



**Forest
Practices
Board**

Management of Karst Resource Features on Northern Vancouver Island

Special Investigation

FPB/SIR/39

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Table of Contents

Board Commentary	i
Executive Summary	1
Introduction	3
Background	3
Legislative and Professional Framework	5
Approach	5
Objectives	5
Scope	5
Selection of Cutblocks	6
Methodology.....	6
Findings	6
Were Karst Resource Features damaged or rendered ineffective?.....	6
Are individuals completing karst field assessments qualified?	7
Do karst field assessments provide adequate information?	7
Were best management practices followed?	10
Conclusion	13
Addendum	15

Board Commentary

This special investigation looked at karst management on northern Vancouver Island and did not determine that any caves or significant karst features had been damaged or rendered ineffective by forestry activities. However, investigators were only able to assess the portions of karst terrain that were readily visible; they did not assess the subterranean portions.

The Board acknowledges that forest management on karst terrain can be challenging, due to identified surface karst features being only a small part of the karst terrain as a whole; and that this is further complicated by legislation that only focuses on caves and very specific karst features. Since much of the karst terrain cannot easily be assessed, the Board believes it is important that forest professionals take a cautious approach when addressing karst features and utilize karst specialists and the best available information when assessing karst features and prescribing management strategies.

Currently, the best guidance for karst management in the province is provided in *The Karst Inventory Standards and Vulnerability Assessment Procedures for British Columbia*¹ and *The Karst Management Handbook for British Columbia*².

Although these two documents are 10 years old and should be reviewed and updated, the Board believes the public would expect that they be given due consideration by forest licensees, as this is the best karst information currently available.

However, during the course of this investigation, the Board found that the guidelines set out in the two karst management documents—including the best management practices—were usually not followed, and it noted inconsistency with karst assessments and management strategies. No rationales were provided regarding why these best management practices were not fully utilized.

The Board encourages forest professionals and other individuals completing the detailed karst assessments to follow best management practices if possible, or to document their rationale if they choose to not follow the practices outlined in these documents. Doing so would help foster public confidence in tenure holders and their professionals to sustainably manage karst.

¹ <http://www.for.gov.bc.ca/hfd/pubs/docs/mr/Mr099.pdf>

² <http://www.for.gov.bc.ca/hfp/publications/00189/Karst-Mgmt-Handbook-web.pdf>

Executive Summary

In March 2007, government issued an *Order To Identify Karst Resource Features For The North Island – Central Coast Forest District*³ (the Order) under the *Government Actions Regulation* (GAR) that forestry activities not damage or render ineffective karst caves, significant surface karst features, and important features and elements within high or very high vulnerability karst terrain in the North Island – Central Coast District. However, the Order does not provide any operational practice requirements, so it is left up to forest professionals and forest licensees to determine how to comply with it.

This special investigation was conducted to assess operations of five licensees operating in the Vancouver Island portion of the district where harvesting and road construction activities have occurred since the Order came into effect. Planning and field practices were evaluated to determine if licensees were compliant with the Order and whether planning and recommended best management practices followed two guidance documents. However, what is important under the current regulatory framework is how operational forestry activities affect karst features, not the process used to achieve the results.

The Board investigators did not determine any karst resource features that had been damaged or rendered ineffective by forestry activities. Licensees prescribed and implemented management strategies for all identified karst features, even though they are only required to protect those features identified in the GAR Order.

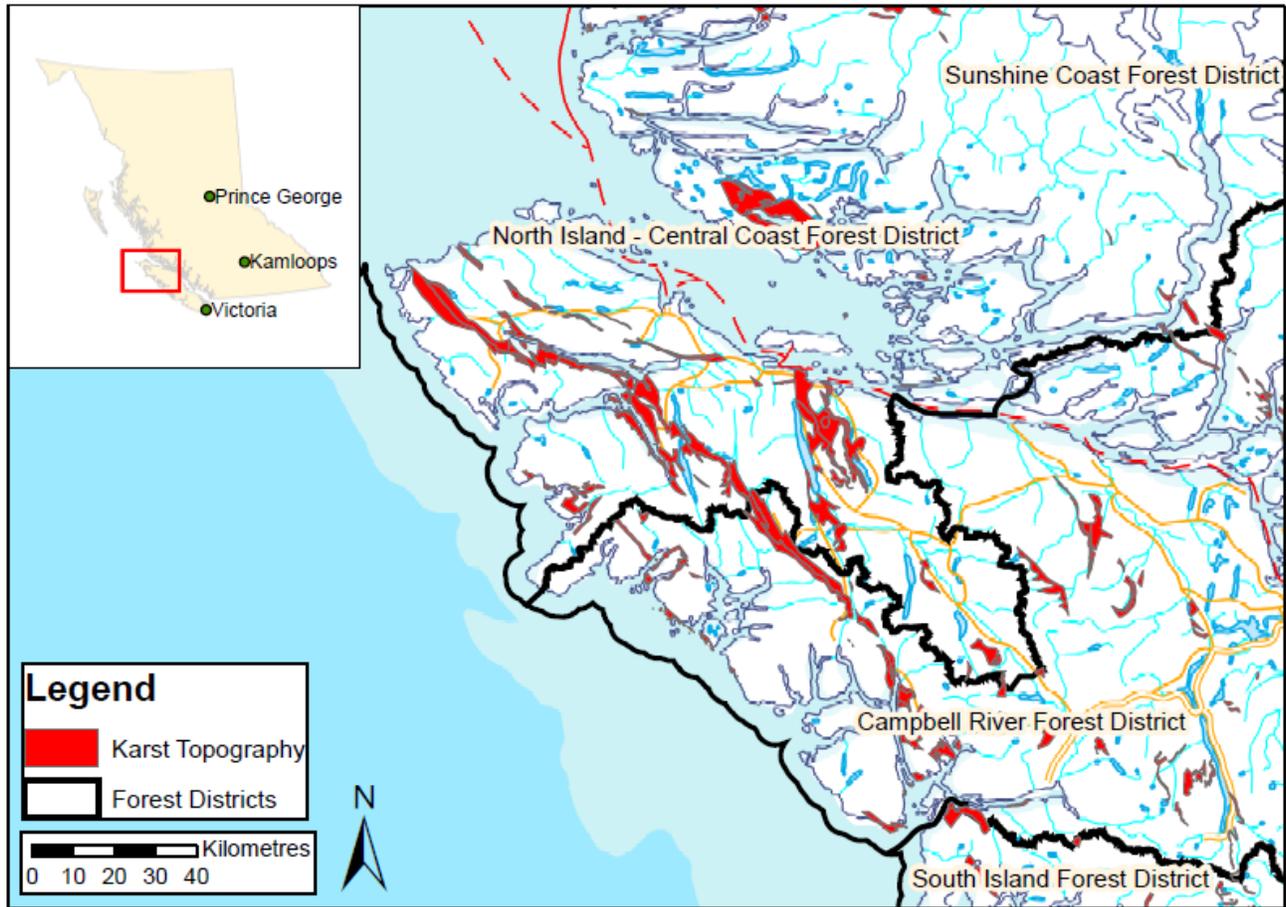
In the forestry context, managing karst features falls within the scope of ‘practice of professional forestry,’ and oversight of assessor qualifications is usually exercised by forest professionals using their professional principles and available guidelines. Since there are no formal qualification criteria for individuals completing assessments, it is up to the forest professional to ensure individuals completing these assessments are qualified.

