance leads to an area that is sufficiently large not to receive daylight” (Williams et al., 2007).

**Sinkholes:** “Sinkholes are bowl-shaped depressions in the ground. They are mostly formed in calcareous karst landscapes by solution weathering or downward movement of sediments. This occurs in various ways and although there is a complex classification of dolines describing these differences, here they are considered all together as sinkholes. A skeletal soil layer is usually present, but bare rock may or may not be exposed” (Williams et al., 2007).

**Caves and cracks in karst:** “Karst caves are formed primarily by solution of bedrock along lines of weakness which water can penetrate. Enlargement may then be aided through other physical processes such as collapse. A cave, in recreational terms, is a macrocavern that a human body can get through, but there are extensive zones of smaller solution voids, down to the order of a few tens of millimetres in diameter, both within caves themselves and within the karst generally. Some research suggests that these voids, which are not directly accessible to humans, actually constitute the major habitat used by obligate cave fauna” (Williams et al., 2007).

**Calcareous cliffs, scarps and towers:** “Cliffs are high steep faces and scarps along the edge of a plateau”, while towers are vertically-sided pillars of limestone rock. “Together, they provide many varied habitats from bare rock that can be colonised only by mosses and lichens to deeper soils supporting woody vegetation, from highly exposed situations to heavily shaded and sheltered habitats, and from very dry to permanently wet surfaces. Hebes, some heath-like shrubs, flaxes and native grasses are important on cliffs. Plants seldom grow on the massive cliff faces but are rooted in the ledges, crevices, and cracks” (Williams et al., 2007).

This report is directed towards mapping and better documenting the best examples of these geomorphic environments in the Waikato Region. Documenting the biotic values of these sites is not part of the goal of this particular project.



*Under Mangapohue Natural Bridge*

## 4.0 Methodology for this mapping and assessment exercise

### 4.1 Source of initial list of sites to be mapped (Appendix 1):

An initial list of the “Top 57 karst sites” in the Waikato Region was provided to the writer (Bruce Hayward) by Waikato Regional Council. The list had been compiled from a Karst Workshop organized by the Regional Council and attended by selected ecologists, speleologists and karst experts, that included Dave Smith and Paul Williams (see acknowledgments) but not attended by me. Documentation suggests that some sites came directly from the Karst Workshop and others were added from the New Zealand Geopreservation Inventory, which I have been convenor for on behalf of the Geoscience Society of New Zealand since 1983.

## 4.2 Source of existing data used in this project

- a. General data on the values of various karst and cave areas in the south Waikato (Smith, 1998) had been a valuable initial source used to help in identifying high value karst sites.
- b. The New Zealand Geopreservation Inventory (Kenny & Hayward, 1996, 2009; updated online version at <https://services.main.net.nz/geopreservation/>) also provided more detailed geoheritage information and maps of many of the selected sites.
- c. A specially commissioned report (Lewis, 2018) provided additional background information of the biological values of the 57 selected sites based on an exhaustive literature and web search.
- d. A set of map polygons on two GIS layers (proposed Outstanding Natural Features (ONFs) and karst overlay – cave catchments) prepared by the present author (Hayward, 2018) for the proposed Waitomo District Scheme was used as a starting point for most of the features in the Waitomo District.
- e. The geoheritage assessment sheets and descriptions of the proposed Waitomo District ONFs prepared by the present author (Hayward, 2018) were used as the basis for the assessment of most of the selected sites in Waitomo District. They were also used as a basis for proposed changes to the list of the Top 57 sites, with recommendations that several abutting or overlapping sites be combined and that several sites be deleted because of their fragility or sensitivity to visitors or because their features did not reach the assessment criteria threshold (see Appendix 1).
- f. The New Zealand Speleological Society's New Zealand Cave Atlas, North Island (Crossley, 2014) contains maps of many of the caves identified in the Top 57 sites and these were used to inform their mapping, description and assessment.

## 4.3 Assessment criteria

The following criteria were used to assess the geoheritage values of all the karst and cave sites in this project:

- a. The extent to which the landform, feature or geological site contributes to the understanding of the geology or evolution of the biota in the region, New Zealand or the earth.
- b. The rarity or unusual nature of the site or feature.
- c. The extent to which the feature is an outstanding representative example of the diversity of Waikato Region's karst landforms and caves.
- d. The extent to which the feature is part of the Waikato SNA karst group of features.
- e. The extent to which the feature contributes to the aesthetic value or visual legibility of the wider landscape.
- f. The extent of community association with, or public appreciation of, the values of the feature or site.
- g. The potential value of the feature or site for public education.
- h. The potential value of the feature or site to provide additional understanding of the geological or biotic history.
- i. The state of preservation of the feature or site.
- j. The extent to which the feature or site is associated with a historically important natural or human event or industry.
- k. The importance of the feature or site to Mana Whenua (not assessed here, as this is more appropriately undertaken by local iwi).

Documentation and weighted scores for each criterion for each site is provided in the attribute table attached to the GIS mapping layers and also in a separate Excel file.

