Frequently Asked Questions:

1. How much harm does farming do to the environment?

Harm is a value-laden judgement regarding community expectations for a stream relative to the impact of a contaminant load (e.g. kg). We use a series of indicators for water quality, which include the nutrients nitrogen (N) and phosphorus (P), sediment and the faecal indicator bacterium – *Escherichia coli* (*E. coli*), but alone or in combination they may not indicate poor water quality. One way to quantify contaminant inputs to streams is to compare losses to those expected under reference conditions - that is if we were not here and land was covered in native bush. A recent assessment [1] showed that on average the percentage of contaminant losses (as median concentrations) caused by humans was:

Indicator	Mean human impact (%)	Range (%)
E. coli	54	40-85
Dissolved reactive-P	38	0-66
Total-P	47	0-68
Sediment (suspended)	64	26-88
Nitrate-N	77	32-91
Total-N	65	24-83

It is fair to say that farming was probably the major cause of these inputs. However, the load depends on catchment conditions, climate and farming practices. There is so much variation (see range) that loads in an agricultural catchment in one part of the country could be lower than under reference conditions in another part of the country.

A more important factor to consider is that a contaminant load has different effects on water quality depending on other factors. For example, periphyton (algae) respond to the concentration of N and P in streams, but only grow if the water is warm and there is ample sunlight and stable flows [2].

2. How did we get in this state?

All human interaction with water will have some impact, often in very small ways, but when those activities involve the use or generation of contaminants in large quantities, the risks of adverse effects on water increase substantially. Farming is such an activity, although there is much variation in impact, depending on things like the type of farming, the way it's carried out, its proximity to water, the soils underlying the farm and its vegetation cover [3]. So farming in New Zealand has been affecting water quality for over 150 years, and in some cases, the impacts of land use undertaken many years ago are only being seen now as contaminants work their way through the environment [4]. However, intensification of land use and land use change, particularly of pasture-based systems such as dairying, over the last 20 years or so has greatly increased pressure on our water resources [5]. Intensification requires increased use of inputs like fertiliser, and generates more contaminants such as animal dung and urine. When managed well, greater intensification does not necessarily lead to greater contaminant loss. However, when losses do occur they tend to be exacerbated by intensification. More and larger animals also have the potential to cause physical damage to paddocks and stream banks [6, 7].

However, if we also look back over the last 50 years there are many drivers that have led us to the current state of water quality. These include:

- Strong economic incentives (e.g. building of infrastructure) to change land use towards more profitable, but high loss uses. Much of this has been driven by decades of low profitability from drystock and forestry operations;
- A lack of high-profit, low-footprint alternative land uses;
- Policy uncertainty in how low farmers must reduce contaminants losses; and
- A slow recognition by primary industries to internalize some of the water quality issues.

The Challenge can assist in correcting each of these drivers.

3. Is it as bad as people say it is?

Reports on the state of water quality [5, 8, 9] use indicators to give a picture of water quality by its components. These indicators are pitted against nationally-derived standards (currently the national objectives framework [10, 11]). A conservative approach was taken in setting the bands within the National Objectives Framework. This is understandable given our wish to maintain or improve our generally good water quality and our unique biodiversity. The data indicates that at many sites one or more of the indicators have breached standards for good water quality. These tend to be associated with agricultural landuse, but the data also shows that some indicators such as P (and sediment) are improving. Furthermore, compared to other developed nations with large primary sectors such as the US, median nitrogen and phosphorus concentrations in our large rivers are lower [12, 13].

4. What do we know about the various contaminants?

Key freshwater contaminants are:

- **Sediment:** fine soil eroded from paddocks, arable fields or forests;
- **Nutrients:** Nitrogen and phosphorus from livestock excreta, soil and fertilizer; and
- **Bacteria:** Indicated by the proxy – *Escherichia coli (E. coli*) from dung.

In urban environments, contaminants enter water bodies mainly through stormwater and wastewater networks, illegal connections to the networks, and leaky pipes, pumps and connections [9].

In agricultural catchments, landuse and landuse practices influence the amount of contaminants that are transported into our water bodies through run-off and artificial drainage networks or via groundwater. Commonly, sediment, phosphorus and *E. coli* are lost by run-off or through artificial drainage networks, while nitrogen is lost as nitrate to shallow or deep groundwater [3] and may be transported to surface waters and/or lost as gaseous emissions in the form of di-nitrogen (N_2) or nitrous oxide (N_2O), a greenhouse gas.