As part of its watchdog role, the Board looks for ways to improve forest management and practices. In this instance, the Board identified opportunities to improve planning and operational strategies for managing karst resource features, and suggests the following:

- The Association of British Columbia Forest Professionals should provide guidance to its membership through professional practice guidelines for completing karst field assessments, which would include qualification criteria. Guideline development should involve the Association of Professional Engineers and Geoscientists of British Columbia and non-professional karst experts, since karst science is interdisciplinary in nature with a strong geoscience basis.
- The Ministry of Forests, Range and Natural Resource Operations should review and update the *Karst Inventory Standards and Vulnerability Assessment Procedures for British Columbia* (Version 2) and the *Karst Management Handbook for British Columbia* (Version 2) to incorporate knowledge and experience gained over the past 10 years.

³ http://www.for.gov.bc.ca/tasb/legregs/frpa/frparegs/govact/orders/DNI_Karst.pdf

Overview Map of Karst Special Investigation



Introduction

In January 2007, the Forest Practices Board published a special report, *Protecting Karst in Coastal BC*. The report concluded that:

- Karst features are sensitive to damage from forest practices, but that sensitivity is often not recognized.
- As a result of the transition to results-based legislation, government no longer protects karst features or terrain through its operational plan approval process. Government can only identify karst features that require protection through a government Order.
- It is up to those who carry out forest practices to determine how best to carry them out in a way that avoids damaging identified karst features.
- Current legislation puts the onus on licensees, professional, contractors and equipment operators to recognize karst and be aware of its significance and sensitivity. It also leaves it to licensees and their resource professionals to determine when expertise is required to plan and to carry out appropriate forest practices.

In March 2007, government issued an Order under the *Government Actions Regulation (GAR)* to protect specific karst resource features in the North Island – Central Coast District (NICCD).

The Board carried out this investigation to assess the effectiveness of forest practices in protecting karst resources on northern Vancouver Island since the Order came into effect.

Background

BC, especially in coastal areas, has some of the most significant karst terrain in North America. Karst is a distinctive topography in which the landscape is largely shaped by the dissolving action of water on soluble rock (usually limestone, dolomite or marble) over many tens of thousands of years. This geological process results in a unique landscape system composed of unusual surface features interconnected with underground drainage systems and caves.



Entrance to a karst cave.

Karst on BC's coast has world renowned recreational caving values, as well as biological, scientific, cultural, hydrological, mineralogical and economic values.⁴ Karst terrain is also highly productive for growing forests and, while forestry may provide access roads for recreational opportunities, forest practices also have the potential to negatively affect karst systems. Harvesting and road construction potentially cause adverse impacts such as physical disturbance and soil erosion to karst surface and subsurface features; alteration of surface and subsurface flows; introduction of fine sediment and woody debris to the subsurface; and, less commonly, the collapse caves with thin ceilings.

Because karst is regionally limited, there is no general objective specified for karst terrain in the *Forest and Range Practices Act* (FRPA). Consequently, six districts⁵ in the South Coast and West Coast Forest Regions issued karst Orders under the GAR to offer some protection. The Orders identify various components or elements of karst terrain to protect, but do not provide any practice requirements or guidelines on how to manage them. This is consistent with the results-based FRPA legislation which leaves it up to forest licensees to carry out their practices in a manner that protects karst terrain.

Forest licensees rely on forest professionals to prescribe activities to adequately manage karst terrain and meet legislative obligations. Forest professionals in turn rely on other professionals and/or specialists, who are trained and experienced in karst systems, to assess and provide recommendations on how best to manage karst resources. In addition to their own knowledge and training, practitioners assessing and prescribing management strategies for karst resources rely on two non-statutory reference or guidance documents.

1. *The Karst Inventory Standards and Vulnerability Assessment Procedures for British Columbia*, Version 2, January 2003 (the 'inventory standards'), describes provincial standards and procedures for conducting karst inventories and deriving karst vulnerability ratings. The inventory standards were developed by the BC government's Resources Information Standards Committee (RISC), which was responsible for establishing standards for natural and cultural resources inventories.
2. *The Karst Management Handbook for British Columbia*, May 2003 (the management handbook), provides guidance on management strategies and best management practices that the licensee may consider when working on karst terrain and around karst features.

⁴ *Karst Management Handbook for British Columbia*, page 5 – 12. <http://www.for.gov.bc.ca/hfp/publications/00189/Karst-Mgmt-Handbook-web.pdf>

⁵ Campbell River, Chilliwack, Haida Gwaii, North Island-Central Coast, South Island and Sunshine Coast.

