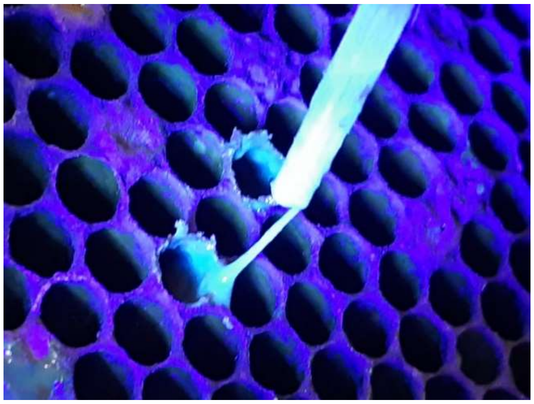


[1]

Final Report

Cost Benefit Analysis of the National American Foulbrood Pest Management Plan

3 August 2022

NIMMO-BELL & ASSOCIATES
A Division of the Prime Group

[1] Photos from www.afb.org.nz

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Glossary of Terms and Abbreviations

Benefit-Cost Ratio (BCR). The ratio of present value (PV) of benefits to PV of costs. This shows benefits generated for each dollar of cost.

Cost benefit analysis (CBA). CBA is an economic analysis tool that informs the efficient allocation of scarce resources across different sectors of the economy to maximise net benefit (i.e., benefits less costs) or utility in decision-making.

Incidence rate. The annual infection rate of AFB. It is expressed as AFB-infected hives over total hives per year. **Recorded incidence rate** is AFB-infected hives notified to the Management Agency. **Actual incidence rate** is assumed to be a higher rate as the recorded incidence rate is considered to be under-reported.

Net Present Value (NPV). Discounting the annual net benefits (i.e., benefits less costs) across the timeframe results in the net present value. NPV measures the true contribution of the policy option to economic welfare. A positive NPV is economically feasible.

1 Executive Summary

The Management Agency for the National American Foulbrood Pest Management Plan engaged Nimmo-Bell to undertake a cost benefit analysis (CBA) of the National American Foulbrood Pest Management Plan (AFB NPMP).

The economic cost of AFB comprises of hive losses and control costs. The 2022/23 annual economic cost of AFB is estimated at $23.2 million ($3.6m hive losses and $19.6m control costs). Of the $19.6m control costs, total levy cost is only $1.7 million, or 8% of total control costs, while 92% is beekeeper costs for detecting and controlling AFB. With no NPMP, the annual economic cost of AFB is estimated to rise to $29.5 million by 2032/33 ($9.4m hive losses and $20.1m in control costs).

With no NPMP, 99,909 hives are forecasted to become infected with AFB over a ten-year period, starting at 5,810 hives in 2023/24 and rising to 13,462 hives in 2032/33. Consequently, hive losses to the beekeeping industry are estimated at $70 million over a ten-year period. This is $4.1 million in annual hive losses in 2023/24 and rising to $9.4 million in 2032/33.

Due to the serious nature of the disease, AFB has been under legislative control since 1906. The most recent change in the legislation occurred in 2012, when the *Biosecurity (National American Foulbrood Pest Management Plan) Order 1998* was amended. This is scheduled to expire on 1 April 2023.

The Management Agency is developing a proposal to the Minister for Biosecurity to amend and extend the Biosecurity (National American Foulbrood Pest Management Plan) Order[2] 1998, in accordance with section 100D of the Biosecurity Act 1993. That process requires an independent CBA to be conducted. This CBA adheres to the requirements of the Biosecurity Act 1993 and National Policy Direction (NPD) for Pest Management 2015.

The goal of the NPMP is to eliminate clinical AFB from managed beehives in New Zealand. The options evaluated in the CBA were a continuation of the current NPMP (Scenario 1), and an amended version of that NPMP with some changes made to assist in improving compliance and effectiveness (Scenario 2). These options were compared against a baseline (Scenario 0) where there is no NPMP in place, and AFB has no centralised form of control.

A Reference Panel of beekeepers and other industry experts was formed to help provide input into the assumptions for the analysis, which were otherwise informed by analysis of existing industry and Management Agency data.

The CBA analysed costs and benefits across a 10-year period.

The benefits calculated are based on avoided costs of AFB. Costs are the beekeeper and industry costs of operating the NPMP activities.

Results are expressed as Net Present Values (NPVs) and Benefit-Cost ratios (BCRs). NPV measures the total net benefit of each option aggregated over the 10-year period, in today's dollars (after adjusting for the time value of money). The BCR compares the benefits against the costs in present value terms to provide a simple measure of return on investment.

The results in NPV terms are shown in the table and figure below.

Both Scenarios 1 and 2 have a positive NPV, around $22 million, with Scenario 2 having a higher NPV by $384,000. The BCR of both options is close to 5.0. Scenario 1 has a slightly higher BCR than Scenario 2. That reflects slightly lower cost-efficiency of the proposed new NPMP compared with the current one, albeit the overall net return on investment is higher.

Scenario 2, the proposed new NPMP results in a 60,140 reduction in the number of hives infected with AFB over a ten-year period when compared to Scenario 0 (no NPMP).

[2] The Biosecurity (National American Foulbrood Pest Management Plan) Order 1998 is scheduled to expire on 1 April 2023

Table: NPV and BCR results

	Scenario 1	Scenario 2
NPV Industry ($'000)	22,269	22,653
Benefit-Cost ratio	5.0	4.8

The flow of costs and benefits over time shows that costs of the proposed new NPMP will outweigh benefits in the first three years, after which benefits outweigh costs and increase steadily until around year eight, when the rate of increase tapers off.

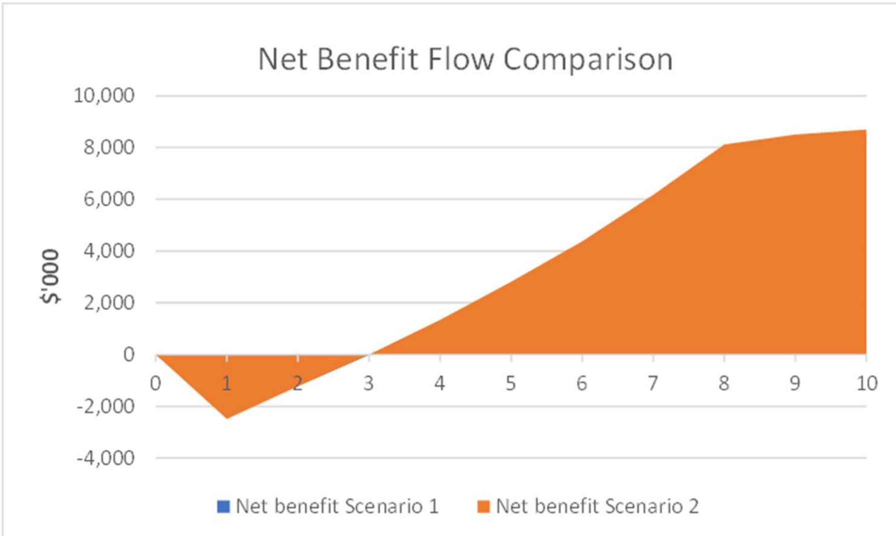

Figure: Annual net benefit flow for Scenarios 1 and 2

Note: Scenario 1 (blue) is not seen in this scale as closely tracking Scenario 2.

Sensitivity analysis shows that the NPV is robust for lower income loss per hive, annual reduction in AFB incidence industry size or higher discount rate. Even if annual reduction in AFB incidence is close to zero, NPV is still positive at about $16 million.

Applying risk analysis to account for uncertainties among sensitive variables, the expected NPV is positive but declines to about $19.3 million due to conservative bias for the annual reduction in incidence rate. The confidence intervals show zero chance of a negative NPV.

Apart from the quantified positive NPV, Scenarios 1 and 2 deliver significant benefits in preserving access to premium export markets in the EU and China, as well as UK market access. Loss of these markets would very likely have a significant negative economic impact on the industry and its contribution to the overall New Zealand economy. Scenario 2, the proposed new NPMP, provides additional risk mitigation for the main risk of programme compliance. In addition, Scenario 2 shows a higher overall net benefit than Scenario 1, albeit the differences are small.

Though Scenario 2 has a slightly lower cost efficiency than Scenario 1, the benefits of risk mitigation cannot all be quantified and may exceed the estimates used in the CBA. The overall analysis therefore supports the choice of Scenario 2, the adoption of the proposed new NPMP, as the preferred option.

The costs of the proposed AFB NPMP are proposed to lie solely with the beekeeping industry as beneficiaries of the plan. No exacerbators have been identified.

2 Introduction

2.1 Statutory requirements

The Management Agency for the National American Foulbrood Pest Management Plan (Management Agency) engaged Nimmo-Bell to undertake a cost benefit analysis (CBA) of the National American Foulbrood Pest Management Plan (AFB NPMP). This independent CBA is needed in order to develop a proposal to the Minister for Biosecurity to amend and extend the Biosecurity (National American Foulbrood Pest Management Plan) Order[3] 1998, in accordance with section 100D of the Biosecurity Act 1993. The CBA of the AFB NPMP adheres to the requirements of the Biosecurity Act 1993 and National Policy Direction for Pest Management 2015.

The statutory requirements for the CBA are:

- *The Biosecurity Act 1993*
    - Section 61 of the biosecurity Act 1993 specifies the matters that must be set out in the proposal, including:
        - the extent to which any persons, or persons of a class or description, are likely to benefit from the plan, s61(2)(c)(viii);
        - the extent to which any persons, or persons of a class or description, contribute to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan, s61(2)(c)(ix);
        - the rationale for the proposed allocation of costs, s61(2)(c)(x); and
        - the marketing overseas of New Zealand products, s61(2)(e)(ii).
    - Section 62 of the Biosecurity Act 1993 describes how the Minister for Biosecurity will determine whether the proposal has satisfied the requirements specified in section 61, including satisfaction that:
        - AFB causes an adverse effect on New Zealand's economic wellbeing, s62(c);
        - The benefits of the plan outweigh the costs, s62(e);
        - Persons who as a group are required to meet any or all the costs of implementing the plan, and
            - would accrue, as a group, benefits outweighing the costs, s62(f)(i), or
            - contribute, as a group, to the creation, continuance, or exacerbation of problems proposed to be resolved by the plan, s62(f)(ii).
- *The National Policy Direction (NPD) for Pest Management 2015* - to ensure that activities under Part 5 of the Act (pest management) provide the best use of available resources for New Zealand's best interests, viz:
    - Clause 6 – directions on analysing benefits and costs; and
    - Clause 7 - directions on proposed allocation of costs for pest and pathway management plans.

