F I N A L R E P O R T

Voluntary Greenhouse Gas Reporting Feasibility Study

Prepared for

Ministry of Agriculture and Forestry

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ES 1 Introduction

The Ministry of Agricultural and Forestry (MAF) commissioned URS New Zealand Ltd (URS) and Firecone to complete a feasibility study of voluntary greenhouse gas reporting of agricultural emissions. This report contains the results of that study. Voluntary greenhouse gas reporting (VGGR) is the voluntary monitoring and reporting of agricultural greenhouse gas emissions at the enterprise (farm) level.

The objective of this study is to provide a technical evaluation of different VGGR options open to the government, and for each option, to investigate the cost implications, advantages and disadvantages and any implementation risks involved. This study does not provide a cost benefit assessment of a VGGR system against any stated government policy objective. However, MAF may use the results of this study to assess how a VGGR would meet policy objectives, compared to other policy options.

The project team completed this study in three phases. The first phase comprised investigation and context setting required to outline possible VGGR options. The next phase comprises the description of possible VGGR systems, and the costs and outputs of each system. The final phase comprises high level advice to government if they choose to implement a VGGR system and includes consultation guidance, risk identification and a suggested project plan for implementation.

ES 2 Agricultural Sector GHG emissions in NZ

Agriculture is responsible for almost 50% of New Zealand's greenhouse gas emissions, with emissions forecast to increase. Agriculturally derived CH_4 and N_2O comprise 33% and 16% of current national $C0_{2e}$ emissions. Enteric CH_4 emissions account for 98% of all agricultural CH_4 emissions and emissions from soils account for 99% of agricultural N_2O emissions.

Emissions from agriculture have risen by approximately 1% per year since 1990. On a sectoral basis dairy and sheep are the biggest emitters, followed by beef cattle. Deer and non-ruminant animals (pigs, poultry and horses) are minor emitters.

Methane emissions arise primarily as a by-product of the fermentation of feed in the digestive tract of ruminants. The biggest single influence on emissions per animal is the quantity of feed eaten. Feed type and age also affect emissions per animal.

Nitrous oxide is released from soils in the nitrification/ denitrification process. The quantity of N deposited onto soils is the major determinant of N_2O emissions. Soil type, form of N and environmental factors (temperature, rainfall) are also important drivers.

At present there are no mitigation technologies available to farmers to reduce CH_4 emissions in a practical and cost effective manner. Individual farmers can influence emissions to a limited degree through individual management decisions that affect individual animal productivity and through the number of animals kept.

Experiments have shown that nitrification inhibitors can substantially reduce N_2O emissions but costs are not conducive to extensive farmer uptake. Individual farmers can also influence emissions through a range of management practices e.g. drainage, liming, the use of stand off pads and reducing the N content of diets although these mitigation practices are not easily captured in emission estimates. Individual farmers can influence estimated emissions through individual management decisions that affect individual animal productivity, since this affects N retention and excretion, and the number of animals kept.

To capture the main drivers of CH_4 emissions, a VGGR system requires, as a minimum, to be able to estimate individual animal feed intake in some way and to record animal numbers. The breakdown of animals by age is desirable.

The minimum requirements for estimating N_2O emissions are animal feed intake, N content of the feed and animal performance. It is highly desirable that soil and climatic information be incorporated into any estimation method as these have major effects on N_2O emissions. As the use of nitrification inhibitors is the mitigation method that is best captured via estimates, it is essential that a VGGR records their use and has routines that quantify their impact.

ES 3 Estimating GHG emissions in NZ

Agricultural GHG emissions cannot be measured at the farm scale, they have to be estimated. The multiple influences on emissions and, in some areas, an incomplete understanding of the processes involved means that any emission estimates are subject to large uncertainties. Choice of estimation method selected for a VGGR will have to balance complexity with data requirements.

Emission factors derived from national emission estimates can be used on-farm but they are unsatisfactory since they offer little helpful information either to the farmer or to government.

New Zealand has a well developed national emissions methodology that can, if desired, form the basis of a farm scale recording system. Adapting the current national inventory model for use at a farm scale is a good option for CH_4 given that the current method has the ability to incorporate individual management actions. Adapting the methodology for N_2O may be less suitable because of the simplicity of the methodology approached compared to the complexity and multiple drivers of N_2O emissions. However the inclusion of a more complex approach to estimating N_2O emissions would be possible.

Farm scale models exist for other on farm purposes that could be adapted to predict GHG emissions at the farm scale. Overseer seems to be the most feasible existing model option for use at present since it has an animal component that is similar to the national inventory methodology and an N_2O prediction routine that can go beyond the national inventory. It is also being used on farms now as a nutrient budgeting tool. However Overseer would require significant redevelopment to incorporate a central calculation model and database and would require updating to include new information and to simplify the interface. The DNDC (DeNitrification DeComposition) model is hampered by the lack of an animal component. The Dexcel Whole Farm Dairy Model has no soil routine and is restricted to dairy cattle only. The EcoMod model has both an animal and soil component but is restricted to single animal classes only and is more of a research model than an on-farm tool.

To provide a farm scale GHG emissions estimation method for the VGGR, consideration should be given to development of a new model based on the national inventory methodology or adaptation of the Overseer model. Both options are based on the national inventory method, make good use of existing data and could provide a simple interface.

ES 4 Greenhouse gas reporting systems in other countries

A number of voluntary greenhouse gas reporting systems exist internationally. The purpose of each system varies, but is typically to provide emitters with protection of current reductions against future policy initiatives and/or to allow emitters to receive public recognition for their achievements.

For each system, participation levels are low but are increasing. For the systems reviewed participations rates appear to represent approximately 10-15% of total emissions for that State/Country.

While most systems allow for reporting of non CO_2 emissions from agriculture participation by agricultural emitters has been minimal. The specific reasons for low agricultural participation in each system have not been reviewed, however it may be related to the time and resource requirement required to estimate non CO_2 agricultural emissions. Also there would be little incentive for agricultural organisations to participate in voluntary systems in the relevant countries (Australia, US, Canada) as their emissions would be minor compared to other industrial sources and the benefits of public recognition and capacity building would be less valuable.

A key benefit to participants results from the opportunity to use system resources to calculate emissions and understand mitigation opportunities. This allows participants to prepare for future policy provisions via capacity building and to report their achievements to the public. The international systems reviewed provided this information through a variety of methods including provision of manuals/protocols or online tools to estimate emissions, provision of information online or in publications on mitigation opportunities, creating opportunities for participants to learn from others (e.g. through seminars or publications of case studies on best practice) and/or by allowing participants access to technical advisors. If capacity building is a desired outcome of a NZ VGGR, the system should enable participants to understand the source of their emissions, mitigation methods and effects and be accompanied by adequate training and tools.

The four voluntary systems reviewed provide a range of opportunities for participants to receive recognition from the public for their achievements. This may occur through the use of logos and branding (e.g. Greenhouse Challenge Plus), by enabling participants to report on participation or achievements (e.g. in annual reports) and/or by requiring participants to report on their emissions, mitigation actions and resulting reductions. The opportunity to advertise participation and achievements appears to be a key driver for participants. If public recognition is a desired outcome of a NZ VGGR, the system should enable participants to report their participation to the public, via marketing and branding, participant statements, award schemes, and/or public access to reports.

Two programmes (Greenhouse Challenge Plus and California Climate Action Registry) include online calculation and reporting tools. Online tools simplify the reporting process for participants, provide opportunities for participants to quickly and accurately view their results (i.e. total emissions), and provide opportunities to improve integrity and security of inputs and results.

As participation by farmers in GHG reporting systems in other countries has been very low, careful consideration would be required to identify how to attract or incentive farmers to participate in a NZ VGGR system.

ES 5 Possible incentives and disincentives for farmers

A range of incentives and disincentives exist that will impact on the likelihood of a farmer participating in a VGGR.

Farmers may be incentivised if participating will provide them with information about their emissions, how to mitigate them and how to offset them. Farmers would be further incentivised if the information they receive delivers a co-benefit, for example the ability to improve productivity or nutrient management.

Farmers may also be incentivised if a VGGR system allows them to respond to market concerns over climate change or demonstrate stewardship, via promotion, advertising and verification.

Farmers may also participate if a VGGR system provides a mechanism to protect baseline emission levels against future allocation of emissions units in an emissions trading environment.

Farmers will be less likely to participate if it is difficult or time consuming to gather or input required information. This would occur if farmers are required to provide data they don't already have access to, the system is complex, they are required to enter data for each farm (as opposed to data for a whole business), information reporting requirements are frequent (every year) and if they are required to collect and enter the information themselves and aren't able to use a third party (e.g. an agent).

Farmers will be disincentivised if they are concerned about the confidentiality of their information and suspect participation would lead to loss of market competitiveness.

Farmers may not participate if they feel that the VGGR will lead to excessive government regulation or they are suspicious about the government's motives behind VGGR.

The incentives listed would not appear to be strong enough on their own to outweigh the disincentives sufficiently to encourage a high participation in the VGGR. Incentives to participate would become much stronger if farmers operated in a policy or regulatory environment that penalised emissions and/or rewarded reductions, as the ability to estimate and therefore manage emissions would then become essential to avoid financial penalties.

Design of any VGGR system should aim to maximise incentives and remove disincentives. An assessment framework is provided in this report to assess likely farmer uptake of any particular VGGR system option.

ES 6 VGGR design options

MAF have specified that a VGGR should include the following elements:

- a registry to receive reports for farmer's emissions
- a system for auditing the reports of on farm emissions, including options for contracting this activity to third parties
- a system to report emissions from individual farms or aggregations of them, to farmers, government and the public
- a system to provide advice to farmers to help them with operating the VGGR system and to enable them to reduce emissions.

  The VGGR option that would deliver MAF's requirements at lowest cost to government could be described as a 'core' VGGR system. Variations of that system would cost the government more but would deliver different outputs both to farmers or the government.

  In order to assess outputs and costs to government of VGGR options, URS and Firecone identified a possible core (lowest cost) VGGR option and variations to that option, and assessed costs and likely uptake by farmers of each.

The core option requires farmers to collect information on their farming operations and annually enter this data online or via email. A central database and calculation system would calculate emissions at a farm level and enable farmers to access this information.

The scope of the core option is limited to methane emissions from enteric fermentation and nitrous oxide emissions from animal wastes and fertiliser application. Farmers would be required to collect information on animal numbers, performance characteristics, diet characteristics and soil and climatic factors. Farmers would be able to provide baseline information that would require entry only once. Other information requirements would be annual.

The central database and calculation module would be based on the existing IPCC methodology for estimating methane and nitrous oxide emissions from agriculture, with updates included to allow for inputs of farm level information for nitrous oxide calculations.

The system would enable farmers to access emissions at their farm level, New Zealand regions and the country as a whole. The system would also provide benchmarking information, individual or total emissions sources, individual GHG or total gases and data on farm management practices provided by other farmers.

The system would be verified via annual audits of a small fixed proportion of scheme participants. Technical assistance would be provided via a help desk, web based instructions and roving technical advisors.

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The New Zealand Emission's Unit Registry (NZEUR) software is unsuitable for the purposes of an agriculture sector VGGR without substantial modification. There is unlikely to be any clear benefit in seeking to modify the existing NZEUR software, instead of commissioning the development of a new bespoke VGGR system. However, consideration should be given to any benefits of ensuring that the system used to run the VGGR is capable of transferring emissions data to the emissions registry. MAF may also wish to investigate whether it would be possible to place some or all of the administrative functions associated with operating a VGGR within the Ministry of Economic Development.

Benefits to farmers are limited to an ability to better understand their emissions and mitigation options and the ability to benchmark performance. Costs to farmers would be relatively low. Based on uptake of similar programmes in New Zealand and the potential benefits and costs to farmers we anticipate that only 1-5% (450-2,250) of New Zealand farmers would participate in this option.

The establishment cost to government of implementing the core system is expected to be in the order of $470,000. Annual operational costs are expected to be in the order of $162,000-$212,000.

Options around participation that are likely to increase farmer uptake include delegation of responsibility for the system to a third party (i.e. industry driven rather than government driven), provision of direct incentives and maximisation of market benefits. In terms of changes to scope, an ability to allow farmers to complete nutrient budgeting and GHG emission estimation would increase uptake, as would an ability to protect emission reductions via reporting of specific emission reduction projects. Allowing a third party to enter information, reducing the regularity of reporting requirements and improving the information feedback to farmers are all also likely to result in increased uptake.

It is not possible to assess cost implications for each option; however options that would increase cost to government include the option to allow reporting by farm block, allowing a choice of estimation methodology, incorporating a nutrient budget ability, allowing reporting of specific emission reduction and improving information feedback to farmers. Increased costs for each of these are expected to be in the range of $15,000-$50,000.

ES 7 Consultation guidance

The New Zealand pastoral industry's contribution to climate change is an emotive and political issue amongst the industry. Farmers are aware of the subject area but their attitudes and responses are not strongly formed and not always well-informed. With relation to a VGGR, farmers are liable to be influenced by the attitudes and responses of their industry leaders and spokespeople and will rely on advice from professional advisors and peers. We therefore recommend a staged consultation approach designed to engage leadership and influencers first (stage one) and, as feedback from them is received, refine the consultation approach to a point where it can be taken to the farming community (stage two). MAF may also consider forming a partnership with the leadership organisations to take the consultation to the farming community. We also recommend that MAF use the initial industry consultation stage (stage one) to confirm the feasibility of the VGGR and finalise the high level design requirements of the system prior to wide scale consultation with farmers.

The ideal approach for consultation on the VGGR system would be as part of consultation on a wider strategy for the pastoral sector on addressing greenhouse gas emissions and the issue of climate change.

Industry leadership will encompass industry political organisations and sector leaders, for example federated farmers, levy funded organisations, and processors and marketers. Consultation with industry leaders should be in the form of one to one discussions with key individuals within the organisations.

Industry influencers will include agricultural consultants, science information providers, the servicing sector and professional advisors such as accountants, bankers and other advisors. Consultation with industry influencers should be of a more general nature and should be carried out at group functions and field days that involve a wider range of group members.

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Stage two consultation with farmers could be considered as bridging the transition between consultation and implementation of the VGGR and therefore will have elements of both consultation and early implementation activities. We do not believe that the VGGR system itself would promote sufficient interest to attract farmer attendance at consultation meetings. It would therefore be best to consult with farmers on this issue as part of normal group activity during other industry initiatives for example dairy discussion groups. The ability to show case the system on an example property would be an advantage at this level of consultation as it would take the concept from the abstract or conceptual level to the practical, increasing understanding and enabling improved feedback.

It will be important for MAF to ensure any time and resources are built into a VGGR project plan to enable adequate consultation and to make changes to the VGGR following each consultation round to improve farmer uptake.