Legislative and Professional Framework

Legislative

The GAR Order for the NICCD designated karst caves, significant surface karst features, and important features and elements within high or very high vulnerability karst terrain as resource features⁶ in March 2007.

The *Forest Planning and Practices Regulation* (FPPR), section 70(1), requires licensees to ensure that primary forest activities⁷ do not, “damage or render ineffective,” a resource feature.

Professionals

Prescribing appropriate management strategies for karst features requires expertise in the field of karstology, as well as adequate training and mentoring in conducting karst field assessments. It is up to the forest professional to ensure that individuals completing karst field assessments are competent, since there are no formal qualification criteria.

A forest professional usually serves as the coordinating and prescribing professional for karst resource values. The Association of British Columbia Forest Professionals (ABCFP) Code of Ethics⁸ requires that forest professionals only practice in those fields where training and ability make the member professionally competent, and to seek assistance from knowledgeable peers or specialists whenever a field of practice is outside the member’s competence.

Approach

Objectives

The Board decided to conduct a karst special investigation of karst to assess whether forest practices are compliant with the NICCD GAR Order and whether the FRPA forest management framework provides for adequate management and protection of karst caves, significant surface karst features and important features or elements, within very high or high vulnerability karst terrain that are designated as resource features under NICCD’s GAR Order of March 2007.

Scope

Investigators assessed forest planning and field practices of five licensees operating in the Vancouver Island portion of the NICCD, where harvesting and road construction activities have occurred since the GAR Order came into effect on March 29, 2007. The investigation focused on the management of individual karst features, not the management of karst terrain as a whole.

⁶ Throughout this document ‘karst resource features’ refer to karst features subject to the GAR Order; ‘non-GAR karst features’ refer to karst features not subject to the GAR; and ‘karst features’ refer to all karst features.

⁷ Primary forest activity includes one or more of **timber** harvesting, silviculture treatments, or road construction, maintenance and deactivation.

⁸ http://www.abcfp.ca/regulating_the_profession/bylaws/documents/ABCFPCodeOfEthics.pdf

Selection of Cutblocks

The five licensees have assessed and identified karst in 68 cutblocks within the Vancouver Island NICCD, since March 2007. The investigation team rated the 68 cutblocks based on a review of the assessments, features identified and proximity to bedrock types associated with karst terrain. The investigation team then selected 21 of the cutblocks with 128 karst features for office and field reviews of planning, road construction and harvesting activities. Six additional cutblocks in close proximity to karst terrain, but identified by the licensees as not having karst features, were also selected for field review. The investigation team confirmed that there were no karst features in these cutblocks and they will not be discussed further in the report.

Methodology

Office reviews evaluated whether the assessments followed the inventory standards and management handbook best management practices. Field reviews assessed the condition of karst features, the management strategies applied and whether primary forestry activities impacted the karst features. Specifically, the special investigation examined:

- Were karst resource features damaged or rendered ineffective?
- Are individuals completing karst field assessments (KFAs) qualified?
- Do karst field assessments provide adequate information?
- Were best management practices (BMPs) followed?

Findings

Were Karst Resource Features Damaged or Rendered Ineffective?

The Board investigators determined that karst resource features had not been damaged or rendered ineffective by primary forestry activities, notwithstanding that ‘damage’ or ‘render ineffective’ is not defined in FRPA or the GAR Order and that there are no legislated operational practice requirements for managing karst resource features. The team assessed damage by evaluating the discernible physical and environmental impacts of primary forest activities with the objectives provided by the management handbook (refer to Appendix II). The objectives are designed to promote sustainable forest practices on karst landscapes while minimizing impacts to timber supply and operational costs.

Physical alteration due to primary forestry activities could not be directly correlated to ‘damaged or rendered ineffective’ since many of the karst features are underground and the interconnection between surface and subsurface features is not readily apparent. To prove damage or rendered ineffective for many karst features would require long-term baseline data to compare features, pre- and post-harvesting, with natural changes. However, there is little research being done in BC to monitor the short-term and long-term impacts of forestry practices on karst terrain.

Are Individuals Completing Karst Field Assessments (KFAs) Qualified?

At present there are no criteria to determine whether an individual is qualified to complete KFAs. The inventory standards and management handbook suggests minimum qualifications for individuals carrying out assessments, including successfully completing the Resource Inventory Standards Committee (RISC) *Karst Field Assessments Training Course* (RISC 2003).⁹ The inventory standards provide general guidance such as the use of licensed professionals and when to involve the caving community or multi-disciplinary teams. These guidelines are cited in the determination rationale for the GAR Order.

Individuals preparing KFAs need to accurately identify karst features and establish their significance. They should also have an understanding of the dynamics of karst processes and karst ecosystems, which requires a level of knowledge and expertise beyond normal forestry education and experience.

Twenty-one assessments were completed; 16 by 5 different consultants, including 9 assessments by engineers and geoscientists who are members of Association of Professional Engineers and Geoscientists of BC (APEGBC) and 5 by licensee staff who are members of the ABCFP. Consultants had varying levels of education¹⁰ and experience related to karst management, and not all had taken the three-day RISC training. It is recommended that assessors take the RISC training to help orient them to the RISC procedures and the inventory standards. However, some professional engineers and geoscientists may have familiarity and experience related to karst geoscience that exceeds knowledge of both the RISC inventory standards and training course.

Do Karst Field Assessments Provide Adequate Information?

The investigation found that karst field assessments were being completed. However, only one KFA followed the inventory standards with respect to mapping, report format and content. In many instances, investigators could not determine if streams associated with the cutblocks were followed downstream for the distances recommended in the management handbook, to ensure karst resources downslope were not impacted.

The inventory standards describe three levels of karst inventories which provide a filtered approach to evaluating karst terrain. Each level has increasing requirements for data collection and evaluation. KFAs are the most detailed assessments, are prepared by licensees to specifically address the karst resources and are incorporated into operational plans. They are primarily detailed surface karst inventories at a 1:5 000 to 1:10 000 scale of the karst area within, and adjacent to, a proposed cutblock and/or the karst area potentially affected by an upslope cutblock or road.