The CBA adopted the guidance provided by the *"Meeting the requirements of the National Policy Direction for Pest Management 2015: Guidance Document"* (MPI, 2015). The guidance for proposers of pest management plans involves:

[3] The Biosecurity (National American Foulbrood Pest Management Plan) Order 1998 is scheduled to expire on 1 April 2023

- Chapter 2: undertaking an analysis of costs and benefits (NPD Clause 6); and
- Chapter 3: undertaking a cost allocation analysis (NPD Clause 7).

For the CBA methodology, the *New Zealand Treasury Guide to Social Cost Benefit Analysis (July 2015)* has been referenced and the CBA framework from the *Ministry for Primary Industries (MPI) Mycoplasma bovis Science Programme Research Project 21577 (Measuring Economic Impacts of Biological Incursions)* has been adopted.

2.2 AFB problem, effects, and baseline

The goal of the NPMP is to eliminate clinical AFB from managed beehives in New Zealand. The goal is not to eradicate AFB (the organism) from New Zealand since the organism is everywhere, including in the soil, which means eradicating the organism is not feasible. However, eliminating the infection from managed beehives (clinical AFB) is possible given that:

- The minimum infective dose for a beehive is 5 million spores; and
- Clinical disease is prevented by avoiding the introduction of large numbers of spores into beehives.

Clinical AFB results in loss of hive income for a year. Although a hive may be identified and replaced within a year, there is likely to have been a reduction in production for a period prior to discovery. Similarly, there is likely to be a period after discovery prior to full production being achieved with a replacement hive.

Clinical AFB is infectious. Destruction of the hive is the main method of control, as use of antibiotics is prohibited by law and has been generally found in other countries not to be very effective. When control measures fail and disease levels get out of control, AFB threatens the viability of a commercial beekeeping business. Large doses of AFB are typically transferred from one beehive to another by failing to identify the presence of clinical AFB, then by transferring items from infected beehives to other beehives. The major sources of AFB spread risk include (AFB Management Agency, 2021):

- Transfer of honey supers and frames;
- Transferring brood frames;
- Making splits, tops or nucs;
- Feeding honey or pollen; and
- Robbing out of honey from severely infected beehives.

Figure 1 shows how AFB spreads.

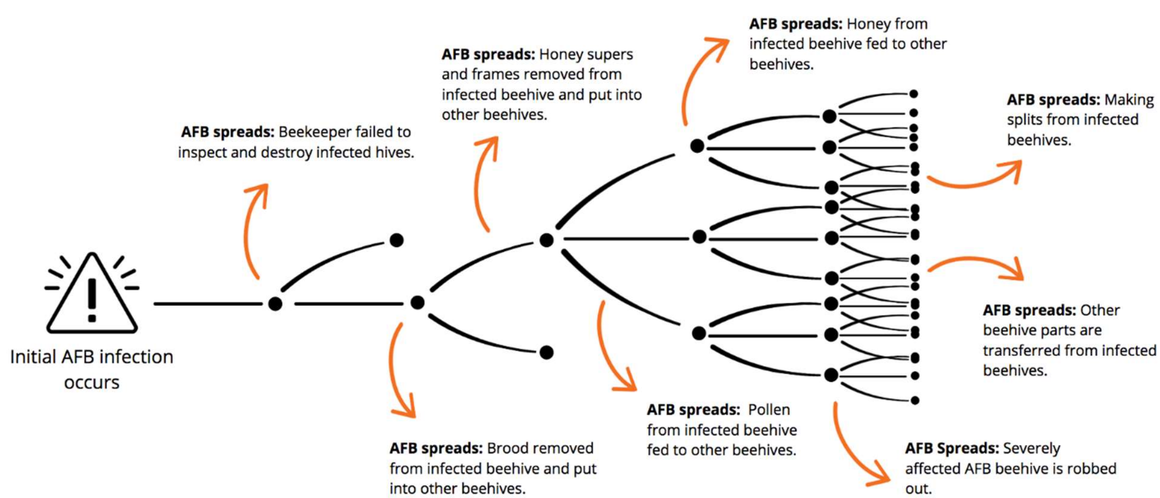

Figure 1: Major sources of AFB spread risk

Source: AFB Management Agency, 2021

The economic cost of AFB comprises of hive losses and control costs. The 2022/23 annual economic cost of AFB is estimated at $23.2 million ($3.6m hive losses and $19.6m control costs). Of the $19.6m control costs, total levy cost is only $1.7 million, or 8% of total control costs, while 92% is beekeeper costs for detecting and controlling AFB. With no NPMP, the annual economic cost of AFB is estimated to rise to $29.5 million by 2032/33 ($9.4m hive losses and $20.1m in control costs).

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Due to the serious nature of the disease, AFB has been under legislative control since 1906. The most recent change in the legislation occurred in 2012, when the *Biosecurity (National American Foulbrood Pest Management Plan) Order 1998* was amended. This is scheduled to expire on 1 April 2023.

2.3 Level of analysis

Determining the most suitable level of analysis, and the associated type of analytical technique used, depends on four criteria prescribed by the NPD. Criteria 1-3 relate to the level of analysis that should be performed in response to a particular situation, while Criterion 4 focuses on the level of analysis that is possible, along with the interactions and weighting between them. Each criterion has been rated using guidance from the NPD Guidance Document (MPI, 2015) during the initial workshop with the Reference Panel (RP) (see Table 1).

Table 1: Determining level of analysis for the NPMP

Rating	Guidance
Assessment Criterion 1: The likely significance of the pest or the proposed measures	
High • High total costs - likely to be millions of dollars over 10 years in levy and compliance costs. • Potential for significant interest, or strong opposing viewpoints in community.	High – Potential for significant interest, or strong opposing viewpoints in community or high total costs
	Medium – Potential for moderate interest, opposing viewpoints in some groups within community, or moderate total costs.
	Low – Not generally likely to be an issue for community public or organisations, or low total costs.
Assessment Criterion 2: Likely costs relative to likely benefits	
Medium • Costs for the programme are likely to be lower than the benefits of the programme as shown in previous NPMP CBA in 2002 ((Nimmo-Bell, 2002)) and 1995 ((Meister & Wilson-Salt, 1995)).	High – Costs for the programme are likely to be similar to the benefits of the programme.
	Medium – Costs for the programme are likely to be lower than the benefits of the programme in most scenarios.
	Low – Costs for the programme are likely to be substantially lower than the benefits of the programme, even if the objectives are not fully achieved.
Assessment Criterion 3: Uncertainty of the impacts of the pest and effectiveness of measures	
Medium	High uncertainty – Not much known about the pest's impacts. Effectiveness of the measures is highly uncertain.

• Known to have impacts elsewhere in similar situations as NPMP has been implemented since 1998.	Medium uncertainty – Known to have impacts elsewhere in similar situations. Similar measures have been effective in other areas, or measures have only been somewhat effective.
	Low uncertainty – Known to have significant impacts,
Assessment Criterion 4: Level and quality of data available	
Medium • Some historical information or data from AFB MA, MPI Apiculture Monitoring Programme, and other sources. • No specific targeted monitoring data as prioritising high-risk cohort and reliant on beekeeper reporting.	High – Very high-quality current distribution data; costs and impacts well established.
	Medium – Some historical information or data from other sources (outside of the region or NZ). No specific targeted monitoring data. Costs and impacts capable of being estimated from case studies.
	Low – Little information available.

To decide on the appropriate level of analysis, the NPD Guidance Document (MPI, 2015) provides a flowchart to balance the four criteria as shown in Figure 2.

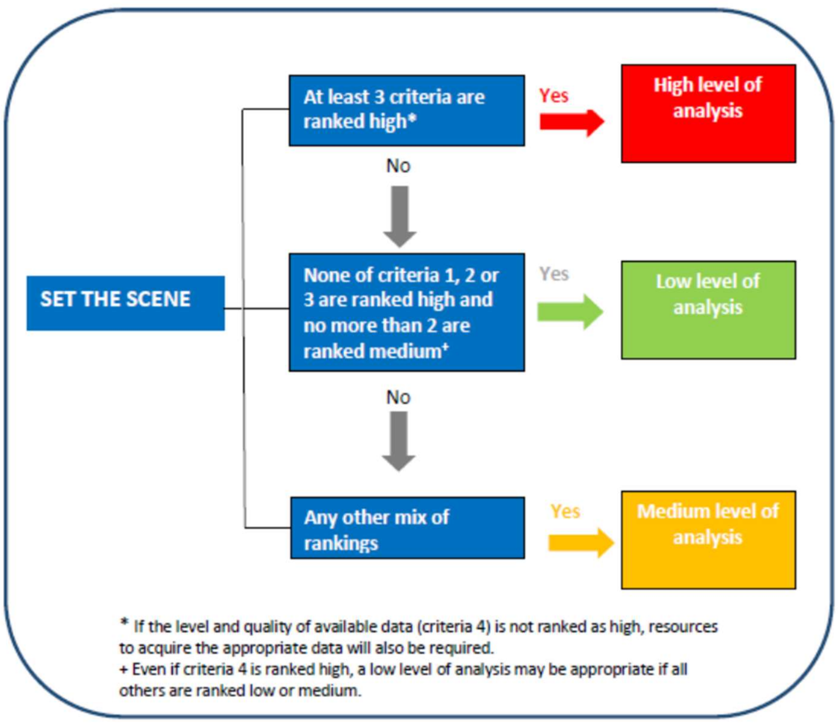


Figure 2: Decision flowchart to determine level of analysis

Source: NPD Guidance Document (2015)

Using the decision flowchart, the level of analysis was determined as medium (see Table 2). The NPD guidance (MPI, 2015) for medium level of analysis are:

- Describe the costs (including effects on values) of each option and quantify/value as many as practicable;
- Describe the benefits of each option and quantify/value as many as practicable;
- Apply cost/benefit analysis techniques for each option;
- Take into account the risks to being successful - as required by clause 6(2)(g) of the NPD; and

- Conclude by choosing the most appropriate option.

Table 2: Decision flowchart results

Question	Answer	Decision
At least 3 criteria are ranked high	No	High level of analysis
None of criteria 1, 2 or 3 are ranked high and no more than 2 are ranked medium	No[4]	Low level of analysis
Any other mix of rankings	**Yes**	**Medium level of analysis**

Due to Criterion One being ranked 'high,' the CBA approach for AFB NPMP undertook a high-level analysis, beyond the medium level of analysis required by the NPD, with the adoption of these additional requirements:

- Apply comprehensive cost/benefit analysis techniques for each option; and
- Apply sensitivity analysis for highly uncertain values to test assumptions.

