

KARST MANAGEMENT GUIDELINES

Policies and Actions

MAY 1999

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Cover photos: Left – South flank of Mt Owen, North-West Nelson Massif (Shanel Courtney); Top right – Karenfield on north flank of Mt Owen (Shanel Courtney); Bottom right – Speleothems in Konrad Cave, Maniapoto Karst (Caves Museum/New Zealand Speleological Society Collection).

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1. INTRODUCTION

The caves at Waitomo and the “Marble Mountain” and caves near Takaka are well known examples of landforms collectively referred to as “karst”. Karst include a variety of distinctive and often spectacular surface and underground features, formed predominantly by the dissolving action of water, which are much prized by iwi and other local people and sought out by visitors and tourists.

Karst areas usually also include distinctive soils, micro-climates, flora, fauna and patterns of hydrology.

Karst is widely distributed throughout New Zealand, often on public conservation land managed by the Department of Conservation, but it is a very minor component of the overall landscape-which makes what is there special. Karst areas or features are often fragile, and require special management to minimise adverse effects. It is, therefore, important that there are well understood guidelines to help to manage them, in order to conserve their unique character.

1.1 Purpose

These guidelines have been prepared to help DOC staff to more effectively manage karst and karst-like areas. They will be used to help to make management decisions about specific sites and implement conservation management strategies. They will also be incorporated in more specific karst management planning documents, similar to, for example, those by Wilde & Worthy (1992) and Smith (1998).

Karst usually occurs in limestone and marble, which has been sculpted by natural waters. The guidelines can also be applied to other landforms that resemble karst (i.e. pseudokarst) but which have been formed in different rocks and by different processes, for example, lava caves.

The policies and actions described in these guidelines should be applied at individual sites in consultation with relevant associates with a special interest in the sites, such as iwi, recreationalists, concession holders, and researchers. In some cases, this may result in modifications to the policies and actions in this document, in order to help to continue to conserve karst and meet the other desired outcomes at a site in a manner that is agreeable to all parties and efficient and cost-effective for both the Department and the associates.

This document is not a detailed description of karst. Readers who want further details are recommended to consult the references. The Museum of Caves/New Zealand Speleological Society library at Waitomo contains an extensive range of journals, books, etc. related to cave and karst management-possibly the largest such collection in the Southern Hemisphere.

1.2 Relationship to legislation and other planning documents

The Department of Conservation’s mission is “To conserve New Zealand’s natural and historic heritage for all to enjoy now and in the future” (Department of Conservation 1998).

The broad goals for New Zealand’s natural heritage apply to karst and karst-like areas. They are derived from national legislation and international agreements, and include ensuring that:

1. All public land held for conservation purposes under the Conservation Act, National Parks Act and Reserves Act is preserved and protected.

2. New Zealand's nationally important, outstanding, distinctive or rare ecosystems, landforms, geological features and scientific features, and outstanding and significant scenery is preserved, protected, restored and/or sustainably managed.
3. A viable network of representative samples of New Zealand's ecosystems, landforms and scenery which originally gave New Zealand its own natural character is protected and restored.
4. A network of riparian (riverbank) zones, lake margins, riverbeds, coastal margins and foreshores is maintained for conservation purposes, and the natural functioning and natural character of bodies of water is maintained.
5. The soil and water services provided by ecosystems in protected natural areas are maintained.
6. The in-situ genetic diversity of indigenous species is maintained.
7. Public and management access to all protected areas and waters is secured.
8. A wide range of outdoor recreational, educational and heritage enjoyment opportunities is provided.
9. Appropriate significant historic heritage is protected, preserved and conserved.

The guidelines in this document formalise general policies and actions for the management of karst, in order to achieve the broad goals.

These guidelines are not, however, a statutory "conservation management plan" under section 17E of the Conservation Act 1987.

2. DESCRIPTION OF KARST

2.1 Definition

A typical karst topography consists of type of topography formed in limestone or marble areas, comprising depressions and holes, and with underground drainage in place of surface streams. Karst areas, therefore, comprise two landscapes, interconnected through a series of structures and dynamic processes.

The relatively accessible and visible surface landscape is characterised by closed depressions or sinkholes (known as dolines) formed either by solution of the surface bedrock or by collapse of underlying caves; elongate depressions formed by the coalescence of several dolines (known as uvala or karst valleys); stream sinks; prominent features such as pinnacles, tors, and bluffs; fissures (grikes) and gorges; natural bridges; blind or dry valleys; and rock outcrops with furrows ranging in depth from a few millimetres to more than a metre, formed as a result of solution of bedrock by rain or from subsoil moisture interaction with bedrock (karren).

The subsurface cave landscape is often unexplored or inaccessible, comprising natural cavities in the earth which act, or have acted in the past, as a conduit for water flow from stream sinks and percolation through cracks to springs or seeps or outgoing streams. Cave systems can be very complex, varying from single rooms, passages, and open shafts to intricate three-dimensional interconnected cavities. Some caves are completely dry and inactive, others totally filled with water; some are periodically flooded, and others permanently contain streams or lakes.

Although each of the surface and underground landscapes may have its own catchment and drainage areas, very often the one bears little relationship to the other. Subsurface streams may cross drainage divides and flow in the opposite direction to the general topographic slope.

The distinctive relief and hydrology of karst arise primarily from the greater solubility of certain rock types in natural waters. It is usually found in hard, non-porous rocks composed of relatively pure calcium carbonate such as limestone and marble (recrystallised or metamorphosed limestone), which are dissolved away by rain and streams carrying carbon dioxide in solution. Other natural physical processes, such as uplift and mass movement, also play a part.

Not all limestones have a structure and porosity conducive to the formation of karst (Williams 1982). For example, Oamaru limestone is quite pure, but doesn't form karst because it is too porous.

Karst can occur in other rock types, although this is uncommon in New Zealand. In addition, karst-like landforms not derived from the dissolution of rock may occur in other rock types; for example, caves formed by lava flows. These are known as pseudokarst.

Karst areas usually include distinctive soils, microclimates, flora and fauna, and patterns of hydrology.

2.2 Location and extent

In New Zealand these landscapes range from extensive areas such as the lowland karst of the Paparoa syncline and the subalpine glacio-karst massifs of North-West Nelson, through to scattered remnant limestone outcrops (refer Figure 1).