⁹ There are two training courses: the RISC standards refer to a three-day extensive field and office training course; an online training course which reiterates the management handbook (<http://www.for.gov.bc.ca/hfp/training/00008/lesson1/index.htm>) takes approximately three hours to complete.

¹⁰ Assessments completed: P. Eng. – eight; undergraduate B.A. – four; undergraduate B.Sc. – two; P. Geo. – one; no designation – one; licensee – five (three by RPFs and two by RFTs).

The special investigation reviewed the KFAs for each cutblock to see if they provided adequate information to allow the licensee to meet the intent of the GAR Order. KFAs, as required by the inventory standards and management handbook, were evaluated to see if they:

- identified karst features;
- determined feature significance;
- determined karst vulnerability; and
- provided management strategies.

Identification of karst features

Karst features were accurately identified by the licensees, both in terms of their respective types and geographic locations. The investigation team field-reviewed 21 cutblocks where KFAs had been completed. One hundred and twenty-three surface karst features¹¹ and 5 caves were identified in the KFAs (Table 1). The investigation team confirmed 122 of the surface karst features and the 5 caves. The investigation team found and inspected 1 additional small cave within a harvest area that was not identified in the assessments. No concerns were noted.

An accurate inventory of karst features and karst terrain allows forest professionals to efficiently plan and prescribe strategies to mitigate the potential impact of planned forestry activities. There is no formal centralized inventory of previously identified important karst features or karst terrain so licensees rely on geological mapping, reconnaissance-level or planning-level karst inventories, field assessments and communication with karst resource users to identify karst features. Some licensees have developed these types of inventories with their own field assessment data for use in their planning.

Meetings between karst resource users, forest licensees and government are an effective means to share information on proposed developments. Although these meetings are sporadic, at least there is some communication in this area. Often caves have high cultural or recreational value, or pose a significant safety concern, and there is reluctance by karst resource users to provide information on their location for fear that such information will reach the public domain and significant features may be damaged by irresponsible use, or someone may be injured. Conversely, without knowing where these areas or features exist, licensees might inadvertently impact these sites.

¹¹ Refer to KISVAP, Appendix D.

Table 1. Karst Features Identified by the Licensee and Reviewed During the Special Investigation

Karst Feature	# of Features	NON-GAR KARST FEATURES		KARST RESOURCE FEATURES	
		# Inside Harvest Area	# Outside Harvest Area ¹²	# Inside Harvest Area	# Outside Harvest Area
Sinkholes	90	70	18	1	1
Riparian*	7	4	3	0	0
Cave Entrances	8	4	3	0	1
Other Surface Features**	18	10	6	0	2
Total Surface Features	123	88	30	1	4
Caves***	5			2****	3
Total Karst Features	128	88	30	3	7

* Karst springs, insurgences, or linear karst streams.

** Karst windows, grikes, shafts, canyons, ridges, gullies and dry valleys.

*** All caves are subject to the GAR Order.

**** One cave entrance was outside of the cutblock but the cave ran under the cutblock harvested area.

Karst vulnerability

Karst vulnerability is the susceptibility of a karst system to change, and is considered to be a function of its inherent characteristics and sensitivity. A vulnerability rating is used to stratify the broader karst terrain into polygons of different sensitivity (with low, moderate, high or very high ratings) and is useful when prescribing management practices for road building and related activities, timber harvesting and post-harvest operations. As the vulnerability ratings progresses from low to very high, the management handbook BMPs become more stringent. In low vulnerability areas the general or baseline BMPs identified for working on karst landscapes are considered sufficient, while on moderate and high vulnerability areas the general BMPs, as well as additional strategies, are recommended. Very high vulnerability terrain may be excluded from harvesting altogether.

The KFAs included karst vulnerability ratings for all 21 cutblocks reviewed. The assessments stated that inventory standards criteria were considered when establishing vulnerability. Nine cutblocks were classified as low vulnerability, nine as moderate and five had portions of high vulnerability. In three cutblocks the areas of high vulnerability were removed from the harvest area. There were no areas of very high vulnerability identified.

Significance evaluation of karst features

KFAs evaluated and established significance for all karst features. However, only 10 features were subject to the GAR Order: 5 caves and 5 significant surface karst features.

Assessing significance is a ‘qualitative evaluation’ of a number of criteria and is dependent on the knowledge, education, training and experience of the individual completing the KFA, and the application of the guidelines and examples provided in the inventory standards. Determining significance involves evaluating the 10 criteria as identified in the inventory standards, which are:

¹² Includes features in wildlife tree patches and outside of cutblock.

dimensional characteristics; connectivity; hydrological; geological; biological; scientific and educational; archaeological and cultural; recreational and commercial; rarity and abundance; and visual quality values. The guidelines contain some tangible examples of the factors to consider, based on dimensional criteria and feature types. However, many criteria are social values and the assessor needs to determine feature significance based on their experience and on the management handbook examples. Assessing significance contains a degree of subjectivity, even though a number of factors and examples are provided in the inventory standards to help consistency.

There was inconsistency in terms of how significance was recorded in the assessments. For example, in some reports the karst features were classed as significant and not significant, in others as low, moderate, or high significance, while in yet others features were rated as not sufficiently significant. The inventory standards and the GAR Order only reference significant karst features; consequently, the investigation only recognized features as significant and subject to the GAR Order if they were identified as significant or high significance in the assessments.

Management strategies

KFAs included management strategies for all karst features, even though most are not subject to the GAR Order. The management handbook recommends BMPs for karst features as a way to protect karst terrain and its associated values from any adverse impacts from forestry activities. BMPs include flagging features in the field, establishing reserves and/or management zones, minimizing soil disturbance, protecting riparian areas (karst springs, sinking streams and watercourses), falling and yarding away, retaining non-merchantable vegetation around features and removing logging debris from features.

Were Best Management Practices Followed?

Operational activities did not follow the management handbook recommended BMPs for 70 percent of the karst resource features and 55 percent of non-GAR karst features. Lack of or undersized, reserves and introduction of logging slash were among the most common inconsistencies with the BMPs.

