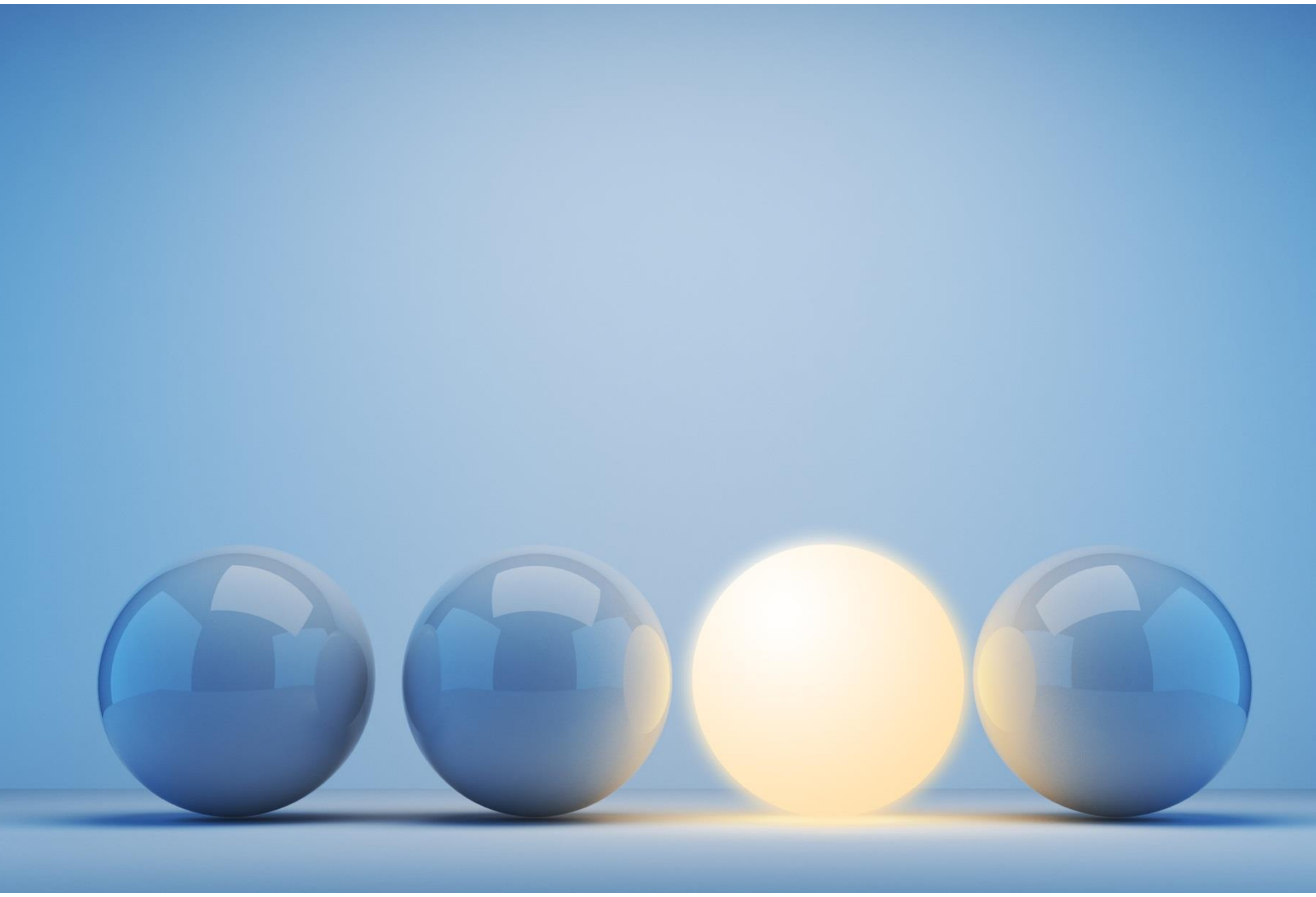

Organophosphate and carbamate reassessment

The costs and benefits of reassessing carbaryl, chlorpyrifos, and diazinon (CDD)

NZIER report to the Environmental Protection Authority

February 2015

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Key points

Objective

This report provides an indicative estimate of the costs and benefits of the reassessment of selected organophosphates and carbamates. These are carbaryl, chlorpyrifos, and diazinon (referred to as CCD organophosphates and carbamates).

The reassessment is focused **only** on the non-crop protection uses of CCD organophosphates and carbamates. These uses include sheep dips, dog and cat collars, industrial, and garden insecticides.

Main findings

Organophosphates and carbamates are highly toxic substances, therefore periodic assessment of their use to ensure removal of substances which pose greatest risk and/or offer few benefits is required to create a dynamic and durable regulatory regime.

The benefits of withdrawing CCD organophosphates and carbamates from the market include:

- reduced risk of acute poisoning. The use of CCD organophosphates and carbamates can lead to users being over-exposed. Avoiding this exposure has the potential to reduce acute poisonings
- a potential reduction in the long term impacts of acute poisoning
- a potential reduction in possible chronic poisoning from CCD organophosphates and carbamates. The EPA risk assessment shows that exposure to operators undertaking sheep dipping, jetting and shearing (diazinon)[1] may be above acceptable levels
- an environmental benefit, particularly in aquatic environments
- "non-use"[2] benefits for the general public knowing that potentially dangerous pesticides are being proactively managed through a reassessment process
- significant longer term trade and trade policy benefits. The reassessment process can ensure that regulatory settings do not allow New Zealand to become an outlier in CCD organophosphate and carbamate use. This could have implications for New Zealand's competitiveness (product sold at a discount to others) or increased risks that New Zealand product is excluded from particular markets.

Costs are mainly those associated with users switching product to other low cost organophosphates or higher priced (and higher quality) chemistry. While these costs are small they could be mitigated further by introducing a low cost permissions scheme (i.e. a delegated authority to a professional such as a veterinarian) that allows specific use of chlorpyrifos and diazinon in specific circumstances.[3] For the carbamate carbaryl, most products are being withdrawn because they are no longer used.

1 A similar finding was made by Australian regulators.

2 By "non-use" values we mean values that cannot be bought and sold in a market. Typically these are environmental, social and cultural values.

3 CCD organophosphates are particularly effective against ticks therefore this approach allows use but only in specific circumstances.

Under the reassessment scenario, the benefits outweigh the costs. The benefits for chlorpyrifos and diazinon are driven by human health considerations and the impact on trade and trade policy over the long term.

Our results are sensitive to assumptions because of the lack of data. Therefore, we have produced lower and upper bound quantified estimates that indicate an incremental benefit.