The major karst areas are the:

- North-West Nelson Marble, including Mount Owen massif, Mount Arthur massif and the northern Arthur Range, and Takaka Hill-Riwaka and Pikipiruna Range-Takaka Valley systems;
- West Coast of the South Island, at Paturau, Karamea and Punakaiki;
- Western Waikato-King Country region, including Waitomo (Maniapoto karst).

These areas include deep and extensive cave systems, such as Nettlebed (889 m deep and 25 km long), Bulmer (over 40 km long), and Gardner's Gut (over 11 km long).

There are numerous smaller karst areas scattered around the country. These areas are generally highly valued for scientific and recreation purposes, and are often subject to higher recreational pressure because of their uniqueness in a region and their small extent.

Pseudokarst is largely confined to basaltic areas in Auckland and Northland, and to the ignimbrite and ash landscapes in the central North Island.

FIGURE 1: DISTRIBUTION OF CARBONATE ROCKS IN NEW ZEALAND



(Based on Williams (1982), with small modifications. Reproduced with permission, original source New Zealand Geological Survey)

3. VALUES OF KARST

Karst is a resource of regional, national and international significance. It is valued for its:

- association with Maori culture
- unique attributes of natural heritage
- importance for natural history research
- utility for recreation and tourism
- role in the supply of water.

3.1 Maori cultural values

In Maori culture, Papatuanuku, the Earth Mother, one of the Primal Parents, is personified in all land, including karst. She nurtures people, and provides the shelter, warmth, food and protection that has enabled people to exist and to continue to prosper. With their combination of caves and waters and uplifting scenery, karst systems provide a particularly significant association of environments in which people can return, literally, to the safety and care of Papatuanuku for whatever purpose or occasion. Karst is therefore of great significance through its association with and usage by tangata whenua.

Tangata whenua acknowledge karst areas also as the dwelling places of entities from other worlds of cultural belief and understanding, that are the taonga (sacred treasures) of iwi. These entities manifest themselves in these places for reasons and at times of their own choosing. Caves are some of the areas where the many worlds and universes come together—the terrestrial, the physical, the spiritual, and the metaphysical. They are the cultural pou (supports) of the beliefs of iwi.

Caves are places of healing, learning, instruction and security for the families of those undertaking the higher aspects of learning; they are places to congregate, to receive or give wise counsel, and places of refuge in hard times.

Some caves or rock shelters also contain writings. These writings are sometimes colloquially referred to as “rock art”. In fact, far from being some form of quaint indigenous art, tangata whenua view these writings as taonga, requiring respect, understanding and preservation. These writings are statements of claim to being of people who existed in other times, words of the past, containing meanings or messages for people to see and understand.

Karst areas are also burial places. These burial sites are, however, not just convenient holes or spaces for putting deceased people. Rather, they are special areas because of the maternal relationship (with Papatuanuku) outlined above. Some of these associations are so old that the deceased are the burial caves themselves.

The significance of specific sites of karst (and other) areas is enshrined in the tikanga and kawa (sacred customs and ceremonies) of those with the whakapapa to talk about them. Even if there are no visible signs of ko iwi (bones) or taonga, the sites may be of cultural significance to tangata whenua. Such sites are “windows in time” that connect the tangata whenua of today with the beliefs, knowledge and responsibilities of their ancestors.

3.2 Natural heritage values

Some surface plants and invertebrate animals (mainly snails), are restricted to limestone and/or marble, and are known as calcicolous species. Many of these favour such calcareous habitats independently of whether or not any karst formation is present.

Karst surface landforms provide a variety of habitats for plant species that are restricted to or favour growing on calcareous soils. They also provide refuges for species that were once more widely spread throughout the landscape. For example, the karst formations at Castle Hill in the Waimakariri Basin in Canterbury provide habitat for the sedge *Carex inopinata* and the grass *Australopyrum calcis* subsp. *optatum* (both highest priority threatened species, category A, see Molloy & Davis 1994), the forget-me-not *Myosotis colensoi* (second priority threatened species, category B), and the rare fern *Anogramma leptophylla*, as well as several indeterminate species.

Caves provide habitats or shelter for a suite of animal species with varying degrees of reliance on or adaptation to dark, cool, moist conditions with low daily variability. Of particular interest are the “troglobites”, species which are wholly adapted to subterranean environments and cannot survive elsewhere. Recent research indicates that the primary habitat for many of these species may actually be the numerous smaller cracks and voids which penetrate the limestone/marble beyond the limits of human-sized caves. Caves may therefore be imperfect “windows” through which these ecosystems may be glimpsed. Some troglobitic species appear to be extremely rare, such as the cave bug *Confuga persephone* (category A).

Non-troglobitic species are often more widespread in distribution, but this is not always the case, e.g. the cave spider *Spelungula cavernicola* (category B, and “wildlife absolutely protected” under the Wildlife Act 1953) which is only known from Buller and Golden Bay. Some caves provide shelter for wetas, including the Poor Knights cave weta (category B), cave dwelling insects (including *Confuga persephone*, category A), long-tailed bats (category B) and occasionally for short-tailed bats (category A)

“Subterranean karst and cave hydrological systems” are included in an international conservation classification of types of wetland (Contracting Parties to the Convention on Wetlands 1998).

3.3 Research values

Some parts of some cave systems are not as prone to the deteriorative effects of climate and erosion as the surface and, in combination with their cool, relatively stable temperatures, have enabled irreplaceable evidence of New Zealand’s environmental history to be preserved. The structure, form and age of these sites and the fragments that they contain (such as sediments, fossils and human artefacts) can be related to such phenomena as past sea levels, earth movements, and erosional cycles. These “time vaults” are important sites for geological, geomorphological, palaeontological and climatological studies.

Bones of bats, birds, amphibians and reptiles are commonly found in caves. The relatively high calcium content and constant microclimatic conditions of caves make them ideal repositories for the long-term preservation of vertebrate bones. Some caves also contain remains of fossil invertebrates, often of previously unknown or locally extinct species.

On the other hand, in some caves the natural processes of erosion of the limestone sometimes expose fine examples of fossils that would otherwise be hidden. Recent finds in New Zealand have included fossilised whale skeletons.

Caves may also have well defined boundaries, zones or habitats which make them excellent natural laboratories for studying and analysing processes such as adaptation, the structure and function of ecosystems, the reactions of ecosystems to induced changes, and microclimatological studies.