3 Methodology

3.1 Overview

The CBA is comprised of costs and benefits across the time horizon (see section 3.3) resulting in annual net benefits (see Figure 3). These annual net benefits are discounted to the present day to generate the net present value (NPV). A sensitivity analysis was conducted on uncertain variables to identify the most sensitive variables. The most likely, high, and low values were identified for the sensitive variables and applied in a risk analysis using Monte Carlo simulation with 5,000 iterations resulting in an expected NPV and a range with 90% confidence interval[5].

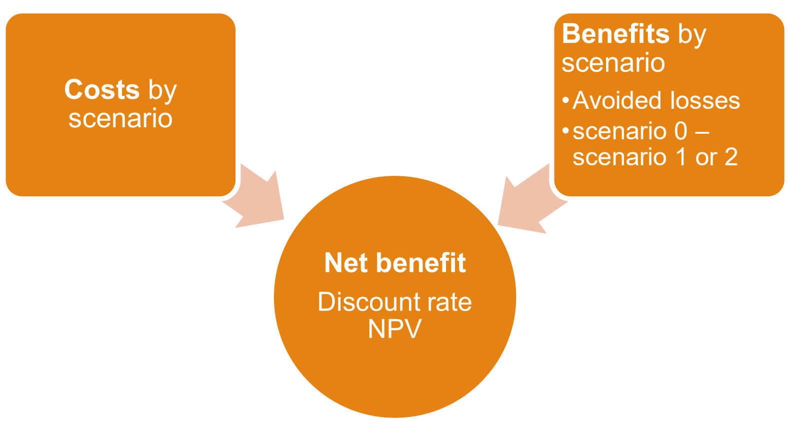


Figure 3: CBA overview

[4] Due to Criterion One being ranked 'high.'

[5] Palisade @Risk software was used for the risk analysis. For each iteration, random values are drawn from each sensitive variable distribution. The sensitive variables are defined by either a triangular or discrete distribution. The sensitive variables are independent by default but where there is correlation, a correlation matrix was developed.

The three scenarios (see section 3.2) for the CBA are Scenarios 0 (no control/NPMP), Scenario 1 (current NPMP), and Scenario 2 (proposed NPMP). Generating costs and benefits used an incremental approach, with Scenario 0 as the base and taking the difference from either Scenario 1 or 2. The benefits are the avoided AFB losses, with Scenario 0 having highest losses as the lack of an NPMP results in a growing AFB incidence rate. Benefits were calculated as:

- Scenario 0 minus Scenario 1 losses (including non-market values if any); and
- Scenario 0 minus Scenario 2 losses (including non-market values if any).

The costs by scenario (Scenario 1 or 2 less Scenario 0) involve (see sections 3.5 and 3.6):

- Beekeeper costs – from surveillance and control activities; and
- NPMP cost - levy

The net benefit is the total benefit (avoided losses) less costs per year under Scenarios 1 and 2.

To build the benefits and costs, epidemiologic data (EpiData) and surveillance/control activities data are needed over the time horizon.

- Benefits (avoided losses) – depends on AFB incidence rate and annual growth or reduction (see section 3.4) and income loss per hive (see section 3.7).
- Costs – depends on number of surveillance and control activities (see section 3.5) and unit costs (see section 3.6).

Data sources to underpin the assumptions for benefits and costs include:

- Statistics – AFB Management Agency, MPI 2021 Apiculture Monitoring Programme, Statistics NZ;
- Literature – NZ and international literature on AFB;
- Interviews – e.g., accredited DECA beekeepers, NZ researchers;
- Reference Panel – comprised of honeybee AFB and science experts, beekeepers, and industry value chain representatives (see Appendix 1 for composition).

Two workshops were held with the Reference Panel as part of an industry consultation and peer review process. The first workshop involved an overview of the NPMP CBA and generating data for cost and benefit drivers. The second workshop involved initial CBA results presentation and critical review of key assumptions and sensitive variables. The outputs from the two workshops were utilised to strengthen the CBA cost and benefit assumptions, including scope of uncertainties in the assumptions.

3.2 Scenarios

As described earlier, the CBA considered three scenarios. Scenario 0 is uncontrolled, where there is no NPMP. Scenario 1 is the current NPMP while Scenario 2 is the proposed NPMP (see Table 4 for current and proposed NPMP). The three scenarios are outlined in Table 3.

Table 3: AFB CBA scenarios

Descriptor	**Description**	**National American Foulbrood Policy**
Scenario 0	Uncontrolled outbreak	No regulatory controls for AFB
Scenario 1	Control policy 1	Current National AFB Pest Management Plan
Scenario 2	Control policy 2	Proposed National AFB Pest Management Plan

The main methods for AFB elimination are:

- Ensuring that all beehives are inspected two times per year; and
- Ensuring that all beehives, honeybee products and appliances associated with cases of AFB are destroyed by burning.

To enable AFB elimination, the NPMP imposes obligations applicable to all beekeepers:

- Registration and identification of apiaries;
- Beehive inspections for AFB and notification of AFB cases;
- Destruction of AFB cases; and
- Rules to prevent the spread of AFB.

A key measure to drive the elimination of AFB are the Disease Elimination Conformity Agreements (DECA), a legal commitment to eliminate AFB from beehives using agreed AFB elimination practices and procedures.

The scenarios are outlined according to surveillance and control obligations in Table 4.

Table 4: Surveillance and control obligations (Scenarios 0 to 2)

<table>
<tr><th></th><th>Scenario 0</th><th>Scenario 1</th><th>Scenario 2</th></tr>
<tr><td colspan="4">Surveillance</td></tr>
<tr><td>Beehive inspection for AFB</td><td rowspan="6">No requirement</td><td colspan="2">Non-DECA holders[6] - inspect at least 1x per year
DECA holders - inspect at least 2x per year</td></tr>
<tr><td rowspan="2">DECA holders know how to recognise and eliminate AFB</td><td colspan="2">Pass a course in AFB recognition prior to signing a DECA</td></tr>
<tr><td>None</td><td>Refresher every 5 years to retain a DECA</td></tr>
<tr><td>DECA holder employees know how to recognise and eliminate AFB</td><td>None</td><td>Employees to pass a course in AFB recognition and a refresher every 5 years</td></tr>
<tr><td rowspan="2">Monitoring and auditing beekeepers</td><td colspan="2">Apiary inspections and honey surveillance</td></tr>
<tr><td>None</td><td>Power to use detector dogs
Diagnostic laboratories to provide all AFB test results to the AFB MA</td></tr>
<tr><td colspan="4">Control</td></tr>
<tr><td>Destruction of beehives and products</td><td rowspan="2">No requirement</td><td colspan="2">Beehives, bee products, materials and appliances associated with a case of AFB are destroyed</td></tr>
<tr><td>Prevent spread of AFB</td><td colspan="2">Do not engage in activities that may spread AFB (see Figure 1)</td></tr>
</table>

[6] Also known as Certificate of Inspection (COI)

<table>
<tr><th></th><th>Scenario 0</th><th>Scenario 1</th><th>Scenario 2</th></tr>
<tr><td rowspan="2">Non-compliance powers</td><td rowspan="4"></td><td colspan="2">• Destruction of beehives posing risk
• Destruction of abandoned hives with AFB
• Power to give direction
• Power to act on default
• Declaration of restricted place</td></tr>
<tr><td>None</td><td>General powers to destroy AFB hives and take other measures to prevent the spread of AFB</td></tr>
<tr><td rowspan="2">Non-compliance deterrence</td><td colspan="2">Maximum penalty for an offence that may be imposed by the court is $5,000 for an individual and $15,000 for a corporation. Prosecution of offenses is financially prohibitive for the AFB MA.</td></tr>
<tr><td>None</td><td>Infringement fine instead of court-imposed fine for breaching four plan rules:
• Obligation to keep honeybees in moveable frame hives
• Prohibition on keeping bees in place other than apiary
• Annual Disease Return
• Certificate of Inspection</td></tr>
</table>

3.3 Time horizon

In accordance with the NPD, the period of analysis, as a general rule, is to encompass the full life cycle of the proposal. The full life of the NPMP is ten years commencing with the expiry of the current NPMP in 2023 until 2032. Years 0 to 10 are set out in Table 5.

Table 5: Time horizon

Year Definitions	Descriptor	Description	FY Name
First day in year prior to new NPMP	Year 0	1 April 2022	
Last day in year prior to new NPMP	Year 0	1 April 2023	
End year before NPNP starts	Year 0	Last year before new NPMP	2022/2023
First year of NPNP	Year 1	First year with new NPMP	2023/2024

0	1	2	3	4	5	6	7	8	9	10
2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33

3.4 Epidemiologic data

3.4.1 Epidemic curve

Incidence rate is the annual infection rate of AFB. It is expressed as AFB-infected hives over total hives yearly. The incidence rate of AFB for the period 1998 to 2021 is shown in Figure 4.

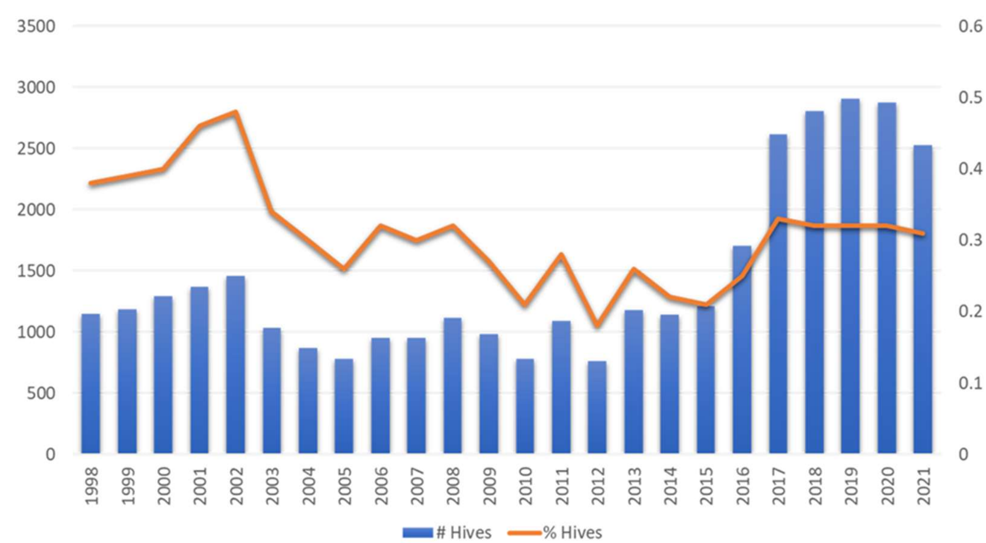


Figure 4: AFB incidence rate (1998-2021)

Source: AFB MA

The incidence rate for 2022 is estimated to be 0.46% based on full year recorded incidence. The spike in varroa incidence in the recent 2021 New Zealand Colony Loss Survey (Stahlmann-Brown et al., 2022) was an early indicator of a likely increase in the AFB incidence rate. This is attributed to the Manuka boom during 2015 to 2017, where hives were split at a fast rate, followed by a market decline in 2019 (after MPI introduced Manuka regulation), which resulted in reduced labour per hive.