The following table summarises the estimated impacts of reassessing CCD organophosphates and carbamates. These costs and benefits are relative to the baseline (or counterfactual).

Summary of Costs and Benefits

PV 8% over 20 years

Costs		Benefits	
Farmers		**Users**	
Switching to other substances	Small, potentially very small if a low cost permissions system is introduced	Health values	Small between $25,000 and $500,000
Manufacturers		**Non-use values**	
Switching to other substances	Negligible cost	Environmental, existence[1], and other non-use values[2]	Environmental impacts: nationally small but could have significant localised impacts
Impact on smaller companies	Although smaller companies are more flexible and move quickly into new activities thereby mitigating this cost	**Economic welfare**	
		Trade and trade policy benefit	Small in the short term (next five years), potentially large over time, particularly if New Zealand becomes an outlier in organophosphate and and carbamates use
Overall impact			**Small monetised gain of between $25,000 and $500,000. Other gains potentially are greater, particularly long term trade and trade policy gains**
Note (1) Benefit to the New Zealand public knowing that organophosphate and carbamate use is being managed appropriately. (2) For example, bequest value for the general public. Knowledge that a regulatory framework dynamically adjusts over time and for future generations i.e. it reflects current scientific knowledge and balances the costs and benefits.			

Source: NZIER

An important issue that also needs to be taken into account is the precautionary nature of the Hazardous Substances and New Organisms (HSNO) Act. It does not require decision makers to fully establish cause and effect before withdrawing a product. Section 7 of the Act stipulates that decision makers:

"shall take into account the need for caution in managing adverse effects where there is scientific and technical uncertainty about those effects".

The HSNO Act requires caution when looking at potential harm. Caution is required because the exposure modelling conducted by the EPA in New Zealand and in Australia (particularly with the use of diazinon for sheep dipping) indicates that workers potential exposure exceeds acceptable levels.

Caveats

It is well established that organophosphates and carbamates cause harm. The indications of human harm are derived from overseas studies and toxicological studies with laboratory animals.[4] However, these studies are characterised by major differences in definitions, sampling sizes, measurement and evaluation methodologies and existence of controls. The context and culture in other jurisdictions are also different e.g. many farm labourers in the USA are illegal immigrants, therefore reporting chemical incidents is a problem.

New Zealand data is limited. It draws on people reporting organophosphate and carbamate poisoning in hospitals. Therefore, we have little information on the type of organophosphates and carbamates that commonly cause patient harm or other impacts that affect the benefits such as avoidance of sick days, time off school or emotional harm. We also do not have any information on long term health effects of poisonings.

This brings considerable uncertainty about the baseline, likely impacts, assumptions and the extent to which costs and benefits found internationally can be translated to New Zealand.

A key difficulty is establishing the 'baseline', or what would have happened in absence of the reassessment process. In this case, the baseline is somewhat artificial because of the announcement effects of reassessment process. Manufacturers have already begun withdrawing CCD organophosphates and carbamates over the past few years because they have second guessed what regulators might do. Therefore, the baseline assumes greater use of CCD organophosphates and carbamates than is actually occurring.

[4] The animal studies have been used by the EPA to derive the acceptable exposure levels.

Contents

Appendices

Tables

1. Introduction

The Environmental Protection Authority (EPA) asked NZIER to examine the costs and benefits of withdrawing selected organophosphates[5] and carbamates from the market. This is part of a wider reassessment of the role of organophosphate and carbamate use in New Zealand. In this specific instance the reassessment includes those CCD uses other than for plant protection.

The reassessment includes concerns over:

- the safety of people and the environment exposed to CCD organophosphates and carbamates
- any build-up of CCD organophosphates and carbamates in the environment, particularly the aquatic environment
- non-market issues such as confidence in the regulatory regime
- other considerations including:
  - trends in countries that compete with New Zealand
  - regulatory trends in other jurisdictions
  - the precautionary nature of the Hazardous Substances and New Organisms (HSNO) Act.

Pesticides have been used for centuries; however it has only been in the last hundred years with the development of synthetic pesticides that they are being used globally. Organophosphates and carbamates are the most widely used group of insecticides principally because they are cheap and effective.[6] However, their acute toxicity causes potential hazards for both professional and amateur users. They may also cause some environmental damage, particularly in aquatic environments. In this specific case chlorpyrifos, carbaryl and diazinon are not widely used in New Zealand and in many instances the substances containing these active ingredients have or are being withdrawn.

Over the past six years, the EPA has reassessed a number of organophosphates and carbamates. Reassessing the CCD substances will give greater clarity and certainty for industry about the tools available to them in future, and avoid an outcome where a substance which poses a greater risk or offers fewer benefits is legally used when other substances or approaches could do a better job. The reassessment allows the EPA to check that the approach being taken effective and efficiently balances appropriate use while providing adequate health and safety protection and mitigating environmental damage.

It is the use of each CCD organophosphate and carbamates that is being investigated. Specifically this includes:

- setting out the costs of market withdrawal including further understanding the market particularly the substitutes for CCD organophosphates and carbamates

5 These are: carbaryl, chlorpyrifos, and diazinon referred to as CCD.

6 See for example http://emedicine.medscape.com/article/1175139-overview and http://eprints.qut.edu.au/16345/1/Kelly_Johnstone_Thesis.pdf

- further understanding the potential costs associated with organophosphate and carbamate use. This includes assessing the evidence that may link organophosphate and carbamate use with adverse health and environmental outcomes
- understanding other issues that may need to be considered when determining the continued use or otherwise of CCD organophosphates and carbamates.

The purpose of this report is to provide a partial cost benefit analysis (CBA) that helps decision makers further understand the pluses and minuses of withdrawing CCD organophosphates and carbamates for non-crop protection purposes from the New Zealand market.

We have drawn on, foreign studies, stances taken in other jurisdictions, perceptions of those involved in the market, previous work commissioned by the EPA on specific substances, and other stakeholder sources. To elicit this information we:

- conducted a limited number of interviews
- reviewed pertinent scientific literature.

The analysis is intended to give policymakers an indication of the likely costs and benefits in an area where there is only limited information.

There remain a number of important uncertainties on the benefits, for example the uncertain linkages between organophosphate and carbamates use and chronic health conditions, since studies are sending mixed messages and many results are ambiguous. As such, the depth of the CBA reflects a snap-shot of current knowledge.

2. The current situation

2.1. Context

The CBA has been undertaken concurrently with other parts of the reassessment process including toxological, ecotoxicology, and risk assessments reports.