ES 8 Risk identification and mitigation

Risks exist at all stages of the project including the design, procurement, engagement, and testing, resourcing, and operational phases. Key risks include a failure to maximise participation via design, inappropriate procurement processes leading to poor system delivery, inability to engage the industry, inadequate resourcing of promotion, consultation or operation of the system and unsatisfactory review and feedback processes. Mitigation measures exist for all risks identified. A more detailed risk assessment should be completed prior at project commencement.

ES 9 Project plan

Prior to commencement of any VGGR development tasks it will be necessary to prepare a project plan identifying specific actions required to implement the VGGR. These include consultation requirements, VGGR development, promotion of the system, provision of technical guidance and system operation. This report identifies key project plan requirements for the core VGGR option.

ES 10 Conclusion

The results of our work suggest that it is feasible for the government to develop and implement a voluntary greenhouse gas reporting system in order to estimate farm level agricultural greenhouse gas emissions. We estimate that the establishment cost of designing and building the core system would be in the order of $470,000, and the annual operation costs in the order of $162,000 - $212,000.

However, for any VGGR option, participation rates are unlikely to be high in the absence of other policy/regulatory initiatives that motivate farmers to reduce emissions. Careful consideration of the likely uptake by farmers is required prior to proceeding with a VGGR.

A VGGR system that is developed and implemented at lowest cost to government is unlikely to maximise participation rates from farmers. Variations to the system may increase participation rates but at increased costs to government. Careful consultation with industry and a well run procurement process will be important for: ensuring adequate participation by farmers; developing the scheme within the indicative budget; and securing the objectives sought by government. Regardless of variations to the system, participation rates may still be low in the absence of financial incentives.

Further assessment of the feasibility of a VGGR system should be completed following clearer identification of required government objectives for such a system.

ES 11 Limitations

URS New Zealand Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Ministry of Agriculture and Forestry. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 13 December 2006 and the letter from MAF to URS clarifying the project way forward dated 26 February 2007. The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions.

This report was prepared between 14 December 2006 and 09 May 2007 and is based on the information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Section 1 Introduction

The Ministry of Agricultural and Forestry (MAF) commissioned URS New Zealand Ltd (URS) and Firecone to complete a feasibility study of voluntary greenhouse gas reporting of agricultural emissions. This report contains the results of that study.

Voluntary greenhouse gas reporting (VGGR) is the voluntary monitoring and reporting of agricultural greenhouse gas emissions at the enterprise (farm) level. Agriculture is responsible for almost 50% of NZ's greenhouse gas (GHG) emissions (MfE, 2006). At present, although agricultural emissions are estimated annually at the national level, there is no formal system in place for farmers to quantify emissions at the farm level. Emission estimates at the farm level would comprise an essential component of any programme designed to reduce emissions and is a pre-requisite for a number of proposals outlined in MAF's public discussion document *Sustainable Land Management and Climate Change* released in November 2006.

The objective of this study is to provide a technical evaluation of different VGGR options open to the government, and for each option, to investigate the cost implications, advantages and disadvantages and any implementation risks involved.

MAF stipulated in their contract that any VGGR option should include:

- a system to report emissions from individual farms, or aggregations of them, to farmers, government and the public
- a registry to receive reports of farms' emissions
- a system for auditing the reports of on-farm emissions, including options for contracting this activity to third parties
- a system to provide advice to farmers to help them with operating the VGGR system and to enable them to reduce emissions.

This study does not provide a cost benefit assessment of a VGGR system against any stated government policy objective.

The project team completed this study in three phases. The first phase comprised investigation and context setting required to outline possible VGGR options. The results of the first phase are contained in sections 3-6 and describe agricultural sector GHG emissions in NZ, available methods to estimate GHG emissions in NZ, GHG reporting systems that exist in other countries and possible incentives and disincentives that might exist for farmers to participate in a VGGR system.

The next phase comprises the description and design of possible VGGR systems, and the costs and outputs of each system. This assessment is contained in section 6. The final phase comprises high level advice to government if they choose to implement a VGGR system and includes consultation guidance, risk identification and a suggested project plan for implementation. This advice is provided in sections 7-9. Section 10 contains a study conclusion.

To complete this study, URS and Firecone subcontracted the services of AgResearch, the AgriBusiness Group and Fronde Systems Group. AgResearch provided input into sections 2 and 3, the AgriBusiness Group provided input into sections 5 and 7, and Fronde provided IT costing information required for section 6.

Section 2 Agricultural sector GHG emissions in NZ

2.1 Introduction

This section describes the key agriculture sources of greenhouse gas (GHG) emissions in New Zealand; methane (CH_4) and nitrous oxide (N_2O). This section includes an overview of the sources of GHG emissions from agriculture, the biological pathways of CH_4 and N_2O and the factors that influence these emissions and the methods to mitigate these emissions. This section concludes with recommendations for minimum data requirements required to calculate CH_4 and N_2O emission estimates at a farm level, for a VGGR in New Zealand.

2.2 Background to New Zealand agriculture

Agriculture plays a major role in the New Zealand (NZ) economy, earning NZ $15.25 billion per annum or 53% of total merchandise exports (Ministry of Agriculture and Forestry (MAF) 2005). In New Zealand, the agriculture and horticulture sector comprises 70,000 individual farms, of these 26% are individually owned, 54% are owned in partnership, 14% are registered limited liability companies and 6% owned by trusts/estates (MAF 2002). Pastoral livestock farming has approximately 45,000 farms, with 13,000 of these being less than 20ha in size. The total number of farms decreased by 10,000 between 1999 and 2002 and there was an approximate 10% fall in the number of livestock farms, although a change in the categorisation of farm types between these two dates makes it impossible to estimate the decline precisely. In terms of the number of animals kept, sheep numbers have been declining in New Zealand since 1982 although the indications are that numbers have now stabilised. Beef cattle numbers are relatively stable whereas deer and dairy cattle numbers have increased in the last 15 years (Table 2-1).

Agriculture is responsible for almost 50% of NZ's greenhouse gas (GHG) emissions and these emissions have been rising at approximately 1% a year since 1990 (MfE, 2006). Current industry targets are for year on year productivity gains in the 2-4% range, meaning that agricultural GHG emissions are projected to continue rising into the near future. The Ministry of Agriculture and Forestry released the public discussion document *Sustainable Land Management and Climate Change* in November 2006 (MAF, 2006). In the document, MAF notes that New Zealand needs to act to protect its economic, trade and environmental interests.

At present, although emissions are estimated annually at the national level there is no formal system in place for individual farmers to quantify emissions at the individual farm scale, although several models are available to allow this to happen. Better quantification by individual farmers is an essential component of any programme designed to reduce emissions and is a pre-requisite for a number of the proposals outlined in MAF's discussion document (MAF, 2006).

Table 2-1 Farm number, animal populations and GHG emissions by sector in New Zealand

	Number of farms (2002)[1]	Number of animals, June 30th 2006 (1990)[2]	Number of animal classes[3]	CH_4 emissions (Gg*/annum) 2004 (1990)[2]	N_2O emissions (Gg/annum) 2004 (1990)[2]
Dairy	14000	5,221,400 (3,440,815)	4	406.9 (237.7)	12.8 (7.6)
Beef	13000	4,430,200 (4,593,161)	11	256.7 (235.5)	7.2 (6.6)
Sheep	13000	40,106,800 (57,852,192)	7	430.0 (535.2)	12.8 (15.8)
Beef & Sheep	2000	Included above			
Deer	2300	1,597,600 (976,291)	7	37.8 (18.5)	1.1 (0.52)

*1 gigagram (Gg) = 1,000 tonnes = 1 kilotonne (kt)

2.3 Greenhouse gas emissions from New Zealand agriculture

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, New Zealand is obliged to compile annual inventories of its GHG emissions (refer to Section 3). In the latest nationally published inventory, for the 2004 calendar year (Ministry for the Environment (MfE) 2006), GHG emissions from the New Zealand agricultural sector totalled 36,867 Gg CO_2 equivalent.. This represents 49.4% of all New Zealand's emissions. Agriculture emissions are dominated by methane (CH_4) and nitrous oxide (N_2O). CH_4 emissions account for 32.8% of total emissions (24,473Gg CO_2 equivalent) and N_2O 16.6% of total emissions (12,394 CO_2 equivalent).

CH_4 emissions arise principally as a by-product of the digestion of feedstuffs by farm animals via a process known as enteric fermentation. In 2004, enteric fermentation emissions accounted for 96.9% of all New Zealand's agricultural CH_4 emissions (23,715 Gg). Other sources of agricultural CH_4 are those arising from stored and pasture deposited animal wastes (746Gg CO_2 equivalent), the burning of tussock grassland in the South Island (0.7Gg CO_2 equivalent) and the burning of crop residues from arable farming (11.3Gg CO_2 equivalent). Since 1990 emissions from enteric fermentation and manure management have risen by 10 and 27% respectively while emissions from the burning of tussock grassland and crop residues have fallen by 75 and 40% respectively. Emissions from the burning of tussock and crop residues are so minor that they will not be discussed further (MfE, 2006) (refer figure 2-1).

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1 http://www.maf.govt.nz/statistics/primaryindustries/business-types/index.htm

2 MfE New Zealand's Greenhouse Gas Inventory 1990 – 2004 ; Http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3734.php

3 Clark et al (2003)

N_2O emissions in New Zealand are completely dominated (98.6%) by those arising from nitrogen (N) in animal wastes (10,330 Gg CO_2 equivalent) and synthetic fertilisers deposited onto agricultural soils (1,976 Gg CO_2 equivalent). Small quantities arise from stored animal wastes (63.5Gg CO_2 equivalent), the burning of tussock grassland (0.1 Gg CO_2 equivalent), the burning of arable crop residues (3.7Gg CO_2 equivalent) and the return of N in legume fixing crops, crop residues and the cultivation of organic soils (99 Gg). Since 1990 emissions from agricultural soils have risen by 24.3% and those from manure management by 67%. In contrast emissions from tussock and arable crop residue burning have declined by 75.3% and 42.4% respectively. Since emissions from any source other than agricultural soils are negligible they will not be discussed further.

In addition to CH_4 and N_2O emissions resulting from agricultural activities, NZ agriculture also emits CO_2 and trace quantities of other gases (N_2O, CH_4, CO) from the combustion of fossil fuels. In the national inventory these are not reported under agricultural emissions but as a sub-category (agriculture, forestry and fisheries) under energy emissions. CO_2 emissions under this sub-category in 2004 were 1143 Gg CO_2, an increase of 3.1% since 1990. There are no data available to separate agricultural emissions from the burning of fossil fuels from those of the fishery and forestry sectors. Agricultural activity related CO_2 emissions will not be discussed further as they are outside the scope of the proposed voluntary greenhouse gas recording system.

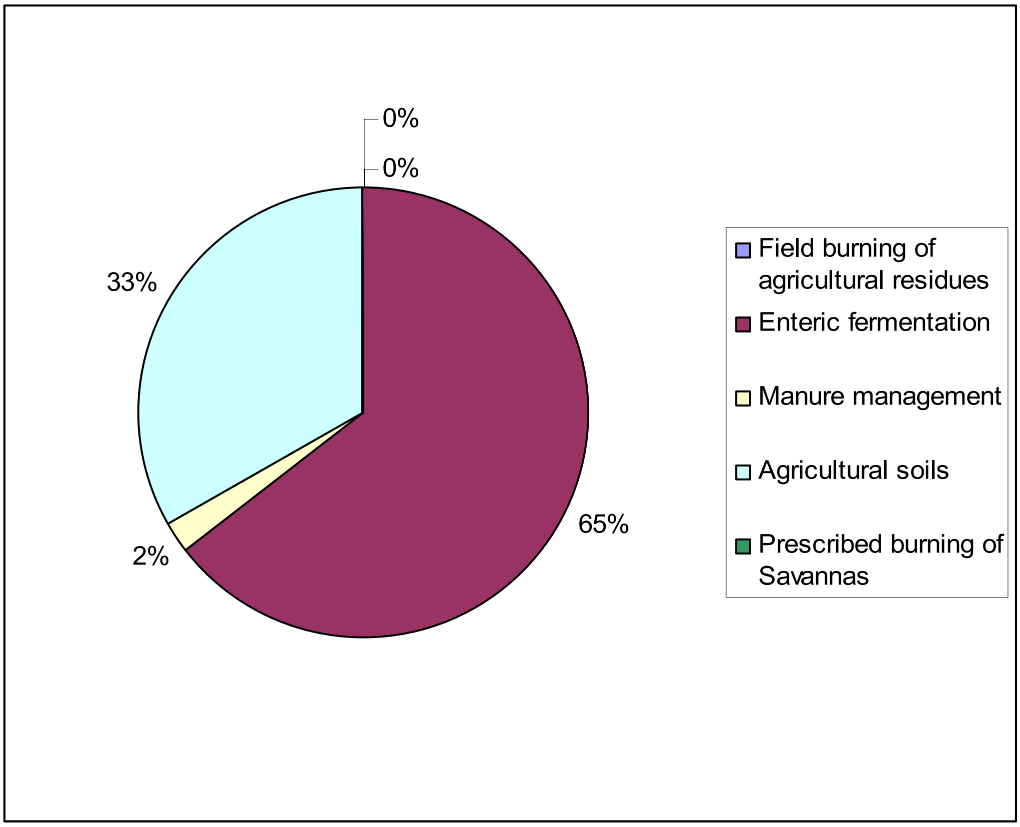

Figure 2-1 GHG emissions from the agricultural sector in 2004 (source MfE, 2006)

2.4 Biological pathways of emissions

2.4.1 Methane (CH_4)

The principle source of CH_4 from ruminants (cattle, sheep, deer and goats) is enteric methane arising as a by-product of the fermentation of feed in the rumen and, to a lesser extent, the large intestine. The rumen contains a large and diverse population of micro-organisms which break down feed to produce volatile fatty acids (VFA's), CO_2 and CH_4. The VFA's produced in the rumen are absorbed and used as an energy source, but most of the CO_2 and CH_4 are removed from the rumen by eructation (belching). Typically more than 80% of the CH_4 is produced in the rumen and the rest in the lower digestive tract (Immig, 1996; Murray *et al.,* 1976). In sheep, 98% of the CH_4 produced is released via the mouth and 2% via the flatus (Murray *et al.,* 1976). The micro-organisms responsible for the production of CH_4 synthesise it from hydrogen, although they do have the ability to use other substrates (Miller, 1995). The removal of hydrogen by methanogens helps maintain a low partial pressure of hydrogen in the rumen without which microbial growth and forage digestion are inhibited (Wolin *et al.,* 1997). As a percentage of the gross energy consumed, 2 - 15% can be lost as CH_4 (Johnson & Ward, 1996), although in temperate forages the range is typically 3.5 – 7.5% (O'Hara *et al.,* 2003). Non-ruminant animals (horses and pigs) also produce CH_4 through enteric fermentation in the large intestine. The quantities emitted by non-ruminant animals are much lower on a unit of feed eaten basis than those produced by ruminant animals because the capacity of the large intestine to produce CH_4 is much lower. In New Zealand emissions from enteric fermentation are dominated by ruminant emissions (Table 2-2), and at the national level emissions from non-ruminant animals are negligible (0.16%).