When the statutory decision maker approved the GAR Order for the NICCD he stated that, “My expectation is that the 2003 *Karst Management Handbook for BC* and the 2003 *Karst Inventory Standards and Vulnerability Assessment Procedures for BC* would provide adequate and appropriate direction for interpreting and applying the Karst Order.”¹³ Therefore the BMPs of the management handbook, if followed, should provide suitable practices for not damaging or rendering ineffective the karst features (refer to Appendix I). Regardless of whether the BMPs were followed, the investigation team assessed each feature individually to determine if forestry activities damaged or rendered them ineffective.

BMPs in the management handbook were developed over a number years with input from government, industry and karst specialists. Using BMPs is a precautionary approach to karst management which recognizes the inherent value of karst resources, that there are unknowns in

¹³ Determination Rationale to Identify Karst Resource Features in the North Island – Central Coast Forest District, March 23, 2007.

how the karst system functions, and the lag time between a disturbance event and the resultant impact.

BMPs are not legally binding and were intended to be applied based on site specific conditions, experience, new information and consideration of operational requirements. The potential impacts of forestry activities on karst features are not well understood; since the connections between surface and subsurface features are often difficult to confirm by direct observation or study, when impacts occur, they are not immediately obvious. Therefore, it is a good practice for licensees to take a cautious approach and manage both karst resource features and non-GAR karst features, recognizing that management strategies will not be the same.

Karst resource features (subject to the GAR Order)

The KFAs identified 10 features subject to the GAR Order: 5 significant surface karst features and 5 caves. The management handbook recommends one to two tree-length reserves be established around significant surface karst features and variable¹⁴ reserves above karst caves. Management strategies other than those outlined in the management handbook can also be considered, as long as the desired result of the protection of the resource feature is achieved.¹⁵

Table 2. Observed Field Practices & Recommended BMPs for Caves & Significant Surface Karst Features Identified by the Licensee

BMP Description	Caves**		Cave Ent		Sinkhole		Karst Window		Karst Canyon	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Maintain a variable timber reserve above the cave.	3	2								
Maintain a two tree length reserve.			0	1	0	1	0	1		
Maintain a one tree length reserve.					0	1			0	1

* A two tree-length reserve is recommended if the feature has its own microclimate.

** A variable timber reserve was not established above the small cave found during the investigation.

As identified in Table 2, licensees did not follow the management handbook BMPs for the five significant surface karst features, and for two of the five caves. Licensees did not establish a reserve around one sinkhole without a microclimate,¹⁶ but did establish reserves around all other significant surface karst features, although the reserves were less than the BMP recommended size.

¹⁴ The variable reserve above a cave is dependent on the cave height and depth below the surface. Refer to the inventory standards for detailed methodology.

¹⁵ <http://www.for.gov.bc.ca/rco/stewardship/CRIT/docs/Karst%20Guidance%20document.pdf>

¹⁶ The climate of small areas differing in extremes of temperature and moisture from the climate outside that area and may provide habitat for rare and unusual flora and fauna.

Non-GAR karst features (not subject to the GAR Order)



Sinkhole protected with high stumps.

BMPs for non-GAR karst features depend on the assessed vulnerability of the karst terrain and type of forestry activity (road building and related activities, timber harvesting and post harvest operations). The management handbook recognizes the need for flexibility on which strategies to employ for non-GAR karst features since a 'one-size-fits-all' approach is not realistic. Strategies should be tailored to the specific feature, and also consider operational constraints such as harvest system (conventional logging, uphill cable, downhill cable and helicopter) and stand structure attributes. For example, it is difficult to control logs when downhill yarding, which may make it difficult to retain understory vegetation; and when it comes to retention, retaining shallow rooted trees prone to windthrow may not be successful.

A total of 88 karst features were inside of the harvest area: 25 on low vulnerability terrain and 63 on moderate or high vulnerability terrain. Table 3 shows the BMPs of the non-GAR karst features on moderate or high vulnerability terrain within the harvest area. Thirty-three of 63 non-GAR karst features within the harvest area did not follow the management handbook recommended BMPs. Introduction of logging debris was the most common inconsistency. It should be noted that some licensees also applied other strategies, such as high stumping, that are not currently included in the management handbook. This practice was considered by the investigators to be effective at avoiding disturbance from machinery and logs being skidded.

Table 3. Observed Field Practices and Recommended BMPs and of the 63 Non-GAR Karst Features Inside Harvest Area on Moderate or High Vulnerability Terrain

BMP Description	Sinkhole (49)		Riparian**** (3)		Cave Entrance (3)		Other (7)	
	Yes	No	Yes	No	Yes	No	Yes	No
Tracks of machinery kept five metres away	45	4	3	0	3	0	7	0
Natural surface drainage patterns maintained	49	0	3	0	3	0	7	0
Side slope of sinkhole not damaged	46	3***	N/A	N/A	N/A	N/A	N/A	N/A
Minimize and/or removal of logging debris**	28	21	3	0	1	2	3	4

* Includes 14 sinkholes where it could not be determined if non-merchantable vegetation was retained.

** Licensees were deemed to have made an effort to remove slash if levels were low.

*** In two instances disturbance was negligible and in only one instance disturbance resulted in exposure of mineral soil.

**** Includes karst spring, swallet and exsurgence.

Conclusion

The Board investigators did not determine that karst resource features (karst caves, significant surface karst features and important features/elements within very high or high vulnerability karst as defined by GAR Order) were damaged or rendered ineffective by primary forestry activities in the operating areas examined by the Board.

However, under current legislation, management of karst features rests with the licensees and they have flexibility on how to manage for karst resource features, so as to meet their legislative obligations. There are two main reference documents guiding the identification and management of karst features in BC, but there is no statutory obligation to follow them. Regardless, the licensees affirm their use of the two documents when preparing assessments.

The Board notes that there are no qualification standards for individuals completing karst assessments. Investigators found that those completing assessments had varying levels of karst-specific experience and education and, while most assessments were done by forest professionals, professional engineers or geoscientists, non-professionals also completed some of them. Consequently, KFAs were not consistent with respect to mapping, terminology and detail, indicating a significant difference in how the inventory standards and guidelines are being interpreted.