2.1.1. Organophosphates

Organophosphates were first recognised in 1854 but their toxicity was not established until the 1930s. Tetraethyl pyrophosphate (TEPP) was the first organophosphate developed as a by-product of nerve gas during World War Two.

Organophosphates are derived from phosphoric acid. They are acutely toxic to vertebrate animals. They are relatively unstable and break down quickly in the environment. There are approximately 100 organophosphates in use in various forms around the world.

Organophosphates are nerve poisons that kill targeted pests (insects) therefore most formulations are insecticides although some have herbicide and fungicide compounds.

2.1.2. Carbamates

Investigations of chemicals that exert an anticholinesterase action on the nervous system similar to organophosphates led in the 1950s to the development of the carbamate insecticides. Carbaryl was the first successful carbamate, introduced in 1956. Carbaryl's advantage was that it can be used as a broad spectrum insect control agent. This has led to its wide use as a lawn and garden insecticide.

The mode of action of carbamate insecticides is very similar to that of the organophosphate insecticides as they inhibit cholinesterase enzymes. However, they differ in action from the organophosphate compounds in that the inhibitory effect on cholinesterase is brief.

Carbamates such as carbarl are lethal for non-targeted insects such as birds and bees and toxic for aquatic organisms.

Use of organophosphates and carbamates

Cheap and effective the global sales of organophosphates are roughly 40% of the world pesticide market.[7] Organophosphates and carbamates are used widely in both industrialised and developing economies.

In New Zealand, for non-crop protection purposes farmers regularly use organophosphates and carbamates although the amount used is small. Manktelow et al (2005) suggest less than a tonne of pesticides are applied to sheep and beef farms per annum. While Pfeffer and Heath (2010) p6 show that the size of the

[7] In the United States organophosphate use is higher at 55%. http://epa.gov/oppfead1/cb/csb_page/updates/2011/sales-usage06-07.html

pesticide market for the control of ectoparasites[8] on sheep is approximately $13 - $15 million per annum. The dog and cat market is also of a similar order (see Table 1).

Table 1 Market size

Sheep, dog and cats, and horse

Market	Use	Size
Sheep	Controls blowflies	$13 - $15 million
Dogs and cats	Mainly fleas	$13 - $14 million
Horses	Controls blowflies	Not known but much smaller than sheep and dogs and cats

Source: Pfeffer and Heath (2010)

There is little specific information on market dynamics; however Pfeffer and Heath (2010) p9 suggest that sales to the dog and cat market have been stable over time and sales to the sheep and beef industry have been reducing in line with the decline of the sector.

2.1.3. Acute and chronic exposure

Acute exposure

Acute poisoning is a situation where exposure causes severe biological harm or death. Organophosphates and carbamates are typically acutely toxic.[9] Organophosphates and carbamates work by inhibiting important enzymes of the nervous system, which play a vital role in the transmission of nerve impulses. With exposure to organophosphates and carbamates, the enzyme is unable to function and a build-up of acetylcholine occurs, which causes interference with nerve impulse transmission at nerve endings.

In humans, poisoning symptoms include: excessive sweating, salivation and lachrimation, nausea, vomiting, diarrhoea, abdominal cramp, general weakness, headache, poor concentration and tremors. In serious cases, respiratory failure and death can occur.

Other consequences may follow high acute exposures. From one to several weeks after exposure, organophosphate and carbamates induced delayed neuropathy and nerve damage may set in. This may begin with burning and tingling sensations and progress to paralysis of the lower limbs.

There is little disagreement about the impacts of acute exposure with children and pregnant mothers being most at risk.[10]

8 Parasites that live on the skin such as fleas.

9 See for example http://depts.washington.edu/opchild/acute.html

10 See for example Busby and Eckstein (2009) pp 53-56.

Avoiding acute exposure is not always seen as a major a priority for users. Of course if label directions are followed – particularly since most organophosphates and carbamates have restrictions on use – then proper legal protections are in place to prevent acute exposure.

However, despite such warnings and directions on use, the possibility that acute exposure can occur is real through:

- direct handling of the organophosphates and carbamates
- daily work around areas where organophosphates and carbamates have been used
- use of contaminated and sometimes inadequate clothing.

Chronic exposure

Understanding of the linkages between chronic exposures and poor health outcomes is limited despite much attention being focused on the possible chronic effects associated with occupational exposure to organophospahtes.

Potential associations between exposures of some organophosphates and neuropsychological effects, immunotoxicity, cancer, obesity, and diabetes have also been found in some studies but the evidence is not conclusive. The on-going research is focused organophosphates rather than carbamates.

Summary

In the risk analysis associated with the EPA's reassessment all uses of diazinon for sheep dipping, jetting and shearing are predicted to result in exposure for workers over the acceptable limit, even when wearing personal protective equipment.

2.1.4. Environmental impacts

Organophosphates and carbamates are toxic and restricting their use is an objective of regulators in many jurisdictions. Their toxicity is the reason they figure in many official cause-for-concern priority lists, especially to the aquatic environment where persistence can occur for up to six months.

In this case, the most important area of concern is the use of diazinon as a sheep dip. The environmental concerns are focused on the:

- run-off from treatment stations and holding paddocks
- disposal of sheep dips.

While the impact will be localised, in its toxic state diazinon could be a significant environmental problem.

The environmental impact also depends on the toxicity of the sheep dip that diazinon is replaced by.

3. Organophosphates and carbamates being reassessed

The CCD organophosphates and carbamates being reassessed are for non-crop protection uses. In the main these are veterinary medicines used to control fleas on dogs and cats and sheep dip to control blowflies.

The CCD are old technology. Most have been used on New Zealand farms since the 1960s. Therefore, they are off patent and typically manufactured by smaller companies.

3.1. Carbaryl

Carbaryl is a carbamate that is an active ingredient in some insecticides to control a range of pests. For non-crop protection purposes in New Zealand carbaryl is used to control fleas, mites, wasps and feral bees (see **Error! Reference source not found.**).

Carbaryl was developed commercially in 1958. It remains a very common insecticide in the United States for home and gardens. In New Zealand use of carbaryl has ceased for most applications, apart from ear drops for dogs and cats which when used according to the product label was shown in the risk assessment carried out by the EPA staff to pose low acceptable human or environmental risks.