Caves contain many types of secondary mineral deposits, known as speleothems (for example stalactites and stalagmites). Speleothems are one of the major terrestrial sources of palaeoclimate information. Most speleothems are formed mainly from calcite, the most common crystalline form of calcium carbonate, which is the main chemical component of limestone and marble. Aragonite and gypsum speleothems are also common. However, there are also occurrences of rare and obscure mineral forms seldom found in nature; of particular note in New Zealand are the palygorskites of the Waitomo area, and the spectacular and abundant quill anthodites of Bulmer Cavern.

3.4 Recreational and tourism values

Karst areas are highly valued for recreation and tourism by many New Zealanders and overseas visitors. For some people, this also includes valuing them for spiritual and other cultural dimensions.

Probably the primary recreation and tourist use is to simply be there to take in and to appreciate the often striking karst surface landscapes. Scenic drives, heritage trails, short walks and roadside amenities all facilitate and contribute to the enjoyment derived from being in these environments. Karst landforms such as the Pancake Rocks at Punakaiki and the magnificent natural arches at Oparara are key attractions.

Large numbers of people also visit caves each year, appreciating their awe-inspiring vaults and caverns and regarding the stalactites and stalagmites and other rock formations as well as the glowworms with a sense of wonder and delight. Tourism in caves such as the Waitomo Glowworm Cave and Fiordland's Te Ana-Au Cave is internationally and nationally significant. For example, the Waitomo Glowworm Cave is one of the top natural attractions and tourist destinations in New Zealand (New Zealand Tourism Board 1993); it receives about 300,000 visitors per year.

Other major recreational activities are rock climbing and caving. Both of these activities are rapidly increasing in popularity and placing increasing pressure on karst and caves. Participants include people from tertiary institutions, schools, scouting groups, youth clubs, adventure tourism and outdoor pursuit organisations, as well as non-affiliated individuals. The largest collective group of recreational cave users is the New Zealand Speleological Society (NZSS), which includes 10 member clubs, and they have played a significant role in developing caving ethics and conservation awareness, and promoting the need for appropriate management.

Commercial adventure caving through "wild" or relatively undeveloped caves is rapidly increasing in popularity and gaining an international profile (e.g. at Waitomo and near Charleston). This activity demands a professional approach to safety standards, conservation and other codes of practice.

3.5 Water supply

In some karst areas the water issuing from caves and springs is an extremely important local resource. The integrity and sustainability of water supplies depends on knowledge and appropriate management of surface sources and associated subterranean drainage patterns.

4. VULNERABILITY OF KARST

4.1 General

The main activities that cause adverse effects on karst are farming, forestry, quarrying and mining, together with urbanisation, recreation and waste disposal.

Karst surface landscapes are also vulnerable to insensitive practice of recreational activities, such as: trampling of vegetation, especially where people congregate (e.g. climbers frequently gather under and around ledges); scrubbing rocks and cleaning crevices for improved climbing holds; and the smothering of vegetation by dumped rubbish. In addition, bolts put into the rocks to aid climbing can degrade the attractiveness of karst, as can graffiti.

Subsurface features are especially vulnerable to careless recreational use, some of which may be essentially irreversible, particularly in areas that had previously been in relatively undisturbed isolation. Just as such areas accumulate evidence of past ages, so too they accumulate evidence of human impacts. Potential impacts include: disturbance of the cave passageways by trampling and erosion, which could stay in place for hundreds of years in a dry passage; broken speleothems and fossils, which may take thousands of years to re-form; the removal of speleothems and fossils; and the disturbance of sediment and its subsequent spread over speleothems and floor deposits. Waste left in caves will decompose much more slowly than on the surface.

The critical factors that need to be understood and addressed for the conservation of karst areas are: water quality, soils, vegetation cover, hydrology, underground climates and air flows, inputs to underground systems (of water, organic debris, silt and chemical wastes), cave deposits (sedimentary and mineral), and cultural uses.

The key to reducing the vulnerability of karst areas to adverse activities lies in educating the public and resource managers about: the values of karst and caves, the critical factors that contribute to their vulnerability, the ways in which these areas can be damaged by thoughtless actions, and the management options to conserve them.

4.2 Cave environments

It is helpful to consider cave energy levels when assessing the potential effects of visitors.

High-energy cave passages are those prone to high-energy events, such as flooding, on a regular basis, causing such caves and underground passages to be regularly modified by rockfalls or flooding. Speleothem formation is rare because any that may form are quickly scoured away or broken off. The impacts of visitors will generally be minimal.

In moderate-energy cave passages, forces such as running water, persistent wind, or animal activities operate at a lower order of magnitude. These caves often contain the most abundant speleothem formations, reflecting abundant saturated water, although conditions are too active for the growth of finer crystals (Tercafs 1993). The effects of visitors may be more evident over a period than in high-energy caves, although they may be masked by occasional flooding and sediment rearrangement.

In low-energy cave passages, a major energy event may be a falling droplet of water. Speleothems in a low-energy cave are characterised by small and delicate formations resulting from the minute amounts of crystal growth. The presence of visitors in a low-energy cave may have a serious effect on the cave environment, as the amount of energy released by them in even a short visit may be more than the cave has experienced in hundreds of years.

In most cases, individual caves are likely to contain components of all three different types of energy level.

Many caves are moderate- or low-energy environments, with essentially little input of energy on a human timescale. The entry of a single caver will change the energy regime, through the way that people behave and move in caves, as well as affecting slightly the heat, light and nutrients there, but generally has little effect on the rock itself. However, this is not the case when visitor numbers are large, as in show caves (e.g. Waitomo Glowworm Cave). The effects of visitors are generally cumulative, possibly synergistic (i.e. the total is more than the sum of the individual components). In other words, the effects of one party of ten cavers will be greater than the effects of two parties of five cavers. In practice, however, the actual effects depend also on management of the group, and a party of 10 well managed and guided cavers will do far less damage than two parties of 5 inexperienced cavers. Correspondingly, a cave that has been “hardened” to carry guided tourist traffic might be far more stable and sustainable than an unmanaged but accessible “wild” cave.

Changes to airflows and humidity in cave systems, which may result from either natural or human activities (e.g. digging through sediment-filled passages for recreational exploration), can have major effects. Cave-dwelling species and growing speleothems often rely on temperature-stable humid microclimates.

The concept of cave energy environments, energy inputs, impacts and remediation techniques is summarised in Table 1.

4.3 Total catchment management

Karst is vulnerable to activities in other (non-karst) parts of surface catchments. It is, therefore, preferable to manage the entire catchment rather than just those portions containing karst. However, subsurface catchments may be difficult to identify because they frequently do not match the apparent catchment boundaries at the surface (e.g. cave streams frequently pass beneath both valleys and ridges on the ground surface).