#### 4.4 Mapping methodology

GIS mapping was done at a scale of 1:10000 using the same GIS aerial photography base map (WRAPS 2012) as used by Waikato Regional Council maps. The preliminary GIS maps (using Topo50 base maps) from the NZ Geopreservation Inventory and Waitomo District proposed ONF mapping project were used as a starting point for many sites. Other sites were mapped from scratch in a desk-top exercise using published cave maps, topographic contours, Google Earth satellite images and oblique aerial photographs supplied by Waikato Regional Council.

The site map boundaries were determined or modified using the following criteria:

- a. Where the whole or part of a site was on public land (e.g. intertidal, esplanade reserves, road reserves, parks and reserves) the boundaries were modified: to better fit the air photo base map; to align with the reserve boundary; or lie within it.
- b. Where the whole or part of a site occurs within private land, the mapped boundaries were more carefully drawn to enclose the minimum land area for realistic protection and wherever possible to exclude areas of habitation and intense farming activities.



*Temperate polygonal karst, Waitomo. Photo by Paul Williams.*

## 5.0 Results

### 5.1 Accepted and mapped sites

After comparison with the Waitomo District ONF assessment exercise and consultation with speleologists, including Dave Smith (one of the main original sources of the list) I have modified the original Top 57 list by (see appendices 2 and 3):

- a. Merging four nominated sites with others that were nominated, because they were smaller parts of sites that had already been nominated and had been combined in the Waitomo District ONF exercise.
- b. Deleting Moa Egg Shell Cave nomination as it is a small, remote and fragile site that is best protected by lack of publicity.
- c. Deleting the nominated Puketiti swamp karst, as had been done in the Waitomo exercise, because it is considered too insignificant and largely in grass.
- d. Adding Karamu Cave in the Waipa District because it had been overlooked and adds another feature in a part of the region with few nominated sites.
- e. Adding Whenuapo karst site because it had been overlooked and has karst and bluff features of sufficient quality just south of Kawhia Harbour.
- f. Adding Waikaretu caves and karst site as there is a distinct lack of nominated sites between Raglan Harbour and Port Waikato, in spite of the widespread presence of limestone.
- g. Following a report on the biotic values of the karst and caves of Waikato by Ian Millar, 2019, four additional caves containing rare and uncommon cave invertebrates have been added. These are: Broken Hill Cave; Ecch Cave; Kairimu System; King George Cavern and Sid's Surmise.

A result of these changes has been to increase the number of sites now documented and mapped here to 58. In addition, five cave catchment areas have been identified and mapped on the separate layer.



*Ruakuri Cave speleothems*

## 5.2 List of accepted and mapped Top 58 sites

Accepted sites mapped and documented in this exercise with their Geoheritage significance A = International, B = National, C = Regional, D = Local district level. The total assessment scores for each site are also given. Sites with an asterisk\* have not been visited and not fully scored. Shortened geomorphic significance statements are also given. See accompanying GIS layer for maps and attribute table or Excel sheet for detailed assessment scores.

No.	Name	Score	Sig	Significance statement
301	Awaroa rocky peaks and karst	72	C	Rocky peaks.
302	Castle Craig bluffs	64	C	Limestone towers and bluffs.
303	Deception Cave	72	C	Spectacular gypsum speleothems.
304	Gardner's Gut Cave	94	B	Longest cave system in North Island; Speleothems; fossil deposit.
305	Grand Canyon Cave	76	B	Large, abandoned cave passage; craybacks.
306	Gibbon Road bluffs	44	C	Long limestone bluffs.
307	Hollow Hill Cave	80	B	Largest cavern in North Island; speleothems.
308	Karamu Cave	76	C	Long stream cave; speleothems in Waipa District.
309	Lake Disappear and karst	108	B	Largest blind valley in North Island; largest ephemeral karst lake in New Zealand.
310	Lake Koraha and Matauratahi	48	C	Karst lake surrounded by forest.
311	Lake Rotokawau	49	C	Karst lake surrounded by forest.
312	Lake Rotokotuku	47	C	Karst lake surrounded by forest.
313	Lower Mangaotaki Gorge bluffs	43	C	High forest-covered limestone bluffs.
314	Mangaokewa Gorge bluffs	43	D	High forest-covered limestone bluffs.
315	Mangaorongo Gorge and natural bridges	54	C	Spectacular limestone gorge and natural bridges.
316	Mangapohue Natural Bridge	90	B	Most accessible natural bridge in region. Two-tiered; craybacks.
317	Mangapohue-Hauturu Road polygonal karst	116	A	Most accessible and one of the best examples of small scale cockpit-style relief (polygonal karst) in New Zealand.
318	Mangapu Cave System	110	B	Second largest underground river in North Island; best karst window (Lost World) in New Zealand.
319	Mangapu Gorge and blind valley	53	C	Small gorge with best example of blind valley in region.
320	Mangawharawhara Stream natural bridges and gorge	100	B	Presence of 2 tunnels and 5 bridges of such large size along one stream is unique in New Zealand.
321	Mangawhitikau Cave System	86	B	One of largest river caves in North Island. Speleothems.
322	Mangawhitikau slit gorge and karst	62	C	Spectacular slit gorge with towering limestone karst.
323	Marokopa Natural Tunnel and Te Ana Kapiti Cave	85	B	One of two largest natural tunnel features in the North Island.
324	Mohakatino karst	44*	C	Forested karst and sinkholes.
325	Old Mountain Road karst	76	C	Karst with small caves and speleothems. Helectites.
326	Pakeho polygonal karst and autogenic aquifer	67	C	Unforested polygonal karst and largest autogenic karst aquifer in North Island.
327	Paparahia Cave	61	C	Unusual cave developed in Miocene limestone; excellent speleothems.
328	Pukeroa Cave System	58	C	Second deepest known cave in the North Island. Speleothems and fossil deposits.
329	Puketiti Flower Cave	90	B	Spectacular gypsum flowers.
330	Raglan coastal karst	68	C	Coastal karst with limestone stacks.
331	Rakaunui coastal karst and ephemeral lakes	130	B	Best area of coastal karst in New Zealand. Ephemeral wetlands in drowned dolines.