Table 2 List of carbaryl substances

HSNO approval number	Substance name	Known trade name	Use pattern	Currently in use
HSR001825	Liquid containing 1.4 – 2.6% 2-hydroxybenzoic acid, 0.7 – 1.3% carbaryl and 0.11 – 0.29% chlorocresol	Fidos ear drops	Ear drops (cats/dogs)	Yes
HSR000672	Dustable powder containing 50 g/kg carbaryl	Kiwicare No Wasps Insecticidal Dust	To control wasps by puffing dust into the nest entrance	This product is no longer produced based on the call for information
HSR000819	Wettable powder containing 800 g/kg carbaryl	Kiwicare Carbaryl Insect Control; Wasp Nest Carbaryl 80 Powder	To control wasps apply into nest entrance; To control pests and fruit thinning in fruit crops, pest in vegetables and ornamentals	This product is no longer produced based on the call for information
HSR001811	Aerosol containing 0.3 - 0.7% carbaryl and 0.4 - 0.8% piperonyl butoxide	-	Combination substance containing carbaryl and piperonyl butoxide	No products on the market

Source: EPA

3.2. Chlorpyrifos

Chlorpyrifos is a broad spectrum, non-systemic organophosphate insecticide with contact, stomach and respiratory action. It acts by cholinesterase inhibition and was first introduced and used in the 1960s.

In New Zealand, non-crop protection did include controlling a broad range of insects. It is also registered for control of some insects in domestic situations, a range of insect pests in home gardens (see **Error! Reference source not found.**). Animal health applications include sheep dips. Domestic uses include crack/crevice treatment in buildings and enclosed bait stations (e.g. for cockroaches). These substances are no longer available for sale in New Zealand.

Table 3 List of chlorpyrifos substances

HSNO approval number	Substance name	Known trade name	Use pattern	Currently in use
HSR001812	Flammable liquid containing 7 - 13 g/litre chlorpyrifos and 100 - 120 g/litre cypermethrin	Flypel	To control blowfly strike, lice and keds on sheep and lambs by to the fleece using the applicator nozzle with drencher	No products on the market
HSR001814	Flammable liquid containing 120 - 180 g/litre chlorpyrifos	Xterminate 10	To control blowfly strike, lice and keds on sheep and lambs by plunge dips, shower dips and jetting	No products on the market
HSR000164	Ready to use bait containing 5 g/kg chlorpyrifos	-	To control insects in and around buildings	No products on the market
HSR000166	Paste containing 5 g/kg chlorpyrifos	-	To control insects in and around buildings	No products on the market
HSR000168	Microencapsulated suspension concentrate containing 200 g/litre chlorpyrifos	-	To control insects in and around buildings	No products on the market
HSR000169	Emulsifiable concentrate containing 240 g/litre chlorpyrifos. Also contains xylene	-	To control insects in and around buildings	No products on the market
HSR000172	Ready to use liquid containing 20 g/litre chlorpyrifos	-	To control insects in and around buildings	No products on the market
HSR001810	Flammable liquid containing 2.5 - 3 % chlorpyrifos	-	To control insects in and around buildings	No products on the market
HSR001816	Flammable liquid containing 32 - 50% chlorpyrifos	-	Veterinary medicine	No products on the market

Source: EPA

3.3. Diazinon

Diazinon is a broad spectrum control for insects (cockroaches, silverfish, ants, and fleas) developed in the 1950s as replacement for DDT. In the United States diazinon was extensively used in gardening and for indoor pest control. Residential use in the USA has been banned since 2004.

In New Zealand, diazinon has been used for more than forty years. Products containing diazinon are registered for use as veterinary medicines; as sheep dips, a powder for treating sheep, horses and dogs, and dog and cat flea collars (see Table 4).

Table 4 List of diazinon substances

HSNO approval number	Substance name	Known trade name	Use pattern	Currently in use
HSR001802	Collar containing 140 - 180 g/kg diazinon and 1.7 - 3.2 g/kg pyriproxyfen	PetScience Flea Collar Plus	Flea collar for cats/dogs	Yes
HSR001807	Collar containing 140 - 180 g/kg diazinon	Vitapet 5 Month Water Resistant Flea Collar For Dogs; Vitapet 5 Month Flea Collar For Cats	Flea collar for cats/dogs	Yes
HSR001953	Flammable liquid containing 360 - 440 g/litre diazinon	TOP CLIP 40	To control blowfly strike, lice and keds on sheep and lambs by plunge and shower dips and jetting	Yes
HSR001741	General purpose Insect spray	-	Insect spray	No products on the market
HSR001808	Solid containing 20 - 50 g/kg diazinon	-	Strike powder	No products on the market
HSR002288	Flammable liquid containing 0.26 - 5% diazinon	-	Blowfly dressing	No products on the market

Source: EPA

3.4. Specific proposal

Under the Hazardous Substances and New Organisms (HSNO) Act the EPA is required to regulate hazardous substances that are imported, manufactured or used in New Zealand.

The purpose of the reassessment is: *to conduct a full evaluation of the risks, costs and benefits associated with these* [CCD] *substances*".[11]

Reassessing CCD organophosphates and carbamates for non-crop protection uses will further assist the EPA in:

- identifying those products that have been withdrawn from the market
- understanding the characteristics of specific products
- understanding the costs of withdrawing selected products
- understanding the linkages between organophosphate and carbamate use and human health and environmental impacts
- identifying other issues that have a bearing on withdrawing CCD organophosphates and carbamates (trade and trade policy, role under the HSNO Act of the regulator, and distributional consequences of withdrawing older chemistry).

The fundamental gain from withdrawing chlorpyrifos and diazinon is a reduction in the risk to human health and a reduction in environmental risk. Carbaryl is being withdrawn because it is no longer being used in New Zealand.

In the "without" reassessment situation the level of organophosphate and carbamate use would remain the same in New Zealand.

4. Approach

We have used a cost benefit framework to examine the costs, benefits, and risks of the withdrawal of selected organophosphates and carbamates for non-crop protection purposes from use in New Zealand.

CBA is a long-established technique intended to identify the economic efficiency of a proposed project or policy change. Efficiency is broadly about maximising outputs obtained from available inputs, but there are different variants used in economics:

- **technical efficiency** refers to the most cost-effective way of reducing pesticide poisoning and improving environmental outcomes, for instance, reducing the range organophosphates and carbamates on the market and/or imposing further use restrictions could reduce the amount of money spent on poison related accidents per person
- **allocative efficiency** refers to the ease with which resources can move across economy to their most productive uses. For instance, improved health and safety outcomes by withdrawing selected organophosphates and carbamates may reduce health spending associated with accidental poisoning and increase resources for other parts of the health system

[11] Environmental Protection Authority (2014) Call for Information. www.epa.govt.nz

- **dynamic efficiency** refers to innovation and changing to new activities or new chemistry over time.

