A NATIONAL CADMIUM MANAGEMENT STRATEGY FOR NEW ZEALAND AGRICULTURE

Dr G J Rys, on behalf of the Cadmium Working Group

Ministry of Agriculture and Forestry, PO Box 2526, Pastoral House, Wellington
gerald.rys@maf.govt.nz

Background

Cadmium is a non-essential, naturally occurring heavy metal. It is found in trace amounts in air, water, soils and some foods. Cadmium is also a naturally occurring impurity in most phosphate sources, and cannot be removed from phosphate fertilisers economically. With continuous phosphate applications, gradual accumulation of cadmium in soil may occur.

Because of its potential for toxicity to humans and other living organisms, concerns have been raised on the effects of gradual long term accumulation in soils. Other than industrial exposure, accidents and smoking, the major route of cadmium intake for humans is through food or water (Bramley,1990; McLaughlin *et al*, 2000).

History of cadmium policy in New Zealand agriculture

In the early nineties, concerns were raised in New Zealand (Bramley,1990) and by the OECD (OECD, 1995) about cadmium in agriculture. From 1991, kidney's from sheep older than 30 months of age have been discarded from the human food chain in the New Zealand meat industry. Significant New Zealand research was carried out during the late nineties to quantify soil and plant cadmium levels (Grey *et al*, 1999,2001,2003; Loganathan *et al*, 1999; Longhurst *et al*, 2004; Roberts *et al* 1997, 2002)

Since 1995, the New Zealand fertiliser industry has had in place voluntary limits for the level of cadmium in fertiliser. From an initial level of 340 mg Cd/kg P between July 1995 – Dec 1996, levels were stepped down gradually to an upper limit of 280 mg Cd/kg P from Jan 1997 onwards. Industry has consistently been below the voluntary limit and now averages about 180 mg Cd/kg P. From 2001, independent audits on fertiliser cadmium content were incorporated into the Fertmark scheme administered by the New Zealand Fertiliser Quality Council.

There was renewed interest in cadmium in the mid-2000s due to Regional Council concerns about historical accumulation in soils and ways to prevent or manage ongoing accumulation (Kim, 2005). The Chief Executive's Environmental Forum established the Cadmium Working Group (CWG) in 2006, made up of central and regional government, agriculture sectors and fertiliser industry representatives.

The CWG was tasked with assessing the potential risks surrounding cadmium in New Zealand's agriculture and food systems, and to develop responses. Three reports were produced covering: the risks to New Zealand agriculture and horticulture, an update on the current levels of cadmium in New Zealand agricultural soils, and a final report setting out the CWG's strategy for managing cadmium over the long term (100 years).

Cadmium Working Group report one – risk assessment conclusions

The CWG's first report (Report of the Cadmium Working Group, 2008), concluded that cadmium in foods currently does not pose a risk to human health in New Zealand. In respect of trade, there is a small risk of exceeding food standards for cadmium in some offal types and some vegetables. However, the CWG felt that if soil cadmium is not addressed, there are risks in New Zealand falling behind the cadmium standards of our trading partners and subsequent damage to our clean green reputation. Also not addressing soil cadmium accumulation may pose risks to the future ability to subdivide land for residential or rural residential purposes, and could affect the ability of landholders to grow certain types of produce.

Current soil cadmium levels

A review (Taylor *et al,* 2007) of available soil data gave a current natural background level of 0.16 mg/kg of soil (range 0 – 0.77mg/kg). The national average across all soils was 0.35 mg/kg of soil (range 0 - 2.52 mg/kg). The national average accumulation rate from 2003 to 2008 was estimated to be 5 µg/kg soil/yr. This is lower than the historical accumulation rate due to a reduction of cadmium concentration in fertilisers i.e. the fertiliser industry voluntary limit below 280 mg Cd/kg P, and lower phosphate application levels. In general, cadmium levels reflect the levels of phosphate application in the various farming systems.