332	Ruakuri Cave	102	B	Major tourist cave for wet and dry visits. Speleothems.
333	Ruakuri Natural Bridge and karst	90	B	Major tourist attraction of forest karst and one of highest natural bridges in North Island.
334	Taranaki Point coastal karst	64	C	Limestone karst and pinnacles on exposed coast.
335	Taumatotara karst and dolines	33*	C	Forested dolines, blind valleys and karst.
336	Tawarau karst	74	C	Most extensive forested karst in North Island.
337	Te Kauri karst	37	D	Low grade karst, forested bluffs and caves.
338	Te Raumauku Maze Cave	90	B	Only known maze cave in North Island.
339	Ten Acre Tomo System	66	C	Impressive large collapse feature with associated caves.
340	Tomac Tomo	61	C	Long cave with wet and dry passages in Waipa District.
341	Torehina karst	56	C	Two small area of caves and karst at north end of Coromandel peninsula.
342	Totoro Gorge karst	56	C	An excellent example of sculptured limestone karstic river gorge.
343	Troopers Rd Cave System	84	B	One of most extensive cave systems in North Island. Excellent speleothems, fossil deposits.
344	Upper Mangaotaki Gorge bluffs	60	C	High forested limestone bluffs and karst.
345	Waikaretu karst and Nikau Cave	72	C	Best speleothems in Waikato District.
346	Waikawau Valley karst	104	B	Spectacular karst, limestone bluffs and cave in north Waikato District.
347	Waipapa Rd Cave System	58	C	Multiple caves with excellent speleothems.
348	Waipuna Cave	80	B	Major cave with forest above and excellent speleothems.
349	Waipuna polygonal karst	88	B	One of the best examples of forested small scale cockpit-style relief (polygonal karst) in New Zealand.
350	Wairere Falls cave and karst	37	D	Small dry cave in small area of limestone bluffs and rocks.
351	Waitomo Forest karst	55	C	Forested dolines, blind valleys and caves.
352	Waitomo Glowworm Cave and resurgence karst	118	B	Nationally important, internationally renowned tourist cave for its accessibility, glowworms and speleothems.
353	Waitomo Stream headwaters Cave System	90	B	One of the longer caves in the North Island. Important speleothems and fossil deposits.
354	Whenuapo karst	62	C	Small plateau of karst and perched ephemeral lake.
355	Broken Hill Cave	38	-	Mainly biotic significance. Extensive rockfalls from fault zone followed by cave.
356	Ecch Cave	34	-	Mainly biotic significance. Long single passage.
357	Kairimu Cave System	44	C	High diversity of cave morphologies and speleothems.
358	King George Cavern and Sid's Surmise	15	-	Biotic significance only.

### 5.3 Cave catchments

Five cave catchments have been identified and mapped and are regarded as those that require more careful management of the water and sediment that runs off them into the most valuable caves in the region. In terms of decreasing priority these are the catchments of:

1. Waitomo Glowworm, Ruakuri, Gardner's Gut and Waipuna Cave;
2. Waitomo Stream headwaters Cave System, where this runoff is also in the catchment of 1 above;
3. Mangapu Cave System, which also includes Mangapu Gorge and blind valley;
4. Troopers Road Cave System;
5. Mangawhitikau Cave System, which includes Waipapa Road Cave System catchment.