If the withdrawal of selected organophosphates and carbamates can reduce the hospital poisoning costs, it will improve technical efficiency. To the extent that it shifts health and environmental resources from one less productive activity to a more productive activity, it also improves the allocative efficiency of resource use. If it also allows new, more efficient ways to control/improve delivery of insecticides it also improves dynamic efficiency over time.

A cost benefit analysis proceeds by comparing effects and outcomes associated with the withdrawal of selected organophosphates and carbamates against what would have occurred under a counterfactual, without the proposed change. This counterfactual can be described as a projection of the status quo into the future as supply and demand conditions change.

4.1. Counterfactual

We need to establish a base line to measure what would happen without the reassessment (the counterfactual). This involves examining in detail the current status quo. It includes a commentary on what exists on the ground at the moment i.e. the existing situation with selected organophosphates and carbamates.

The counterfactual also includes examining the likely future policy developments. While this can be speculative, we have focused on examining recent policy changes and any expectations for future developments. The aim is to identify how policies are likely to change over the next 20 years, to establish a realistic base case.

The counterfactual used here is the regulatory settings prior to any organophosphate and carbamates reassessment for non-crop protection purposes plus any likely regulatory advances that could occur.[12] This will be used as a baseline to measure the potential costs and benefits associated with the withdrawal of organophosphates and carbamates.

Specifically, this means that companies who are currently withdrawing CCD organophosphates and carbamates from the market would not be. Current behaviour suggests that they have second guessed the reassessment process and are withdrawing CCD organophosphate and carbamate products voluntarily.[13] In the baseline case we would also expect that other jurisdictions would be withdrawing organophosphates and carbamates gradually from the market in line with trends over the past fifteen years.

Setting up the counterfactual is difficult because there is:

- limited baseline data from which to measure any change
- uncertainty about what initiatives could be trialled in the absence of the reassessment process
- the unusual nature of the pesticides markets around the world given the:
  - stances taken by regulatory authorities

12 The counterfactual would consider other regulatory policies that have a bearing on pesticide regulation other than further reassessments of organophosphates and carbamates.

13 This has come from a number of unrelated industry sources all of whom would like to remain anonymous.

– the difficulty in identifying reliable harm estimates
– political environment can provide unanticipated regulatory outcomes.

Therefore, there are potentially a number of credible counterfactuals. The one we assume here is open to question, and should be treated as "work in progress". We treat the counterfactual here as a tentative "peg in the ground".

We assume that the regulatory setting would be similar those currently in place without a reassessment process going on. It would also incorporate any changes expected over the over the next twenty years.

In the current status quo, initiatives may reduce the amount of organophosphates and carbamates as time goes on as new softer chemicals are developed. In this case also overseas jurisdictions will remove CCD organophosphates from sale more quickly than in New Zealand.

4.2. Stakeholders

This is a 'partial' cost benefit analysis in the sense that some effects will be too difficult to reliably quantify. For instance, it may well be that there is a benefit to society from the withdrawal of organophosphates and carbamates.

While we can identify these societal benefits (i.e. improved environmental outcomes) as a welfare gain, it is not feasible to value them in economic terms, given time and resources. For practical reasons this analysis has concentrated on effects that are readily quantified and valued, and we have described qualitatively the effects that cannot be readily quantified or valued.

From the feedback from various stakeholders, experience of the private sector, reports to government departments, and other published material a number of costs and benefits have been identified that need to be considered in the CBA, whether they can be quantified or not. A number of groups are considered to be important:

- **users of organophosphates and carbamates**. A potential benefit occurs to this group since we expect less incidents of poisoning
- **producers of organophosphates and carbamates**. A small cost to producers as since they switch to another substance
- **general public.** A benefit to the general public accrues with the knowledge that they may be less exposed to organophosphates and carbamates and that regulatory agencies are being proactive in safeguarding public health
- **the environment.** Less likely organophosphates and carbamates will impact on environmental outcomes
- **producers of agricultural export**. Will gain over the long run be because regulatory regimes and competitor production systems will be comparable with New Zealand i.e. New Zealand will not be an outlier in organophosphate use and therefore not a potential barrier to trade.

5. Costs and benefits

We have focused on the costs and benefits associated with the withdrawal of CCD organophosphates from the market. In this way, stakeholders receive a "big picture" view of the likely costs and benefits.

The frame of the CBA includes a:

- twenty year CBA to cover the foreseeable future
- discount rate[14] of 8%, in line with standard Treasury guidance.

5.1. Costs

The costs have been developed by examining the literature and talking with market participants. Information is scarce and market share information is tightly held (see Pfeffer and Heath, 2010).

We have made a number of assumptions to assist in developing the costs. Of particular importance is that the number of substitutes on the market is large; therefore, the costs of swapping from one product to another are negligible.

The removal of CCD products is unlikely to cause major costs for users. To illustrate this point, below we set out the number of substitutes for diazinon in the various markets.

Table 5 Number of Alternatives to Diazinon

Alternatives to control ectoparasites on sheep	Alternatives to control ectoparasites on dogs and cats	Alternatives to control ectoparasites on horses
11	14	4

Source: Pferrer and Heath (2010)

One possible issue is that the reassessment of CCD organophosphates and carbamates for non-crop protection purposes leads to the reassessment of all "cheaper" organophosphates and carbamates on the market. Of particular concern is controlling ticks, which the cheaper organophosphates are particularly effective in treating.

It is likely that other organophosphates and carbamates will be reassessed at some stage. A potential way around this problem is the use of a permission system where a suitably qualified person (such as a veterinarian) can be delegated power to authorise the use of older chemistry in specific circumstances (including diazinon). Assuming that the chemistry is available or easily imported from a reliable source, then this could be a cost effective way of withdrawing older chemistry and reducing potential harm but allowing some exceptions to maintain flock health.

[14] The discount rates reflects the time value of money i.e. $1 today is worth more than a $1 next year. The discount rate reflects the time value of public money and is currently set at 8%.

Another consideration is that the costs of some substitute products can be higher but this is mitigated by an improvement in quality.

The newer chemistry is also more expensive. However, in most situations it is more effective at controlling fly strike. So while the older chemistry is cheaper there is a trade-off between price and quality (effectiveness). In the specific case of veterinary use for diazinon and chlorpyrifos there are substitutes that are available (see Table 6). Therefore the costs of CCD withdrawal are likely to be minimal.