The Cadmium Management Strategy

The objective of the Cadmium Management Strategy (Report of the Cadmium Working Group, 2011) is "***To ensure that cadmium in rural production poses minimal risks to health, trade, land use flexibility and the environment over the next 100 years".*** The **s**trategy's approach is to focus on the key risk areas of:

- Protecting human health.
- Maintaining trade access and a vibrant productive agricultural sector.
- Maintaining flexibility in land use options.

Protecting the environment, particularly soil health and function, groundwater and natural ecosystems.

The strategy identifies two main strands of risk (Figure one) dealing firstly with health and trade, and secondly with land use flexibility and environmental risks. These two risk areas are monitored through a) a food monitoring programme, and b) soil and fertiliser monitoring programmes. This provides key information for identifying problems and threats, which can be addressed thought education and management programmes. The strategy was independently reviewed (Warne, 2010).

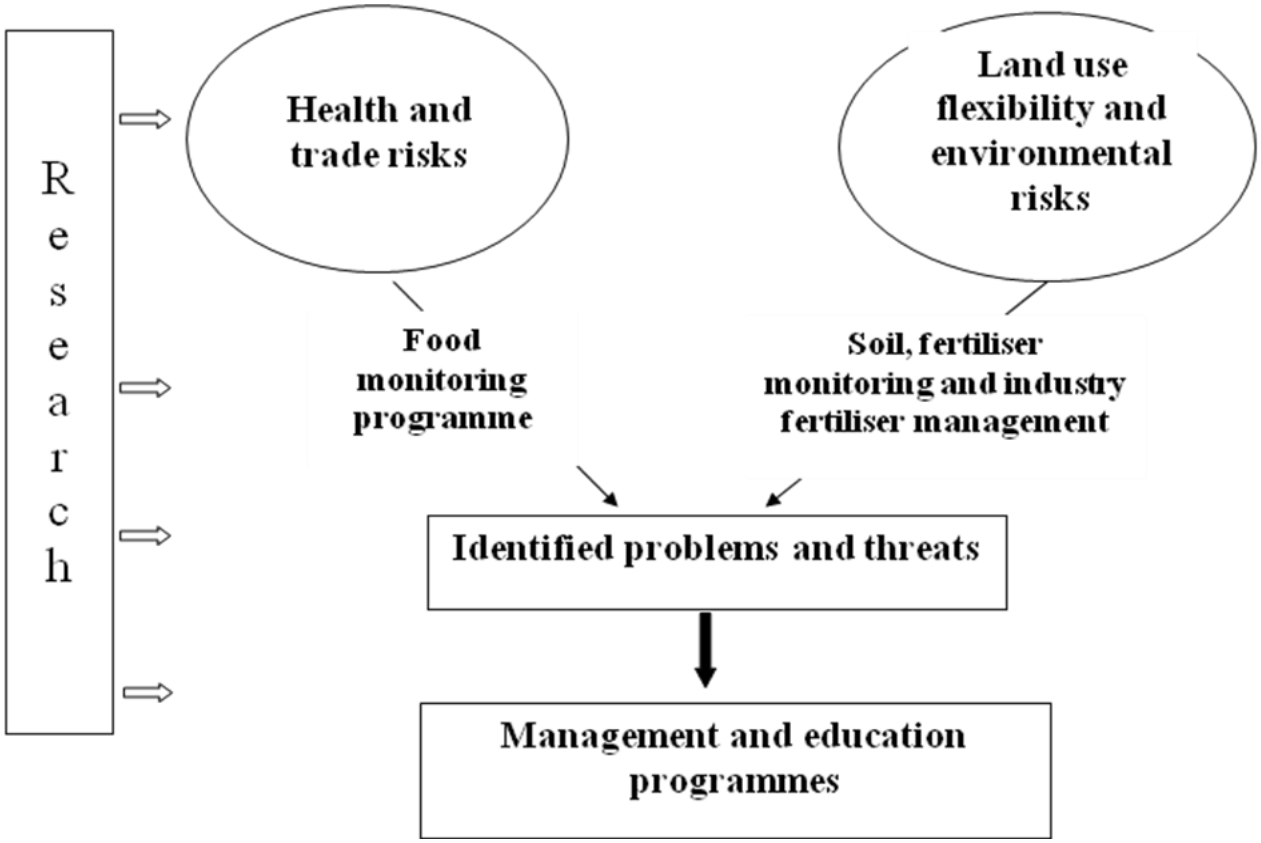
Cadmium Management Strategy work programmes

The strategy comprises a number of work programme that cover:

- Governance
- Food Monitoring
- Fertiliser Management
- Management and Education
- Environmental Monitoring and Research

The strategy work programmes are summarised in appendix one.