#### 5.4 Priority sites for improved field mapping

The present assessment and mapping exercise has been entirely desktop-based relying on the field experience of the writer and the expert advisors. Some sites had not been visited by any of the team or only briefly and certainly not with the aim of mapping their extent. For these reasons some of the privately owned sites should be visited and the extent of the high value karst areas assessed in the field and mapping improved. These sites in order of priority are:

1. Mangawharawhara Gorge and natural bridges
2. Waitomo Forest karst
3. Taumatotara karst and dolines
4. Paparahia Cave
5. Lake Disappear and karst
6. Torehina karst
7. Pakeho polygonal karst
8. Old Mountain Road karst

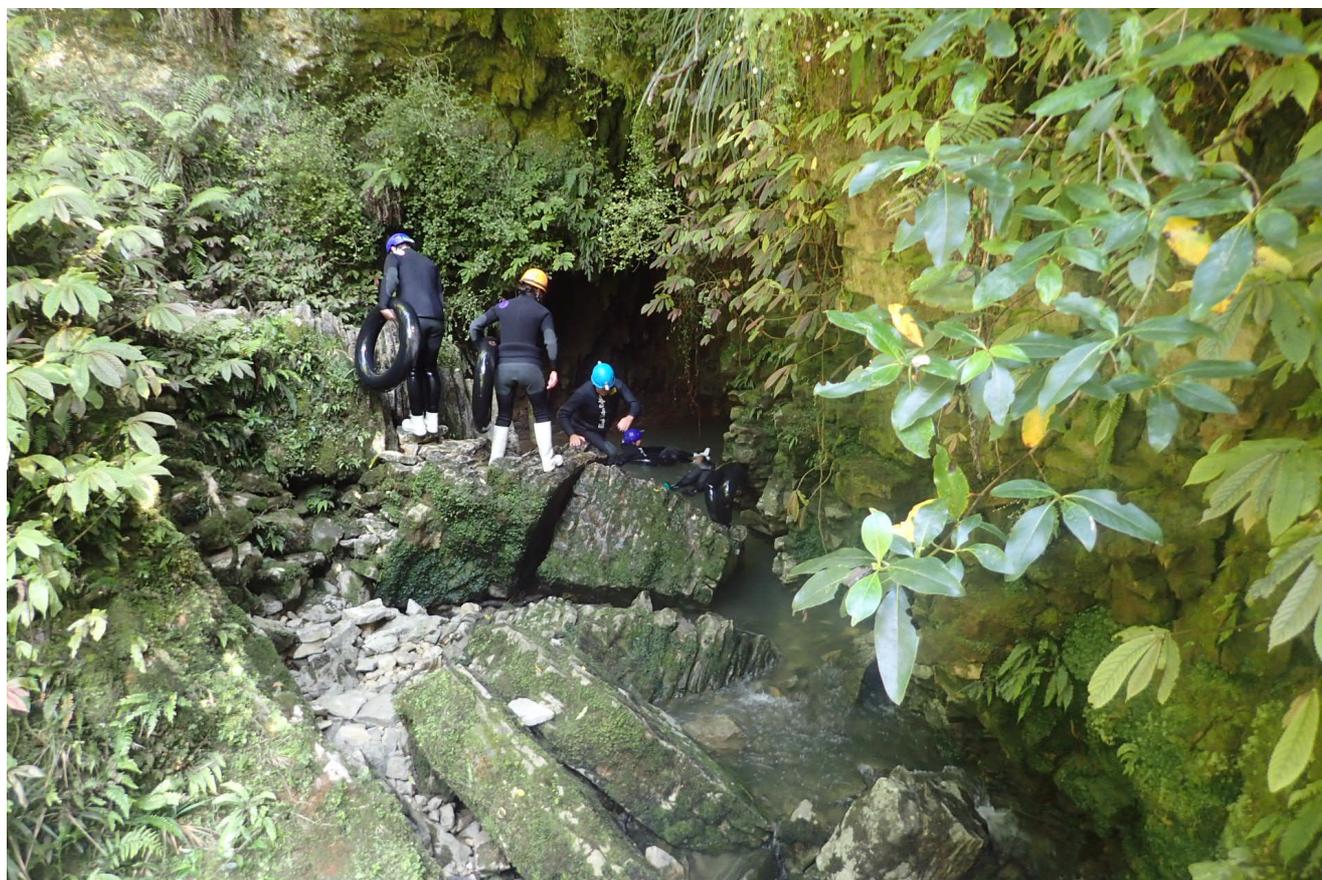
Other sites on private land may require field visits if their boundaries need to be refined further.



*Straw speleothems in Ruakuri Cave*

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*Ruakuri Cave resurgence in Ruakuri Cave and Bush Reserve*

## Appendix 1

Initial list of identified Top 57 SNA karst sites with notes on how they have been treated in this exercise.