Sediment comes off the land and clogs up the rivers making them brown and dirty, but the biggest impact is that the sediment then forms a mat over the bed of the stream, and cuts off all the habitat for the life in it.

High concentrations of nitrogen and phosphorus promote aquatic algae and plant growth; some algae are toxic. In addition, very high concentrations of nitrate can be toxic to fish and macroinvertebrates.

Most strains of *E. coli* are not toxic, but *E. coli* is found in the intestines of mammals, and is well correlated to pathogenic microbes such as *Campylobacter* sp. This makes it an excellent indicator of faecal matter if detected in rivers or lakes. Therefore, concentrations of *E. coli* are used to assess the risk of activities in freshwater such as wading or swimming to public health.

5. What has science been doing about it, and how has it helped?

Science has focused on quantifying the magnitude of the problem, isolating where the problem occurs and is most problematic and on providing solutions to mitigate the loss of contaminants from land and their effect in water. For instance, we know that for the contaminants listed above dairying loses more N than drystock farming, but sediment could be just as high if not higher from drystock. Landuses practices such as spreading farm dairy effluent onto wet soils that results in loss through artificial drainage networks can result in a considerable amount of a catchment's *E. coli* load (e.g. 58%) [14]. However, there is a simple fix to stop this – apply at low rate and when the soil can absorb the effluent [15].

Science has come up with over 40 strategies to mitigate the loss of contaminant from land to water [16]. We also know that the majority of contaminants come from a small area of the farm – called critical source areas. If we target out mitigation strategies to critical source areas we can increase the cost-effectiveness of mitigations by 6-7 times [17]. Indeed, modelling has shown that targeting mitigations to critical source areas and applying mitigations on the basis of cost-effectiveness (not subjective assessments) can enable us to achieve large reductions (30-50%) in N and P losses at minimal cost (< 10% farm EBIT) [18, 19].

When implemented correctly and consistently, we have seen improvements in water quality indicators at a catchment scale. This can take the shape of decreasing sediment or *E. coli* concentrations, or maintenance of N concentrations while the production of milk solids is increasing [20]. As important context, if the farm practices of 10-15 years ago were being used without today's mitigations, farm-scale losses of water quality contaminants such as *E. coli* from newly converted land would be up to 90% greater [14, 15].

6. What can farmers do about it?

Farmers can do three things:

1) Implement strategies to mitigate the loss of contaminants from their land to water. A full list is available here (http://www.mfe.govt.nz/sites/default/files/assessment-strategies-mitigate-impact-loss-contaminants-agricultural-land-freshwater_0.pdf). Over 40 of them have had a full cost-benefit analysis done on them allowing farmers to mix and match the most suitable and cost-efficient strategies for your farm and land and any catchment level targets. Additional strategies are available, but have not been fully tested or priced.
2) Optimise your property by implementing mitigations in critical source areas (areas that account for the majority of contaminant losses, but come from a minority of the farm or catchment) and

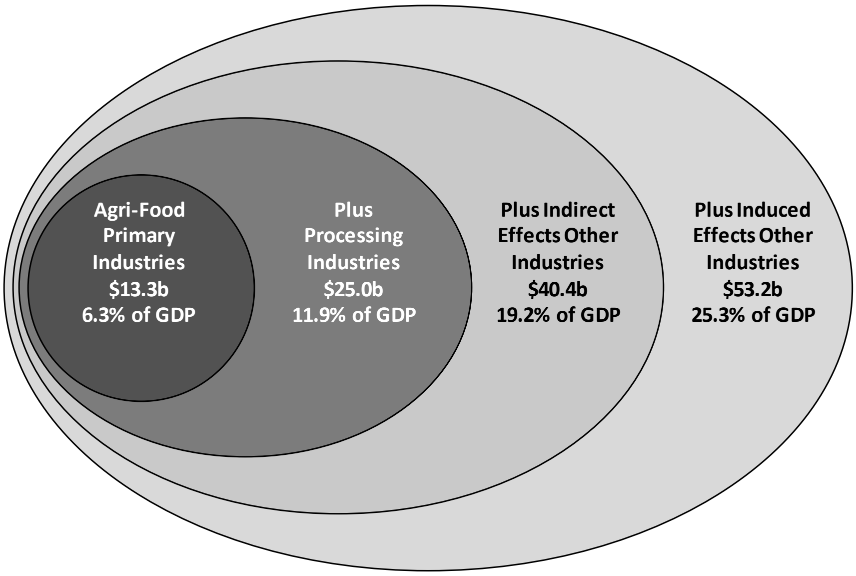
making better use of the productive potential of your land elsewhere. This may include some land use change within the farm.