Table 6 Representative Retail Costs of Product Containing the Range of Actives Available for Controlling Louse and Fly Strike on Sheep

Cents per adult sheep/lamb

Active	Plunge or shower dipping (adult)	Jetting (adults)	Jetting (lambs)	Pour-on or applicator (adult)	Pour-on or applicator (lamb)
Diazinon	5 – 6	Na	2 – 4	Na	Na
Chlorpyrifos	5 – 9	Na	Na	Na	Na
Propetamphos	5 – 6	Na	Na	Na	Na
Pyrethroids	Na	Na	Na	21 – 86	15 – 58
Spinosad	15 – 30	40	16	No data	No data
Ivermectin	Na	61	No data	Na	Na
Diflubenzuron	24	40	No data	65 – 194	32 – 65
Triflumuron	Na	No data	No data	46 – 58	22 – 28
Cyromazine	24 – 57	32	No data	105 – 140	34 – 50
Dicyclanil	Na	Na	Na	151	No data
Note: Diazinon, chlorpyrifos, and propetamphos are all organophosphates.					

Source: Pfeffer and Heath (2010)

Carbaryl is a pesticide which is used across multiple spectrums. This reassessment examines non-crop protection carbaryl products such as home garden/wasp killer products. Costs are minimal with this pesticide as there are multiple substitutes.

In summary, the withdrawal of CCD organophosphates and carbamates are likely to have negligible costs given the wide range of substitutes and the continued withdrawal of these products from the market. One possible longer term cost is the potential for some substitute products to be more expensive. This will become more of concern if other substitute organophosphates and carbamates are reassessed. This could be mitigated if a cost effective way is developed to allow limited use of older organophosphate chemistry (a permissions system).

Therefore the removal of CCD organophosphates and carbamates from the market is unlikely to create costs for New Zealand farmers and dog and cat owners.

5.2. Benefits

Understanding the benefits of withdrawing selected organophosphates and carbamates from the market is fraught with difficulty. The data is poor[15] and there is controversy over their human impact where the scientific evidence ranges from inconclusive to a probable harmful impact.[16]

The benefit focus[17] is on exposure of users (typically farmers, farm workers and the children of farmers and farm workers) to organophosphates and carbamates for non-crop protection purposes.

Unfortunately, the information and data we have does not allow us to distinguish between individual organophosphates and carbamates and their uses therefore the benefits are characterised as the impact of a general removal from the market (Hazardous Substances Surveillance System data).

Studies of the potential impact of organophosphates and carbamates and regulatory reviews and updates are relatively frequent since the mid-1990s. So the spotlight on their use has not diminished. The benefits may occur in a number of areas. These include a reduction in:

- long and short term acute poisoning
- prolonged low level exposure
- detrimental environmental effects.

Below we set out what we know about the benefits of withdrawing CCD organophosphates from the market.

5.2.1. Acute poisoning

The literature and expert opinion is unequivocal about the impact of acute exposure to organophosphates and carbamates[18] to the point where the World Health Organisation has develop a comprehensive code of conduct for diagnosis and treatment of pesticide poisoning.[19] For neuropsychological outcomes, peripheral neuropathy and psychiatric illness there is overwhelming evidence to show substantial harm can be caused by acute exposure to organophosphates.

Some of the harm effects are discussed briefly in Section 2.1.3. Organophosphates kill an estimated 200,000 people each year from self-poisoning in the developing world. This is about 15% of the total numbers poisoned. The bulk of non-fatal cases exhibit neuropsychological outcomes, peripheral neuropathy and psychiatric illness.

To illustrate this point Table 7 sets out the differences in information/expert opinion (if any) on acute poisoning. There is no disagreement between expert opinion and the scientific evidence. These products are designed to attack the nervous systems of

15 The Centre for Public Health Research at Massey University runs the Hazardous Substances Surveillance System (HSSS) on hospital data relating to hazardous substances. The data has only limited use since it does not identify the product that caused hospitalisation.

16 Note the discussion in section 2.1, particularly on chronic use.

17 That is, the benefits of withdrawing organophosphates and carbamates.

18 See for example http://emedicine.medscape.com/article/167726-overview ; http://www.ncbi.nlm.nih.gov/pmc/articles /PMC2493390/ and http://www.bmj.com/content/334/7594/629

19 See http://www.who.int/whopes/recommendations/IPCSPesticide_ok.pdf

insects and mammals. Acute exposure will cause a harmful reaction depending upon the degree of exposure in the short and long term.

Table 7 Amount of Agreement on Acute Poisoning

		Amount of evidence (number and quality of independent sources)		
		Limited evidence	Medium evidence	Much evidence
Level of agreement (on a particular finding)	High agreement	Na	Na	Many papers setting out the impacts of acute poisoning e.g. COT (1999 & 2013), Eddleston (2008) and all expert opinion
	Medium agreement	Na	Na	Na
	Low agreement	Na	Na	Na

Source: NZIER

New Zealand data does not tell us which organophosphate or carbamate is responsible for the poisoning incident. From CPHR data we only know how many people were poisoned by organophosphates and carbamates. However, withdrawing CCD organophosphates and carbamates will have some positive impact. To understand the magnitude of the impact we have:

- examined the number of organophosphate poisoning cases between 2006 and 2010 (70 according to CPHR HSSS data)
- taken out those to do with self-harm (approximately 20%). We assume that no access to CCD organophosphates is not barrier to self-harm
- divided by 5 to get an average annual impact (11.2 poisonings a year)
- multiplied the average stay in hospital – typically one day ($4,648 per day)[20] by the number of poisonings (11.2) equalling $52,000 per annum.
- assumed this benefit over the foreseeable future (20 years) and discounted by 8% equalling approximately $500,000 (present value).

We have taken the present value figure ($500,000) calculated above and applied an expected value to the estimate (see Appendix A) to reflect our uncertainty about the benefit i.e. the reduction in exposures that require hospital treatment as a result of withdrawing CCD organophosphates and carbamates. The expected value ranges between 5% and 100%. The actual value will be at the lower end of the scale because:

- replacing CCD organophosphates and carbamates with other products may be just as harmful (e.g. other organophosphates)
- not all poisonings are associated with CCD organophosphates and carbamates which are under review.

20 http://www.pharmac.health.nz/assets/pfpa-v2-1-cost-resource-manual.pdf Updated to 2014 dollars.

Since we are only able to monetise hospital stays we see this as a very conservative cost[21] e.g. we have not included any estimate of the costs associated with the long term effects known to be a potential consequence of acute organophosphate poisoning. Also international literature suggests that poisonings are under reported in many instances (Busby and Eckstein, 2009).