The relationship between surface conditions and subsurface processes and features is important and needs to be appreciated. For example, logging, mining and road construction can greatly accelerate the natural level of erosion of karst soils, and can dump large quantities of silt into cave streams. This could destroy the habitats of cave fauna and raise streambed levels (which will result in higher flood levels). In addition, such activities often increase surface runoff of water, thereby increasing the frequency and size of flooding events in cave systems. Silt deposition and flooding may reach areas of the cave which have been unaffected for centuries, impacting on features preserved there. In the longer term, altering surface land uses (e.g. from forest to pastoral farming) may alter soil through-flow rates and chemistry of percolation waters, affecting processes such as the deposition of speleothems.

A karst area is, therefore, best protected by maintaining the intact surface vegetation, soils and hydrological systems over the whole catchment affecting the area. In many instances, this will require co-operative management between many landowners.

Table 1 Cave energy environments, energy inputs, impacts and remediation techniques

Cave Energy Level	Cave Environment	Natural Energy Inputs	Natural Impacts	Human Energy Inputs	Human Impacts	Remediation
High	<ul style="list-style-type: none"> • Usually one major stream passage • Streams, shaft or tomo entrances • Little or no upper level development 	<ul style="list-style-type: none"> • Strongly flowing water • Strong air circulation • Flood debris/silt • Rock falls • Waterfalls 	<ul style="list-style-type: none"> • Scoured walls/floors • Natural dam/rockpiles • Silt/mud banks • Logjams 	<ul style="list-style-type: none"> • Swimming • Climbing • Clambering • Lighting • Eating • Diving • Mapping 	<ul style="list-style-type: none"> • River bed disturbance • Wall bolts • Rubbish (boots, gloves, flotation) • Dive lines 	<ul style="list-style-type: none"> • Carry in-carry out policy • Use natural anchors
Moderate	<ul style="list-style-type: none"> • Usually multi-level systems • Tomo, dry and stream entrances • Lots of dripstone formations - usually massive or high in roof/ledges • Seasonal climatic changes • Stream ecology/deposits 	<ul style="list-style-type: none"> • Some stream flow • Cave "breathes" • Bedrock percolation • Dripwater • Pitfall deposits • Flood debris • Silt deposits 	<ul style="list-style-type: none"> • Flood debris/silt • Talus debris at tomos • Rockfalls • Periodic habitat destruction (fooding) 	<ul style="list-style-type: none"> • Climbing • Walking/wading • Crawling • Diving • Lighting • Souveniring • Tourist development • Blasting • Mapping 	<ul style="list-style-type: none"> • Speleothem soiling and breakage. • Silt and mud disturbance and transfer • Dive lines • Rubbish • Wall bolts • Stream bed disturbance • Fossil and sub-fossil destruction • Lampenflora growth 	<ul style="list-style-type: none"> • Party management • Education • Guides • Route marking • Monitoring • Natural anchors • Site identification and protection • Removal of impactable material • Management plans • Carry in-carry out policy
Low	<ul style="list-style-type: none"> • Predominantly dry • Spectacular decorations • Fragile floor deposits • Maybe crystal pools and rare speleothems • Very stable cave climate • Important fossil or sub-fossil remains 	<ul style="list-style-type: none"> • Dripwater • Pitfall deposits 	<ul style="list-style-type: none"> • Adverse effects virtually nil, apart from animal, plant, and talus debris at base of tomos • Major cave speleothem development • Isolated rockfalls 	<ul style="list-style-type: none"> • Climbing • Walking • Crawling • Squeezing • Digging • Blasting • Camping • Collecting • Lighting • Mapping • Tourist development • Burying 	<ul style="list-style-type: none"> • Speleothem soiling and breakage • Floor deposit disturbance • Rubbish • Track marking and tracking • Fossil and sub-fossil destruction • Atmospheric change • Habitat destruction • Lampenflora growth • Cultural desecration 	<ul style="list-style-type: none"> • Gating • Route marking • Party registration and permits • Guides • Education • Signage • Washing stations • Carry in-carry out policy • Detailed monitoring • Ecological evaluations • Management plans

5. MANAGEMENT POLICIES FOR KARST

The Department will manage karst areas following seven broad policies:

1. The Department will manage karst in accordance with the principles of the Treaty of Waitangi and specific iwi settlement agreements.
2. The Department will manage areas of karst that it administers primarily to protect their tangata whenua and other cultural values, and natural heritage and research values, by maintaining natural flows and cycles of air, water, and energy.
3. The Department will foster a range of educational, recreational and tourism activities in karst areas, for the safe enjoyment and appreciation of suitable karst features and values, to the extent that this is not inconsistent with the other goals.
4. The Department will promote appropriate protection for internationally, nationally and regionally significant karst features that are not under its management.
5. The Department will establish a viable network of representative areas of the karst ecosystems, landforms and landscapes which originally contributed to New Zealand's own natural character.
6. The Department will promote understanding of the attributes, values, vulnerability and management of karst areas to departmental staff, external agencies, the public, and associates.
7. The Department will work co-operatively with other people to minimise adverse impacts of external activities and processes on karst areas.

6. DOC ACTIONS TO CONSERVE KARST AREAS

Subject to resource availability, the Department will undertake the following actions to effectively achieve its broad management policies for karst areas. Many of these actions are drawn from the IUCN Guidelines for Cave and Karst Protection (Watson et al. 1997), which are presented in Appendix 1.

The actions are grouped into those related to:

- Overall actions to conserve the karst natural heritage of New Zealand
- Planning the management of protected natural karst areas administered by DOC
- Protection of karst areas from visitor impacts
- Concessions in karst areas
- Non-routine activities in karst areas
- Protection of karst on private land and other public land
- Staff training and capacity

6.1 Overall actions to conserve the karst natural heritage of New Zealand

The Department will:

- Formally protect a representative selection of karst sites as protected natural areas (which include the total karst catchments, where possible).
- Assess the likely effects on karst areas of current and proposed activities.

- Protect karst areas from the extraction of rocks, soils, vegetation, and water where this will interrupt the processes that generate and maintain them.
- Safeguard the quantity and quality of water inputs to karst systems (through formal protection of an entire catchment and/or environmental management controls).
- Minimise the erosion of soils and alteration of soil properties (such as aeration, aggregate stability, organic matter content, and a healthy soil biota) which affect karst areas.
- Manage and protect known taonga or waahi tapu in co-operation with local tangata whenua. (Guidelines for implementing the principles of the Treaty of Waitangi are described in Annex A of the Department of Conservation (1997).)
- Not knowingly publicly reveal the location of waahi tapu, except with the consent of tangata whenua.
- Encourage people to report the discovery of cultural or natural features to the Department.
- Provide for the sustainable use of cultural materials by tangata whenua.
- Promote the Department's karst management approaches to other management agencies.