The 1998-2021 incidence rate shows an annual reduction of 0.88%, while the target reduction under the NPMP is 5%. For the period 1984-1991 when there was no NPMP, the annual growth in incidence was 12.58%.

The incidence rate is considered to be under-reported. The actual incidence rate is assumed to be higher by 1.52x than the recorded incidence, as shown in the 2016-2019 longitudinal study of apicultural practice and disease prevalence (Hall et al., 2021) where AFB was found in 0.47% of the hives (11 hives out of 2,356) inspected over the three years. This is 52% higher or 1.52x more than the 0.31% recorded incidence average over 2016-2019.

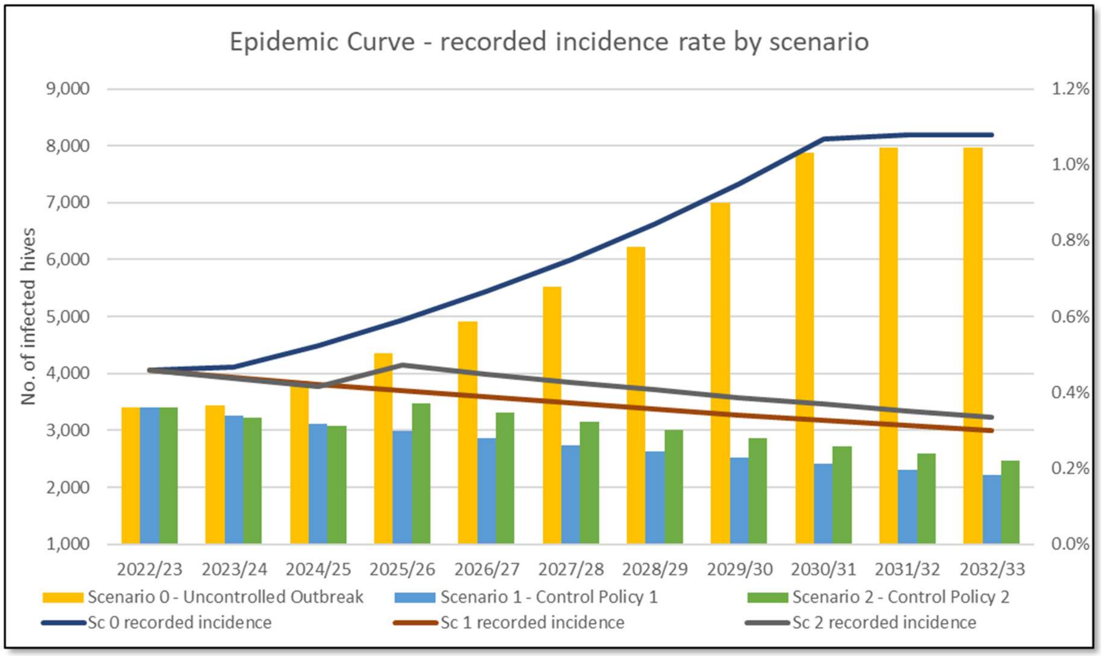
With these data, the assumptions and epidemic curves are illustrated in Table 6 and Figure 5, as follows:

- Scenario 2 assumes 5% annual reduction, the target since the 2012 NPMP amendment, and a 20% improvement over the Scenario 1 reduction rate;
- Scenario 0 has a ceiling of 1.2% recorded incidence, as the beekeeping industry took a more active leadership role in the management of AFB during the 1990s in response to the incidence of AFB reaching 1.2%;
- The number of infected hives is based on industry size (total hives) and COI and DECA sub-groups (refer to next sub-section);
- Scenario 2 shows a higher recorded incidence trend due to assumed improved reporting by year 3 of 20%, but actual incidence is lower as higher industry compliance leads to better AFB control; and
- Scenario 2 results in a 60,140 reduction in the number of hives infected with AFB over a ten-year period when compared to Scenario 0.

Table 6: Epidemiologic variables (Scenarios 0 to 2)

Epidemiologic variables	Scenario 0	Scenario 1	Scenario 2
Recorded incidence	0.46% (2022)		
Actual incidence	1.69x of recorded incidence Assumed incidence recording declines by 10% due to no NPMP	1.52x of recorded incidence	1.22x of recorded incidence Assumed 20% improved recording by year 3 from higher compliance
Annual trend (%)	+12.58	-4.2%	-5%

Recorded AFB incidence:



Assumed actual incidence:

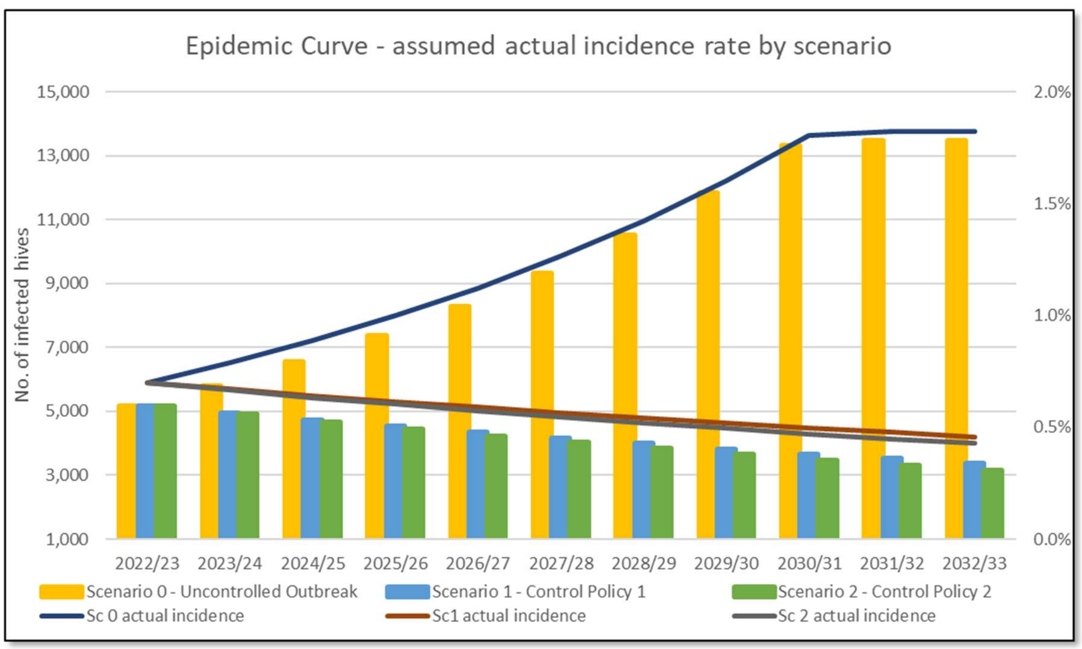


Figure 5: Epidemic curve – recorded and assumed actual incidence rate 2022/23 to 2032/33 (Scenarios 0 to 2)

3.4.2 Compliance groups

The industry has been segmented by compliance behaviour, viz COI (certificate of inspection) and DECA (Disease Elimination Conformity Agreement) holders; with each group having assumptions for various parameters. The two compliance types are illustrated in Table 7 (see also Table 4).

Table 7: Beekeepers by compliance types

Parameters	Certificate of Inspection (COI)	Disease Elimination Conformity Agreement (DECA)
Size	50% of beekeepers and 7% of hives	50% of beekeepers and 93% of hives
AFB inspection	Accredited DECA beekeepers inspect hives annually and issue COI	Inspect hives minimum 2x per year
Recorded incidence	3.7x higher[7] incidence than DECA	

3.4.3 Industry size

Hive numbers peaked in 2019 at about 925,000 (Figure 6) but beekeeper and apiary numbers continued to grow. Hive numbers are estimated at 738,000 in 2022. For the next 10 years, hive numbers were assumed to stabilise at 738,000. A sensitivity analysis was done on the impact of further decreases in hive numbers on the economics of AFB control. The results of this are summarised later in this report.

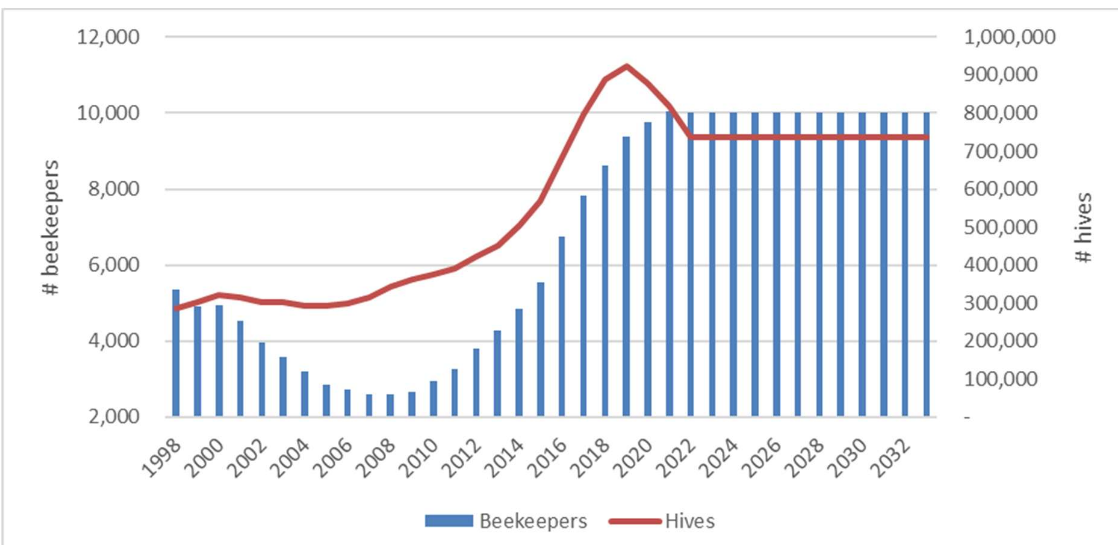


Figure 6: Industry size by number of hives, actual (1998-2021) and forecast (2022-2033)

Source: AFB MA (actual), Reference Panel (forecast)

Table 8 shows the breakdown of hives by COI and DECA compliance types.

[7] Colony Loss Survey 2021 (Stahlmann-Brown et al., 2022) shows less than 250 hives have 3.7x higher incidence.