The identification of karst features within and adjacent to cutblocks was reasonable, with road locations and cutblock boundaries sometimes modified to mitigate impacts of forestry activities on karst features. Assessments included management strategies for karst resource features and non-GAR karst features and licensees made an effort to manage both, even though they are only required to not damage or render ineffective karst resource features. However, managing non-GAR karst features is good practice and should continue, since the precise connections between surface and subsurface karst features are often unknown, and not managing all karst features may result in unintended consequences.

Management strategies were identified for individual karst features. However, the strategies did not always follow BMPs which were developed as a cautious approach for managing karst systems and individual karst features. Regardless, the investigation did not find that karst features were damaged or rendered ineffective.

Finally, opportunities for improvement in the planning and management of karst features which should be considered by government, licensees, and professionals, including the ABCFP, were identified by the Board. These improvements include:

- Ongoing communication with karst recreational users.
- A centralized inventory of Karst Resource Features identified through karst field assessments and those of provincial or global significance would help government and the industrial resource sectors ensure the features are appropriately managed or protected.

- Updating of the management handbook and inventory standards (Version 2). They were released in 2003 and since then forest management has evolved and the standards and guidelines may no longer reflect current knowledge.
- Introduction of professional karst management guidelines by the ABCFP, including training, skills and qualifications required to conduct KFAs where the management of karst features falls within the scope of practice of the professional forestry. The ABCFP should also assess the benefits of producing technical papers, such as one on sinkhole management. Guideline development should involve the APEGBC and non-professional karst experts since karst science is interdisciplinary in nature with a strong geoscience basis.

Research needs to be carried out to provide quantitative and qualitative definitions of what damage or renders ineffective means to karst terrain or resources.

Addendum

Subsequent to the field work component of this investigation, a concern was forwarded to the Board noting that Western Forest Products Inc. (WFP) harvested next to a significant karst feature that is subject to the GAR Order. This feature, known as the Devil's Bath, is located about 23 kilometres southwest of Port McNeill. This harvesting was not in the scope of this special investigation or the sample of sites examined, so is not included in the reported results.

Although WFP demonstrated diligence in assessing and managing karst features throughout this investigation, this incident highlights the need for forest professionals to be vigilant when managing around karst topography.

The Devil's Bath is a steep-walled sinkhole containing a one hectare lake with naturally occurring coarse woody debris. It is connected via multiple caves and conduits extending for nearly a kilometre to Benson River, and much of this network provides habitat for salmon. Devil's Bath is one of the largest features of this type in North America and it has a large viewing platform and interpretive sign kiosk overlooking the Devil's Bath.



Platform overlooking Devil's Bath.

In September 2012, WFP logged an area immediately adjacent to Devil's Bath. WFP planning documents identify Devil's Bath as a large karst feature but staff did not recognize its significance or undertake a karst field assessment. The Karst management handbook provides best management practices (BMP) that recommend a feature like Devil's Bath have a one to two tree-length reserve. A BMP indicates, "the reserve size/shape may need to be adjusted to manage for visual quality when the feature has a high recreational value." However, the adjacent mainline forest road was built in the 1960s prior to the recognition of karst values in forest management and prior to any karst guidelines being in place. As the

road is within one tree-length of the edge of the feature at its closest point, maintaining a one to two tree length reserve is not practicable in some spots. WFP advised the Board that two danger trees¹⁷ were felled beside Devil's Bath that resulted in two logs sliding into the lake. In addition, part of the new harvest area is visible from the viewing platform.

Compliance and enforcement staff from the Ministry of Forests, Lands and Natural Resource Operations visited the site in September 2012 and determined that, although two logs were inadvertently introduced into the feature, there was no apparent damage and it did not render the feature ineffective.

¹⁷ A tree that is hazardous because of location or lean, physical damage, overhead hazards, deterioration of the limbs, stem or root system, or any combination.

While no apparent harm has been done to the feature and karst processes have not been compromised, the visual quality around Devil's Bath has arguably been affected, at least temporarily. Maintaining aesthetic and visual quality is an objective for features of this significance.

WFP acknowledges that a more thorough assessment of the site's karst features should have taken place prior to the harvesting. WFP did act promptly to review and amend its operational and planning processes when this issue was brought to its attention. WFP's actions included a review by a professional geoscientist/karst expert, and development of new procedures that included consideration of the recreational value and uniqueness associated with a karst feature of this significance.

This incident reaffirms that forest professionals need to ensure they have the knowledge to identify, assess and provide appropriate management strategies consistent with the significance of karst features, and that they involve additional expertise where necessary. It also highlights a potential opportunity for government to evaluate karst features with high regional and provincial significance and ensure adequate protection is provided for these features.

Appendix I: Field Review of Management Practices

Karst Features Subject to the GAR Order

The investigation considered the management of five caves and five significant surface karst features in relation to the order. A sixth cave, not identified as a cave in an assessment, was reviewed in the field during the investigation because it is subject to the GAR Order.

Caves

Management handbook BMP

Maintain a variable timber reserve above a significant cave that is dependent on the depth of the cave and the dimensions of the cave. Surround the timber reserve with an adjacent management zone of an appropriate size to protect the reserve from windthrow.

Field observations

A total of five caves were identified in the assessments and reviewed in the field. Three caves were managed according to the BMPs and two were not.

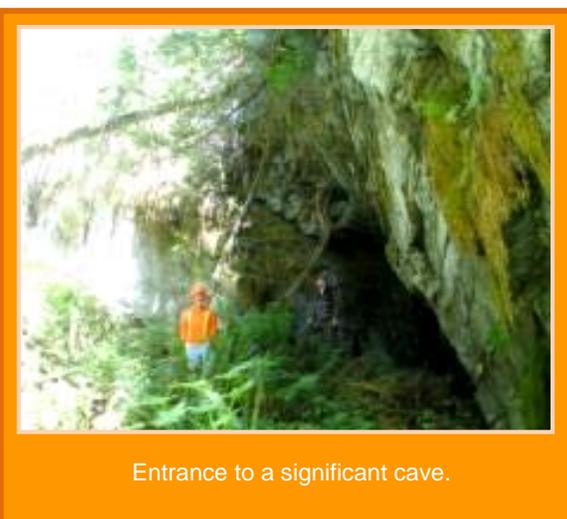
- Four caves originated outside the cutblock boundary:
 - three were managed according to the BMPs, and
 - one ran under the cutblock and was not managed according to the BMPs.
- One cave originated inside the cutblock and was not managed according to the BMPs.