Figure one: Structure of the National Cadmium Management Strategy



Governance

The governance part of the programme aims to oversee the strategy and ensure that the component work streams, organisations and agencies are co-ordinated and resourced. The Governance work stream will ensure that priorities, actions and resources are in place to meet the objectives of the strategy. Its major elements are discussed below.

A Cadmium Management Group (CMG) will be established, to replace the CWG, comprising all key stakeholders in rural production and environmental management. Members will represent sectors rather than organisations. The CMG will meet at least annually and more frequently if necessary, and will report annually to the Director General of MAF and relevant stakeholders.

The CMG will ensure that all agencies are acting in a co-ordinated manner to deliver on the aims of the strategy. It will define requirements and set priorities on:

- Research
- Monitoring (food, soil and fertiliser)
- Implementation of strategy
- Communications, information and education

The CMG will co-ordinate communications that:

- Explain the issues and risks associated with cadmium.
- Describes how the cadmium management strategy addresses those issues and how it fits with the programmes of its members.
- Describes the roles of the Cadmium Management Group.
- Provides updates on information derived from the monitoring and research programmes
- Provides information for landholders on cadmium.

The CMG will develop and implement a strategy to ensure the risk based guidelines for management of cadmium are in place by 2017. The CMG will liaise between industry groups, research funding agencies and research organisations to ensure that the research priorities of the Cadmium Management Strategy are implemented.

The CMG will liaise with agencies over the regulatory framework for cadmium. It will work with MFE, MAF, industry groups and regional councils to develop and refine regulatory approaches towards national consistency to managing cadmium to ensure the protection and sustainability of our agricultural systems as well as the wider ecosystems in which they operate. The CMG will also advocate for consistency of regulatory approach among agencies managing cadmium.

The CMG will periodically review the relevance and appropriateness of the Cadmium Management Strategy. It will lead a major review of the Cadmium Management Strategy in 2017 that includes a wider group of stakeholders. This review will assess the:

- Performance of the strategy in managing risks related to cadmium.
- New information which has arisen on cadmium impacts and management to determine whether the objectives or work programmes should be altered.
- The effectiveness of the governance arrangements.

Food Monitoring

Food monitoring is the primary tool for ensuring that risks from cadmium to human health and trade that derive from food for sale are adequately managed. Since these risks could be significant, both to the community and the economy, it is essential that the food monitoring programme is well formulated and able to address all foreseeable risks, but it needs to do so in a cost effective manner. The Cadmium Management Strategy will implement a three level approach to monitoring, based on identifying and managing cadmium risks shown in Table 1.

Level 1 - Identification – Total Diet Study (TDS)

The TDS is the best indicator available for the status of cadmium in New Zealand diets (Vannort & Thomson, 2005). The TDS is undertaken on a 5 yearly basis, and involves sampling from supermarkets and other retail outlets of representative foods in the New Zealand diet. The data is collated on an individual product and calculated on a whole diet basis.

The CWG intends that the TDS continues as the first line risk management approach for cadmium in food. However, it is of key importance that we are able to discern trends in the data from this survey, because good trend information will provide long lead times to understand what action is required. This trend information is needed both at a dietary level and for individual products.

The objectives for the TDS are to:

- Continue with the five yearly survey, with periodic reviews to ensure that the timing and sensitivity of the programme are appropriate.
- Ensure that the testing, data collection and storage, and analysis are able to provide trend information on changes in cadmium status.
- Ensure that information is available at the total diet and product group level, and for specific risk groups in the population.
- Monitor the status of cadmium in overseas trading partners to enable comparison with New Zealand product and health status.