We have no data on under-reporting in New Zealand, although the EPA has alluded to the problem of under reporting in previous reassessments.[22] In the United States critics of current statistics suggest that figures are unrealistic and under represent the actual number of poisonings. Farmers and farm workers are less likely to report harmful exposure unless they are gravely ill. Contributing to this problem is that doctors misdiagnose overexposures as stomach flu, bronchitis or asthma. Some critics even suggest that undiagnosed cases of farm-worker exposure may outnumber diagnosed cases (Busby and Eckstein, 2009).

5.2.2. Prolonged low level health impacts

Understanding the health impacts of low level chronic exposure has not been easy and work continues particularly in the United States and Britain. Also this work is at the boundaries of scientific knowledge.

The EPA[23] is concerned with the potential health effects from the risk of short and long term exposure. The degree of exposure is measured by well established methodologies used to carry out the risk assessments. Where these assessments indicate that the risks are greater than the acceptable level, regulators will consider action.

This is why when studies conflict, regulators have been more inclined to restrict use and sometimes ban chemicals even if cause and effect has not been fully established.

To illustrate the conflicting information,

21 Other costs include emotional and physical harm unrelated to hospital stays, benefits of knowing organophosphates are being withdrawn from the market (existence values), and productivity losses (including ancillary costs of medical treatment e.g. travelling cost to and from hospital and the costs of raising taxes to fund public health.

22 EPA (2013) Decision. Application for the Reassessment of a Group of Hazardous Substances. 27th June 2013

23 Like other regulators in the industrialised world.

Table 8 sets out the differences in information/expert opinion on chronic poisoning. There is disagreement within expert opinion and the scientific evidence on the impact of chronic exposure (see section 2.1.3).

The CPHR HSSS does not distinguish between chronic and acute poisonings, although we have assumed that most cases are acute cases represented in the HSSS figures.

This has not been used in quantifying the CBA because we do not have any data that allows us to illustrate the benefit value. It is very difficult to conclusively determine that chronic exposure to a particular chemical has caused illness in a person. People are exposed to a range of chemicals every day and other factors such as diet, lifestyle and genetic dispositions all play a role in affecting people's health.

Table 8 Amount of Agreement on Chronic Poisoning

		Amount of evidence (number and quality of independent sources)		
		Limited evidence	**Medium evidence**	**Much evidence**
Level of agreement (on a particular finding)	**High agreement**	Na	Na	Na
	Medium agreement	Na	COT (1999 & 2013) finds evidence inconclusive	Ross et al (2013) finds significant evidence of chronic impacts. US EPA (2014) finds evidence – particularly chlorpyrifos.
	Low agreement	Na	Na	Na

Source: NZIER

5.2.3. Detrimental environmental effects

We have little information on the environmental impacts of CCD organophosphates and carbamates used for veterinary purposes. The EPA has identified diazinon (sheep dip) as the main environmental concern, particularly runoff from treatment stations and holding paddocks and disposal. While localised, the environmental impact of diazinon while it remains toxic could be significant.

Another possible cost is the residues on wool (diazinon) since it may focus attention on farm practices and limit export eco-labelling potential.

6. Other issues to be considered

We have not conducted any sensitivity analysis on the quantified figures because of the lack of quantified information. There are a number of other factors that need to be taken into account in when assessing the risks, benefits and costs of reassessing CCD organophosphates and carbamates for non-crop protection purposes. These are examined below.

6.1. Trade and trade policy issues

In a recent submission to the EPA on organophosphate and carbamates plant protection insecticides, Beef + Lamb New Zealand and the Deer Industry New Zealand (p4 paragraph 2.6) state that they are: "*not aware of any concerns among overseas customers about the continued use of organophosphates in New Zealand to control insect*[s]".

While this statement is geared towards pasture protection it could also be true for veterinary uses of organophosphates and carbamates. However, the statement only holds for the short run. This CBA needs to consider how things might change over the foreseeable future.[24]

6.1.1. Practices undertaken by competitors

New Zealand has invested heavily at being an "insider" in world trade i.e. our rules and regulations conform to those in our (mainly industrialised nation) markets and competitors such as Australia. This has allowed New Zealand to trade in those often restricted markets despite the strict biosecurity, hygiene and other regulations within those markets. Many of New Zealand's potential competitors cannot match this e.g. Latin American beef suppliers are unable to get rid of foot and mouth disease.

However, if New Zealand is using chemicals that our competitors are banning or severely restricting the use of, New Zealand needs to take notice. We do not want our major competitors differentiating themselves in the market in a way that suggests they have a higher quality and safer product.

A good example of this is the Australian restrictions on diazinon. Diazinon restrictions were motivated by the risk the chemical poses to rural workers.

The main issue is that New Zealand is using diazinon for sheep dipping and the Australians are not.

6.1.2. New Zealand is a policy taker in world markets

It is generally accepted that New Zealand is policy taker in world markets. If regulators act to developed new standards of some description[25] in our major markets, New Zealand typically has to conform to those standards whether or not they are based on solid science or not.

If New Zealand practices differ substantially from our major markets and regulatory action is initiated which puts New Zealand producers in a more difficult position (i.e. the adjustments to organophosphate and carbamates use are much larger and cause much more disruption in New Zealand) then it becomes a policy consideration.

6.1.3. Trends in organophosphate and carbamate use

A further consideration is trends in organophosphate and carbamate use in major markets. This is a particular concern for older organophosphates and carbamates such as the CCD organophosphates and cabamates introduced into New Zealand in the 1950s and 1960s.

The withdrawal of these organophosphates and carbamates in the developed world could trigger regulatory authority or buyer action that disrupts the marketing efforts.

None of these issues are likely to be bought to bear in the next five years. However, New Zealand policy settings need to be aware of the micro steps occurring in our major markets and by competitors and adjust their settings accordingly.

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24 We have used 20 years to equate to the foreseeable future.

25 For example in the late 1970s European authorities prescribe new hygiene standards for New Zealand meat works. They did not apply the same standards to their own meat works until many years later.

6.2. HSNO Act considerations

A key issue for decision makers is the degree of certainty required by the regulation before a substance is withdrawn. Where regulation is precautionary in nature then legislation may require regulatory action. In the case of US of Ethyl Corp v EPA the judge commented:

"*where a statute is precautionary in nature, the evidence difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific knowledge, the regulations designed to protect the public health, and the decision that of an expert administrator, we will not demand rigorous step-by-step proof of cause and effect*" Busby and Eckstein, 2009, p62.