6.2 Planning the management of protected natural karst areas administered by DOC

The Department will undertake the following actions for the karst areas that it administers:

- Carry out basic inventory work to identify the extent, nature and values (including Maori cultural values, where iwi concur that this is appropriate) of the areas.
- Emphasise the three-dimensional integrated nature of karst areas: i.e. rock, water, soil, vegetation, and atmosphere elements, and cave energy levels.
- Identify threats (including threatened species) and opportunities, and appropriate management responses.
- Prioritise actions to: ensure that a representative selection of karst sites is declared as protected natural areas, remove or mitigate threats, restore damaged features (as much as practicable), and provide a range of recreational and educational opportunities for the safe enjoyment and appreciation of suitable karst features and values.
- Develop monitoring programmes.
- Liaise with karst user-groups.

Appendix 2 lists people within the Department who have knowledge and/or expertise in the management of karst.

6.3 Protection of karst areas from visitor impacts

Management planning and controls will seek to match visitor numbers, use patterns and behaviour to the nature of the karst resource.

The Department will:

- Liaise with tourism operators, local caving and climbing and other user groups, educational organisations, and police and cave search and rescue co-ordinators, as well as their national bodies, to ensure they are aware of, and adhere to, management guidelines (e.g. the NZ Speleological Society Ethical Guidelines, given in Appendix 3).
- Avoid releasing information that will encourage or facilitate people to search for karst features, including fossil deposits, which may be at risk from inappropriate or unformed use.
- Monitor the condition of high-use and vulnerable karst sites, in order to assess and improve the effectiveness of current management practice(s).
- Minimise the vulnerability of significant karst features to visitor impacts by educating visitors about the fragility of karst areas and appropriate behaviours they should follow. On-site and visitor centre information and interpretation panels and associated publications are good media for education and safety. The Castle Hill (Kura Tawhiti) Conservation Area Code of Conduct for Recreational Activity is attached to provide an example of an interpretation panel (Appendix 4).
- Restore damaged features for tourism rather than opening new areas (where appropriate).
- Investigate new mechanisms to restrict access to karst sites that are sensitive to or currently being damaged by visitors. Options include: (i) re-categorising areas for entry by permit only (e.g. as nature reserves or scientific reserves) or (ii) establishing a system that only permits holders of a recognised qualification (e.g. approved by the New Zealand Qualification Authority) to enter specified areas.
- Limit public access (e.g. using structures or notices) where the vulnerability of significant karst features to visitor impacts cannot be adequately reduced by user education or appropriate works.

6.4 Concessions in karst areas

The Department will:

- Process all applications for concessions in karst and cave areas in accordance with the relevant legislation, conservation management strategy, any relevant conservation management plan, and the Department's standard operating procedures.
- Consider whether there are less vulnerable or already modified features where the concession would be more appropriately located.
- Limit the effects of concession activities on karst and cave areas by restricting access to appropriately qualified concessionaires, so as to ensure adequate protection of the area's natural, cultural, and historic resources.
- Consider, and where appropriate invite, applications for the provision of facilities and services currently provided by the Department but which may be better provided by a concessionaire.
- Where possible, provide information to concessionaires about the values of a karst site, its fragility, and restrictions on visitor behaviour at the site in order to conserve it.
- Ensure that concessionaires provide appropriate interpretation to their clients, particularly about the fragility of a site and restrictions on visitor behaviour at the site in order to conserve it.

- Identify areas where concessionaires may be able to assist by raising public awareness of conservation in karst and cave areas.
- Monitor all concessions to make sure that conditions are adhered to.
- Monitor all concessions for direct, indirect, and cumulative effects of their operations. Should the effects of a concession be considered unacceptable, the operating conditions of the concession agreement may be varied to mitigate them, or the concession agreement may be terminated.
- Investigate reports of unauthorised commercial activities on land administered by the Department. Appropriate action to authorise as a concession, prosecute, or prohibit the activity will be taken.

The Department will ensure the adequate protection of the natural, cultural, and historic resources of karst and cave areas by setting concession operating conditions that address (but are not limited to):

- Group sizes and guide/client ratios.
- Leadership requirements such as guide training and/or qualifications.
- Access routes and interpretation techniques.
- Requirements for the protection of specific sites, e.g. route-marking in certain areas.
- Waste removal and disposal requirements (e.g. spent carbide, food scraps, and wrappers).
- The type of lighting system to be used; i.e. electric (preferable where practical) or carbide.
- Monitoring by the concessionaire of relevant activities and impacts.

6.5 Non-routine activities in karst areas

When considering requests for non-routine activities such as search and rescue training exercises, army exercises, filming, weddings, or any other activity in karst areas, the Department will:

- Consider the appropriateness of the proposed activity, and the susceptibility of the area to impact from it.
- Consider whether there are less vulnerable areas, or already modified features, where the activity could be more appropriately located.
- Assess the benefits and costs of the proposed activity to other users of the karst area.
- Assess any safety issues with regard to obligations under the Health and Safety in Employment Act 1992.
- Establish formal links with the New Zealand Speleological Society, police, search and rescue, and army co-ordinators regarding debriefs for training exercise.

6.6 Protection of karst on private land and other public land

The following factors will be considered when evaluating whether to seek the protection of karst on private land and public land managed by other agencies:

- Degree of representativeness of existing protected natural areas containing karst, and geographical and environmental location.
- Geological, hydrological and biological attributes and significance.

- Overall scientific significance.
- Cultural and historic attributes and significance.
- Scenic, educational, recreational and tourism attributes and significance.
- Type and level of threat and degree of urgency of response.

Protection mechanisms that may be considered include:

- acquisition
- covenant, with associated contributions to the management costs by the Department (e.g. fencing, tracks, interpretation signs)
- voluntary management actions by landowner
- Resource Management Act controls.

Appendix 5 provides information on legal ownership of caves.

6.7 Staff training and capacity

The Department will:

- Foster the development of appropriate karst management expertise and capacity through staff training. This will include training (in conjunction with iwi) to raise awareness of the cultural significance of karst to tangata whenua.
- Develop methods for conservation management (e.g. methods for determining acceptable impacts, and for monitoring) in accordance with the Standard Operating Procedure Toolkit (Department of Conservation 1998), and follow these.
- Acquire specialist equipment to appropriately manage karst.