Table 1: Monitoring Risk Management Framework

Level		Type	Source	Aim	Responsibility
1	Identify	Total Diet Study (TDS)	Dietary exposure via synthesised model diets	Primary screening for risk to consumers. Understanding of trends in Cd in NZ diets at a mean and sub-population basis	MAF
2	Assess	Specific risk product surveys (SPRPS)	Risk products identified by TDS and by other information	Assess level of risk to trade and human health	MAF and industry, depending on product and survey requirements
3	Manage	Apply interventions and reduce risks	Confirmed risks from SPRPS	Ensure trade and human health risks are below acceptable threshold	Industry, with MAF input in high risk situations

Level 2 – Assess

The TDS is useful as a primary screening process, but it would be expensive and unnecessary to upgrade it to the point where it was able to fully assess the risks for each product group. For this reason the CWG proposes a second tier monitoring programme targeted at specific products. These target products would be selected on the basis of:

- Information from the TDS.
- Known risk products that are important from a trade perspective, including ones that are not currently addressed by MAF.
- Monitoring information from overseas that indicates risk products.
- Other information such as soil monitoring data, varietal information or management practices that may raise risks, particularly in sensitive trade areas.

Once target products have been identified, MAF and the relevant industry body will enter into negotiations to determine the:

- Monitoring requirements
- Responsibilities
- Funding

MAF will provide assistance and advice but will not necessarily undertake the monitoring. However, they will provide oversight to ensure that risks to human health, and collective risks to trade for New Zealand's image are well managed.

Traceback of products to individual producers may well be incorporated at this stage, although this will be dependent on survey design and testing. It is intended, however that the monitoring programme will assist with understanding of why particular products exceed maximum levels and correcting this where necessary.

The objectives for the Level 2 monitoring are:

- Assess level of risk from specific products.
- Ensure that trade in those products is protected.
- Ensure that NZ's collective trade risk from damage to its image is managed appropriately.

Level 3 – Manage

Once specific risks have been established, a programme will be established to ensure that the risks are managed to acceptable levels. This level of monitoring will link closely with management and mitigation programmes on farm. The objective of this level of monitoring is to provide information to support management and mitigation interventions, including traceback where required to the farm level.

Programmes at this level will be very specific to the product type and risk level. These programmes will be developed by MAF and industry, with responsibility determined according to the nature of the product and the level of risk. Where industry undertakes responsibility, MAF will continue to provide expertise and oversight.

Soil and Fertiliser Monitoring and Fertiliser Management

Soil Monitoring
Soil monitoring is the primary tool for determining the ongoing status of cadmium in New Zealand, and the way it is accumulating over time. Monitoring of soils will be undertaken by a number of organisations:

- Fertiliser industry as part of industry self management
- Regional councils as part of their State of the Environment monitoring
- Research organisations.

The industry self management programme will involve regular soil testing for cadmium as part of the management system. The sampling depths from the industry programme and the monitoring undertaken for State of the Environment reporting are not fully aligned, and the appropriateness of the monitoring depth should be addressed by the review for the interim guidelines and at the 7 year review for the risk based guidelines.

Responsibility

- FertResearch – co-ordination
- Fertiliser companies – soil testing
- Regional councils – State of Environment reporting

Fertiliser Monitoring
Fertiliser monitoring is an important part of managing cadmium build up and base information for a mass balance approach to understanding cadmium behaviour in the soils and environment. A fertiliser monitoring programme is currently undertaken by the NZ Fertiliser Quality Council. The role of the Fertiliser Quality Council is to provide the independent Fertmark auditor who as well as monitoring nutrient levels, also monitors cadmium levels in all phosphate fertilisers. This is done through a combination of fertiliser company reporting from their own laboratories and Fertmark random testing at dispatch points throughout New Zealand, using the Fertmark laboratory testing methods. All results are reported to Fertiliser Quality Council.