No.	Site name	New No.	Treatment/modified name	GIS layer
201	Tawarau	336	Tawarau karst	Surface karst
202	Mangapu River cave system	318	Mangapu Cave System	Cave
203	Karst windows - Lost World, Hamland Hole, Wellington Hole	318	Merged with 202	
204	Mangapu Gorge	319	Mangapu Gorge and blind valley	Surface karst
205	Mangawhitikau River cave system	321	Mangawhitikau Cave System	Cave
206	Mangawhitikau Gorge	322	Mangawhitikau slit gorge and karst	Surface karst
207	Koropupu Gorge	322	Merged with 206	
208	Mason's Dry cave system	321	Merged with 205	
209	Waipapa Rd cave system	347	Waipapa Rd Cave System	Cave
210	Pakeho karst	326	Pakeho polygonal karst	Surface karst
211	Limestone downs karst	346	Waikawau Valley karst	Surface karst
212	Rakaunui peninsula	331	Rakaunui coastal karst and ephemeral lakes	Surface karst
213	Black system - F1, Fred, Virginia etc	343	Troopers Rd Cave System	Cave
214	Deception cave system	303	Deception Cave	Cave
215	Waitomo master system cave	353	Waitomo Stream headwaters Cave System	Cave
216	Ruakuri Cave	332	Ruakuri Cave	Cave
217	Waipuna karst	349	Waipuna polygonal karst	Surface karst
218	Waipuna cave	348	Waipuna Cave	Cave
219	Ruakuri Natural Bridge	333	Ruakuri Natural Bridge and karst	Surface karst
220	Lake Rotokawau	311	Lake Rotokawau	Surface karst
221	Gardner's Gut Cave	304	Gardner's Gut Cave	Cave
222	Waitomo Glowworm Cave	352	Waitomo Glowworm Cave and resurgence karst	Surface karst
223	Ruakuri Bush	333	Merged with 219	
224	Torehina caves	341	Torehina karst	Surface karst
225	Lake Disappear	309	Lake Disappear and karst	Surface karst
226	Lake Rotokotuku	312	Lake Rotokotuku	Surface karst
227	Lake Koraha	310	Lake Koraha and Matauratahi	Surface karst
228	Taumatotara karst	335	Taumatotara karst and dolines	Surface karst
229	Marokopa Natural Tunnel	323	Marokopa Natural Tunnel and Te Ana Kapiti Cave	Surface karst
230	Helictite Hole	325	Old Mountain Road karst	Surface karst
231	Tomac Tomo	340	Tomac Tomo	Cave
232	Grand Canyon Cave	305	Grand Canyon Cave	Surface karst
233	Puketiti Flower Cave	329	Puketiti Flower Cave	Cave
234	Mangapohue karst	317	Mangapohue-Hauturu Road polygonal karst	Surface karst
235	Waitomo Forest	351	Waitomo Forest karst	Surface karst
236	Mohakatino karst/cave systems	324	Mohakatino karst	Surface karst
237	Paparahia Cave	327	Paparahia Cave	Surface karst

238	Upper Mangaotaki gorge	344	Upper Mangaotaki Gorge bluffs	Surface karst
239	Lower Mangaotaki Gorge	313	Lower Mangaotaki Gorge bluffs	Surface karst
240	Ten Acre Tomo system	339	Ten Acre Tomo System	Surface karst
241	Pukeroa system	328	Pukeroa Cave System	Cave
242	Mahoenui SR (Gribbon Rd)	315	Mangaorongo Gorge and natural bridges	Surface karst
243	Mangaokewa Gorge	314	Mangaokewa Gorge bluffs	Surface karst
244	Te Kauri SR	337	Te Kauri karst	Surface karst
245	Hollow Hill cave	307	Hollow Hill Cave	Surface karst
246	Taranaki Point	334	Taranaki Point coastal karst	Surface karst
247	Raglan north head	330	Raglan coastal karst	Surface karst
248	Mangapohue Natural Bridge	316	Mangapohue Natural Bridge	Surface karst
249	Te Raumauku maze cave	338	Te Raumauku Maze Cave	Cave
250	Wairere Falls Cave	350	Wairere Falls cave and karst	Surface karst
251	Awaroa ridge tors	301	Awaroa rocky peaks and karst	Surface karst
252	Puketiti swamp karst	-	Recommended delete as not sufficiently significant	
253	Castle Craig	302	Castle Craig bluffs	Surface karst
254	Gribbon Road	306	Gribbon Road bluffs	Surface karst
255	Mangawharawhara Stream	320	Mangawharawhara natural bridges and gorge	Surface karst
256	Totoro Gorge	342	Totoro Gorge karst	Surface karst
257	Moa Egg Shell Cave	-	Recommend delete as too fragile to risk publicising location	



*Lake Disappear*

## Appendix 2

Recommended additional cave and karst sites and sites for cave catchments layer.

New No.	Name	Recommended by	GIS layer
308	Karamu Cave	Peter Crossley	Cave
345	Waikaretu karst and Nikau Cave	Dave Smith	Surface karst and cave
354	Whenuapo karst	Peter de Lange	Surface karst
355	Broken Hill Cave	Ian Millar	Cave
356	Ecch Cave	Ian Millar	Cave
357	Kairimu Cave System	Ian Millar, Dave Smith	Cave
358	King George Cavern & Sid's Surmise	Ian Millar	Cave
	Mangapu Cave System catchment	Peter Crossley, Dave Smith	Cave catchments, Priority 3
	Mangawhitikau Cave System catchment	Peter Crossley, Dave Smith	Cave catchments, Priority 4
	Troopers Road Cave System catchment	Peter Crossley, Dave Smith	Cave catchments, Priority 5
	Waitomo Glowworm, Ruakuri, Gardner's Gut and Waipuna Caves catchments	Peter Crossley, Dave Smith	Cave catchments, Priority 1.
	Waitomo Stream headwaters Cave System catchment	Peter Crossley, Dave Smith	Cave catchments, Priority 2



*Karst in the Torotoro Gorge site*

## Appendix 3

List of accepted sites, the naturally uncommon ecosystems they contain and notes on how each site has been mapped. Abbreviations: DS = Dave Smith; JK = Jill Kenny; PC = Peter Crossley; PdL = Peter deLange; PW = Paul Williams.