7. GLOSSARY

associates: organisations with a stake in conservation. With regard to karst, key associates include groups representing iwi, recreationalists (especially climbers and cavers), conservationists, concessionaires, other tourism users, and scientists.

concessionaires: people who have been granted a lease, easement, licence or permit to trade, occupy or run a business on public conservation land areas administered by the Department.

dolines: closed depressions or sinkholes in a karst area, formed either by the solution of the surface bedrock or by collapse of underlying caves. Also known as sinkholes. (Soons & Selby 1982, and Gary et al. 1974).

grike: a vertical fissure in limestone, such as a joint enlarged by solution. (Soons & Selby 1982).

karren: furrows, ranging in depth from a few millimetres to more than a metre, formed as a result of solution of bedrock by rain or from subsoil moisture interaction with bedrock, in karst areas (Gary et al. 1974).

karst: distinctive surface and subsurface landforms that primarily arise from the greater solubility of certain rock types in natural waters. Karst usually develops in relatively pure, hard carbonate rocks such as limestone and marble (recrystallised or metamorphosed limestone), although not all limestones and marbles form karst, and it

can occur in other rock types. Karst areas usually also include distinctive soils, microclimates, flora and fauna, and patterns of hydrology. The name is derived from a limestone plateau in the Dinaric Alps, which are located between Croatia and Bosnia-Herzegovina.

lampenflora: plants such as algae, mosses and ferns which occur in the vicinity of lighting fixtures due to the heat, light and available levels of nutrients and moisture.

mass movement: the movement of a portion of the land surface down a slope (e.g. slumps, shallow landslides and debris flows).

monitoring: the act of measuring change in the state, number or presence of the characteristic(s) of something.

pseudokarst: karst-like landforms not derived from the dissolution of rock. These may occur in other rock types; caves, for example, can be formed by the processes associated with the movement of lava.

speleothem: a secondary mineral deposit formed inside a cave; e.g. stalactites (hang down) and stalagmites (point up) (based on Soons & Selby 1982).

syncline: a fold in rocks (or the landscape) in which the strata dip inwards from both sides towards the axis (based on Soons & Selby 1982).

synergistic: when the total effect or impact is more than the sum of the individual actions.

talus: a collection of fallen loose rock fragments forming a slope at the base of a steeper rock face.

tomo: a shaft in limestone country.

troglobite: an animal species that can only live in a humid, dark, food-poor, deep cave environment, and displays associated morphological changes (e.g. elongation of limbs and sensory structures, eye loss or reduction, and pigment loss).

uvala: a large surface depression (up to several kilometres in diameter) in karst areas, formed by the coalescence of adjoining dolines (Gary et al. 1974, Whittow 1984).

visitors: people who come to experience an area. They include independent visitors and clients of concessionaires, from New Zealand and overseas.

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9. ACKNOWLEDGEMENTS

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10. APPENDICES

APPENDIX 1. IUCN Guidelines for Cave and Karst Protection (Watson et al. 1997)

1. Effective planning for karst regions demands a full appreciation of all their economic, scientific and human values, within the local cultural and political context.
2. The integrity of any karst system depends upon an interactive relationship between land, water and air. Any interference with this relationship is likely to have undesirable impacts, and should be subjected to thorough environmental assessment.

3. Land managers should identify the total catchment area of any karst lands, and be sensitive to the potential impact of any activities within the catchment, even if not located on the karst itself.
4. Destructive actions in karst, such as quarrying or dam construction, should be located so as to minimise conflict with other resource or intrinsic values.
5. Pollution of groundwater poses special problems in karst and should always be minimised and monitored. This monitoring should be event-based rather than at merely regular intervals, as it is during storms and floods that most pollutants are transported through the karst system.
6. All other human uses of karst areas should be planned to minimise undesirable impacts, and monitored in order to provide information for future decision-making.
7. While recognising the non-renewable nature of many karst features, particularly within caves, good management demands that damaged features be restored as far as is practicable.
8. The development of caves for tourism purposes demands careful planning, including consideration of sustainability. Where appropriate, restoration of damaged caves should be undertaken, rather than opening new caves for tourism.
9. Governments should ensure that a representative selection of karst sites is declared as protected areas (especially as [IUCN] category I - IV...) under legislation which provides secure tenure and active management.
10. Priority in protection should be given to areas or sites having high natural, social or cultural value; possessing a wide range of values within the one site; which have suffered minimal environmental degradation; and/or of a type not already represented in the protected areas system of their country.
11. Where possible, a protected area should include the total catchment area of the karst.
12. Where such coverage is not possible, environmental controls or total catchment management agreements under planning, water management or other legislation should be used to safeguard the quantity and quality of water inputs to the karst system.
13. Public authorities should identify karst areas not included within protected areas and give consideration to safeguarding the values of these areas by such means as planning controls, programs of public education, heritage agreements or covenants.
14. Management agencies should seek to develop their expertise and capacity for karst management.
15. Managers of karst areas and specific cave sites should recognise that these landscapes are complex three-dimensional integrated natural systems comprised of rock, water, soil, vegetation and atmosphere elements.
16. Management in karst and caves should aim to maintain natural flows and cycles of air and water through the landscape in balance with prevailing climatic and biotic regimes.
17. Managers should recognise that in karst, surface actions may be sooner or later translated into impacts directly underground or further downstream.