Responsibility
Fertiliser companies will continue to test cadmium levels in product using Fertmark testing methods, and this will be reported to and audited by the Fertiliser Quality Council. This represents a continuation of the current management arrangements for fertiliser. The Fertiliser Quality Council will provide the fertiliser monitoring information to the Cadmium Management Group on an annual basis.

Fertiliser Management
Given that phosphate fertilisers are a primary source of cadmium to agricultural soils, it is appropriate to develop programmes that manage cadmium accumulation. The proposed programme is industry based and aims to ensure that cadmium is maintained at levels in the soil where it poses a low and acceptable risk to the health of the soil and maintains its suitability for use for agricultural purposes.

The fertiliser programme is based on a tiered system. The *Tiered Fertiliser Management System* (TFMS) is a system for linking soil cadmium levels to management action. It was independently reviewed (Warne, 2010). The management tiers are based on increasing soil cadmium levels, with specific fertiliser recommendations to address loading rates at each tier. It aims to ensure that soil cadmium levels remain within a recommended range of values over 100 years.The TFMS has four tiers.

At:

- Tier 1, there are no limits on the application of phosphate fertiliser other than a five yearly screening soil test for cadmium status. The trigger value to move to tier 2 - 0.6 mg Cd/kg soil.
- Tier 2, application rates are restricted to a set of products and application rates to manage accumulation, so that cadmium does not exceed acceptable threshold within the next 100 years. Landholders are required to test for cadmium every five years using approved programmes. The trigger value to move to tier 3 - 1.0 mg Cd/kg soil.
- Tier 3, application rates are further managed by use of a cadmium balance programme to ensure that cadmium does not exceed an acceptable threshold within 100 years. The trigger value to move to tier 4 - 1.4 mg Cd/kg soil.
- Tier 4, above tier 4, no further accumulation of cadmium is allowed. The trigger value - 1.8 mg Cd/kg soil.

At Tiers 2, 3 and 4 landholders will be required to use a set of management practices to limit the risks posed by cadmium to the food chain and environment. These management practices will link with the management and education work programme and the food monitoring programme.

The Cadmium Working Group recognises the value of the tiered system in raising greater awareness of the issues of cadmium for landholders, in reducing the rate of diffuse accumulation in agricultural soils, and in managing bioavailability of cadmium when soil concentrations are elevated. The trigger values at which tiers are implemented will correspond to the guideline values for cadmium management in agricultural soils in New Zealand. The process for identifying these guideline values and associated sampling protocols was determined by an independent review (Warne 2010).

Responsibility

Industry will implement the tiered management strategy and will report to the CMG on key elements of the strategy, and particularly on progress in ensuring that cadmium accumulation is as low as is reasonably achievable[1].

Management and Education

In order to address risk areas once they have been identified, a management and education programme will be developed. Where problems are identified in particular soils or produce, there is a need to ensure that growers are equipped to respond with appropriate strategies. There is no intention at this stage to undertake a broad scale education programme, but rather

[1] As per the ALARA ("as low as is reasonably achievable") principle used in food safety.

to target information to specific problem properties and products. A requirement for specific mitigation strategies will be triggered in one of two ways:

- Risk product groups where exceedances have been identified through the food monitoring programme.
- High soil cadmium levels identified in the soil monitoring programme.

Where this occurs, the CWG intends that there will be a specific process developed to ensure that risks to the food chain are appropriately managed. The development of the mitigation strategies is seen largely as an industry responsibility, with input from research agencies and the MAF. The mitigations may include:

On farm

- Use phosphate fertilisers with low levels of cadmium.
- Maintain soil pH at the upper recommended limits for crop type.
- Maintain high organic matter in soil.
- Alleviate any zinc deficiency in the soil.
- Avoid fertiliser blends and irrigation water containing high levels of chloride.
- Use crop varieties which have a lower level of cadmium uptake.

Off farm

- Product testing;
- Product exclusion;
- Product mixing.

It is anticipated that the research programme will refine and develop the range of practices available for managing cadmium uptake.