Table 2-2 Enteric CH4 emissions from New Zealand livestock in 2004 (Source MfE 2006)

Livestock type	Animal population (1000's)	Emission factor (kg CO_2 equivalent/head/ year)	Total emissions from enteric fermentation (Gg CO_2 equivalent /annum)
Dairy cattle	5,119	1668	8,538
Non-dairy cattle	4,528	1180	5,343
Sheep	39,572	227	8,983
Goats	137	189	26
Deer	1,720	462	795
Horses	78	378	29
Swine	385	32	12
Poultry	23,183	0	0
Total			23,725

A secondary source of CH_4 is that arising from the anaerobic fermentation of voided faecal material. In grazing animals, where faecal material is deposited directly onto pastures, only small amounts of CH_4 are emitted per unit of deposited material but large amounts can be emitted per unit of faecal material that is stored prior to being deposited onto land. In New Zealand agriculture ruminant livestock graze outdoors for 365 days per year and most faecal material is deposited directly onto pastures, although in the dairy sector some faecal material is deposited in or around the milking shed and this may be stored for varying lengths of time. Faecal material from horses will be deposited mainly on pastures but that from pigs and poultry will often be stored prior to deposition onto land. Emission factors per head and per animal species per annum are presented in Table 2-3. CH_4 emissions from manure management are negligible for non-dairy cattle and sheep, while pigs have the largest per head emissions, and dairy cattle the largest per annum emissions.

Table 2-3 CH4 emissions from manure management in New Zealand 2004 (Source: MfE 2006)

Livestock type	Animal population (1000's)	Emission factor (kg CO_2 equivalent/head/ year)	Total emissions from manure management (Gg CO_2 equivalent /annum)
Dairy cattle	5119	357	1,827
Non-dairy cattle	4528	15	68
Sheep	39,572	2	79
Goats	137	4	1
Deer	1720	4	7
Horses	78	44	3
Swine	385	420	162
Poultry	23,183	2	46
Total			2,193

2.4.2 Nitrous oxide (N_2O)

Nitrous oxide emissions from agricultural soils arise from nitrification and denitrification processes (Figure 2-2). Denitrification is the stepwise reduction of soil nitrate (NO_3) to gaseous nitrogen compounds, with N_2O being one of the intermediate products (Haynes & Sherlock, 1986). It is an anaerobic process that requires a NO_3 substrate, a restricted oxygen supply and suitable pH and temperature conditions (Firestone, 1982; Mosier *et al.,* 1996). Nitrification is an aerobic process which in most soils is controlled by the availability of ammonium (NH_4) (Schmidt, 1982).

Nitrous oxide (gas)

↑

Ammonia (gas)→Nitrite→Nitrate→Nitrite→Nitric oxide→Nitrous oxide→Nitrogen

(gas) (gas)

Nitrification Denitrification

Figure 2-2 Production of nitrous oxide by nitrification and denitrification (adapted from: O'Hara et al, 2003)

There are two principal sources of nitrogen (N) substrate in grazed pastoral systems; recycled dietary N and applied synthetic fertilisers. Ruminants are relatively poor converters of ingested dietary N into products, and the retention of N in meat, wool or milk ranges from 3 - 25% of the N ingested (Whitehead, 1995). As a result, large quantities of N are re-cycled via excreta deposited directly onto pastures by grazing livestock. The relative importance of these two sources of N substrate to nitrous oxide production is likely to vary markedly from country to country. In New Zealand pastoral agriculture, where there is a strong reliance on the biological fixation of N by forage legumes rather than synthetic fertiliser N, the vast majority of emissions arise from excreta N deposited by grazing animals. Table 2-4 presents detailed data on N_2O emissions by livestock type and emission pathway.

Table 2-4 Nitrous oxide emissions by livestock type and emission pathway (source: calculated from MfE 2006). All figures in Gg CO_2equivalent/annum

	Dairy cattle	Non-dairy cattle	Sheep	Deer	Non-specific	Total
Fertiliser applications						
Synthetic N					1,976[1]	**1,976**
N from lagoons	171				18.6[1]	**189.6**
N from solid storage					5.7[1]	**5.7**
Pasture deposited animal waste	3,809	2,219	3,971	331	.25[2]	**10,330.25**
Manure management						
N from lagoons	.15				1.6[2]	**1.75**
N from solid storage					9.8[1]	**9.8**
Other					37	**37**
Other emissions					103[3]	**103**
Total	**3,980.15**	**2,219**	**3,971**	**331**	**2,152**	**12,653**

[1] No information is available to allocate emissions to a particular sector

[2] Pigs, poultry, goats & horses

[3] Burning of crop residues & cultivation of organic soils

2.5 Factors influencing CH_4 and N_2O emissions

As enteric CH_4 emissions arise as a by-product of a fermentation process the biggest influence on the quantity of CH_4 produced is therefore the amount of substrate fermented i.e. the amount of feed eaten. Thus, at a farm level the biggest factor influencing how much CH_4 a single animal produces is the level of productivity since this governs how much an animal will eat. Total farm CH_4 emissions will therefore be determined largely by the number of animals kept and their level of productivity.

A secondary influence on enteric CH_4 emissions is the type of feed consumed (Blaxter and Clapperton 1965); feeds that ferment rapidly to produce a high proportion of proprionic acid (e.g. cereals) produce less CH_4 than fibrous feeds (e.g. fresh and dried grasses). In the New Zealand situation, where animals graze outside 365 days a year and have a diet that comprises mainly fresh forage, the type of feed eaten appears to have little influence on CH_4 emissions per unit of intake (Clark 2006).

For any given feed, emissions per animal will increase as the quantity of feed eaten increases, although the amount of CH_4 produced per unit of intake does not necessarily remain constant since at high levels of feed intake, with some feeds at least, the increased rate of passage of feed through the digestive tract results in a lowering of the quantity of CH_4 produced per unit of feed (Blaxter & Clapperton 1965). This effect seems to be minor in ruminants fed fresh forage (Clark 2006).

A third factor is age; young sheep (i.e. <1 year old) produce less CH_4 per unit of feed eaten (Ulyatt and Lassey 2005) although the reasons for this are not known.

This means that in practice the quantity of feed eaten and to some extent the age of the animal are the major determinants of estimated CH_4 emissions (Clark et al 2004). However, our understanding of the influence of diet, especially fresh forage diets, on CH_4 emissions is incomplete and measurements of emissions from individuals and groups of animals on a wide variety of diets show considerable variation (Clark et al 2004). At the farm level, the type of diet will have an indirect effect on CH_4 emissions through its effect on feed intake; a higher quality feed (e.g. leafy grass) will have different intake and animal performance characteristics than a poor quality feed (e.g. stemmy grass)

Methane emissions from animal wastes deposited on pastures (faecal material) are determined by the amount of substrate deposited and, to a lesser extent temperature and moisture, which determine the rate at which it is fermented (IPCC 2000). Only small quantities of CH_4 are produced from animal wastes deposited directly onto pastures; the IPCC default value for New Zealand climatic conditions is 1% meaning that very little CH_4 is produced by this route. Much larger quantities of CH_4 per unit of substrate are produced when animal wastes are stored in anaerobic conditions. Fortunately in New Zealand it is only in the dairy sector that animal wastes are stored to any extent; these are wastes deposited in and around the milking shed by lactating cattle and these comprise 5% of the total animal waste produced by dairy cattle. Pig and poultry wastes are stored but our populations of these species are small and emissions correspondingly small. Emissions from stored animal wastes are influenced by the conditions, under which the material is stored, the manner in which it is treated prior to storage and the length of the storage period. At the farm level, the quantity of faecal material deposited onto pastures or stored in some way is determined by the quantity of feed eaten and its digestibility; faecal material = intake x (1-digestibility). Other influences will be treatment prior to storage, type of storage, length of storage and location of the farm.

Nitrous oxide emissions from soils are principally determined by the quantity of synthetic N applied or the quantity of N deposited by animals; at the national scale emissions are calculated as a fixed proportion of the amount of N deposited. Ruminant diets in New Zealand have a high N content because of the presence of N fixing legumes in our pastures and these concentrations are higher than those needed by the animal. Hence a large proportion of the N consumed is deposited back onto pastures in the form of dung and urine. In general, low producing animals (non-growing, non-lactating) will retain a smaller proportion of ingested N than high producing animals (lactating, rapidly growing). At a farm level the N content of the diet will vary in both space and time and be determined by the % clover in the pasture, the quantity of synthetic N fertiliser applied and the non-clover pasture species balance. Synthetic N fertilisers influence the N content of plants (Simba & Alberda 1980), and hence the N content of the diet, although since there is an inverse relationship between legume content and applied N (Ledgard & Steele 1992) in New Zealand the increased use of N fertiliser may not change the N content of the diet in most situations.

In addition to the quantity of N deposited onto pastures the form in which it is deposited also has an influence on emissions; different emissions have been recorded from N deposited as urine or faecal material (see MfE 2006). However, not enough evidence is yet available for New Zealand to apply a differential emission factor for N deposited as urine or faecal material (MfE 2006). There is little farmers can do to influence whether N is deposited as urine or faecal material in grazing animals although some condensed tannin containing species, such as sulla, can affect N partitioning in the animal.

Environmental conditions have a very large influence on N_2O emissions, in particular rainfall, and this interacts with soil type such that water filled pore space is a major determinant of emissions (Kelliher et al 2003). At the national inventory level a standard methodology is applied irrespective of time of year, location or environmental conditions and hence the only influence on estimated emissions is the quantity of N returned/applied. At the farm level this will not be the case and N_2O emissions from the same quantity of deposited N will vary in both space and time.

2.6 Mitigation of CH_4 and N_2O

The current and potential technologies for mitigating agriculture emissions of CH_4 and N_2O in New Zealand have been extensively reviewed (see O'Hara et al 2003; Clark et al 2003; Clark et al 2005) and only a brief summary will be presented here. In New Zealand ruminant animals graze outdoors all year and receive little supplementary feed and so the management options for reducing emissions are constrained. In the northern hemisphere, efforts to reduce N_2O emissions are concentrated more on those from stored manures which make up a tiny proportion of New Zealand emissions. Internationally in the developed world there is little focus on reducing enteric CH_4 emissions from ruminants because (a) they tend to be small compared with industrial emissions and (b) because in many developed countries (e.g. USA, UK & Japan) they are going down due to decreases in livestock numbers.

Reducing the number of animals is the simplest and most effective method of reducing GHG emissions from agriculture although, because of economic considerations, it is unlikely to be the method of choice in New Zealand.

It is possible to manipulate GHG emissions on farm by balancing the number of animals and level of productivity of each animal. From a GHG perspective, it is better for farmers to produce a given amount of product from fewer high producing animals than a larger number of low producing animals. This is because a smaller proportion of the energy consumed by a high producing animal is used for maintenance. By keeping fewer high producing animals the total amount of energy required to produce a given amount of product is therefore less and GHG emissions are correspondingly reduced. For example, in lactating dairy cows O'Hara et al (2003) estimate that a doubling of milk yield from 12kg/d to 24kg/d increases intake per animal by only 48% and reduces emissions per unit of product by 26%. In addition, CH_4 production per unit of intake by an individual animal goes down as the quantity of feed eaten goes up (Blaxter & Claperton 1965) which reinforces the premise that, from a GHG perspective at least, it is better to keep fewer high producing animals. Productivity per animal in New Zealand has increased consistently over time meaning that the amount of GHG emitted per unit of product has also been falling. In the sheep sector meat and wool output has increased since 1990 but emissions have fallen; productivity per animal, and hence emissions per animal have increased, but this has been more than compensated for by decreases in the sheep population. In the dairy sector, emissions per unit of product have decreased but total emissions have increased; emissions per animal have increased as productivity per animal has increased but this has also been accompanied by increases in the dairy cattle animal population. From an individual farmer perspective reducing farm GHG emissions by increasing the level of performance of each animal is only guaranteed to work if animal numbers and/or the quantity of produce produced is controlled.

Changing the type of feed can also reduce emissions; replacing some of the New Zealand forage diet with grain would directly reduce CH_4 emissions and indirectly reduce N_2O emissions (lower N concentration in the diet) but is unlikely to be economic at current grain prices. Manipulating forage species and/or forage quality can influence CH_4 emissions from individual animals but the scope for reductions by these methods appears to be small. Feeding forages with lowered N content and/or feeding forages that change the partitioning of N between that retained and excreted in faeces/urine will reduce N_2O emissions although again the scope for this seems small at the present time.

Modifying the rumen fermentation process can in theory reduce CH_4 emissions. Certain additives (e.g. monensin, fumaric acid) have been found to reduce emissions in some circumstances but so far results in forage fed ruminants have been disappointing. Monensin is used widely in New Zealand as a bloat control agent but efforts to reduce emissions by feeding monensin to New Zealand's pasture fed ruminants have met with very mixed success. Direct modification of the rumen microbial population may also be possible by methods such as vaccination or the introduction of non-CH_4 producing hydrogen utilisers such as acetogens but these methods are in the early stages of development and are many years away from the market.

There is considerable variation between animals in the amount of CH_4 they emit from the same quantity of feed and in the future it may also be possible to breed for low CH_4 producing animals. At present it is possible to identify low CH_4 producing animals experimentally but the stability of the low producing trait has not been established.

For a given management regime any process that reduces the quantity of N deposited or applied to soils will reduce N_2O emissions. Dietary manipulation is difficult in many situations since animals graze 365 days a year but supplementary feeding of such things as grain and maize silage will reduce the quantity of N returned to pastures as these feeds have lower N concentrations than pasture. Maximising productivity per animal and keeping less animals (*cf* CH_4 emissions) also reduces the quantity of N produced as less feed is needed to generate a given amount of product. Reductions by this method are subject to the same constraints as noted above for CH_4 reductions.

Reductions in N_2O emissions can be brought about by manipulating soil conditions (e.g. liming and draining, avoiding compaction) and by avoiding the deposition of N on pastures during wet periods (e.g. the use of stand-off pads in winter, timing of N fertiliser applications). The possible size of reductions by these methods ranges from 4-7% (Clark et al 2001). Reductions by these methods are available immediately although they may be difficult to quantify.