Table 8: Industry size COI and DECA beekeepers hive numbers (2022-2033)

		0	1	2	3	4	5	6	7	8	9	10
	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33
COI												
Hives	57,212	57,212	57,212	57,212	57,212	57,212	57,212	57,212	57,212	57,212	57,212	57,212
Beekeepers	5,017	5,017	5,017	5,017	5,017	5,017	5,017	5,017	5,017	5,017	5,017	5,017
DECA												
Hives	680,788	680,788	680,788	680,788	680,788	680,788	680,788	680,788	680,788	680,788	680,788	680,788
Beekeepers	4,997	4,997	4,997	4,997	4,997	4,997	4,997	4,997	4,997	4,997	4,997	4,997
Total hives	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**	**738,000**
Total beekeepers	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**	**10,014**

Source: AFB MA (actual), Reference Panel (forecast)

3.5 Control and surveillance activities

Surveillance activities to detect AFB and related variable names include (see Table 4 for description):

- Surv1: Annual Disease Return
- Surv2: COI inspection
- Surv3: DECA inspection
- Surv4: AFB training DECA beekeeper
- Surv5: AFB training DECA employee
- Surv6: AFB training DECA beekeeper refresher
- Surv7: AFB training DECA employee refresher
- Surv8: MA inspection COI defaulters[8]

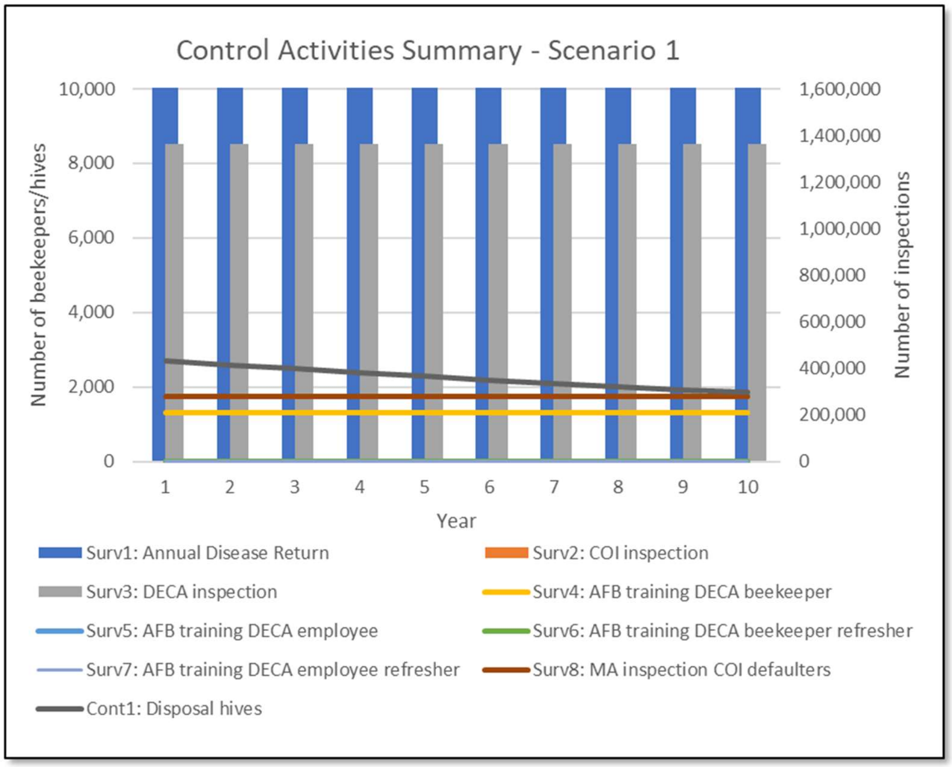
Control activities to manage AFB and related variable names include:

- Cont1: Disposal hives
- Cont2: Replacement hives

The numbers and types of surveillance and control activities undertaken in the 10-year NPMP period for Scenarios 1 and 2 are illustrated in Figure 7. The surveillance activities are quantified as number of beekeepers or hives impacted (left axis) or number of inspections (right axis). Control activities are quantified as number of hives impacted (left axis).

The purpose of these charts is to show graphically at a glance the difference between the two NPMP scenarios in terms of activities undertaken. For example, Scenario 1 has nil Surv5: AFB training DECA employee, Surv6: AFB training DECA beekeeper refresher, and Surv7: AFB training DECA employee refresher hence these three lines are at zero while Scenario 2 shows these lines from zero to 1,362.

[8] Beekeepers who fail to submit COI undergo mandatory inspection by Accredited Person 2 (AP2) dispatched by Management Agency on cost recovery basis.



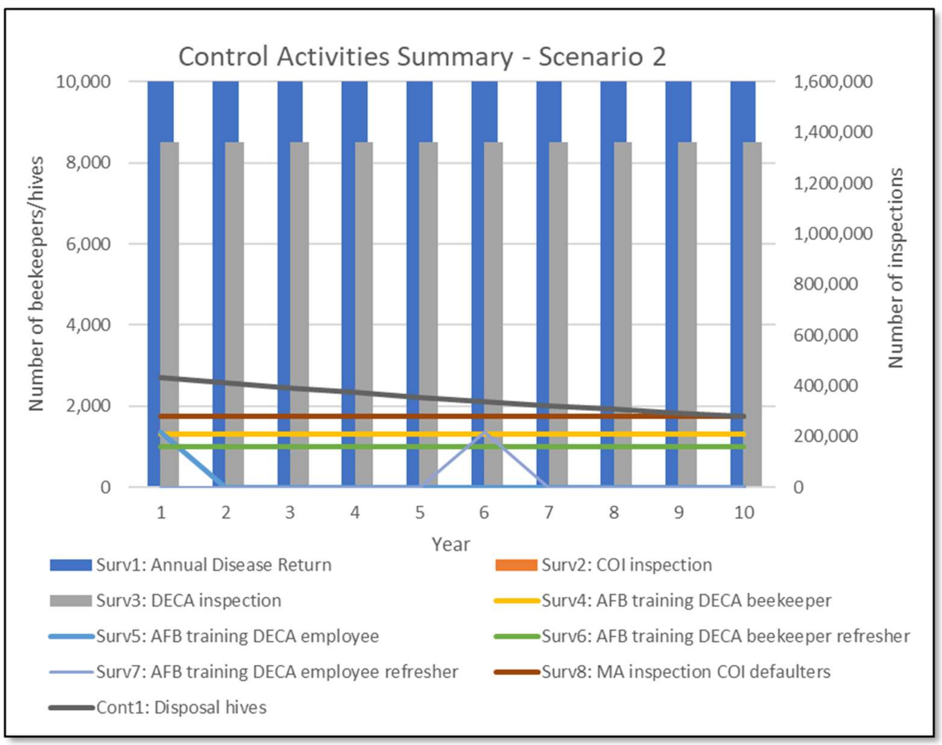


Figure 7: Surveillance and control activities across 10-year NPMP period (Scenario 1 and Scenario 2)

Notes:
(1) The surveillance activities are quantified as number of beekeepers or hives impacted (left axis) or number of inspections (right axis). Control activities are quantified as number of hives impacted (left axis).
(2) Cont2: replacement of hives not shown as assumed to be same number as Cont1: disposal of hives.

The assumptions driving the volume of surveillance and control activities are shown in Appendix 2.

3.6 Costs

The costs of the NPMP are:

- control and surveillance activity costs; and
- national programme costs.

The surveillance and control costs by scenario for COI and DECA beekeepers are illustrated in Table 9.

Table 9: Surveillance and control costs (Scenarios 0 to 2)

	Scenario 0	Scenario 1	Scenario 2
Surveillance			
Surv1: Annual Disease Return	No	**$18** = COI minimum 20 minutes each beekeeper, with assumed nominal rate of $54 per hour[9]. Driver of cost is apiary registration and de-registration. 15% of apiaries register/de-register each year. 1.17 mins per apiary for this 15% of total apiaries.	
Surv2: Certificate of inspection	No	50% of beekeepers and 7% of hives less COI defaulters (see Surv8 below). Done by accredited DECA beekeeper. Based on interview of 2 COI inspectors, **cost is $42 for first 2 hives and $10 per hive** for those with more than 2 hives.	
Surv3: DECA inspection	Same as Sc 1 since commercial are diligent about disease control	50% of beekeepers and 93% of hives. **$20/hive** = 2 hive inspections per year (15% of total hours per year (weekly hrs x 52) x hourly rate / hives per employee.	
Surv4-7: AFB training	No	DECA Beekeeper upon registration = 1,300 registrations based on 2019 beekeeper numbers.	• DECA Beekeeper upon registration • Employees of commercial beekeepers (500 hives/employee) • Beekeepers and employees refresh every 5 years
Surv8: MA inspection COI defaulters	No	• COI defaulters - 35% of COI beekeepers • **Minimum is $73/beekeeper and $19 per hive** for those with more than 2 hives (AFB MA).	
Control			
Cont1: Disposal hives	$350 per hive for labour and material costs to burn and bury infected hive		
Cont2: Replacement hives	$650 per hive (reasonable condition hive, includes 2 brood boxes and 1-4 honey boxes with bees (including valuations as part of business sale) - range $500-$800		

Sources: MPI 2021 Apiculture Monitoring Programme, Management Agency, Reference Panel, interview of accredited DECA beekeepers

The national programme costs are the AFB levy, set at $40/beekeeper and $1.70/hive.

[9] Average manager hourly rate from MPI Apiculture Monitoring Programme.

3.7 Income loss

The loss due to AFB is costed as equivalent to one year's income per hive. Although a hive may be identified and replaced within a year, the reduced production prior to discovery and that after discovery, with a replacement hive taking time to achieve full production, is assumed to be equivalent to one year's production loss. Using the same argument, although a full year's production is lost, there is no corresponding reduction in expenses associated with the infected hive (Nimmo-Bell, 2002).

The Reference Panel estimated income per hive ranging from $170-$1,000, depending on the crop, with $400 as break-even. The income per hive was also estimated using industry statistics and triangulated with information from value chain experts. This resulted in income per hive being calculated at $832, which is at the upper end of the Reference Panel range. The income sources were (see Appendix 3 for income per hive derivation):

- Honey (97%) – manuka and non-manuka;
- Pollination (2.8%); and
- Other bee products (0.3%).

Considering the current level of industry unsold manuka honey inventories and possible reductions in income that may result, as well as further feedback from the Reference Panel, the most likely estimate for income per hive for the CBA was set at $700.

3.8 Aggregated benefits and costs

All data generated from preceding steps are extracted for quantifying benefits and costs and consolidated. The benefits and costs for Scenarios 1 and 2 are generated and the net present value (NPV) calculated.