Education of farmers/growers will be undertaken on an individual basis using existing one on one advisors. The key routes will be:

- Fertiliser representatives.
- Industry extension personnel
- Regional council land managers.

Each industry sector will develop access to the necessary resources (fact sheets, management guidelines) to assist advisors and farmers/growers.

<u>Responsibility</u>
Primarily the responsibility will lie with industry organisations in conjunction with fertiliser representatives. MAF will have a support and oversight role. MfE, MAF, regional councils and other agencies will provide support and assistance in their statutory roles.

Environmental Monitoring and Research

Environmental Monitoring

There is a need for more information on the status and impacts of cadmium in the wider New Zealand environment at present. The key needs are for a groundwater monitoring programme and research monitoring of cadmium status (and impacts) in other parts of the environment.

Several regional councils are intending to begin monitoring for groundwater, but it would be useful if there were a standardised system in place for periodic inclusion of cadmium in the list of items tested in groundwater monitoring programmes. It would also be useful if this information were collated centrally for use by agencies and the CMG.

Monitoring of cadmium in the environment will initially form part of the research programme on cadmium environmental impacts. The results of that research will determine the nature and extent of any further monitoring programmes in this area.

ResponsibilityRegional councils – groundwater monitoring.Research agencies – environmental monitoring.MfE – facilitate the standardisation of testing and collation of data.

Research

The research work stream underpins all the other work programmes. The research priorities break down into three key areas that approximately correlate with immediate, medium and long term priorities. The research will be prioritised to fit into the risk based guidelines development.

Immediate research– Knowledge required to improve management of cadmium

This knowledge will support the monitoring, management and mitigation work streams, and will be closely related to the information that comes out of the monitoring and traceback programmes. Key research priorities include:

- Information about soil cadmium concentrations.
- Pathways and transport mechanisms within soil and the soil-plant-animal systems in a New Zealand context, particularly in the context of identified exceedances.
- Soil management techniques to minimise cadmium uptake.
- Varietal variation in cadmium uptake with a view to exploiting genetic variation in uptake[2].
- Cost-benefit analysis of risk-based approaches to managing cadmium.

Medium term research– Information needed to review the strategy

The strategy will be reviewed in 7 years, and it is important that the group is at that stage able to assess the success of the strategy, and to understand whether it adequately addresses the risks faced. The major issues in this medium term priority relate to those areas not addressed currently in the strategy, particularly the environmental and groundwater impacts of cadmium.

[2] Plant breeding will be a key tool for growers of high risk crops, because it is well understood that particular varieties of plant appear to have high cadmium uptake rates, even in relatively low soil cadmium levels. Where specific product lines are identified as at risk in the NZ situation, it is important that industry work with plant breeders to assess current varieties to see if they are accumulators and to include cadmium as a selection trait. Although breeding is a long term solution, because of the long lead times, the linkages between industry and plant breeders needs to be established at an early stage. Low cadmium varieties represent a simple, effective and easily adopted technology for the management of cadmium risks.

However, information is also required for the CMG to understand whether the current focus on food monitoring as the primary risk management tool is appropriate, and whether a soil based approach is potentially effective and desirable.

Key medium term research priorities are:

- Understanding of cadmium levels suitable for different land uses and animal classes.
- Environmental and ecological impacts of cadmium both *in situ* (soil organisms) and in the wider ecosystem.
- Risks from cadmium in groundwater in relation to drinking water standards.
- Cost-benefit analysis of the cadmium management strategies and alternative actions.
- Soil cadmium balances and appropriate tools.

Long term research

The working group recognises that the continued build up of cadmium in New Zealand soils is not an ideal situation, even if it is unavoidable at present. The drivers in the most sensitive jurisdictions tend toward less and less acceptability of environmental harm and the presence of potentially harmful substances in food products. Furthermore there are important drivers in the fertiliser industry that may reduce the attractiveness of single superphosphate as a phosphate source. These include the presence of other undesirable trace elements, potential for more restricted access to low cadmium phosphate rock suitable for single superphosphate, and increased transport and application costs that reduce its cost advantage.