In New Zealand the HSNO Act states:

"All persons exercising functions, powers, and duties under this Act, including but not limited to, functions, powers, and duties under sections 28A, 29, 32, 38, 45, and 48, shall take into account the need for caution in managing adverse effects where there is scientific and technical uncertainty about those effects". Section 7: amended, on 31 December 2000, by section 4 of the Hazardous Substances and New Organisms Amendment Act 2000 (2000 No 89).

This suggests that there is a need for caution to protect human health and environmental outcomes and that cause and effect do not need to be firmly established before regulators act in withdrawing substances.

6.3. Distributional issues

In the New Zealand, typically (although not in all cases) those marketing older chemistry are smaller New Zealand companies, while newer chemistry is marketed by much larger foreign owned multinationals.

The withdrawal of older CCD organophosphates and carbamates is more likely to impact on smaller New Zealand firms marketing the products. However, this issue is mitigated somewhat by the flexibility of New Zealand companies as they can move from marketing one product to another.

7. Results

The section above has indicated the basis on which the CBA has been developed. The results are summarised below. On the basis of the central "conservative" assumptions, the quantified analysis returns a net benefit.

However, the robustness and representativeness of the analysis is influenced by:

- substantial gaps in the data
- any bias and errors in information provided by participants (employers, employees and government workers)[26]
- the potential magnitude of unquantified benefits, such as benefits associated with trade policy benefits over the longer term.

7.1. Costs

Table 9 shows that there are minimal costs associated with farmers moving to substitute products. They can either move to other organophosphates and carbamates or newer chemistry, which in some cases are more effective.

Manufactures also face similar minimal costs in moving from one generic to another. The withdrawal of CCD organophosphates and carbamates will impact more on smaller companies; however we expect these companies to adapt quickly and move to other activities or other chemicals.

The costs of removing CCD organophosphates and carbamates from the market are small.

7.2. Benefits

The quantified benefits stem from the avoided medical costs associated with poisonings. These are expected to be between $25,000 and $500,000 but at the lower end of this scale.

However, these quantified costs do not take into account other costs associated with poisonings e.g. emotional and physical harm, unrelated to hospital stays, benefits of knowing organophosphates and carbamates are being withdrawn from the market, and productivity losses including ancillary costs of medical treatment e.g. travelling cost to and from hospital and the costs of raising taxes to fund public health. It also does not include the potential long term costs of health effects subsequent to acute poisonings or the potential impact of on-going chronic exposure to organophosphates and carbamates.

There are also other costs associated with environmental damage (small) and other non-market values such as existence values (i.e. the benefit of knowing that regulators acting responsibly).

[26] To try and avoid bias and errors we asked a standard set of questions of each interviewee and where possible cross-checked answers with different sources.

Potentially an even larger long term benefit is to ensure that New Zealand's environmental practice does not deviate from policies and practices developed by competitors (e.g. Australia) and in New Zealand's major markets. Being an outlier in organophosphate and carbamate use over the longer run might mean that we incur significant adjustment costs if these products are banned or competitors obtain a marketing advantage from non-use of selected organophosphates and carbamates.

Table 9 Summary of Costs and Benefits

PV 8% over 20 years

Costs		Benefits	
Farmers		**Users**	
Switching to other substances	Small, potentially very small if a low cost permission's system is introduced	Health values	Small between $25,000 and $500,000
Manufacturers		**Non-use values**	
Switching to other substances	Negligible cost	Environmental, existence[1], and other non-use values[2]	Environmental impacts: nationally small but could have significant localised impacts
Impact on smaller companies	Although smaller companies are more flexible and move quickly into new activities mitigating this cost	**Economic welfare**	
		Trade and trade policy benefit	Small in the short term (next five years), potentially large over time, particularly if New Zealand becomes an outlier in organophosphate use
Overall impact			**Small monetised gain of between $25,000 and $500,000. Other gains potentially are greater, particularly long term trade and trade policy gains**
Note (1) Benefit to the New Zealand public knowing that organophosphate use is being managed appropriately. (2) For example, bequest value for the general public. Knowledge that a regulatory framework dynamically adjusts over time for future generations i.e. it reflects current scientific knowledge and balances the costs and benefits.			

Source: NZIER

8. Conclusions

Of the components that could be plausibly quantified, results suggest that expected benefits of withdrawing CCD organophosphates and carbamates for uses other than plant protection outweigh the costs.

The principal benefits included:

- avoidance of acute poisoning from CCD organophosphates and carbamates
- a potential reduction in the long term impacts of acute poisoning
- a potential reduction in possible chronic poisoning from CCD organophosphates and carbamates. The EPA risk assessment shows that exposure to operators undertaking sheep dipping, jetting and shearing (diazinon) may be above acceptable levels
- environmental benefits, particularly restricting the use of diazinon for sheep dipping
- small non-use benefits for the general public knowing that potentially dangerous pesticides are being proactively managed and that the regulatory regime will assist in avoiding adverse health outcomes and environmental outcomes
- significant longer term trade and trade policy benefits by ensuring New Zealand does not become an outlier in CCD organophosphate and carbamate use. Being an outlier increases the risks of New Zealand produce being excluded or sold at reduced prices in selected markets.

We must stress that there are limitations in the quantified analysis due to the lack of information available on the benefits. The robustness of the analysis is influenced by the potential bias in the information provided. However, it also excludes quantified information on some of the key benefits, such as the potential value of chronic organophosphate and carbamate poisoning, because they could not be quantified or cause and effect have not been sufficiently established.

Of further importance is the precautionary nature of the HSNO Act. Cause and effect do not have to be established before decision makers act on reassessment. The HSNO Act requires caution in managing adverse effects.

The figures in this report should be regarded as an order of magnitude calculation rather than a definitive measure and the analysis can use improved information if it becomes available.

9. References

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http://www.pharmac.health.nz/assets/pfpa-v2-1-cost-resource-manual.pdf

Appendix A Expected value of acute poisonings

Table 10 Expected value calculations for the cost of hospital visits

Total cost of all organophosphate poisonings discounted (8%) over 20 years	$511,109
Percentage level	Expected value
5%	$25,555
10%	$51,111
15%	$76,666
20%	$102,222
25%	$127,777
30%	$153,333
35%	$178,888
40%	$204,444
45%	$229,999
50%	$255,555
55%	$281,110
60%	$306,666
65%	$332,221
70%	$357,776
75%	$383,332
80%	$408,887
85%	$434,443
90%	$459,998
95%	$485,554
100%	$511,109

Source: NZIER