The most promising avenue for reducing N_2O emissions is the use of nitrification inhibitors. Work in New Zealand by Di & Cameron, (2002, 2003) has found that the nitrification inhibitor DCD can reduce N_2O emissions from urine treated grassland by up to 80% following spring and/or autumn applications of urine with or without DCD. This suggests that DCD can be a potent method for reducing emissions from the main source of emissions in New Zealand, urine patches. Products containing DCD are readily available commercially in New Zealand but at present the product costs are such that adoption by farmers is low.

From the above it is clear that for CH_4, although there are some potential methods for directly reducing emissions, the options available now for New Zealand farmers are limited. However, it is important to make a distinction between direct methods that can reduce emissions per unit of feed processed in the rumen and indirect methods that do not reduce emissions per unit of feed but can reduce total emissions. As already discussed above, an individual farmer can alter emissions by balancing stock number and stock performance. Improving the quality of the diet by better pasture management means that less intake is needed to meet a given level of performance and live weights gains are increased and target slaughter weights are achieved quicker. Other indirect methods of reducing emissions are improving reproductive performance so that less replacement animals are kept e.g. lambing/calving animals at a younger age, improving gestation rates. In the short term these indirect methods can be used by individuals to manipulate their farm GHG emissions.

At present nitrification inhibitors offer the best possibility of substantial decreases in N_2O emissions although the costs appear to prohibit rapid and widespread uptake. At the individual farm level however there is scope for smaller manipulations (standoff pads, draining and the introduction of lower N feeds) as well as the animal management methods described in the previous paragraph for CH_4.

2.7 Summary

Agriculturally derived CH_4 and N_2O comprise approximately half of the current national $C0_{2e}$ emissions. Table 2-5 provides a summary of the main components of the agricultural emissions and the influences on these.

Table 2-5 Breakdown of Non CO_2 agricultural emissions and influences on these

GHG emission source	Percentage contribution to overall agricultural sector emissions	Influences
CH_4 from enteric processes	64.2%	Amount of feed, type of feed, age of animal
CH_4 from pasture deposited wastes	2%	Amount of feed, digestibility, pasture temperature and moisture
N_20 from pasture deposited wastes	28%	Diet, animal productivity, soil conditions, climate
N_2O from fertiliser application	5.3%	Soil conditions, climate
Other sources	0.5%	
TOTAL	100%	

Emissions from agriculture have risen by approximately 1% per year since 1990. On a sectoral basis dairy and sheep are the biggest emitters, followed by beef cattle. Deer and non-ruminant animals (pigs, poultry and horses) are minor emitters. Emissions from dairy cows have risen by 76% in the last 15 years while those from sheep have fallen by 20%. Beef cattle emissions have risen by 8%.

Methane emissions arise primarily as a by-product of the fermentation of feed in the digestive tract of ruminants. The biggest single influence on emissions per animal is the quantity of feed eaten. Feed type and age also affect emissions per animal.

Nitrous oxide is released from soils in the nitrification/ denitrification process. The quantity of N deposited onto soils is the major determinant of N_2O emissions. Soil type, form of N and environmental factors (temperature, rainfall) are also important drivers.

At present there are no mitigation technologies available to farmers to reduce CH_4 emissions in a practical and cost effective manner. Individual farmers can influence emissions to a limited degree through individual management decisions that affect individual animal productivity and through the number of animals kept. There may also be options for changing diets and modifying rumen fermentation activity but the research findings in this area are mixed and inconclusive.

Experiments have shown that nitrification inhibitors can substantially reduce N_2O emissions but costs are not conducive to extensive farmer uptake. Individual farmers can also influence emissions through a range of management practices e.g. drainage, liming, the use of stand off pads and reducing the N content of diets although these mitigation practices are not easily captured in emission estimates. Individual farmers can influence estimated emissions through individual management decisions that affect individual animal productivity, since this affects N retention and excretion, and the number of animal kept.

2.8 Recommendations

A voluntary greenhouse gas reporting system for agriculture should focus on emissions of CH_4 and N_2O as these sources comprise nearly half of the current national $C0_{2e}$ emissions. . Further the VGGR should focus on enteric CH_4 emissions which account for 64% of the overall agricultural emissions and N_2O emissions from pasture deposited wastes which account for 28% of the overall agricultural emissions.

The VGGR should also focus on the sectors that contribute the major sources of emissions, that is dairy, sheep and beef cattle.

Desired information inputs for a system to estimate CH_4 and N_2O emissions at the farm level will be:

- Diet (nature and volumes);
- Animal numbers, type and age;
- Animal productivity;
- Soil type
- Climatic factors (rainfall and temperature)
- Nitrification inhibitors.

Section 3 Estimating GHG emissions in NZ

3.1 Introduction

This section contains an assessment of methods that could be used to estimate GHG emissions at a farm scale in New Zealand.

There is no existing tool or system available in New Zealand to specifically estimate GHG emissions at the farm scale. New Zealand follows a methodology to estimate GHG emissions at a national level as part of its commitment to the United Nations Framework Convention on Climate Change. This methodology could be adapted to use at the farm scale to provide the methodology behind the VGGR system.

Farm scale models exist for other on farm purposes (e.g. the Overseer® model used for nutrient budgeting) that could be used to predict GHG emissions. Some of these models adopt the national inventory methodology as a basis for estimating emissions, while others contain different, process based methodologies. The government could choose to adapt one of these farm scale models to provide both the methodology and the interface of a VGGR, or could choose to create a new model and interface based on the national inventory method.

This section contains an overview of the national inventory methodology for both CH_4 and N_2O and contains an assessment of the value of adopting this methodology at a farm scale for the VGGR.

This section then provides an overview of the existing farm scale tools available and assesses, using a number of predetermined criteria, the advantages and disadvantages of adapting an existing model, or creating a new model to provide the basis of the VGGR. Recommendations are then provided in relation to development of a VGGR to estimate GHG emissions at the farm scale in New Zealand.

3.2 National inventory method

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, New Zealand is obliged to compile annual inventories of its GHG emissions. These inventories are externally reviewed to assess whether they comply with international best practice. To help countries develop robust GHG inventories the Intergovernmental Panel on Climate Change (IPCC) publishes guidelines and methodologies that can be followed or adapted to suit national circumstances (IPCC 2000, IPCC 1996). IPCC guidelines are separated into two broad categories; Tier 1 inventories and Tier 2 inventories. Tier 1 inventories are relatively simple inventories that require less data and rely heavily on the use of published default values. Tier 2 inventories have greater data requirements, and use more complex methodologies to estimate emissions for individual circumstances rather than relying on default values. Developed countries such as New Zealand are expected to use Tier 2 inventories wherever possible, especially for sectors where GHG emissions make up a major component of the national emissions. In New Zealand, because of the importance of agricultural emissions to the national emissions profile Tier 2 methods have been developed for both agricultural CH_4 and N_2O inventories.

National emissions estimated using IPCC methodologies are top down estimates that use data aggregated at the national scale. They therefore provide no information at the farm scale; although using default emission factors (e.g. emissions per head of stock) it is possible to estimate individual farm emissions. These estimates however will be differentiated at the farm level by animal population only rather than the broad range of individual circumstances that will influence emissions in practice. To date in New Zealand there has been no concerted effort to estimate national emissions from the farm scale up although some models can be used to estimate emissions at the farm scale.

Section 3 Estimating GHG emissions in NZ

In any discussion on the methods available for estimating agricultural GHG emissions at any scale the following issues are relevant:

- CH_4 & N_2O emissions from agriculture can only be measured experimentally at the individual animal, sub herd or paddock scale – emissions at farm, regional or national scale are estimated
- emissions are not constant over time – CH_4 & N_2O emissions vary hourly, daily, weekly, monthly & annually
- emissions vary in space – patch, paddock, farm & region
- there are multiple influences on emissions – environmental, physical and biological
- the processes influencing emissions are not fully understood.

The above points mean that when deciding on an appropriate method for on-farm estimates the emissions model complexity will have to be balanced with the data required to drive the model. In addition, uncertainties surrounding any estimates are likely to be large.

3.2.1 CH_4 national inventory method

Details of the methods adopted in New Zealand for estimating CH_4 emissions are outlined briefly in the annual national inventory report (MfE 2006); full details for enteric CH_4 can be found in Clark et al (2002) and for emissions from manure management in Saggar et al (2004). Only brief details will be given here. A schematic of the current CH_4 inventory method is presented in Figure 6-2.

The methodology adopted involves three basic steps

1) Detailed categorisation of animal populations using data from the Ministry of Agriculture and Forestry (MAF) annual census/survey. These population models break down the population into species (e.g. dairy cattle, non-dairy cattle, sheep etc) and sub-categories within each species (e.g. breeding ewes, breeding rams, lambs etc) on a monthly basis.
2) Estimation of the quantity of feed eaten by the 'average' animal in each species and sub-category on a monthly basis. This is done by estimating the energy requirements of the average animal using algorithms developed by CSIRO in Australia (SRC 1990). The data needed for these estimations includes animal size, animal age, animal productivity (milk yield, growth rate), and diet quality. Energy requirements can be converted into the quantity of feed eaten from a knowledge of the energy concentration of the ingested diet.
3) Estimation of the quantity of CH_4 emitted per unit of feed ingested. These values are obtained from measurements made on representative groups of animals in New Zealand.

When generating values for the CH_4 national inventory methodology the following approach is adopted:

- emissions from each sub-category each month are estimated from consumed x CH_4 emitted /unit feed x population number.
- total emissions for each sub-category are the sum of monthly emissions
- emissions for each species are the summation of annual emissions from each sub-category; and
- national emissions are the summation of annual emissions from each species.

The only exceptions to the above methodology are emissions from minor species (goats, horses, pigs and poultry) where IPCC or New Zealand derived default values are used.

Emissions from manure management involve steps 1 and 2 above. After estimating the quantity of feed eaten by each sub-category of animal, the quantity of faecal material produced is estimated from data on diet digestibility. Emissions from faecal material are then determined using a mixture of New Zealand and internationally published data. As with enteric CH_4 emissions IPCC default values are used for non-ruminant animals.

The data requirements of the national inventory method are modest although even then data are not readily available in all circumstances and some estimation is required. The data requirements and sources are summarised in Table 3-1. All data are needed at the national level only.

Table 3-1 Data needs and sources for national CH4 inventory

Data needed	Dairy cattle	Beef cattle	Sheep	Deer
Annual population by livestock sub-category	MAF livestock statistics	MAF livestock statistics	MAF livestock statistics	MAF livestock statistics
Live weight	Livestock Improvement Corporation (LIC) survey	Estimated from MAF slaughter statistics	Estimated from MAF slaughter statistics	Estimated from MAF slaughter statistics
Animal Productivity	LIC Dairy statistics	Estimated from MAF slaughter statistics	Estimated from MAF slaughter statistics Wool yields from Meat and Wool New Zealand (MWNZ)	Estimated from MAF slaughter statistics
Monthly diet quality (digestibility, metabolisable energy), N %)	Farm survey, assumed not to vary with time	Farm survey, assumed not to vary with time	Farm survey, assumed not to vary with time	Farm survey, assumed not to vary with time

3.2.2 N_2O national inventory method

The two main pathways for N_2O emissions from New Zealand agriculture are those arising from synthetic N applications and those arising from the direct deposition of animal wastes onto pastures. The methods used to estimate emissions arising from these pathways are briefly described in the annual national inventory report (MfE 2006) and full details can be found in the IPCC's report *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (*IPCC 2000). Only a brief description will be given here. A schematic of the current N_2O inventory method is presented in Figure 6-3.

The methodology for N_2O estimates from synthetic N applications and the deposition of animal wastes has two basic steps.

1) An estimation of the quantity of N deposited onto pastures. For synthetic N fertilisers, data on the total quantity of fertiliser sold in New Zealand is obtained from the Fertiliser Manufacturers Research Association (FMRA). There is no attempt to break down fertiliser usage on a sectoral basis. To estimate animal deposition of N, data on the quantity of feed eaten are combined with data on the N content of feed and an estimate of the amount of N retained in animal products (meat and milk); N consumed – N retained = N deposited onto pastures. The estimation of feed intake follows exactly the same methodology as described for CH_4 above. N deposition by pigs and poultry is estimated using IPCC default values.

2) The estimation of direct and indirect emissions arising from the deposited N. Irrespective of the source of N deposited on pastures a similar methodology, albeit with slightly different parameter values, is used to estimate N_2O emissions. Direct emissions are simply a fixed proportion of the N applied/deposited. Indirect emissions of N_2O arise from two sources, volatilised ammonia (NH_3) and nitrogen oxides (NOx) which are returned to soils during rainfall and then re-emitted as N_2O; and leaching/run off of N which enters water systems and emits N_2O on its movement to the sea. Fixed proportions of the deposited/applied N are assumed to be lost to volatilisation and leaching, and fixed quantities of N_2O arise from leached and volatilised N. The parameter values used to estimate emissions are a mixture of IPCC defaults and New Zealand specific values.

Since the estimation of N_2O emissions requires an estimate of herbage intake as the first step in calculating N intake and retention, the data needs are exactly the same as the CH_4 inventory up until the point that herbage intake is calculated. The only additional data needed to complete the calculations are the N% of the ingested diet (Table 3-1).

3.3 Value of adopting the national inventory for VGGR

The advantages and disadvantages of using the national methodology at the farm scale are presented in Table 3-2.

Table 3-2 Advantages/disadvantages of using the national inventory methodologies at a local scale

Advantages	Disadvantages
Methodology well developed & relatively simple	A national 'average' non-process based method that doesn't capture individual circumstances well, especially for N_2O
Uses existing data and/or data available to individual farmers	Some mitigation options difficult to fit into methodology
Some ability to incorporate mitigation technologies	Not as accurate as process based approaches because some important driving variables (e.g. climate and soil type) are not included and doesn't capture range of managements practised on farms
Individual farm data can be used to improve national methodology/emission estimates	
Methodology accepted by international monitoring agencies (UNFCCC) & is fixed for first commitment period of Kyoto Protocol	

From a purely technical perspective the current national CH_4 emission methodology does have the ability to incorporate the principal drivers of CH_4 emissions if it is used at a farm scale. This is basically because animal numbers/type and feed intake are the biggest influences on CH_4 production. Diet quality influences are partially taken into account during the estimation of intake, although the direct effect of changes in diet on CH_4 emissions per unit of intake are ignored if constant values are used for CH_4/kg DMI. Any attempts to develop a more process based approach to predicting CH_4 emissions from a detailed characterisation of feeds are hindered by the complexity of the data needed to run process based models and the lack of direct cause/effect understanding between feedtype and CH4 emissions. . A lack of data from animals grazing fresh forage diets rules out at this stage the use of less empirical approaches to predicting CH_4 emissions from the wide variety of feeds and feeding conditions encountered in practice. Taking into account the status of technical knowledge the current national inventory approach to estimating CH_4 emissions would appear to be suitable for use in an on-farm recording system.