The group considers it important that longer term research is implemented focused in areas that may lead to no net accumulation of cadmium in soils. There are a number of New Zealand specific areas of research that may be profitable to pursue, particularly if implemented in conjunction with other industry priorities. Potential areas of research include:

- Alternative sources of low cadmium phosphate.
- Remediation approaches where this may be necessary.
- Understanding of the costs and benefits of a strategy of no net accumulation.
- Increasing the efficiency of phosphate use.

Responsibility

Different parts of the research programme will be implemented according to the priorities of the member bodies. The CMG will be responsible for ensuring that the full portfolio of research is implemented in the near term. MAF and MfE will take an active role in persuading government funded research agencies to put more research emphasis into cadmium. This will involve co-ordination among the bodies represented on the CMG, and communication with key research funding and provision organisations. It will be important to identify this as a priority in organisation's research strategies as well.

Conclusions

The strategy presents an exemplar of industry / regional and central government cooperation in the development of a non-regulatory approach to address the accumulation of an element that has the potential to be an issue in the long term. It recognises that some elements need to be considered over the very long term, and sets out to establish a mechanism and processes to achieve this.

Membership of the CWG and acknowledgements

Fonterra, HortNZ, Meat and Wool NZ, Federated Farmers, Arable Food Industry Council, MAF, MfE, NZFSA, FertResearch, Ravensdown, Ballance, Environment Waikato, Greater Wellington Regional Council, Environment BOP, Environment Canterbury, Taranaki Regional Council. The Cadmium Working Group was chaired by Dr John Helstrom.

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The New Zealand Food Safety Authority was restructured with the Ministry of Agriculture and Forestry from 1 February, 2011. All references to MAF in the text are to the combined MAF.

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Appendix 1: Summary of Cadmium Management Strategy Work Programmes

Work Programme	Risks addressed	Method	Key features	Responsibility	Implementation milestones
Governance	Human health, trade, land use flexibility, environment	Strategy management	Cadmium Management Group with all key stakeholders	Convened by MAF	Meet annually
		Risk based guideline development	Risk based soil guidelines	CWG. MFE, Industry	Completed in line with 7 year review of strategy.
Food Monitoring	Human health, trade		Total Diet Study, and specific monitoring of risk products. Management practices introduced where ML exceedances occur	NZFSA, with assistance from industry groups	Underway, report in late 2011. 5 yearly thereafter
Soil and fertiliser management	Land use flexibility, environment	Soil Monitoring	Regular soil testing,	Fertiliser industry, regional councils	Immediate implementation, annual reporting.
		Fertiliser Monitoring	Regular testing and 6 monthly fertiliser audits	Fertiliser Quality Council	6 monthly reports. Ongoing, annual report to CMG.
		Interim Guidelines	Independent international expert commissioned by CMG.	Convened by MAF with MFE	Develop interim guidelines for adoption by CMG by 30 September 2010
		Fertiliser management	Tiered fertiliser management system aligned with interim guidelines: 4 trigger values: 'a' trigger value - 0.6 mg Cd/kg 'b' trigger value - 1.0 mg Cd/kg 'c' trigger value - 1.4 mg Cd/kg 'd' trigger value - 1.8 mg Cd/kg	Fertiliser industry	Immediate implementation, annual reporting on management actions. Industry to develop indicators by first reporting period.
Management and Education	Human health, trade, land use flexibility, environment		Management practices to minimise the risk of cadmium to food chain and environment	Industry, with oversight from NZFSA	6 months for implementation. Inclusion in training courses.
Environmental Monitoring and Research	Human health, trade, land use flexibility, environment	Environmental monitoring	Programme to be developed to determine impact on groundwater and environment	Regional Councils	12 months, EW to co-ordinate.
		Research	Research to address immediate requirements as well as longer term needs. Information to be developed for review in 7 years.	Cadmium Working Group – MAF, MfE with MoRST	12 months - review of science and data needs funded by parties.