The sixth cave identified by the investigators was inside a cutblock and a road was immediately next to and possibly over a cave passage with a very thin ceiling (less than two metres). This cave was not managed according to the BMPs.

Significant Cave Entrance

Management handbook BMP

Maintain a two tree-length reserve and an adjacent management zone of an appropriate size to protect the reserve from windthrow.



Field observations

An assessment identified one cave entrance as significant. The reserve around this cave entrance was less than two tree-lengths and no adjacent management zone was apparent. No windthrow was evident and the primary forestry activities did not impact the cave entrance.

Management did not follow the BMPs.

Sinkhole

Management handbook BMP

Maintain a one tree-length reserve, or a two tree-length reserve if the sinkhole has a distinct microclimate, and an adjacent management zone of an appropriate size to protect the reserve from windthrow.

Field observations

Two sinkholes were identified as significant in an assessment and one of them was considered to have its own microclimate. This sinkhole was located outside the cutblock below a road. All timber between the sinkhole and the road was maintained, but the edge of the sinkhole was within 15 metres of the road. No adjacent management zone was apparent. Changes to light, shade and relative humidity occurred, which likely altered the microclimate.

The other significant sinkhole was located inside the cutblock adjacent to the road. No reserve was established, ground disturbance was noted along the edge of the sinkhole and minor amounts of ballast and logging debris was introduced. No sediment transfer or diversion of water into the sinkhole was noted.

Neither sinkhole was managed according to the BMPs.



Karst window

Management handbook BMP

Maintain a two tree-length reserve since the feature was deemed to have its own microclimate and an adjacent management zone of an appropriate size to protect the reserve from windthrow.

Field observations

One significant karst window was identified and had its own microclimate. This feature was incorporated into a wildlife tree patch (WTP) with an approximate one tree-length reserve, which is less than the BMP.



Karst Canyon

Management handbook BMP

Maintain a one tree-length reserve and an adjacent management zone of an appropriate size to protect the reserve from windthrow.

Field observation

The one significant karst canyon was identified and abutted a cutblock. A reserve was established against the outer edge of the canyon but a one tree-length reserve was not established along the entire length of the canyon adjacent to the cutblock. Minor amounts of post-harvest edge windthrow were observed. The BMP was not followed.



Karst Features Not Subject to the GAR Order and on Moderate or High Vulnerability Terrain

A total of 118 surface karst features identified in the investigation were not subject to the GAR Order, but were assessed for adherence to the management handbook BMPs. Of these, 30 features were excluded from the harvest area¹⁸ (18 sinkholes, 3 riparian features, 3 cave entrances and 6 other surface karst features). Eighty-eight of these were surface karst features within the harvest area (Table 1).

Licensees are not required to establish reserves on non-GAR features and the management handbook recommends minimizing surface disturbance when primary forest activities are conducted around them.

Roads (including landings and quarries)

Examples of management handbook BMPs

- maintain natural surface drainage patterns
- avoid locating roads, landings and spoil sites near surface karst features
- avoid locating long-term roads and landings on exposed well developed epikarst¹⁹
- use overland road construction techniques
- avoid constructing roads on top of caves

Field observations

In general, road construction avoided karst features and drainage was well controlled. There were instances where roads were relocated to avoid karst features. However, not all karst features could be avoided and there were a few instances where road debris, mostly ballast rock, was introduced into the feature.

¹⁸ Located outside the cutblock boundary or in a wildlife tree patch.

¹⁹ The upper surface of karst, consisting of a network of intersecting fissures and cavities that collect and transport surface water and nutrients underground; epikarst depth can range from a few centimetres to tens of metres.

Harvesting

Examples of management handbook BMPs

- flag or otherwise identify the karst feature in the field
- fall and yard away
- keep the tracks of ground-based equipment at least five metres from the edge of the karst feature
- avoid diverting water into the karst feature
- avoid disturbing side slopes of sinkholes
- avoid introducing logging debris and cleaning out introduced logging debris if doing so will not damage the feature

Management handbook BMP

Flag or otherwise identify the karst feature in the field.

Field observations

It was difficult to determine if all features were marked in the field prior to harvesting. For example, marking was usually evident when high stumps were used to mark the feature during harvest operations, as was done for a significant number of features. This appears an effective form of marking with respect to achieving several BMPs goals such as falling and yarding away trees and minimizing soil disturbance and the introduction of logging debris. In other situations, marking was not evident, and it could not be determined if the feature was not marked, or if harvesting activities had removed the field marking.

Management handbook BMP

Fall and yard away.

Field observations

It was difficult to determine if ‘fall and yard away’ was employed without being on site during falling and yarding activities. There were no instances identified where removal of trees caused physical damage that resulted in diverting water or sedimentation into non-GAR karst features which may affect natural rates of air exchange.

Management handbook BMP

Keep the tracks of ground-based equipment at least five metres from the edge of the karst feature.

Field observations

Wheels of ground-based machinery infringed on the edge of four sinkholes. There was no evidence of sediment transfer or drainage alteration as a result of this infringement. Machine traffic was well-managed around the other features within the harvest area.

Management handbook BMP

Avoid diverting water into the karst feature.

Field observations

There were no harvesting or road constructing activities altering surface drainage patterns into karst features.