Predicting N_2O emissions is complex because of the large number of variables influencing the processes of N_2O formation. The present national methodology does not attempt to capture many of these complexities (e.g. soil type and climate) and hence some of the major influences on emissions are not taken into account. When estimating emissions at the farm scale it would be preferable if these local influences could be captured in the methodology, although a more complex approach has greater data needs and these data may not be always readily available. Choosing a more appropriate methodology for farm scale use will therefore have to balance simplicity with accuracy of prediction. Developing a more appropriate farm based method of recording will also provide excellent data at the national level for testing the appropriateness of the national estimation method.

3.4 Existing farm scale models that could be used to estimate GHG emissions

Although there have been no systematic attempts to calculate emissions at the individual farm scale in New Zealand there are several tools/models available that could possibly be used in a Voluntary Greenhouse Gas Reporting (VGGR) system. These range from simple approaches using derived emission factors that need minimum on-farm data, to complex process based models that are, judged from a farm perspective, data hungry. While only a few models have been used to model agricultural GHG emissions there are many more models that could estimate emissions with relatively small modifications, especially if IPCC methodologies are adopted for farm scale emission estimates. For example, any model that can estimate intake from animal performance and feed quality can predict CH_4 emissions per animal if a fixed factor is used for the quantity of CH_4 emitted per unit of intake. The addition of data on the N% in the feed will allow for the estimation of N_2O emissions. The only methods considered in this report are New Zealand methods. Scientists throughout the world have been modelling agricultural GHG emissions at a range of scales but, for these to be useful in New Zealand, they have to capture the specific New Zealand farm circumstances and this is almost certain to mean extensive and time consuming modification. For example DNDC, a model used by Landcare scientists in New Zealand is used in both North America and the UK to predict N_2O emissions but has had to be substantially modified over a number of years for it to be suitable for use here.

3.4.1 Derived emission factors for CH_4 & N_2O

New Zealand uses country specific Tier 2 methods for estimating CH_4 and N_2O emissions and does not rely on published emission factors. However, CH_4 emission factors can be derived for New Zealand by dividing national estimates of total emissions for each animal species and species sub-category by annual population figures. Similar data can be derived for N_2O emissions. Derived emission factors are available for sub-categories of the principle rumen species by age and gender and these could be used to estimate annual emissions at the farm scale very simply. The only farm specific data needed by a farmer would be annual population data broken down by species and sub-category.

The national inventory methodology attempts to model the ‘average’ situation and does not refer to any specific situation or farming system and so nationally derived emission factors have limited applicability in any given situation and will result in large errors in estimated emissions at the farm scale. The only influence a particular farm business has on emissions calculated using derived emissions factors is the species population/type. In addition, using derived emission factors makes it very difficult to incorporate mitigation technologies in an on-farm recording scheme. From a farmer perspective the use of derived emission factors does not provide data that is helpful in estimating emissions from a particular management regime or in managing farm GHG emissions. From a government perspective it does not provide any new information on national emissions. As a general principle it would seem preferable for emissions to be estimated independently at the farm scale and built up to provide a national picture, rather than national estimates determining individual farm emissions.

3.4.2 Methods being used to predict CH_4

DNDC[4] is a soil process model used by Landcare that has a grass growth component from which herbage intake and hence CH_4 emissions can be estimated. Environmental variables such as rainfall, temperature and solar radiation are used to predict grass growth and a fixed proportion of the herbage grown (70%) is assumed to be eaten; CH_4 emission is a fixed proportion of the quantity of grass consumed (CH_4/kg DMI taken from the national inventory). This approach is very simple and requires little farm scale data since climate data at local scales are available from published sources. This method can provide an alternative method at a national scale and give regional estimates of emissions. However, it is unsuitable for a farm scale emission estimation method since it does not take any account of individual farm circumstances (e.g. mix of stock, animal performance, quality of herbage, management expertise) and does not allow the incorporation of mitigation technologies. It does not predict CH_4 emissions from faecal material deposited onto pastures.

Overseer®[5] is a soil nutrient balance model with an animal component that is extensively used as a nutrient budgeting model. Individual animal herbage intakes (cattle & sheep) are estimated using performance data and energetic algorithms in a manner analogous to that used in the national inventory method. These intake data are then combined with the CH_4/kg DMI figures used in the national inventory to predict CH_4 emissions. CH_4 emissions from pasture deposited faecal material are estimated as per the national inventory model. Estimated in this manner the data requirements at the farm level mirror the data required when estimating the national CH_4 inventory; animal populations (monthly), live weight gain/milk yield, live weight and herbage quality (monthly). Of these, herbage quality may be the most difficult to obtain in many farm situations. Estimating emissions using the Overseer approach has the advantage that there is considerable scope for individual farm actions to be reflected in the farm emission inventory. The summing of individual farm emissions can be used to validate not only national emission estimates but the data used in the national emission estimates.

The Dexcel Whole Farm Model[6] is a comprehensive farm simulation model for use in the dairy industry. It has the flexibility to operate at a relatively simple or complex level (e.g. it has several ways of estimating animal intake) and can predict intake, and hence CH_4 emissions using CH_4/kg DMI constants. It can also predict enteric CH_4 emissions from first principles using detailed information on the intake of different dietary components. It also has all the information needed to predict CH_4 emissions from faecal material using the methods employed in the current New Zealand national inventory. The principal drawback of the model is that it works only for dairy cattle. In addition, because of the complexity of some of the processes, it requires data that may not be readily available on farm (e.g. detailed chemical characterisation of feed). This is especially true if trying to predict CH_4 emissions from first principles. The model in its current form is perhaps better characterised as a research model rather than a model that can be used on-farm.

4 DeNitrification DeComposition (Li et al., 1992)

5 Overseer is a registered trademark of AgResearch. The software and its output are copyrighted to AgResearch Ltd 2005.

6 Dexcel's Whole Farm Model (Beukes et al., 2004)

EcoMod[7] is a linked soil/animal/plant model that can predict CH_4 emissions at the farm scale with data requirements similar to those used in the national inventory. The model estimates intake from animal performance and diet quality in a similar manner to the national inventory and uses CH_4/kg DMI taken from the national inventory method to predict CH_4 emissions. It also has all the information needed to predict CH_4 emissions from faecal material using the methods employed in the current New Zealand national inventory. The model works for sheep and cattle but its use in a farm scale emission exercise is limited by its ability to handle a single class of animal only (e.g. milking dairy cows) rather than the mix of classes (milking, dry, mixed age) that are found on farms. The model in its current form is perhaps better characterised as a research model rather than a model that can be used on-farm.

3.4.3 Methods being used to predict N_2O

DNDC, a process based model for estimating N_2O emissions, has been used by Landcare scientists to estimate N_2O emissions at a farm and regional scale (Giltrap et al 2006). The model uses national inventory data to predict N input to soils or assumes that a constant proportion of N intake (estimated from grass growth and utilisation) is retained by animals. The model computes on a daily time step using daily temperature and rainfall data but uses average daily N input values (annual total/365). The process based nature of the model makes it attractive for use at a farm scale because it can capture the individual circumstances that influence N_2O emissions. The model does however require data that may not be available at the farm level scale (e.g. clay content of soil, organic carbon content, daily temperature, rainfall and solar radiation) although national databases may be able to supply some of these data at a sufficient level of detail. The single biggest drawback of the model is that it has no animal component and hence has limited ability to predict at the individual farm level the quantity and timing of N deposited onto pastures. The quantity and timing of N deposition are crucial to emission estimates derived from a process based model.

Overseer® predicts N_2O emissions in two ways. Firstly, it can mimic the methodology used in the national inventory (in fact some constants used in the national inventory methodology are taken from Overseer®); animal intake is combined with dietary N% data to estimate soil N deposition and N_2O is estimated using the algorithms presented in Figure 6-2. The model can also use a modified approach that utilises individual farm soil information to adapt emission estimates to local circumstances. The data requirements using the IPCC approach are the same as those for the national inventory and, as has already been discussed, should be available on many farms. The modified IPCC approach is more data hungry as it does require some individual farm soil and climatic information. Overseer® would appear to provide an option that is somewhere between the full process based approach of DNDC and the national inventory methodology. This option allows for individual farm circumstances to be better reflected in emission estimates without excessive additional data demands.

EcoMod also has a soil process module that can predict N_2O emissions at a farm scale. N input to the soil, based on animal intake estimated from animal performance, is used to drive a detailed soil N model of which N_2O is one of the outputs. At this stage, although the model can estimate N_2O emissions, the accuracy of the predictions is still being tested. As with DNDC the data required to run the soil module make it difficult to envisage EcoMod being used as a farm prediction model.

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[7] EcoMod, is funded by AgResearch, NZ

3.5 Value of adapting an existing farm scale model or creating a new model

This section contains an assessment of the value of adapting one of the existing farm scale models (described in Section 3.4) to provide both the methodology and the interface of a VGGR, or, alternatively creating a new model based on the national inventory method. Section 3.5.1 sets out a set of criteria for assessment of each option. Section 3.5.2 contains a table providing a summary assessment for each option against the set criteria.

3.5.1 Criteria for assessment

For a VGGR system to have any chance of success it is likely to need to meet a minimum set of requirements.

From a government perspective it requires;

- an ability to predict CH_4 and N_2O with some accuracy;
- a limited number of modifications
- compatibility with existing methods to develop the National Inventory
- an ability to use data collected at the local scale to obtain national values
- legal robustness (if a VGGR is later used as part of a mandatory system involving rewards/penalties)
- international acceptance of the method, including compatibility with IPCC methods for the first commitment period of the Kyoto protocol.

From a farmer perspective it needs to;

- provide information on the effectiveness of GHG mitigation strategies – to allow the farmer to cost-effectively minimise GHG emissions
- be simple to access and user friendly
- utilise existing data wherever possible and not require the collection of additional data unless absolutely necessary
- link if possible to other farm-based calculations e.g. nutrient budgeting to provide a co-benefit
- allow individual actions (e.g. mitigation) to be reflected in estimated farm GHG emissions
- be a well tested methodology that will not be continually revised due to methodological improvements

3.5.2 Assessment

Table 3-3 contains an assessment of the suitability of (1) adapting any one of the four existing models or (2) creating a new model based on the national inventory method. The assessment is completed against the criteria outlined in 3.5.1 above.

Table 3-3 Assessment of options to adapt model or create new model

Criteria	Options				
	Adapt an existing model				Develop new model (based on inventory method)
	DNDC	*Overseer*	*Dexcel Whole Farm Model*	*EcoMod*	
General characteristics	Strong on soil processes but very weak on N inputs to the soil and has no animal component.	Widespread use as a nutrient budgeting model. Has both an animal and soil component.	Model 'platform' that can incorporate a variety of models. Very strong animal component (dairy only) but no soil component.	Has a mechanistic soil model and an animal performance intake model.	N/A
Ability to predict N_2O and CH_4	Predicts CH_4, N_2O predictions still being refined.	Predicts CH_4 & N_2O.	Can predict CH_4 by more than one method. Doesn't predict N_2O.	N_2O predictions still being refined, CH_4 predicted using NZ inventory method.	A computerised method already exists at a national scale for CH_4 & N_2O and can be easily modified to work at a farm scale. Limited ability for national N_2O methodology, to incorporate determinants of emissions at farm scale.
Modifications required	Animal component that can estimate DMI and N inputs to the soil. Needs to be made more user friendly.	Animal component algorithms need updating to fit in with current national inventory method. Needs to be made more user friendly.	Beef & sheep capability + N_2O capability. Needs to be made more user friendly.	Capability to have more than a single class of animal essential. Needs to be made more user friendly.	N/A
Compatibility with national inventory methodology	Does not use national inventory methodology.	Predicts CH_4 & N_2O using national inventory methodology & has capacity to go beyond IPCC method for N_2O.	Can use national inventory methodology for CH_4, does not predict N_2O.	CH_4 predicted using NZ inventory method, N_2O predictions still being refined.	Provides potential for validation of national inventory.

Criteria	Options				
	Adapt an existing model				Develop new model (based on inventory method)
	DNDC	*Overseer*	*Dexcel Whole Farm Model*	*EcoMod*	
Ability to use local data	Not good for CH_4, good for N_2O.	Good for CH_4, not so good for N_2O.	Good for CH_4. Does not estimate N_2O.	Good for CH_4, good for N_2O.	Good for CH_4, does not capture N_2O drivers well.
Legal robustness	Complexity of inputs may remove legal robustness.	Yes as uses national inventory method.	Complexity of inputs may remove legal robustness. Doesn't use inventory method.	Yes as uses national inventory method.	Yes as uses national inventory method.
Simple & user friendly	Research model that requires an expert user.	Model designed for use by researchers & farmers, but not user friendly.	A research model up to now but a decision support version planned.	Research model only that requires an expert user.	Simple dedicated model that can be tailored to needs of users. Default or individual values can be used.
Good use of existing data	High data requirement e.g. organic carbon, clay content, daily temperature, rainfall & solar radiation but these may be obtainable at a local scale from national databases.	Data requirements for GHG emissions modest.	Detailed chemical characterisation of feed required.	High data requirement as it runs on a paddock scale with a daily time step e.g. soil parameters, daily temperature, rainfall & solar radiation.	Most data needs expected to be available at the farm level. Can include default values if required.
Co-benefits	Co-benefits as it can predict N leaching, CO_2 respiration & NH_3 volatilisation.	Widespread use as a nutrient budgeting model.	No	Can predict N leaching, CO_2 respiration & NH_3 volatilisation.	Sole use, could be adapted to include nutrient budgeting.
Reflects individual actions	Not well for CH_4	Yes	Yes for CH_4	Yes for CH4	Yes
Stable estimates	Good for CH_4. Not good for N_2O.	Yes	Good for CH_4. Not good for N_2O.	Good for CH_4, N_2O still being developed.	Yes
Issues	Process based approach. Work needed to interface an animal model. Complex to operate.	Requires simplification.	Complex model limited to the dairy sector. Adding N_2O capability simple if IPCC method used. Does not mimic the national inventory method.	Process based approach. Complex. Does not use national inventory	Requires creation of a new model. Not good on inclusion of farm scale N_2O determinants.