No.	Site name	Ecosystems	Mapping notes
301	Awaroa rocky peaks and karst	Cliffs, caves and cracks	Rocky knolls on private land mapped precisely; upland karst in forested reserve mapped using GNS QMap limestone outcrop and topography.
302	Castle Craig bluffs	Cliffs, caves and cracks	Rocky crags on private land mapped precisely from air photos but all of Ngahuinga Bluff Scenic Reserve included as forest cover prevents seeing rocky areas.
303	Deception Cave	Cave and cave entrances	Mapped using DS approximate knowledge of cave location. Not well known nor documented.
304	Gardner's Gut Cave	Cave and cave entrances	Mapped using cave plans in NZ Cave Atlas and PC and DS knowledge of cave entrance locations.
305	Grand Canyon Cave	Cave and cave entrances	Grand Canyon Nature Reserve boundaries used for section of reserve overlying the cave.
306	Gribbon Road bluffs	Cliffs	Bluffs mapped precisely on both private and reserve land using oblique and vertical aerial photos and topo map contours.
307	Hollow Hill Cave	Cave and cracks, cave entrances	Boundaries of Hollow Hill Scenic Reserve used.
308	Karamu Cave	Cave and cave entrances	Mapped using cave plans in NZ Cave Atlas and PC and DS knowledge of cave entrance locations.
309	Lake Disappear and karst	Cliffs, sinkholes	Mapped using oblique and vertical aerial photos and topo contours of blind valley, of two dolines and two lines of limestone bluffs, all on private land.
310	Lake Koraha and Matauratahi	Cliffs, sinkholes	Mapped using information of PdL and topo50 map of dolines within DoC land and private land. All forested.
311	Lake Rotokawau	Sinkhole	Only mapped the doline around the lake in privately-owned forest land.
312	Lake Rotokotuku	Sinkhole	Only mapped fenced-off wetland vegetation around the lake. On private land.
313	Lower Mangaotaki Gorge bluffs	Cliffs, cracks	Mapped using aerial oblique and vertical photos for Waitomo District Council.
314	Mangaokewa Gorge bluffs	Cliffs	Mapped using oblique and vertical aerial photos all in forest and almost all in Mangaokewa Gorge Scenic Reserve.
315	Mangaorongo Gorge and natural bridges	Cliffs, caves and cracks	Only included forested area that includes the gorge and its margins. Half in Mangaorongo Scenic Reserve and half private.
316	Mangapohue Natural Bridge	Cave entrance, cliffs	Only included forested area containing the bridge and short gorge, all within the Mangapohue Natural Bridge Scenic Reserve.
317	Mangapohue-Hauturu Road polygonal karst	Cracks, cliffs, sinkholes, caves	Mapped area recommended as best polygonal karst by PW. All private land, about half QEII covenant. Mostly forested except north-east of Hauturu Rd where it is dense mix of farmed grassland, dolines, rocks and forest patches.
318	Mangapu Cave System	Caves and cave entrances	Mapped route of cave using NZ Cave Atlas cave plan and knowledge of PC and DS of cave entrances. All under private farmland.
319	Mangapu Gorge and blind valley	Cracks, cliffs, cave entrances, sinkholes	Mapped mostly forested gorge and valley bottom some rocky and doline areas. All in private farmland.