The benefits stream stems from avoided losses of high numbers of infected hives in the uncontrolled outbreak (Scenario 0) compared with Scenario 1 (current NPMP) or Scenario 2 (proposed NPMP). The benefit is generated by:

- The difference in infected hives between Scenario 0 (highest number) and Scenario 1 or 2 for each compliance type (COI and DECA); and
- Multiplying yearly differences by income per hive.

Scenario 2 benefits stream generated $42 million avoided losses over ten years representing $28.6 million in Present Value.

The costs associated with the relevant NPMP for Scenarios 1 and 2 are generated by:

- Differences in numbers of surveillance and control activities undertaken between Scenario 1 or 2 (higher number of activities due to NPMP) and Scenario 0 (some nil activities as no NPMP) for each compliance type (COI and DECA);
- Multiplying yearly differences by unit costs per activity; and
- Industry size numbers multiplied by $40/beekeeper and $1.70/hive for national programme costs.

Scenario 2 incremental surveillance, control and national programme costs are $5.8 million over ten years, reducing from $3.1 million in 2023/24 to -$1.4 million in 2032/33 representing $5.9 million in Present Value. The incremental surveillance, control and national programme costs from 2029/30 onwards is less than zero as the savings from reduced[10] hive disposal and replacement costs are greater than the incremental surveillance and national programme costs.

Summing the benefits and costs for COI and DECA, the difference between benefit and costs is the net benefit stream. Two metrics are generated to assess economic impact of Scenarios 1 and 2:

- Net present value:
    - Whether Scenarios 1 or 2 contribute to economic welfare;

[10] Resulting from the reduced incidence of AFB compared to Scenario 0.

- Calculated by discounting the net benefit stream using the current NZ Treasury social opportunity cost of capital (real, pre-tax, default rate).[11]
- Benefit-cost ratio:
  - Multiple of benefits generated for each dollar of cost;
  - Calculated by taking the ratio of present value[12] of benefits to present value of costs.

4 Results

4.1 Net present value

The annual flow of net benefits for Scenario 1 (current NPMP vs uncontrolled) and for Scenario 2 (proposed NPMP vs uncontrolled) shows losses in early years up to year 3 (2025/26) and positive benefits from year 4, as higher income losses from growing AFB infected hives offset NPMP costs (see Figure 8). The net benefit is plateauing by year 10 owing to a ceiling for recorded incidence shown in the epidemic curve (see Figure 5).

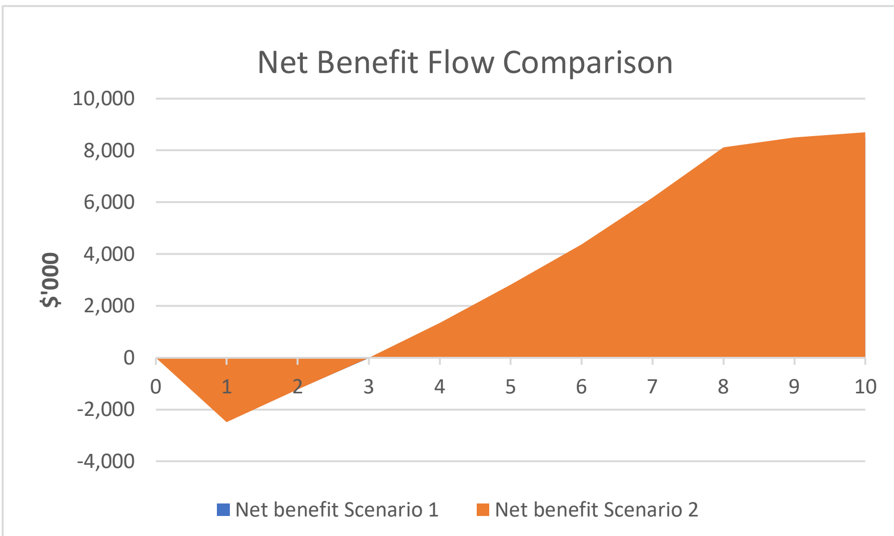


Figure 8: Annual net benefit flow for Scenarios 1 and 2

Note: Scenario 1 (blue) is not seen in this scale as closely tracking Scenario 2.

Both Scenarios 1 and 2 have a positive NPV, with Scenario 2 having a higher NPV by $384,000 (see Table 10). The BCRs are similar at about 5x, with Scenario 2 showing slightly lower cost efficiency due to amendments to mitigate NPMP risks of success (see Table 4 and section 5.3).

Table 10: NPV and BCR results

	Scenario 1	Scenario 2
NPV Industry ($'000)	22,269	22,653
Benefit-cost ratio	5.0	4.8

[11] Source: https://www.treasury.govt.nz/information-and-services/state-sector-leadership/guidance/financial-reporting-policies-and-guidance/discount-rates

[12] The present value is derived by discounting the benefit and cost streams using the NZ Treasury discount rate.

4.2 Sensitivity analysis

A sensitivity analysis was conducted to assess impact on the NPV of changes of key variables. The variables selected are those with a higher degree of uncertainty and greater impact on NPV.

The variables selected for sensitivity analysis and associated magnitude of change that reflect their uncertainty are shown in Table 11.

Table 11: Variables for sensitivity analysis

Variable	**Most likely[a]**	**Magnitude of change[b]**		
	Value	**Sensitivity 1**	**Sensitivity 2**	**Sensitivity 3**
Income loss ($ per hive)	$700	+$100 [c]	-$100	NA
Annual trend incidence rate	-5.0%	+10% [d]	-20%	-79%
Industry size (number of hives)	738,000	-88,000	-188,000	NA
Discount rate (%)	5%	Add 1% to 5% rate	NA	NA

Note:
(a) The second column is the most likely value.

(b) The magnitude of change columns shows uncertainty range - either higher or lower than the most likely value.

For example, (c) Sensitivity 1 for income loss per hive is higher by +$100 which is $800 ($700 + $100) as shown in Table 12.
(d) Sensitivity 1 for annual trend incidence rate is higher by +10% which is -5.5% (-5.0% x 10% + -5.0%) as shown in Table 12.

The results of the sensitivity analysis are shown Table 12. The impact of sensitivity analysis on Scenarios 1 and 2 are of similar levels of magnitude. Among the variables, the most sensitive are income loss (1.26x) and industry size (1.22x) based on sensitivity indicator[13] analysis. For example, a 14% decline in avoided income loss per hive results in a greater 18% decline in NPV. The annual trend in incidence rate is the least sensitive variable. Taking annual reduction rate in incidence to -0.88% (long term 1998-2021 annual reduction rate) from -4.2% is a 79% decrease but the NPV only declines by 28%. More important, this extremely low reduction rate still delivers a positive NPV of about $16 million.

Table 12 also shows a breakeven analysis for income loss per hive and industry size. Reducing both these variables to $337/hive and 355,000 hives results to an NPV of zero for Scenario 1 and to slightly higher figures[14] for Scenario 2. This means both these variables need to fall by 52% for the NPMP to be not worthwhile.

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[13] Multiple showing % change in NPV for every % change in input variable.

[14] At large reductions in variables, Scenario 2 has slightly lower NPV than Scenario 1 since the 20% improvement off a small base and the 1.2% incidence rate ceiling reached by year 8 limit the amount of benefits to cover higher compliance costs of Scenario 2. This is the case for the 79% reduction in annual trend for incidence rate and the 52% reduction for income loss and industry size.

Table 12: Sensitivity analysis: NPV and BCR for Scenarios 1 and 2

	Assumption	Change %	NPV Sc1 ($'000)	Change %	NPV Sc2 ($'000)	Change %	BCR Sc1 (x)	Change %	BCR Sc2 (x)	Change %
Most Likely			**22,269**		**22,653**		**5.0**		**4.8**	
Income loss ($/hive)										
Most Likely	700									
Sensitivity1	800	14%	26,254	18%	26,733	18%	5.7	14%	5.5	14%
Sensitivity2	600	-14%	18,283	-18%	18,572	-18%	4.2	-14%	4.1	-14%
Annual trend incidence rate										
Most Likely Scenario 2	-5.0%									
Sensitivity1	-5.5%	10%	22,974	3%	23,457	4%	5.3	7%	5.2	7%
Sensitivity2	-4.0%	-20%	20,775	-7%	20,999	-7%	4.3	-12%	4.2	-13%
Sensitivity3 (Sc 1 -0.88% long term trend)	-1.1%	-79%	15,999	-28%	15,590	-31%	3.0	-40%	2.8	-42%
Industry size ('000 hives)										
Most Likely	738									
Sensitivity1	650	-12%	19,057	-14%	19,359	-15%	4.1	-17%	4.0	-17%
Sensitivity2	550	-25%	15,407	-31%	15,617	-31%	3.3	-33%	3.3	-33%
Breakeven rate for income loss and industry size										
Income loss $337/hive and industry size 355,000 hives (Sc1)		-51.8%	-	-100%	- 122	-101%	1.0	-132%	1.0	-80%
Income loss $340/hive and industry size 358,000 hives (Sc2)		-51.5%	119	-99%	-	-100%	1.0	-80%	1.0	-79%
Discount rate										
Most Likely	5%									
Sensitivity1	6%	20%	20,307	-9%	20,652	-9%	4.6	-7%	4.5	-7%

4.3 Risk analysis

With the uncertainty among sensitive variables, the most likely, high, and low values[15] were identified (see Table 13) and applied in a risk analysis using Monte Carlo simulation with 5,000 iterations to generate an expected NPV and a range with 90% confidence interval. Income loss is $100 above or below the most likely. Industry size is most likely to stabilise at the estimated 2022 number of hives, but there is chance it declines further to either 650,000 or 550,000 hives. The annual trend in incidence either improves by 10% or declines to the long-term trend. This is biased to the low side to be conservative.

Table 13: Range for uncertain variables

Income loss ($/hive)	
Most Likely	700
High	800
Low	600
Industry size ('000 hives) by 2024/25	
Most Likely	738
Moderate decline	650
Severe decline	550

[15] High value means there is 5% chance there is a higher value and low value means there is 5% chance there is a lower value. They are not the absolute maximum or minimum values in the range.

Annual trend in incidence rate	Sc1	Sc2
Most Likely	-4.17%	-5.00%
High	-4.58%	-5.50%
Low	-0.88%	-1.06%

Source: Reference Panel, AFB MA

The uncertain variables are all independent except for annual trend in incidence rate, which is correlated with disposal rate variables. Appendix 4 shows the dependent variable and the correlation matrix.

Randomly drawing values from the probability distribution[16] of each uncertain variable for an iteration produces an NPV. With 5,000 iterations, the expected (mean) NPV and confidence interval are shown in Figure 9.