Criteria	Options				
	Adapt an existing model				**Develop new model (based on inventory method)**
	DNDC	*Overseer*	*Dexcel Whole Farm Model*	*EcoMod*	
Suitability for VGGR	Not suitable for VGGR system due to lack of an animal model and heavy data needs.	Yes, but would require modification if centralised and simplification.	Not suitable in its current form unless it is used in conjunction with a separate beef & sheep model.	Not suitable for VGGR system due to heavy data demands, lack of verification of N2O module and limitations of animal categorisation.	Appropriate if the scheme operates centrally for both data storage and GHG computation since a new model would be needed in this option. Appropriate if strong desire to use national inventory. The scheme could operate centrally at the processing level & the data storage level or operate centrally for data storage but locally for the calculations.

3.6 Summary

Agricultural GHG emissions cannot be measured at the farm scale, they have to be estimated. The multiple influences on emissions and, in some areas, an incomplete understanding of the processes involved means that any emission estimates are subject to large uncertainties. Choice of method will have to balance complexity with data requirements.

Emission factors derived from national emission estimates can be used on-farm but they are unsatisfactory since they offer little helpful information either to the farmer or to government.

New Zealand has a well developed national emissions methodology that can, if desired, form the basis of a farm scale recording system. Adapting the current national inventory model for use at a farm scale is a good option for CH_4 given that the current method has the ability to incorporate individual management actions. Adapting the methodology for N_2O may be less suitable for because of the simplicity of the methodology approached compared to the complexity and multiple drivers of N_2O emissions.

Overseer seems to be the most feasible existing model option for use at present since it has an animal component that is similar to the national inventory methodology and an N_2O prediction routine that can go beyond the national inventory. It is also being used on farms now as a nutrient budgeting tool. DNDC is hampered by the lack of an animal component. The Dexcel Whole Farm Dairy Model has no soil routine and is restricted to dairy cattle only. EcoMod has both an animal and soil component but is restricted to single animal classes only and is more of a research model than an on-farm tool.

Any model that can predict feed intake from data on animal size and performance can be used in a VGGR if the national inventory approach is used. However, if the national inventory approach is to be used it would seem preferable to use the existing inventory methodology as the methods used have been subjected to international scrutiny. The scheme could operate centrally at the processing level & the data storage level or operate centrally for data storage but locally for the calculations.

3.7 Recommendations

To provide a farm scale GHG emissions estimation method for the VGGR, consideration should be given to development of a new model based on the national inventory methodology or adaptation of the Overseer model. Both options are based on the national inventory method, make good use of existing data and could provide a simple interface.

Overseer is already being used by farmers for nutrient budgeting therefore provides a co-benefit to farmers and would offer a familiar interface. Overseer provides good estimates for N_2O but would require significant redevelopment to incorporate a central calculation model and database, and also updating to include the new animal routines used in the national inventory, and to simplify the interface.

A new model based on the national inventory method could provide the simplest option of enabling submission of data to a central calculation model and database, and could also be developed to enable calculation at the farm level. A new model would require inclusion of a more complex approach to estimate N_2O emissions and incorporation of a range of currently available mitigation practices. This would require inclusion of data entry for local factors such as soil and climate at the farm level and use of nitrification inhibitors. As a new model based on the national inventory method is likely to be the simplest option of providing a VGGR system, it is also likely to provide the most economic option for government.

Section 4 Greenhouse gas reporting systems in other countries

4.1 Introduction

This section provides a review of GHG reporting systems that are in place in other countries, and identifies aspects of those systems that could be considered for a VGGR system for New Zealand agriculture. This review contributes to the proposed VGGR system options outlined in Section 6.

The first part of this section contains a review of GHG reporting systems in place internationally and identifies those that are most relevant to a New Zealand VGGR system for agriculture. The second part of this section contains a more detailed review of the four systems of most relevance to New Zealand and identifies the key aspects and outcomes of each system. The final part of this section provides recommendations, based on this review, for a VGGR system in New Zealand.

4.2 Overview of GHG reporting systems

Table 4-1 below contains a list of GHG reporting systems that exist in other countries. Systems included were identified via an internet search, consultation with MAF and consultation with a GHG inventory specialist.

Table 4-1 indicates whether each system is voluntary or mandatory, the system purpose, the sponsor (e.g. Government), the target audience, the level at which the system is operated (e.g. national or State) and whether the system allows for agriculture emissions to be included.

The systems that are most relevant to this study are those that allow for voluntary reporting, are operated at a national (or state) level and include (or intend to include) agricultural emissions. These systems are highlighted in the table below and reviewed in more detail in Section 4.3.

Table 4-1 Overview of GHG reporting systems

System	Voluntary or mandatory?	Purpose	Sponsor	Target	Operational level?	Non CO_2 emissions from agriculture included?	Reference
Greenhouse Challenge Plus (Aus)	Voluntary	Enable organisations to understand and reduce emissions and advertise their participation.	Government	All entities	National	Not yet	http://www.greenhouse.gov.au/challenge/
Voluntary Reporting of Greenhouse Gases (US)	Voluntary	Enable organisations and individuals who have reduced their emissions to record their accomplishments.	Government	All entities	National	Yes	http://www.eia.doe.gov/oiaf/1605/frntvrgg.html
California Climate Action Registry (US)	Voluntary	Enable organisations and individuals who have reduced their emissions to record their accomplishments.	Government	All entities	State	Yes	http://www.climateregistry.org/

Section 4 Greenhouse gas reporting systems in other countries

System	Voluntary or mandatory?	Purpose	Sponsor	Target	Operational level?	Non CO_2 emissions from agriculture included?	Reference
GHG Challenge Registry (Canada)	Voluntary	Provide the information organisations need to limit their net greenhouse gas emissions.	Government	All entities	National	Yes	http://www.ghgregistries.ca/challenge/index_e.cfm
Climate Leaders (US)	Voluntary	Help companies to set GHG reduction goals and inventory their emissions to measure progress.	Industry/Government partnership	Large industry	National	No	http://www.epa.gov/climateleaders/
Eastern Climate Registry (US)	Voluntary	Provide a platform for state voluntary and mandatory GHG reporting programs and to standardise methodologies.	Government	All entities	Multi State	Unknown, registry still in development	http://www.easternclimateregistry.org/
World Economic Forum GHG Register	Voluntary	Create a globally consistent platform for disclosure of GHG emissions inventories and targets.	Organisational	Industry	International	Yes	http://www.pewclimate.org/we_forum.cfm
Emissions Trading Registry (UK)	Voluntary	Track GHG emissions allowance holdings and transfers.	Government	Large industry	National	No participation to date	http://etr.defra.gov.uk
Mandatory greenhouse gas reporting system (Canada)	Mandatory	Improve accuracy of emissions reporting, provide information for future policy and lay the foundation for a future emissions trading system	Government	Large industry	National	No	http://www.statcan.ca/english/survey/business/greenhouse/greenhouse.htm
Chicago Climate Exchange	Voluntary	Provide emission registry, reduction and trading system, volunteers agree to meet reduction targets.	NGO	Large industry	State	No	http://www.chicagoclimatex.com/

4.3 Review of four relevant GHG systems

Table 4-1 indicates that those systems currently in place that are most relevant to a VGGR for agriculture in New Zealand are the Greenhouse Challenge Plus Programme in Australia, The Voluntary Reporting of Greenhouse Gases (1605b) Programme in the US, the California Climate Action Registry, and the Canadian GHG Challenge Registry. Each of these systems allow for voluntary reporting, are operated at a national (or state) level and include (or intend to include) agricultural emissions. Each of these systems is described in more detail below.

4.3.1 Greenhouse Challenge Plus (Australia)

Greenhouse Challenge Plus is a voluntary GHG reporting initiative applicable to all states in Australia[8]. The programme commenced in 1995 as the Greenhouse Challenge Programme and was re-launched as Greenhouse Challenge Plus in 2005 to incorporate several new features such as Greenhouse Friendly product certification and the Generator Efficiency Standards. The purpose of the programme is to reduce emissions, integrate greenhouse issues into decision making and provide more consistent reporting of emissions (AGO, 2005). The programme is also designed to accelerate the uptake of energy efficiency.

The programme is operated by the Australian Greenhouse Office[9] (AGO) and is open to all industry sectors. Industry participants commit to measure and monitor emissions, carry out actions to abate emissions and improve energy efficiency, submit annual progress reports, allow access to data for national and state reporting purposes and agree to participate in independent verification.

The process commences with a statement of intent to participate in the programme. Organisations then work with an industry advisor to lodge (using a standardised form) a *cooperative agreement* containing a net emissions inventory and a tailored action plan to mitigate emissions. Non-agricultural emissions are calculated using online tools and reported in tonnes CO_2 equivalent (agricultural emissions are treated differently, as explained below). Participants must then complete annual *progress reports* either via an online tool (OSCAR) or via submission of a manual document. Participants are required to report on gross emissions generated from the following sources: purchased electricity, stationary energy, transport energy, waste and other (e.g. industrial emissions). Participants may either calculate emissions generated using a factors and methods workbook or can go directly to OSCAR, which calculates emissions automatically as raw data is entered. Participants are also required to make annual public statements about their participation in the programme. Participants are required to include basic greenhouse gas emissions information in their annual public statement for example the type of GHG emissions created and source of those emissions. Participants can include emissions inventory information in their public statements if desired.

Currently around 10% of programme members are from the agricultural sector. Owing to the difficulty of measuring land based (non-CO_2) emissions; these members are not currently required to report quantitatively on these aspects of their operations. The Australian Greenhouse Office approach focuses on reducing emissions through assisting members to benchmark their performance against best practice for managing agricultural emissions. The Australian Greenhouse Office has developed an agriculture specific reporting framework for Greenhouse Challenge Plus, which enables farmers to assess themselves against best practice, develop action plans for improving their ratings, and track progress over time. The system has been designed to be complementary to existing environmental management systems used on farms[10].

8 http://www.greenhouse.gov.au/challenge/

9 Australian Government, Department of Environment and Heritage

10 Telephone conversation, Anthony Macgregor, AGO, March 2007

Participants are expected to benefit primarily through an increased understanding of their emissions leading to opportunities for cost savings. Participants are also able to network and learn from other participating businesses, and gain recognition for their reductions through the use of Challenge plus logos and marketing material. The government provides assistance via industry advisors and online tools and guides.

Participants can choose between different participation levels. Organisations participating at the standard level are 'members' and are required to complete the key steps listed above (i.e. measure GHG emissions and make annual progress reports and public statements). Participants that require more time to become members can join as associate members, until they can meet the member requirements. Participants may also join as 'leaders'. Leaders are required to publicly disclose their emissions and their achievement of abatement actions annually in a public statement. Currently only one organisation is participating in the scheme as a leader. Facilitative agreements are also available to industry organisations who wish to use their structures, memberships and networks to increase industry awareness of climate change issues, and promote emissions reduction opportunities.

While the system is voluntary, government legislation requires that companies receiving more than $3 million/annum in fuel excise credits must join the programme. The principal industry types covered by this requirement are the mining and transport industry sectors. This requirement has been successful in increasing participants by approximately 70 companies.

The government operates an independent verification process to verify cooperative agreements and progress reports. Members are selected for verification on the basis of a random sample, and once a member has been verified they will not be selected again in a 4 year cycle. Verification is carried out by independent verifiers, therefore building additional capacity amongst service providers. Greenhouse Challenge Plus has been gradually increasing the number of participants verified and aim for 5% of participants per year. In 2006 the office commissioned 40 independent verifications. Verification is paid for by the Australian Government, therefore a number of companies request independent verification.

At December 2006, the Greenhouse Challenge Plus programme included over 750 members. The Greenhouse Challenge Plus website[11] contains a number of endorsements of the programme from participating industry organisations and multi-national corporations. Endorsement statements comment on the value of the tools and assistance that are available through the programme, the value of the programme in enabling organisations to build on and develop existing programmes and the opportunity the programme provides for organisations to demonstrate their credentials. Sector groups can agree for the information they provide to the programme to be used to feed into Australia's national GHG inventory, as a method of cross checking government level estimates.

Participation levels have steadily increased since commencement in 1995. The Prime Minister set recruitment targets for the programme for 2000 and 2005, leading to a recruitment drive which was successful in increasing participation.

The Greenhouse Challenge office has also targeted iconic companies in Australia for recruitment, which has in turn encouraged additional participation by other companies. Participation continues to increase as companies identify the benefits of capacity building.

The Greenhouse Challenge Plus Director, Jean-Bernard Carrasco, notes that a key benefit of the programme is the development of a partnership between industry and government to build capacity with regard to measuring and mitigating greenhouse gases. The programme is projected to contribute approximately 15 million tonnes of emissions reduction each year in 2008-2012. The cost to government to date is AUS $ 24 million over four years[12].

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11 http://www.greenhouse.gov.au/challenge/members/endorsements.html

12 Telephone conversation, Jean Bernard Carrasco, AGO, March 2007

4.3.2 Voluntary Reporting of Greenhouse Gases (US)

The Voluntary Reporting of Greenhouse Gases (1605b) Programme[13] is a voluntary GHG reporting initiative open to all states in the US. The programme commenced in 1992 and has recently been revised. The purpose of the programme is to set up a system to enable organisations and individuals who have reduced their emissions to record their accomplishments.

The programme is operated by the United States Government (Department of Energy (DOE)) and is open to individuals, households, industry or industry organisations, including agriculture.

Reporting entities are able to report on annual emissions of greenhouse gases and/or specific projects to reduce emissions. The programme allows entities to select the level of detail and scope for their reports. An entity wishing to demonstrate a higher level of accountability to the public is expected to provide a higher level of detail in their reporting. Participants are able to report on all six main GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF6).

For emissions reporting, entities are encouraged to report baseline emissions for a baseline period of 1987-1990 and to report for subsequent calendar years on an annual basis. The programme provides general guidelines and specific guidance for agricultural emission sources. The agricultural sector guidelines note that entities may report on emissions by either estimating emissions only (from fuel use, fertilizer use, manure lagoons, etc.) or by accounting for carbon flows to and from the atmosphere (capture of carbon, perhaps offsetting some portion of emissions to arrive at net amounts of emissions). Entities may develop a comprehensive emissions report or report on one or more of; carbon emissions from fuel use, CO_2 from electricity use, methane emissions from manure, N_2O emissions from fertilizer and nitrogen use or adjustments to CO_2 emissions from carbon flows.

Entities may report for an entire organisation or for a specific part of the organisation. Both direct and indirect emissions may be reported.

For project reporting, the government provides broad guidelines on calculations but entities select their own method. Every project must establish a baseline estimate (reference case) against which the project reductions are measured. Reporting can occur in long form (detailed account of emissions, emission reductions, sequestration) or in short form (brief synopsis of emissions reduction achieved). Entities may report by paper, electronically via email or via the internet.

The government provides written forms, instructions and technical guidance for entities to report. The information is made available via a public use database (including individual responses). The programme requires an entity to certify that the information contained in the report is correct but no independent or government verification occurs (DOE/EIA 2005).