18. Pre-eminent amongst karst processes is the cascade of carbon dioxide from low levels in the external atmosphere through greatly enhanced levels in the soil atmosphere to reduced levels in cave passages. Elevated soil carbon dioxide levels depend on plant root respiration, microbial activity and a healthy soil invertebrate fauna. This cascade must be maintained for the effective operation of karst solution processes.
19. The mechanism by which this is achieved is the interchange of air and water between surface and underground environments. Hence the management of quality and quantity of both air and water is the keystone of effective management at regional, local and site specific scales. Development on the surface must take into account the infiltration pathways of water.
20. Catchment boundaries commonly extend beyond the limits of the rock units in which the karst has formed. The whole karst drainage network should be defined using planned water tracing experiments and cave mapping. It should be recognised that the boundary of these extended catchments can fluctuate dramatically according to weather conditions, and that relict cave passages can be reactivated following heavy rain.
21. More than in any other landscape, a total catchment management regime must be adopted in karst areas. Activities undertaken at specific sites may have wider ramifications in the catchment due to the ease of transfer of materials in karst.
22. Soil management must aim to minimise erosive loss and alteration of soil properties such as aeration, aggregate stability, organic matter content and a healthy soil biota.
23. Stable natural vegetation cover should be maintained as this is pivotal to the prevention of erosion and maintenance of critical soil properties.
24. Establishment and maintenance of karst protected areas can contribute to the protection of both the quality and quantity of groundwater resources for human use. Catchment protection is necessary both on the karst and on contributing non-karst areas. Activities within caves may have detrimental effects on regional groundwater quality.
25. Management should aim to maintain the natural transfer rates and quality of fluids, including gases, through the integrated network of cracks, fissures and caves in the karst. The nature of materials introduced must be carefully considered to avoid adverse impacts on air and water quality.
26. The extraction of rocks, soil, vegetation and water will clearly interrupt the processes that produce and maintain karst, and therefore such uses must be carefully planned and executed to minimise environmental impact. Even the apparently minor activity of removing limestone pavement or other karren for ornamental decoration of gardens or buildings has a drastic impact and should be subject to the same controls as any major extractive industry.
27. Imposed fire regimes on karst should, as far as is practicable, mimic those occurring naturally.
28. While it is desirable that people should be able to visit and appreciate karst features such as caves, the significance and vulnerability of many such features means that great care must be taken to minimise damage, particularly when cumulative over time. Management planning should recognise this fact and management controls should seek to match the visitor population to the nature of the resource.

29. International, regional and national organisations concerned with aspects of karst protection and management should recognise the importance of international co-operation and do what they can to disseminate and share expertise.
30. The documentation of cave and karst protection/management policies should be encouraged, and such policies made widely available to other management authorities.
31. Data bases should be prepared listing cave and karst areas included within protected areas, but also identifying major unprotected areas which deserve recognition. Karst values of existing and potential World Heritage sites should be similarly recorded.

APPENDIX 2. Department of Conservation Staff with Expertise in the Management of Karst Areas

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APPENDIX 3. New Zealand Speleological Society Ethical Guidelines

The Society expects that the following code will help to guide the actions of New Zealand Speleological Society affiliated clubs and individual members, and promote an ethical approach to caving by other cave users.

Conservation and Protection of Caves:

1. We will take care to avoid destruction or disfiguration of cave decorations (speleothems), and any other natural feature of caves.
2. During exploration sensitive areas will be taped off and routes will be marked for future use.
3. In sensitive areas tracks will be rigidly adhered to, and where applicable route markers followed.
4. We will not disfigure caves by unnecessary markings. Survey marks will be small, inconspicuous and removable.

5. In areas of clean flowstone floors, muddy clothing or boots will be removed.
6. We will not leave rubbish in caves; our own or other people's. Flash-bulbs, batteries, wrappings, and other refuse must be carried out of the cave.
7. We will carry spent carbide out of the cave and wherever possible encourage the use of battery operated lights
8. We will where practical discourage camping in caves.
9. Under usual circumstances we will discourage the practice of urinating or leaving faeces in caves.
10. Where there is no alternative to underground camps faeces where practical will be removed from the cave.
11. When carrying out water tracing work only those tracing agents which present no danger to the cave flora or fauna will be used.
12. We will also ensure that water supplies are not adversely affected by tracing agents, and before carrying out experiments we will obtain water rights from the applicable catchment authority.
13. We will not construct a gate or a barrier in a cave without first obtaining approval of NZSS Council, and the landowner or administering authority.
14. We will not construct a gate in a cave without an accompanying sign explaining the reason for restricting access, and the circumstances under which authorised visits are possible.
15. We will not interfere with, force, or damage a legitimately erected gate or barrier.
16. Bolts for rigging in caves should only be used as a last resort.
17. Under no circumstances will modifications be made to a cave, or cave entrance, other than to gain access
18. We will not remove any deposit, speleothem, sub-fossil remains, flora or fauna, or any other naturally occurring thing from a cave or karst area without first obtaining permission from the administering authority.
19. Anything removed from a cave or karst area where permission is granted will, where appropriate, be lodged with a recognised museum or scientific organisation.
20. The classification of caves and karst areas for the purpose of conservation and preservation will be in accordance with the Society's Cave and Karst Management Policy.
21. We will honour the classification of caves and karst areas determined by government agencies e.g. Department of Conservation.
22. The Society will consult government agencies to assist them in preparing classifications of caves and karst areas.
23. We will respect Maori tapu relating to burial caves and will not enter such caves without permission. All human remains, artefacts, and other objects will be left undisturbed. No photographs will be taken without obtaining permission.
24. When camping in natural areas or on farmland we shall carefully observe the established Minimum Impact Code and rules of good camping conduct, especially in the lighting of fires and the removal of rubbish. We will bury our faeces when camping.
25. In order to conserve and protect our cave and karst resource we shall encourage other organisations or groups that use caves to adopt these guidelines.

Cavers and Landowners:

26. We will seek and confirm specific approval in advance from the owner before entering a cave or crossing private property. On no account will we take access for granted.
27. We will respect the privacy of landowners.
28. We will respect restrictions placed on access to caves, for example, during the lambing season.
29. We will take care to avoid interference with crops or stock, and ensure that all gates are left as found.
30. We will, where a cave entrance has been blocked by the landowner to prevent injury to stock, re-block the entrance after use; and will liaise with the owner to erect a fence or some other mutually satisfactory means of protecting the entrance.
31. We will not conduct any substantial dig, or use explosives, on the surface or underground without the permission of the landowner (or administering authority). We will make secure or cover any hole which has occurred as a result.
32. We will not be accompanied by a dog, or carry a firearm without the prior consent of the landowner (or administering authority).
33. We will always have available a current Society membership card to show the landowner (or administering authority) when necessary.

Public Relations:

34. We will obtain permission from the managing authority before entering a tourist cave, and will treat guides and other officials courteously.
35. We will when visiting the area of another group or club co-operate and liaise with that group/club.

Publishing Information:

36. We will be discreet in disseminating information that might endanger caves or karst areas. In particular we should not reveal the location of entrances in newspapers.
37. We will not publish, or draw media attention to scientifically, ecologically, or physically sensitive caves or karst areas without prior consultation with NZSS Council.
38. We will in reporting our work, particularly to the media, avoid and discourage sensationalism, exaggeration and unwarranted statements.
39. We will, in publishing our work, take particular care to acknowledge other people's contribution to the work involved, either as clubs, groups or individuals, whether by published work, personal communications, or whatever.