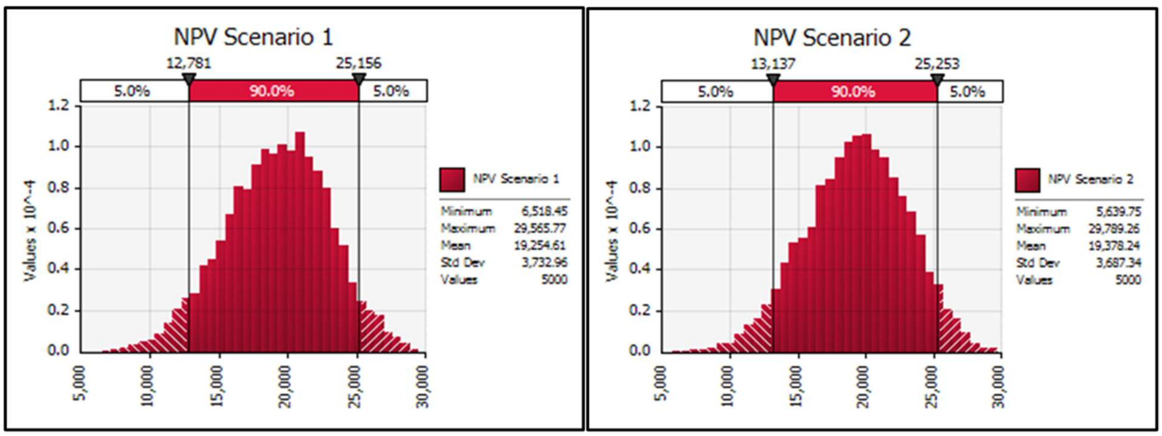

Figure 9: Expected NPV and confidence intervals (Scenario 1 and 2)

The expected NPV from the Monte Carlo simulation is about $19.3 million, lower than the most likely NPV calculated in the CBA, and the difference between Scenarios 1 and 2 NPV narrowed to about $124,000.

5 Discussion

5.1 Quantitative impact

The NPVs for Scenarios 1 and 2 from the AFB NPMP CBA are positive, amounting to approximately $22.5 million, as the losses from uncontrolled AFB exceed the NPMP compliance and control costs. The sensitivity analysis shows the NPV is robust for lower income loss per hive, annual reduction in AFB incidence industry size or higher discount rate. Even if annual reduction in AFB incidence is close to zero, NPV is still positive at about $16 million.

Applying risk analysis to account for uncertainty among sensitive variables, the expected NPV is positive but declines to approximately $19.3 million due to conservative bias for the annual reduction in incidence rate. The confidence intervals show zero chance of a negative NPV.

Scenario 2 has higher NPV than Scenario 1. However, the NPV advantage of Scenario 2 declines as sensitive variable values are reduced, since extra costs of the proposed NPMP are fixed, while the avoided losses benefit declines due to reduced impact of the expected 20% performance improvement from the current

[16] All uncertain variables used triangular distribution (simplified normal distribution) except industry size which was a discrete distribution.

NPMP to the proposed NPMP[17]. At significant reductions in variable values, the NPV advantage reverses, so that Scenario 2 has lower NPV than Scenario 1 (see footnote 14).

In line with the dynamics described above, Scenario 2 also has a slightly lower BCR than Scenario 1. This implies slightly lower cost efficiency for Scenario 2, albeit the overall benefit obtained is higher.

5.2 Non-quantitative or qualitative impact

There are several negative impacts under Scenario 0 (no NPMP) that are not quantified and can be considered qualitative benefits of the NPMP (Scenarios 1 and 2). These include:

- Avoided loss of infrastructure and capabilities (Table 14); and
- Consequential impacts of increased prevalence of AFB on potential markets and the environment (Table 15).

Table 14: Loss of NPMP infrastructure and capabilities

Infrastructure/Capability loss	Impact
Apiary register	• Market access - Apiaries not registered by a 'competent authority' hence will not meet the Overseas Market Access Requirement[18] (OMAR) for the European Union (EU), a premium market worth $63 million accounting for 13% of total honey exports,[19] with 33% higher than average export prices, and the United Kingdom (UK), a sizable market worth $71 million, accounting for 15% of total honey exports[20]. • Adversely impacts MPI's surveillance programme for exotic honeybee pests. • Compromises MPI's ability to mount an effective incursion response to a newly introduced honeybee pest or disease – as they won't know where the apiaries are or who owns them.
Authorised Persons under the Biosecurity Act (AP1 and AP2)	• Reduced human capability to respond to incursion – Management Agency employs or contracts the majority of the New Zealand workforce that is competent to respond to an exotic pests or disease affecting honeybees.
Advocacy with regional councils	• Management Agency proposes to consult with regional councils to advocate for beekeepers for the same exemptions provided to farmers under air quality management plans (i.e., burning AFB hives).

[17] To illustrate for annual trend in incidence rate variable, 20% of 5% reduction at 0.4% incidence is 0.0040% in avoided losses benefit (30 hives) while 20% of 1% reduction at 0.4% incidence is only 0.0008% in avoided losses benefit (6 hives).

[18] EU and UK OMAR state: Honey and other apiculture products must be derived from healthy hives which are operated in compliance with the Biosecurity (National American Foulbrood Pest Management Plan) Order 1998 and have not been treated with dangerous substances. Source: MPI

[19] For 2021 year ending June (Statistics NZ).

[20] For 2021 year ending June (Statistics NZ).

Table 15: Impact of increased prevalence of AFB

Increased AFB prevalence	Impact
Increased prevalence of AFB in honey[21]	• Significantly reduces the quantity of honey that is eligible for export to China (top export market for honey worth $101 million accounting for 21% of total honey exports[22] with 12% higher than average export prices). • Increases the probability of China detecting AFB in NZ honey at its border risking an import ban[23].
More burning of hives	• Reduced air quality.

Two other qualitative impacts were assessed to be not benefits. These are:

- Use of antibiotics to treat AFB:
    - Increases the risk of residues in honeybee products, hence MPI will need to start running an antibiotics residue monitoring programme under a cost recovery scheme from beekeepers.
    - Potential adverse consumer reaction to antibiotics in their honey (depending on the efficacy of MPI's monitoring programme).
    - The Reference Panel advised that registration of antibiotic to treat AFB is unlikely to be completed during the 10-year time horizon for the NPMP CBA.

- Pollination ecosystem services:
    - The increased prevalence of AFB relative to the size of the industry is unlikely to impact pollination ecosystem services.
    - A 25% reduction in pollination leads to a 15% reduction in yield. This reduced yield was valued at $295 million for New Zealand open pollinated crops (Sandhu et al., 2016).
    - However, the number of hives deployed for pollination is estimated at less than 85,000[24] and the 1.2% AFB incidence rate ceiling for Scenario 0 means a minimum of 724,500 hives are still available for pollination services.

5.3 NPD risks to success of NPMP

As control of AFB relies on beekeeper compliance, the main risk to the success of the AFB NPMP is regulatory or the extent to which the NPMP will be implemented and complied with. The proposed NPMP under Scenario 2 introduces risk management enhancements as illustrated in Table 16.

[21] Historical AFB surveillance survey data found significantly higher prevalence of AFB spores in retail honey samples than recorded annual incidence rates would suggest. For example, at a 0.89% recorded AFB incidence rate in 1993, 25% of retail honey samples were found to contain AFB spores. Another study in 2018 showed 14% prevalence of spores at 0.32% recorded AFB annual incidence. Even though some other studies showed lower rates, there is clearly a risk that spore incidence in honey may be substantially higher than recorded AFB incidence data suggest. Data Source: AFB Management Agency.

[22] For 2021 year ending June (Statistics NZ).

[23] The Chinese authorities have threatened to ban honeybee product imports from New Zealand if they detect AFB in any shipments of honey. Source: AFB Management Agency.

[24] Source: Reference Panel member

Table 16: Compliance risk mitigation under Scenario 2

Compliance risk	Scenario 2 NPMP changes
DECA holders know how to recognise and eliminate AFB	Completion of refresher training every 5 years to retain a DECA
DECA employees know how to recognise and eliminate AFB	DECA employees pass course on AFB recognition and complete refresher training every 5 years
Non-compliances with plan rules are detected	• Diagnostic laboratories to provide AFB test results to MA • Notification of transfer of beehive ownership within 7 days, ADR rule to require Beekeeper Registration Number • Enabling AP2s to use detector dogs
Beekeepers are deterred from non-compliance	New ability to impose infringement fines in lieu of impractical/costly court-imposed fine for breaching: • Obligation to keep honeybees in moveable frame hives (c11) • Prohibition on keeping bees in place other than apiary (c15) • Annual Disease Return (c27) • Certificate of Inspection (c32)
Impacts of non-compliance are mitigated	New power to destroy AFB beehives, and prevent the spread of AFB when power to give directions is impractical

Source: AFB MA

The four/five main risk types under clause 6(3)(a) of the NPD are discussed below.

5.3.1 Outcome risk

The technical and operational risks of the option (i.e., outcome risk)

Elimination of clinical AFB from managed beehives can be achieved if beehives affected with clinical AFB are found and destroyed before they infect one other beehive, i.e., the R-value is less than 1.0. This is achieved via two primary mechanisms:

- Regular inspection of beehives for AFB, at least twice a year, spring and autumn; and
- Destroying all beehives, honeybee products and materials associated with cases of AFB.

Changing management practices to limit the movement of risk items between beehives is also of assistance, namely:

- Reducing the amount of brood spread between beehives;
- Reducing the making of splits, tops and nucs;
- Stopping honey or pollen feeding;
- Implementing apiary quarantine systems to prevent the movement of infected beehives or beehive parts between apiaries; and
- Sterilising beekeeping equipment.

Many beekeepers have successfully eliminated AFB from their beehives using these methods. The Management Agency's HiveHub database records indicate that 89% of beekeepers have not recorded a case of AFB in the last 3 years (since 1 July 2019). Analysis by beekeeper segment reveals that:

- 94% of hobbyist beekeepers (<11 colonies) have not had a case of AFB in the last 3 years;
- 75% of semi-commercial beekeepers (11-250 colonies) have not had a case of AFB in the last 3 years; and
- 37% of commercial beekeepers (>250 colonies) have not had a case of AFB in the last 3 years.

Eliminating AFB from a beekeeper's beehives is not a difficult or complicated task. The Management Agency has reduced the annual incidence of AFB in non-compliant high risk beekeepers' beehives by 90% per year simply by:

- Ensuring that all beehives are inspected two times per year; and
- Ensuring that all beehives, honeybee products and appliances associated with cases of AFB are destroyed by burning.