Management handbook BMP

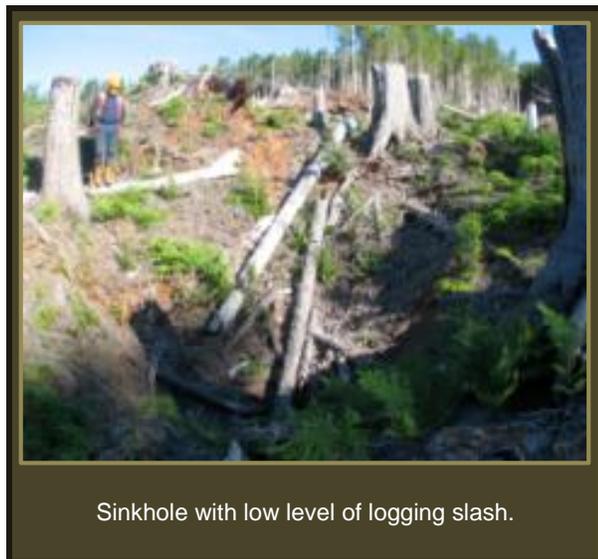
Avoid disturbing side slopes of sinkholes.

Field observations

No machine traffic was noted in any sinkhole. There was minor disturbance on several sinkholes due to the removal of trees disturbing the duff, and in a few instances there was evidence of minimal exposed mineral soil. None of the disturbance has resulted in surface sediment transfer or redirection of water into karst features.

Management handbook BMP

Avoid introducing logging debris and cleaning out introduced logging debris if doing so will not damage the feature.²⁰



Field observations

Logging debris (logs and large branches) levels were field-reviewed, confirmed through photographs and assigned a subjective rating of high or low. Logging debris was introduced into all 63 karst features on moderate or high vulnerability terrain within the harvest area. It is estimated that 21 features (33 percent) had high levels of slash and 42 (77 percent) had low or negligible levels of slash.

The investigation noted that using high stumps around the feature to deflect logs being skidded was very effective in reducing the amount of logging debris introduced to the karst feature and in keeping the tracks of ground based machinery away from the feature. The use of high stumps is suitable for ground-based skidding operations, but is less effective in cable ground where it is more difficult to control the logs.

²⁰ Introduction of organic matter into a karst feature may alter the physical and chemical properties of the soil. This will affect the properties of water percolating through the soil into the epikarst and underground drainage systems. Naturally occurring organic material exists in karst features with ongoing contributions from litter fall, windthrow and natural tree mortality. Debris introduced as a result of harvesting is likely to occur and will happen in a much shorter time than naturally occurring sources, but the total contribution from logging may be more or less than natural sources. How much introduced logging debris is acceptable before it can be classified as damage to the karst feature could not be determined.

Post- Harvest Windthrow

Windthrow is not considered a primary forest activity and does not fall under the GAR Order, although windthrow along the edge of cutblocks is often attributable to the primary forest activity. Natural stands in this ecological and climatic region are exposed to widespread windthrow and fire, and harvest can affect the pattern of local occurrence. Post-harvest windthrow is a prevalent risk on Northern and Western Vancouver Island. Most licensees conduct pre-harvest windthrow assessments in areas where the risk of occurrence has been identified to provide operational recommendations to mitigate that risk.

Nevertheless, no windthrow physically impacted the karst resource features. Where windthrow did occur on non-GAR karst features, there was some compaction on the edge of the feature and some organic material was introduced to the feature. Most of the organic debris was in the form of suspended stems and branches.

There were no instances where windthrow altered natural drainage or exposed mineral soil resulting in sedimentation into the bottom of a significant or non-significant sinkhole

Appendix II: Assessing Damage

The investigation team assessed damage by evaluating the discernible physical and environmental impacts of primary forest activities on karst terrain using the following objectives provided by the management handbook.

- **Maintain the capability of karst landscapes to regenerate healthy and productive forests after harvesting.**

This objective is being met through licensee's obligations to meet legislative soil disturbance and reforestation objectives.

- **Maintain the high level of biodiversity associated with karst ecosystems including surface and subsurface habitats.**

Above ground biodiversity is being met through licensee's stand level objectives for wildlife trees and coarse woody debris, landscape level objectives for old growth and seral targets, and established reserves around most significant karst features. The investigation team did not assess how primary forest activities affected below-ground biodiversity.

- **Maintain the natural flows and water quality of karst hydrological systems.**

Natural surface drainage patterns of karst or non-karst hydrological systems were not altered. The complete or substantial removal of forest cover through harvesting or natural events, such as windthrow or wildfire, alters the amount of precipitation introduced to the karst system through changes to canopy interception and evapotranspiration. The investigation team could not determine how forest cover removal affected subsurface flow rates, karst solution processes or subsurface biodiversity, or how forest cover removal from harvesting differed from natural events such as windthrow, fires or natural mortality.

- **Maintain the natural rates of air exchange between the surface and subsurface.**

Harvesting and road construction caused some disturbance to sinkhole side slopes. There was no evidence that the disturbance altered air exchange rates.

- **Manage and protect significant surface karst features, and subsurface karst resources.**

Licensees identified and prescribed management strategies for all significant surface karst features. However, none of the significant surface karst features were managed according to the management handbook BMPs and the level of protection varied.

- **Provide recreational opportunities where appropriate.**

Most recreational opportunities are associated with karst caves. The investigation team did not find any instance where forestry activities had impacted access to caves, or their recreational opportunity.

- **Protect significant karst features from physical damage.**

There was minor impact on one significant sinkhole and no reserve was established but this did not result in any sediment transfer or diversion of water into the sinkhole.

- **Maintain any site-specific microclimate conditions and habitat/biodiversity characteristics associated with significant karst features.**

Two surface Karst Resource Features had their own microclimate—a sinkhole and a karst window. The reserves established around these features did not meet size recommended in the management handbook BMPs. The microsite was altered in the sinkhole but not the karst window.

- **Prevent soil erosion and sediment transfer from significant sinkholes into subsurface openings or caves.**

The investigation team did not find any sediment transfer or soil erosion into subsurface caves or openings of the two significant sinkholes.

- **Provide a measure of aesthetic experience for significant surface karst features with high recreational values.**

The investigation team did not identify any significant surface karst feature as having a high recreational value.