3) Consider more radical land use change by factoring in the suitability of your land relative to others within or outside of your catchment for high value and low footprint farming systems. Such systems may not be the same as those being used by yourself or immediate peers.

7. What benefits does farming have for NZ?

Farming or agriculture is New Zealand's largest export industry and probably the one it is best known for internationally. Primary production is the backbone of New Zealand's stable and globally competitive export economy. New Zealand is one of the most efficient agricultural economies with a reputation for producing internationally significant research, agricultural practices and products.

Trade is an essential element of our ongoing economic prosperity and our exports of goods and services make up around 30 percent of gross domestic product (GDP). Agriculture directly accounts for over half of our export earnings and 6% of our total GDP. However, when you factor in supporting industries, this increases to a quarter of GDP (see figure [21]). GDP per capita is closely related to export performance. Successful exporting countries generally have high GDP per capita and a standard of living to match. As a result, wages are higher and working hours not too arduous. People enjoy good health, benefits and education and can afford other luxuries of life – modern cars, houses, holidays, leisure goods and other comforts.



We are the largest exporter in the world of dairy products and lamb, and our dairy products account for one third of the global dairy trade. Export revenues total some $36 billion a year and are fast-growing.

Agriculture, forestry, fisheries and related industries employed over 141,000 people in New Zealand (as of June 2015), this is 6% of our total workforce.

8. Why do we need the Challenge?

The Challenge is needed because the quality of our environment is crucial to our quality of life as New Zealanders, and farming is very important to our economy. But our waterways are under increasing pressure and, while at a national level there are some positive indicators, there are also some significant downward trends in water quality. In some parts of the country declines are occurring quite rapidly [9]. At the same time, New Zealand farmers (and New Zealanders as a whole) are deriving only a small proportion of the retail value of what is produced on farm [22]. Most is captured by overseas players. The message from all of this is that we need to do things very differently; how we add and capture value from the things we produce and how (and what) we farm. The challenge is needed because if we are going to make these changes, and make them quickly, we need to gather and share a lot of information with local and central Government, industry and NGOs.

9. What is the challenge going to do over the next 2 years?

The challenge is focussing its research effort on three interrelated areas: see the “Revised Strategy” and “Revised Business and Research Plans” documents on the website for more details. These address the incentives for changing the way we farm, options or choices in how we farm, including potential new farming systems, and the mechanisms and processes we need to enable those changes to take place.

1) Research is needed to understand the ways in which we can create or capture additional value through demonstrating to markets that our products have attributes (including environmentally sustainable means of production) which consumers are willing to pay more for and using the value to incentivise sustainable landuse and landuse practices.
2) In terms of options we are looking at the science to support innovation in farm systems and technologies, and the knowledge base needed to ensure that land uses are appropriately matched to environmental, social and cultural constraints and opportunities.
3) Enablers of change that we are investigating over the next two years include the role of collaborative decision-making in encouraging enduring solutions to land and water issues, and the potential for a mātauranga-centred framework to encourage innovation in Māori land-based economic development.

10. When will we see improvements in water quality?

Research has shown significant decreases in contaminant losses to water can be achieved with mitigations at the farm scale. However, depending on the flow-path taken from the farm to the stream and in-stream processes, there can be a significant delay between imposing mitigations on-farm and improvement in water quality indicators. Furthermore, unless these mitigations are consistently applied across a catchment, decreases will be diluted by those who do not apply them. If implemented consistently in small to moderate-sized catchments, trends would only be detected after 5 years with samples taken monthly [23]. More commonly, 10 years of data are required [20]. However, in catchments where streams are fed by old groundwater carrying nitrate, the time between landuse change and the change being detected in streams may be several decades [4].

The challenge is trying to ensure that beneficial changes are seen at a farm and catchment scale occur faster and in a way that can be predicted so that future objectives can be assessed and reached within acceptable timeframes.

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