There is no technical or operational difference between the current (Scenario 1) and the proposed (Scenario 2) NPMP. Both versions require beekeepers to ensure that:

- Beehives are inspected for AFB 1 x per year for non-DECA holders (clauses 32 and 33);
- DECA holders inspect beehives at least 2x per year (clause 37);
- Beehives, bee products, materials and appliances associated with a case of AFB are destroyed (clause 28); and
- They do not engage in activities that may spread AFB (clauses 29 and 31).

The primary objective of the current and proposed NPMP is to reduce the annual incidence of AFB by 5% per year. As the 5% annual reduction target is significantly lower than the 90% reduction demonstrated by Management Agency enforcement actions, the technical and operational risks that may prevent the achievement of the primary objective are assessed as being negligible.

5.3.2 Regulatory risk

The extent to which the option will be implemented and complied with (i.e., regulatory risk)

As explained in 5.3.1, beekeepers are responsible for undertaking the actions required to eliminate AFB, and beekeepers are responsible for funding the implementation of these actions. There is no difference in the core compliance costs to beekeepers under the current (Scenario 1) and proposed (Scenario 2) NPMP.

The regulatory risk associated with the implementation of the both the current and proposed version of the NPMP is very high.

The evidence for this risk assessment is through enforcement activities of the Management Agency demonstrating that that the annual incidence of AFB can be reduced by 90% per year. However, from 1998 to 2021, the National American Foulbrood Pest Management Plan has only achieved an average annual incidence reduction of 0.88%.

The proposed changes to the NPMP (Scenario 2) are designed to better mitigate the regulatory risks associated with the current NPMP (see Table 16).

The residual regulatory risk after the implementation of the proposed NPMP remains high (that is the regulatory risk decreases from very high to high).

The additional training and education requirements associated with proposed amendments to the NPMP will effectively reduce non-compliance by beekeepers and employees that are willing to eliminate AFB but may not have the skills or knowledge (or may have forgotten). However, this will have no impact on beekeepers that are intentionally non-compliant and may only have a limited impact on beekeepers that are non-compliant due to competing operational priorities.

Modifying the behaviour of beekeepers that are intentionally non-compliant or who are non-compliant due to competing operational priorities requires creating an expectation that their non-compliance will be detected, and the offending punished. This requires increased surveillance and monitoring to detect offending and the practical ability to impose penalties.

On the effectiveness of a penalty in increasing compliance, AFB MA data shows higher compliance for DECA beekeepers over COI beekeepers who defaulted on Annual Disease Return deadline. The penalty for DECA beekeepers is the loss of DECA while COI beekeepers have effectively no penalty. DECA holders have about 15% higher compliance over COI beekeepers in 2021 (i.e., 99.2% vs 86.1% compliance).

While a high residual regulatory risk associated with Scenario 2 is less than ideal, it is important to consider that the pest management plan is only attempting to achieve an annual 5% reduction in annual incidence (when an annual 90% reduction is technically feasible – assuming 100% of beekeepers were compliant).

5.3.3 Legal risk

The risk that compliance with other legislation will adversely affect implementation of the plan (i.e., legal risk)

Air quality management plans implemented by regional councils under the Resource Management Act 1991 are making it difficult for beekeepers in some locations of New Zealand to destroy AFB hives (by burning). The Management Agency proposes to consult with regional councils to advocate that beekeepers should be afforded the same exemptions as they currently provide to farmers.

This is equally applicable to scenarios 0, 1, and 2, noting that the Management Agency will not be able to consult with regional councils on beekeepers' behalf under scenario 0.

5.3.4 Socio-political risk

The risk that public or political concerns will adversely affect the implementation of the options (i.e., "socio-politico risk")

No risks in this category identified. The public in general are considered to be supportive of initiatives that result in "healthy bees".

5.3.5 Other material risk

No other risks have been identified.

5.4 NPD cost allocation

The costs of the proposed AFB NPMP are proposed to lie solely with the beekeeping industry as beneficiaries of the plan. No exacerbators have been identified.

6 Conclusion

Both Scenario 1 (the current NPMP) and Scenario 2 (the proposed NPMP) result in a positive NPV of $19.3 million with an expected BCR of over 4x, implying that benefits exceed costs by this multiple in present value terms. Either option can be adopted and will deliver net benefits to the industry. However, Scenario 2 provides additional risk mitigation for the main risk of programme compliance. In addition, Scenario 2 shows a higher overall net benefit than Scenario 1, albeit the differences are small.

Though Scenario 2 has a slightly lower cost efficiency than Scenario 1, the benefits of risk mitigation cannot all be quantified and may exceed the estimates used in the CBA.

As a result, Scenario 2 is the preferred option over Scenario 1. There will remain a need during the new NPMP period to identify and monitor performance indicators and cost effectiveness of the extra compliance costs to ensure the additional benefits are delivered.

Apart from the quantified positive NPV, Scenarios 1 and 2 deliver significant benefits in preserving market access and premium pricing for the EU market ($63 million in annual sales) and the China market ($101 million in annual sales), as well as access to the $71 million UK market. Losing market access implies surplus honey production (nearly half of export volume i.e., 47.2%) would need to target second-best export markets at reduced prices, and/or alternatively, if not able to be sold at a price above its cost, shrinkage of total production. Either way, loss of these markets would very likely have a significant negative economic impact on the industry and its contribution to the overall New Zealand economy.

7 References

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8 Appendices

8.1 Appendix 1: Reference Panel membership

Name	Organisation
Technical/Science experts	
James Sainsbury/ Michelle Taylor	Bee Biology and Productivity Team at Plant & Food Research
Phil Lester	Professor of Biology in the Victoria University School of Biological Sciences
Richard Hall	Research Scientist for ApiWellbeing project at Ministry for Primary Industries Wallaceville Lab
Ben Phiri	Senior Advisor at Ministry for Primary Industries Wallaceville Lab -surveillance programme for exotic pests and diseases of honeybees
Beekeepers	
James Malcolm	Canterbury beekeeper
Neil Stuckey	North Auckland beekeeper
Hector Urquhart	Nelson/Tasman beekeeper
Processing/Marketing	
Luke Jellet	Manager, Strategic Partnerships Supply, Comvita Ltd
John Hartnell	Honey Exporter, Beekeeper, Consultant to Poultry Farmers and Beekeepers, previous Chair of the Management Agency Board

8.2 Appendix 2: Assumptions for surveillance and control activities

Scenario 0	COI	DECA
Inspection per hive/year	0	2
Number of AFB training DECA beekeeper per year	0	0
Number of hives/employee	N/A	500
Number of AFB training DECA beekeeper refresher	0	0
AFB training DECA employee refresher	0	0
% of MA inspection COI defaulters/year	N/A	N/A
Disposal hives	46%	46%
% of COI compliant hives >2 hives	N/A	N/A
% of COI defaulter hives >2 hives	N/A	N/A
% of COI compliant beekeepers >2 hives	N/A	N/A
% of COI defaulter beekeepers >2 hives	N/A	N/A
Scenario 1	**COI**	**DECA**
Inspection per hive/year	1	2
Number of AFB training DECA beekeeper per year	0	1300
Number of hives/employee	N/A	500
Number of AFB training DECA beekeeper refresher	0	0
AFB training DECA employee refresher		
% of MA inspection COI defaulters/year	35%	N/A
Disposal hives	54.8%	54.8%
% of COI compliant hives >2 hives	92.1%	N/A
% of COI defaulter hives >2 hives	91.7%	N/A
% of COI compliant beekeepers >2 hives	42.7%	N/A
% of COI defaulter beekeepers >2 hives	28.7%	N/A

Scenario 2	COI	DECA
Inspection per hive/year	1	2
Number of AFB training DECA beekeeper per year	0	1300
Number of hives/employee	N/A	500
Number of AFB training DECA beekeeper refresher	0	1000
AFB training DECA employee refresher	0	0
% of MA inspection COI defaulters/year	35%	N/A
Disposal hives	54.8%	55.3%
% of COI compliant hives >2 hives	92.1%	N/A
% of COI defaulter hives >2 hives	91.7%	N/A
% of COI compliant beekeepers >2 hives	42.7%	N/A
% of COI defaulter beekeepers >2 hives	28.7%	N/A

Disposal rate of infected hives

Behaviour	Incidence multiple for following year
All hives thoroughly inspected 2x per year AND all AFB hives destroyed (compliant behaviour)	0.1
AFB hives not destroyed (most likely)	2
AFB hives not destroyed (high estimate)	4

AFB hive disposal rate

		Current long term		Most likely		Sensitivity	
Scenario	Sc 0	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2
% of all AFB hives destroyed	46.0%	53.1%	53.2%	54.8%	55.3%	54.4%	54.7%
Annual trend incidence	12.58%	-0.88%	-1.06%	-4.20%	-5.00%	-3.33%	-4.00%

8.3 Appendix 3: Income per hive with industry statistics

Industry major income sources:

- Honey (97%) – manuka and non-manuka
- Pollination (2.8%)
- Other bee products (0.3%)

Bee product		2021
Honey	tonnes	20,500
Honey	**$'000**	**653,833**
Manuka	tonnes	9,382
Non-manuka	tonnes	11,118
Manuka	$/kg	64
Non-manuka	$/kg	5
Pollination	**$'000**	**19,238**
Fruits - kiwifruit, avocado, etc	hives	67,500
Vegetable seeds	hives	15,000
Fruits - kiwifruit, avocado, etc	$/hive	235
Vegetable seeds	$/hive	225
Other bee products income	**$'000**	**2,254**
Beeswax	tonnes	148
Live bees	package	15,754
Queens	units	3,968
Beeswax	$/kg	8
Live bees	$/package	57
Queens	$/unit	58
Total hives		811,731
Income per hive ($)		**832**

Source: MPI Apiculture Monitoring Programme, Statistics NZ, Reference Panel

8.4 Appendix 4: Annual trend in incidence correlation with disposal rate

@RISK Correlations	Trend incidence rate Sc2	Trend incidence rate Sc1	Disposal rate Sc1	Disposal rate Sc2
Trend incidence rate Sc1	1			
Trend incidence rate Sc2	0	1		
Disposal rate Sc1	0	-1	1	
Disposal rate Sc2	-1	0	0	1

Note: Matrix shows the correlation of dependent variable (disposal rate) to independent variable (annual trend in incidence rate) given as instruction for the @Risk analysis. 1 is positive correlation (all along diagonal which is simple identity) while -1 is negative correlation. Disposal rates have negative correlation to the independent variable. For example, in the bottom row, disposal rate Scenario 2 is negatively correlated since @Risk must choose a low value when trend in incidence rate Scenario 2 is a high value.