320	Mangawharawhara Stream natural bridges and gorge	Cave entrances, cliffs, cracks	Upper part follows boundaries of Grand Canyon Nature Reserve. Remainder in private land mapped as precisely as possible to include gorge, tunnels and associated rocky areas and vegetation.
321	Mangawhitikau Cave System	Caves and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland with some forest packets.
322	Mangawhitikau slit gorge and karst	Cave entrances, cracks, cliffs	Upper part in Koropupu Scenic Reserve. Remainder in private farmland mapped as precisely as possible to include gorge, tunnels and associated rocky areas and vegetation.
323	Marokopa Natural Tunnel and Te Ana Kapiti Cave	Cave and cave entrances, cracks, cliffs	Mostly mapped using Marokopa Natural Tunnel Scenic Reserve boundaries but Te Ana Kapiti Cave boundaries are in privately owned forest land.
324	Mohakatino karst	Sinkholes	Mapped using Topo 50 indications of dolines and sinkholes. All under forest, mostly in Mohakatino Conservation area.
325	Old Mountain Road karst	Cliffs, caves, cracks, cave entrances	All private land forest and farmland. Mapped using knowledge of DS.
326	Pakeho polygonal karst and autogenic aquifer	Sinkholes, cliffs, cracks	All privately owned farmland with scattered patches of vegetation. Part of a large area of karst in farmland. Mapped using vertical and oblique aerial photos to include best area of polygonal karst and avoid farm buildings.
327	Paparahia Cave	Cave and cave entrance, doline	Mapped extent of cave under forest and doline at head.
328	Pukeroa Cave System	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland.
329	Puketiti Flower Cave	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland.
330	Raglan coastal karst	Cliffs, cracks	Mapped using aerial oblique and vertical photos and previous work by JK for NZ Geopreservation Inventory. Mapped precisely around rocky limestone areas along coast.
331	Rakaunui coastal karst and ephemeral lakes	Caves and cracks, cave entrances, cliffs, sinkholes	Mapped using aerial oblique and vertical photos and previous work by JK for NZ Geopreservation Inventory. Assisted by information from PdL. Some mapped using boundaries of Rakaunui and Awakino Scenic Reserves. On private land, boundaries precisely mapped around rocky and vegetated areas and some ephemeral lakes in dolines.
332	Ruakuri Cave	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. Mostly beneath private farmland and bush.
333	Ruakuri Natural Bridge and karst	Caves and cracks, cave entrances, cliffs	Mapped using GNS QMap limestone outcrop and known occurrences of karst on tourist tracks. All within Ruakuri Caves and Bush Reserve.
334	Taranaki Point coastal karst	Cliffs, cracks	Mapped using aerial oblique and vertical photos and precisely mapped to only include limestone rocky outcrops and associated vegetation. All in private land except intertidal.
335	Taumatotara karst and dolines	Caves and cracks, cave entrances, cliffs, sinkholes	All under forest and therefore only able to be mapped using Top 50 contours that show large scale blind valleys and dolines. Cave location provided by PdL. Mostly in a Nga Whenua Rahui covenant and some in DoC Taumatotora Stewardship area.

336	Tawarau karst	Caves and cracks, cave entrances, cliffs, sinkholes	All under forest and shown on GNS QMaps to be underlain by outcropping limestone. Therefore all area lies within boundaries of DoC administered land.
337	Te Kauri karst	Caves, cave entrances, cliffs.	All within Te Kauri Park Scenic Reserve. Mapped using aerial oblique and vertical photos and cave locations and information from PdL.
338	Te Raumauku Maze Cave	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC of location of cave entrances. All under private farmland.
339	Ten Acre Tomo System	Caves and cracks, cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland.
340	Tomac Tomo	Caves and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC of cave entrances, supported by vertical aerial photos. All under private farmland and forest.
341	Torehina karst	Caves and cracks, cave entrances	Mapped extent based on limestone outcrop map of Kear (1955) and information from Fow (1967). Boundaries informed by vertical air photos and personal knowledge. Small forested area. All areas in private ownership.
342	Totoro Gorge karst	Cliffs and cracks	Same boundaries as previously prepared for Waitomo District Council ONF, based on field visit, mapping of JK and vertical aerial photos. All in private land and precisely mapped to only include outcropping limestone rocks and associated vegetation.
343	Troopers Rd Cave System	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of location of cave entrances. All under private farmland with some forest patches.
344	Upper Mangaotaki Gorge bluffs	Cliffs and cracks	Bluffs mapped using oblique and vertical aerial photos and topo contours. Upper portion boundaries same as QEII covenant. Middle portion is within Mangaotaki Scenic Reserve and lower portion in privately owned forested land.
345	Waikaretu karst and Nikau Cave	Cave, cave entrances, cliffs	Mapped based on aerial photos of bluffs and partly by QEII boundary (south block).
346	Waikawau Valley karst	Caves and cracks, cave entrances, cliffs	Mapped precisely around outcropping limestone karst and bluffs with associated vegetation using oblique and vertical aerial photos. All in private farmland.
347	Waipapa Rd Cave System	Caves and cave system	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of location of cave entrances. All under private farmland.
348	Waipuna Cave	Cave and cave system	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland and forest.
349	Waipuna polygonal karst	Caves and cracks, cave entrances, cliffs, sinkholes	Mapped using oblique and vertical aerial photography and edge of forest. Half within Waipuna Scenic Reserve and other half privately owned.
350	Wairere Falls cave	Cave, cliffs and cracks, cave entrance	Mapped using vertical aerial photos of cliffs and rocks in farmland including cave location provided by DS. On private land.
351	Waitomo Forest karst	Caves and cracks, cave entrances, sinkholes	Mapped from extent of dolines shown on Topo 50 maps and DS's knowledge of location of caves and karst.