APPENDIX 4. Castle Hill (Kura Tawhiti) Conservation Area Code of Conduct for Recreational Activity

Castle Hill (Kura Tawhiti) Conservation Area is a special place. People have been drawn to it from the time of first habitation of the area, through to Ngai Tahu occupation and up to the present day. Not only humans have felt the influence of the features of the area. A range of plants and animals have been shaped by the special qualities of its environment. A number of these are not found elsewhere and need to be looked after in their natural habitat.

Past activity has caused major modification to the area and put many of these special plants at risk. Current management procedure recognises the cultural significance of the area to Ngai Tahu and aims to restore the indigenous ecosystem and preserve historic and cultural features. To enable this to happen, and promote enjoyment and appreciation of the area, the Department of Conservation has developed this code of conduct for all visitors to the area. Camping continues to be excluded from the activities allowed. All visitors are asked to adhere to the intent of this code of conduct during their visit.

All Visitors to Castle Hill (Kura Tawhiti) are Asked to:

Approach through the approved marked entrance

Remain on the official access way to the Conservation Area The paddocks through which the access way passes are private property.

Only go to the toilet in the provided toilet facilities Indiscriminate toileting within the area will offend Ngai Tahu's spiritual and cultural values and may contaminate springs and streams fed by runoff water. Disturbance and damage to protected or endangered plants can occur from the deposition of faeces and urine. (Many of the endangered plants are of an inconspicuous form and grow in sheltered concealed places that are typically sought by people wishing to relieve themselves.)

Refrain from digging holes or otherwise disturbing the surface of the ground. There are a number of sites within the Conservation Area that are waahi tapu (sacred ground) or of other archaeological significance. These are not marked and any disturbance is a matter of concern.

Minimise the adverse effects of trampling by:

- Where practicable, moving through the Conservation Area on the existing tracks.
- Not gathering at the base of rock faces. Many indigenous plants grow in habitats at the base of rocks.
- Congregating on areas where there is a well developed grass sward. These are the wider open spaces between the rock outcrops. Large groups of people congregating in areas cause trampling and wearing. This is detrimental to native plants. Much of the grass sward in the open spaces between the rocks is of introduced grasses.
- Avoid forcing your way through patches of small bushes or trees. These are the remnant members of a once extensive scrub and forest ecosystem.

Respect the protection being given to areas that are fenced These may be the sites of an endangered species or a species re-establishment site.

Observe the requirement not to camp in the Conservation Area and light no fires

Take all rubbish out of the area This includes what may be perceived as biodegradable food scraps. Castle Hill (Kura Tawhiti) Conservation Area is not a rubbish dump.

Refrain from making any marks on the surface of rocks as memorials of your visit The rock surfaces are the habitat of small plants such as lichens. They are old surfaces that should retain their natural appearance for all to see and appreciate. Their natural appearance is part of what makes this area special. Graffiti and unnatural marks detract from the natural and spiritual qualities.

Consider others Remember this is a special place for many people who come to appreciate the natural qualities of the area. Loud speech and music are not appropriate.

Rock Climbers Note

Do not brush or prepare any rock surfaces The rock surfaces are the habitat of small plants such as lichens.

Do not clean out or “garden” any cracks, clefts or other hollows or depressions in the rock surfaces that support vegetative growth These are important refuges for a range of species (plant and animal) that have been destroyed in the wider environment.

Do not place any rock bolts on new climbing routes or replace existing bolts The area already has a large number of “bolted” climbs. The placing of bolts is an activity that requires specific permission from the Department of Conservation. There is no automatic “right” that allows climbers to bolt routes in this, or any other, conservation area. If you discover an unsafe bolt and are unable to remove it, contact the Waimakariri Area office at Arthur’s Pass. The intention to install any foreign object in an area designated for protection requires assessing and judging appropriately. Bolts constitute an intrusion into the natural environment. They have an impact on the appearance of the rocks and have chemical weathering effects on the rocks. There is a definite, if minor, change to the ecosystem in the vicinity of a bolt.

Avoid the gatherings of people at the base of rocks The base of rocks are frequently the habitats of indigenous plants.

When you have finished your day’s activity, remove all equipment from the area

Summary

Approach through the approved marked entrance.

Remain on the official access way to the Conservation Area.

Go to the toilet only in the provided toilet facilities.

Avoid digging holes or disturbing the surface of the ground

Minimise the adverse effects of trampling by:

- Where practicable, moving through the Conservation Area on the existing tracks.

- Refraining from gathering at the base of rock faces.
- Congregating only on areas where there is a well developed grass sward.

Avoid walking through patches of small bushes or trees.

Respect the protection being given to areas that are fenced.

Refrain from making marks on the surface of the rocks as memorials of your visit.

Do not camp in the Conservation Area.

Light no fires.

Respect others' presence and cultural perspective with appropriate noise levels.

Take rubbish out of the area.

Rock Climbers

Do not brush or prepare any rock surfaces.

Do not clean out or "garden" any cracks, clefts or other hollows or depressions in the rock surfaces that support vegetative growth.

Do not place any rock bolts on new climbing routes or replace existing bolts.

Minimise the possibility of trampling plants at the base of rocks.

Remove all equipment from the area.

Enjoy and Look After the Outdoors

APPENDIX 5: Ownership of Caves

Ownership of caves is broadly based on the old common law doctrine "*Cujus est humus ejus est usque ad coelum et ad inferos*"-that is, "Whose is the soil, theirs is also that which is above it and below it". Therefore legal definition is achieved by defining the area on the surface. The above doctrine has some exceptions, particularly in relation to statutes reserving mineral rights of private land to the Crown under the Crown Minerals Act, 1991.

Nevertheless the ownership of caves (or more precisely the walls thereof) generally will be by whoever owns the soil above and around them. A surface survey of the land under which a cave is located is acceptable to District Land Registrars for the purpose of registration of the title (Thode S 1982 *Opinion on Status, Ownership, Access, and Mineral Rights of Caves*. Unpublished legal opinion. Department of Lands and Survey, Hamilton).

It is imperative that an accurate cave survey be undertaken before a reserve is established over a cave. The British Cave Research Association Grade 5 Survey (a system adopted by the NZSS) has been shown to be accurate enough for this purpose. An accurate cave survey will ensure that adequate attention has been given to the location of entrances and the extent of passages.

The relevant Treaty of Waitangi claims must be taken into account.