The United States Department of Agriculture supports and operates the Voluntary Reporting of Greenhouse Gases-Carbon Management Evaluation Tool (COMET-VR). COMET-VR is a decision support tool for agricultural producers, land managers, soil scientists and other agricultural interests. COMET-VR provides an interface to a database containing land use data from the Carbon Sequestration Rural Appraisal (CSRA) and calculates in real time the annual carbon flux using a dynamic Century model simulation. Century is a generalized biogeochemical ecosystem model which simulates carbon (i.e., biomass), nitrogen and other nutrient dynamics. The model simulates cropland, grassland, forest and savanna ecosystems and land use changes between these different systems. Users of COMET-VR specify a history of agricultural management practices on one or more parcels of land. The results are presented as ten year averages of soil carbon sequestration or emissions with associated statistical uncertainty values. Estimates can be used to construct a soil carbon inventory for the Voluntary Reporting of Greenhouse Gases (1605b) Programme. The tool does not produce N_2O emission estimates. The tool provides comprehensive emission factors for a wide variety of emission sources from dairy, sheep, and animal farms and other pastoral and crop based agricultural production activities.

13 http://www.eia.doe.gov/oiaf/1605/frntvrgg.html

The DOE releases an Annual Report (and associated Summary Report) on the programme in December of each year. For the 2005 year, the Summary Report notes that 221 entities reported in accordance with the programme, of which 97 were from the electric power sector. The 221 reporting entities in 2005 represent companies that account for approximately 13 percent of total U.S. greenhouse gas emissions (DOE/EIA 2005).

The summary report also provides an overview of numbers of entities reporting since 1994. Since 1994 only 1 report is recorded for the category 'agricultural production: crops'. There are no other agricultural categories listed, but a catch-all category exists which has received up to 3 reports per year (but none since 2003). Agricultural reporting into the programme is therefore minimal. The specific reasons for low agricultural participation have not been reviewed, however there would seem to be little incentive for DOE to encourage agricultural organisations to participate as their emissions would be minor compared to other industrial sources. The benefits to farmers may also therefore be less, as the benefits of public recognition and capacity building would be of less value when farmers are not a major contributor to the overall GHG profile.

A testimony by the Administrator of the programme in 2000 noted that benefits of the programme included allowing organisations to estimate their emissions, providing opportunities for organisations to learn about and implement mitigation opportunities (including through their peers), creating a database of emission reductions that can be used to evaluate future policy instruments and identification of accounting issues to be addressed in future policy (Hakes 2000).

The programme has recently been revised to enhance measurement accuracy, reliability and verifiability. The revised programme creates a two tier system. Large emitters are now required to submit "entity-wide" emissions inventories. The threshold for being a "large emitter" is relatively low: annual average emissions exceeding 10,000 tons CO_2 equivalent. DOE envisions that the only reporters excluded from "large emitter" status would be households, and some farms, forest operations, and small businesses.

As part of the revision, the EIA has also developed a Simplified Emissions Inventory Tool (SEIT) to enable participants to determine if they are small or large emitters and to identify de minimis emissions sources which can be excluded from inventories. The SEIT comprises a spreadsheet. Participants enter activity data and total emissions are calculated and automatically summed at the bottom of the spreadsheet.

4.3.3 California Climate Action Registry (US)

The California Climate Action Registry[14] (the Registry) was established by California statute as a non-profit voluntary registry for greenhouse gas (GHG) emissions in October 2002.

The purpose of the Registry is to help entities establish GHG emissions baselines against which any future GHG emission reduction requirements may be applied. The registry also aims to enable companies to demonstrate environmental leadership and increase operational efficiency. Registry participants include businesses, non-profit organizations, municipalities, state agencies, and other entities.

Using any year from 1990 forward as a base year, participants can record their GHG emissions inventory. When organisations become participants, they agree to register their GHG emissions for all operations in California, and are encouraged to report nationwide. Both gross emissions and efficiency metrics are recorded. The Registry requires the inclusion of all direct GHG emissions, along with indirect GHG emissions from electricity use. The Registry requires reporting of CO_2 emissions for the first three years of participation, and reporting of all six GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF6) after three years of participation. The registry allows for reporting of agricultural emissions (including N_2O and CH_4) and uses the IPCC methodologies to estimate these.

14 http://www.climateregistry.org

The Registry has developed a General Protocol and additional industry-specific protocols (for cement, forestry and power/utility) which give guidance on how to inventory GHG emissions for participation in the Registry. Protocols include what to measure, how to measure, the back-up data required, and certification requirements.

The process commences with lodgement of a statement of intent. Entities then calculate their emissions using relevant protocols and the registry's web based reporting tool *CARROT* (Climate Action Registry Reporting Online Tool). Entities must then hire a registry approved third party contractor to certify their emissions data, and must report certified emissions data on the registry website by December 31 annually.

Participants receive online assistance including guidelines, protocols and access to *CARROT.* The registry office runs seminars and workshops for participants to attend. Participants may also use specific marketing material and logos. The State of California agrees to offer participants its best efforts to ensure that participants receive appropriate consideration for early actions in the event of any future state, federal or international GHG regulatory scheme.

The public can view annual emissions reports for any participating entity.

The State of California provided an initial $1 million grant to develop the GHG protocols and CARROT and provides ongoing funding, although the programme has become progressively self-funded through grants and earned income. In 2005 the programme received 30% state funding with the 70% balance being made up of 46% private foundation grants and 24% earned income (CCAR 2005).

In the first reporting period (2003) the Registry had 34 members and no certified data. At 2005, the California Climate Action Registry reported 64 members of which 44 were expected to register certified data for 2000 to 2004. In 2005, the Registry expected its member reports to cover 12% of the adjusted[15] total for the State of California (CCAR 2005).

Registry members at 2005 predominantly included power generation companies and government agencies and did not include any agricultural companies (CCAR 2005).

The registry completed a member survey in July 2005 and found that the principal reasons for organisations participating included learning more about their GHG emissions profile, demonstrating environmental leadership and learning the information and skills needed to be competitively positioned in the future.

The Second Biennial Report (CCAR 2005) contains a number of comments from participating organisations. Participants comment that the registry allows companies to demonstrate environmental leadership, that the registry is the de facto standard for collecting GHG information and has international credibility and that the registry provides useful assistance to companies wanting to get a handle on their emissions.

4.3.4 Canadian GHG Challenge Registry (Canada)

The Canadian GHG Challenge Registry©[16] is Canada's voluntary publicly accessible national registry of greenhouse gas baselines, targets, and reductions. The Canadian GHG Challenge Registry began in 2005 as an offshoot of the Voluntary Challenge Registry (VCR), which was established in 1995 as a key element of Canada's National Action Program on Climate Change. The GHG Challenge Registry's purpose is to encourage private and public sector organizations to voluntarily limit their net greenhouse gas emissions, as a step towards meeting Canada's climate change goals.

15 Adjusted to exclude those portions for which the Registry is not gathering data.

16 http://www.ghgregistries.ca

The primary objective of this Registry is to challenge both current and potential registrants from all economic sectors and geographic regions to demonstrate meaningful actions which contribute towards the reduction of Canada's GHG emissions.

The programme operates around preparation of annual action plans, which are lodged with the registry and made publicly available. Preparation of an action plan requires development of an inventory of emissions, establishment of business as usual projections, setting targets to reduce emissions, identifying measures to reduce emissions and recording the results achieved. Participants can use any year from 1990 forward as a base year to record their GHG emissions inventory. Organisations have flexibility to delineate their organisation (e.g. whole organisation or specific site) and can report direct and indirect emissions. The programme provides an online guide which provides emissions factors for estimating emissions, alternatively participants may refer to industry association guidelines for specific processes. The guidance on emissions factors includes agricultural emissions from livestock and agricultural emissions from soils.

Once received, the Registry office verifies each action plan and awards each a bronze, silver or gold status, depending on the level of detail of reporting and actions included.

Participants can access guidelines, templates and tools online. Currently there are 286 registrants. None of these are listed as belonging to the agricultural sector. As for the US system, the specific reasons for low agricultural participation have not been reviewed, however it is likely incentives to both Government and farmers are minimal as agricultural enterprises do not contribute a significant proportion of GHG emissions to the overall national profile.

Table 4-2 Review of relevant reporting systems

System	Primary Purpose	Emissions Quantification	Scope	Start date	Non CO_2 emissions from agriculture included?	Verification	Participation
Greenhouse Challenge Plus (Aus)	Public recognition	Factors and methods workbook or online calculation tool	6 GHGs[17] Entity level	1995	No; agricultural specific approach in development	Up to 40 projects randomly selected for third party verification annually.	700 members at December 2006, 10% agricultural sector
Voluntary Reporting of Greenhouse Gases (US)	Baseline protection	Guidance available but participants may select methodology	6 GHGs Entity and/or Project level	1992	Yes	No	221 members at December 2005 (representing 13% of total US GHG emissions), minimal agricultural reporting
California Climate Action Registry (US)	Baseline protection Public recognition	General Protocol and industry-specific protocols or online calculation tool	6 GHGs Entity level	2002	Yes	Third party certification required	64 members at December 2005 (representing 12% of total (adjusted) Californian

17 6 GHGs refers to CO_2, CH4, N_2O, HFCs, PFCs, and SF6

System	Primary Purpose	Emissions Quantification	Scope	Start date	Non CO_2 emissions from agriculture included?	Verification	Participation
							GHG emissions), no agricultural members
GHG Challenge Registry	Public recognition	Guidance on emissions factors	6 GHGs Entity or Facility level	2005	Yes	Registry office reviews reports prior to grading	286 registrants , no agricultural participants

4.4 Summary

A number of voluntary greenhouse gas reporting systems exist internationally. The purpose of each system varies, but is typically to provide emitters with protection of current reductions against future policy initiatives and/or to allow emitters to receive public recognition for their achievements.

For each system, participation levels are low but are increasing. For the systems reviewed participation rates appear to represent approximately 10-15% of total emissions for that State/Country.

While most systems allow for reporting of non CO_2 emissions from agriculture, participation by agricultural emitters has been minimal. The specific reasons for low agricultural participation in each system have not been reviewed. There would seem to be little incentive for scheme sponsors to encourage agricultural organisations to participate in voluntary systems in the relevant countries (Australia, US, Canada) as their emissions would be minor compared to other industrial sources and the benefits of public recognition and capacity building would be less valuable. The design of those systems reviewed has not been focussed on maximising participation by agricultural enterprises.

A key benefit to participants results from the opportunity to use system resources to calculate emissions and understand mitigation opportunities. This allows participants to prepare for future policy provisions via capacity building and to report their achievements to the public. The international systems reviewed provided this information through a variety of methods including provision of manuals/protocols or online tools to estimate emissions, provision of information online or in publications on mitigation opportunities, creating opportunities for participants to learn from others (e.g. through seminars or publications of case studies on best practice) and/or by allowing participants access to technical advisors.

The four voluntary systems reviewed provide a range of opportunities for participants to receive recognition from the public for their achievements. This may occur through the use of logos and branding (e.g. Greenhouse Challenge Plus), by enabling participants to report on participation or achievements (e.g. in annual reports) and/or by requiring participants to report on their emissions, mitigation actions and resulting reductions. The opportunity to advertise participation and achievements appears to be a key driver for participants.

Two programmes (Greenhouse Challenge Plus and California Climate Action Registry) include online calculation and reporting tools. Online tools simplify the reporting process for participants, provide opportunities for participants to quickly and accurately view their results (i.e. total emissions), and provide opportunities to improve integrity and security of inputs and results.

4.5 Recommendations

This review highlights GHG reporting system aspects that could be considered for inclusion in a voluntary GHG reporting system in New Zealand. These are summarised below:

- Capacity building is a key benefit of international systems reviewed. If capacity building is a desired outcome of a NZ VGGR, the system should enable participants to understand the source of their emissions, mitigation methods and effects and be accompanied by adequate training and tools.
- Public recognition is also a key benefit to participants. If public recognition is a desired outcome of a NZ VGGR, the system should enable participants to report their participation to the public. Public reporting can include marketing and branding, participant statements, award schemes, and/or public access to reports.
- Inclusion of an online calculation and reporting tool may provide benefits to participants; however this would need to be assessed against the specific requirements of the New Zealand farming community.
- Review of the published GHG emission factors (in the US, Australia, Canada and the Netherlands) for agricultural emissions sources and types may be useful in identifying a methodology for a VGGR in New Zealand.
- None of the systems investigated have a high participation rate from small to medium enterprises and in particular from agricultural businesses. A NZ VGGR system would need to consider carefully how to attract or incentivise farmers or their agents to participate.

Section 5 Possible incentives and disincentives for farmers

5.1 Introduction

This section contains an overview of the possible factors that may provide incentives or disincentives to farmers to participate in a VGGR. Where applicable, the review provided in this section has been used to contribute to development of the VGGR options provided in the next section of this report (Section 6).

This section also contains an assessment framework that can be used to assess the likely uptake of farmers, of any particular VGGR option. This assessment framework is used to complete a high level assessment (contained in Section 6.4) of the likely uptake by farmers of a core VGGR option. More detailed assessment of a VGGR option could be completed at any future stage using this framework.

The information provided in this section is based on the professional experience and knowledge of the AgriBusiness Group, a sub consultant to the project team. The project team did not consult directly with farmers to complete this section.

5.2 Incentives to participate

This section discusses possible benefits that could be provided in a VGGR system that would incentivise farmer uptake.

5.2.1 Financial incentives

Currently, farmers are not directly financially penalised for emissions or rewarded for emission reductions. Introduction of financial incentives (for example via an emissions trading regime) would be expected to significantly increase participation in a VGGR, as farmers would need to understand the source of their emissions and how to manage emissions in order to avoid financial penalties or accrue rewards.

In the absence of a direct financial driver, overall participation rates would be expected to be low, but may increase slightly as a result of other incentives including stewardship, market demand and the ability to protect baseline emissions (each of which is outlined in more detail below).

5.2.2 Stewardship

There is a general desire amongst the farming community to be, and be seen to be, acting as responsible stewards of the land and environment and to be recognised as such by the wider New Zealand and international communities. This driver has increased lately as the benefits of sustainability have become increasingly accepted and expected by the public, markets, regulatory agencies and farmers themselves.

Farmers may perceive a benefit in participating in a VGGR if they anticipate that a VGGR would enable them to achieve and demonstrate a responsible stewardship approach within their farming systems.

For this benefit to be realized, an organisation (e.g. industry or export group) would be required to provide promotion and/or branding of the system, and assistance to farmers.