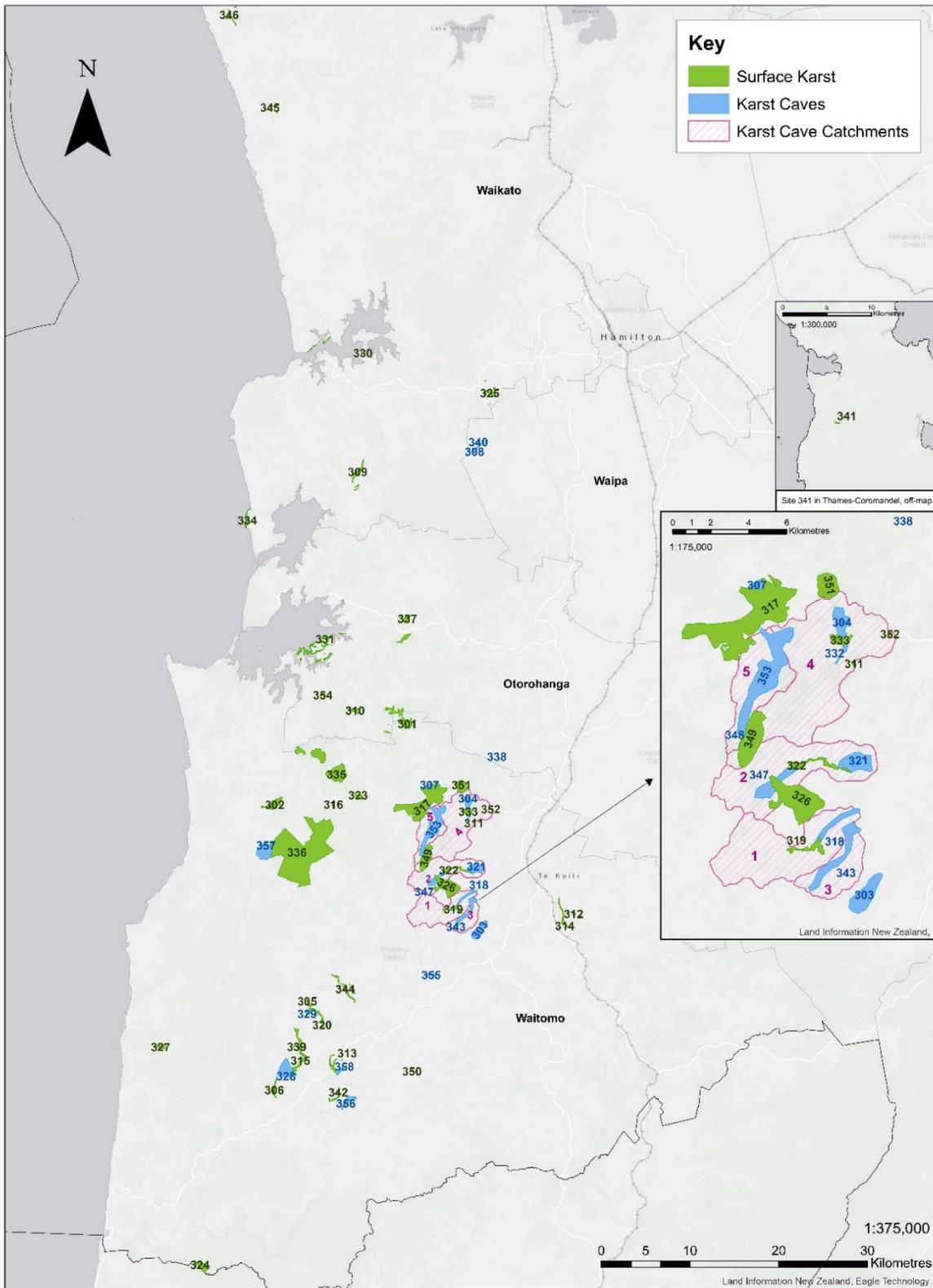
352	Waitomo Glowworm Cave and resurgence karst	Cave and cracks, cave entrances, cliffs	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. Mostly private land, small part in Waitomo Caves Scenic Reserve.
353	Waitomo Stream headwaters Cave System	Caves and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland with some patches of forest.
354	Whenuapo karst	Cliffs, sinkholes	Under forest. Mapped from information provided by PdL and from topographic contours showing extent of plateau dolines and vertical aerial photos of rocky ridge crest. Half in Nga Whenua Rahui covenant and half in private forest.
355	Broken Hill Cave	Cave and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland with some patches of forest.
356	Ecch Cave	Cave and cave entrance	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. All under private farmland with some patches of forest.
357	Kairimu Cave System	Caves and cave entrances	Two thirds under forested DoC reserve. Western third under steeply dissected private farmland. Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances.
358	King George Cavern & Sid's Surmise	Caves and cave entrances	Mapped extent of cave system using NZ Cave Atlas and knowledge of PC and DS of cave entrances. Most under private farmland with some patches of forest. Lower section of King George under DoC reserve land.



*Virginia Cave, Troopers Road Cave System*

## Appendix 4

Location of top 58 karst sites of this report.



**Top 58 Karst SNA Sites in the Waikato Region**

Disclaimer: The map and its information is confidential; please do not release this information or make it publicly available.