5.2.3 Market incentives

Farmers may be incentivised to participate in a VGGR if they receive market pressure to respond to a consumer focus on the impacts of agriculture on climate change (e.g. food miles and carbon footprints). This situation may arise if an industry group responded to the market by introducing standards or criteria to demonstrate a response to climate change and passed this requirement onto farmers. In such a case, participation in a VGGR may provide a method of allowing farmers to demonstrate their compliance.

Farmers would be able to strengthen their claims to the market, if a VGGR included a form of verification or auditing, providing reassurance to the market that farmers' estimates were accurate and mitigation measures reported correctly. This would require the VGGR to include an auditing/verification component, and the ability of farmers or industry groups to report on their compliance with this system.

5.2.4 Protecting baseline emissions

The government is currently reviewing a range of options to manage GHG emissions in the future, including establishment of an emissions trading market (MAF, 2006).

Farmers may identify a benefit in participating in a VGGR if they anticipate that an allocation of emission units will occur based on a baseline emission level and the VGGR allows them to demonstrate previous emission levels and the effect over time of any previously implemented emission reduction projects. This would effectively ensure that farmers who had reduced emissions over time were not 'penalised' for any emission reductions they had achieved prior to the introduction of an emissions trading scheme.

For this benefit to occur a VGGR would need to provide a method of recording baseline emissions, a method for farmers to record their mitigation projects and the effectiveness of those projects, and the resulting annual changes to emission levels.

5.2.5 Information about emissions and mitigation opportunities

A VGGR that delivered information to farmers about their farm's emission profile and enabled farmers to effectively maximise mitigation opportunities may provide an incentive to farmers. For this to occur, the VGGR would be required to deliver information about the existing emissions profile of a farm, provide a modelling capability to allow farmers to identify how different management techniques would affect their emissions profile, and provide specific information about how to apply those management techniques. The VGGR system may also be useful if it provided information that enabled farmers to benchmark their performance against their peers. The level of benchmarking detail possible would need to be weighed up against confidentiality issues.

The incentive provided by information provision would strongly increase, if other incentives existed to encourage farmers to reduce emissions (e.g. trading regimes, emissions taxes), as information provision would allow farmers to act to reduce their emissions as much as possible, and therefore avoid penalties or accrue benefits.

Farmers may still be motivated to act in the absence of an incentivised environment, if they anticipated such an environment in the future, and could therefore perceive a benefit in terms of gaining knowledge in preparation for future action.

5.2.6 Information about offset opportunities

Offset opportunities exist through a range of mechanisms including planting of vegetation or may exist through the ability to purchase credits in the future. Because mitigation opportunities are limited, in a financially driven environment (e.g. trading regime) the farming community may consider the ability to offset emissions as more desirable and cost effective than management options that mitigate emissions.

A VGGR that provides the capability to calculate the degree of offset required may provide a benefit to farmers. For the benefit to occur, the VGGR would be required to deliver information about the existing emissions profile of a farm, and a modelling capacity to allow farmers to identify how different offset techniques would affect their profile, and specific information about how to apply these offset techniques.

This benefit would increase in an incentivised environment (refer Section 5.2.1 above).

5.2.7 Ability to improve productivity

The scientific and farming communities continue to introduce technologies and management changes designed to improve productivity, some of which also deliver GHG emission reductions. Examples include improvements in the efficiency of ruminant nutrition processes and reduction in loss of nitrogen from pasture systems. Improvements in productivity can deliver the co-benefit of a reduction in GHG emission per head of animal (refer Section 2).

A VGGR that delivers GHG emission profile and reduction information which is either used to decrease GHG emissions via improvements in productivity or provide information that can also be used to improve productivity may be seen as an incentive to farmers to participate, particularly in a financially driven environment (e.g. trading regime).

For this to occur, the VGGR would be required to deliver detailed and accurate information about the specific area of emissions losses from within the farming system. These losses would need to be calculated and expressed as losses per unit of inputs and outputs. In that way farmers would be able to consider their own emissions performance within a productivity framework and consider emissions as losses that reduce the efficiency of their productive system.

5.2.8 Ability to improve nutrient management

The dairy industry has voluntarily adopted nutrient budgeting as one of the key targets within its "Clean Streams Accord"[18] (refer Table 5-1). Dairy farmers commit to carry out a nutrient budgeting exercise and match fertiliser application to the requirements of their farm. The purpose of the budgeting exercise is to reduce nutrient loss, therefore increasing productivity on farms (see above), reduce nutrient application costs and to reduce environmental impacts of nutrient loss into groundwater or surface water.

A VGGR that delivers GHG emission profile and reduction information and information to manage and reduce nutrient loss may be seen as an incentive to farmers, particularly in a financially driven environment (e.g. trading regime), as it would allow them to complete two tasks through a single step.

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18 The Clean Streams Accord is an accord between Fonterra, Regional Councils, Ministry for the Environment and the Ministry of Agriculture and Forestry.

Section 5 Possible incentives and disincentives for farmers

The table below contains a review of two programmes, currently operated in the agriculture sector in New Zealand, which have elements similar to a possible VGGR system. This review has been used to inform both the incentives and disincentives described in this section.

Table 5-1 Comparison with similar programmes

Programme	Description	Uptake
Nutrient budgeting	Nutrient budgeting is being promoted by a number of agencies as a tool that can be used by farmers to calculate and match fertiliser application to the nutrient requirements of a specific property in order to reduce losses of nitrogen and phosphorus. Nutrient budgeting has the dual benefit of reducing environmental impacts and providing efficiency gains. The programme Overseer® (Section 3.4.2) is an example of a model that is being promoted by local government and by some industry groups to carry out nutrient budgeting.	Nutrient budgeting is an exercise which delivers a number of benefits to farmers and would be relatively easy for farmers to implement owing to the amount of assistance available. Following 5 years of heavy promotion of the nutrient budgeting requirement in the "Clean Streams Accord", and the fact that nutrient budgeting is a requirement of participation, only 33% of farmers have completed the nutrient budgeting requirement (MfE, 2006a).
DairyBase	DairyBase is a national benchmarking system set up and promoted by the dairy industry in order to provide benchmarking capability for productive and financial performance information. The system works on submission of information to a central database through initial property registration of core data and then provision of actual performance data. The second level data provision is mainly done through accountants and consultants who can enter data (which is created for tax or other standard reporting needs) on line. This reduces complexity and farmer technical engagement. The dairy industry has a long history of localised benchmarking within discussion groups and peer groups and therefore is well aware of the benefits that can be gained from benchmarking. Promotion of the DairyBase system has been heavy both within the farming community and the accountant /consultant communities during its development and since it became operative approximately 9 months ago.	There are a multitude of drivers within the assessment framework that are positive for a high level of uptake or engagement for dairy farmers. However, at present only 7% of the possible participants have registered to belong to the system and of those 32% have submitted actual data to give an effective uptake rate at this stage of 2.3% [19].

[19] Mathew Newman: Dexcel, personal communication

5.2.9 Ability to 'demystify' the science

Farmers are more likely to participate in a VGGR if they perceive that it will contribute to a "demystification" of the science and technology behind GHG emissions. On its own, this is unlikely to be perceived as a benefit, but a VGGR that delivered any of the other benefits outlined in this section and contributed to an improvement in farmers understanding of the science, is likely to attract higher participation rates.

For this to occur, the VGGR would need to provide information in a simple manner, be easy to use, and include provision of appropriate technical support. This is an important consideration in system design.

5.3 Disincentives to participate

This section discusses possible costs that could be incurred in a VGGR system and other disincentives to farmer uptake.

5.3.1 Mitigation opportunities

At present, opportunities for farmers to mitigate agricultural emissions are largely limited to nitrification inhibitors (refer Section 2). Although ongoing research would be expected to develop further mitigation opportunities over time, the current absence of strong mitigation opportunities may limit farmers' participation in a VGGR, even if financial or other incentives exist.

5.3.2 Capital costs

The only direct cost to farmers would be the requirement to own (or have access to) a computer and have internet connectivity. Most farmers already own a computer and have access to the internet. Direct costs would therefore be limited to the requirement to maintain internet connectivity and for those who don't already, obtain a computer.

5.3.3 Time and effort

The principal cost to farmers is expected to be the time and effort required to collect and submit data to the reporting system. Possible disincentives relating to time and effort are described in detail below under specific subject headings.

Information required

The time farmers would be required to spend on a VGGR would be minimised if the information required to be entered into the system is already available or can easily be derived from other sources, such as an existing nutrient budgeting system or farm management software.

The time cost to farmers will also vary depending on the level of assessment they are required to carry out before submitting their results. Costs to farmers will decrease if they are able to input raw data and the system is able to carry out the modelling internally.

Data entry into a VGGR may include posted hard copy, e-mailed electronic copy or on-line data entry. Farmers may be disincentivised if their options for data entry are limited.

Depending on the design of a VGGR system, it may be possible for third parties to provide, complete analysis/modelling and enter the information for farmers. If the VGGR requires an initial comprehensive data set, followed by updates only in subsequent years, it may be possible for third parties to provide the initial data set with farmers providing the subsequent data. Employment of a third party would increase direct costs to farmers; however this would decrease their indirect time costs. Costs to farmers would be reduced by use of third parties, if the provision of third party services was provided free of charge. This may occur if the government felt that use of third parties would improve the integrity of the system and data set.

Complexity of system

Time costs to farmers will increase if the system is complex and difficult to use as it will take longer for farmers to understand the system and enter information.

Entity level

It is becoming increasingly common for farm businesses to comprise multiple land holdings across both farming types and geographic regions. Costs to farmers may increase if they are required to report on each holding, and will decrease if they are able to report at an overall business level.

Frequency of reporting

The time costs to farmers will increase with the required frequency of reporting. Costs will decrease if farmers are able to report either a less detailed set of information after the initial yearly report, and/or they are able to report less than annually (e.g. every two years) following the initial yearly report. However it should be noted that allowing farmers to report less than annually may reduce farmers' engagement in the process.

5.3.4 Concern about confidentiality

Farmers would be less likely to participate if they were concerned that the specific information they provided was available to parties other than the system administrators or if they suspected the integrity of the system with regard to confidentiality. Farmers tend to be very reluctant to submit any form of individual farm data that is able to be identified back to them (directly or indirectly) and accessed by third parties. This disincentive would be removed if farmers knew that the information they provided was able to be viewed by system administrators only and that all information retained its confidentiality and that only aggregated data is reported.

The ability of a farmer to benchmark his/her performance against other farmers may be an incentive to participate. A benchmarking capability could still be provided in a confidential system by providing information to an individual farmer on their performance against local, regional or national averages as long as the comparator datasets were sufficiently aggregated to maintain confidentiality of information.

5.3.5 Suspicion about purpose

Farmers will be less likely to participate in a VGGR if they do not receive clear information about the purpose of the VGGR. Lack of transparency about the purpose of a VGGR could lead farmers to perceive that their participation in the system could be used to contribute to a future regulatory system, with possible costs to farmers. This may reduce participation, or may lead to skewed results, if farmers are suspicious of the government's future purpose for the information in the VGGR. Participation is likely to increase if farmers feel comfortable that they are receiving honest information about the current purpose of the VGGR and its possible future role.

5.4 Proposed assessment framework

Table 5-2 below provides a proposed framework that could be used to assess the likely uptake of farmers of a VGGR. The subjects listed in the assessment framework have been derived from the scoping of incentives and disincentives provided in this section. For each subject area, we have provided key questions that should be answered to provide an assessment of likely uptake.

This assessment framework is used to complete a high level assessment (contained in Section 6.4) of the likely uptake by farmers of the core VGGR option described in Section 6. More detailed assessment of a more highly developed option could be completed at any future stage using this framework:

Table 5-2 Framework to assess likely uptake by farmers

Subject	Key Questions
Possible incentives	
Financial incentive	Are there any financial incentives for farmers to reduce their emissions?
Demonstrate stewardship	Does the VGGR enable a farmer to both increase and demonstrate an increase in on farm stewardship?
Respond to market	Does the VGGR provide an ability to respond to market concerns around climate change (e.g. branding, logos, certification)?
Protect baseline emissions	Does the VGGR allow a farmer to record emissions baselines and subsequent reductions to protect early reducers in the case of a future grandfathering scheme?
Receipt of information	What information is provided to farmers about their emissions, mitigation opportunities and offset ability?
Ability to improve nutrient management or productivity	Does the VGGR provide a co-benefit in terms of the ability to also manage nutrients or improve productivity?
Ability to use third parties	Can a farmer use a third party to collect, model or enter information (as required)?
Increase understanding	Does the VGGR provide information in such a way that through participation, farmers will be better able to understand the science of greenhouse gas emissions and reductions?
Possible disincentives	
Mitigation opportunities	Do mitigation opportunities exist?
Direct costs	Will a farmer have any additional capital costs (e.g. purchase of a computer)?
Time and effort	How complex are the data input requirements?
	Does the system provide a farmer with flexibility around the level at which he/she can report (i.e. entity level or whole business level?)

Subject	Key Questions
	Is a farmer required to report a full set of information every year, or do requirements decrease in subsequent years and/or does the frequency of reporting decrease?
Confidentiality/Perception of reduced competitiveness	Will the VGGR enable others to access individual farm level information potentially reducing an individual farmer's competitiveness? Is confidentiality ensured?
Suspicision about motives	Is the government being transparent information about the current and future use of the system?

5.5 Summary

The incentives for farmers to participate in a VGGR are limited in the absence of financial incentives to reduce emissions. Even in such an environment, opportunities for farmers to mitigate emissions are limited. Experience from other reporting schemes (including Dairy Base and nutrient budgeting) show very low farmer uptake rates even in situations where the system is being heavily promoted by an umbrella sector organisation and indirect benefits exist (for example better understanding of fertiliser application requirements and therefore possible operational cost savings). It is therefore unlikely that farmers will voluntarily participate in a VGGR without financial incentives, and even then, participation may be hindered by the lack of mitigation opportunities. This may be countered to some extent by the desire of farmers to improve their stewardship or respond to the market, in line with an increasing focus on sustainability.

If farmers are driven to participate, there are key elements of VGGR design which should be taken into account to maximise benefits. Benefits will be greater if:

- farmers are provided with information about a farm's emissions profile, a modelling capacity to identify how different management techniques would affect the profile, and information about how to apply mitigation
- farmers are able to easily understand the information provided and it helps them to 'demystify' the science of climate change
- the information farmers receive could also help them improve productivity or nutrient management
- the VGGR allows farmers to respond to market concerns over climate change or demonstrate stewardship
- the VGGR provides a mechanism for farmers to protect baseline emission levels against future grandfathering
- direct costs (for data gathering and entry) are minimised;
- confidentiality provisions are included in the VGGR;
- the system is simple to use.

The incentives and disincentives outlined in this section can be used to assess the likely uptake of farmers of any particular VGGR option proposed. Table 5-2 provides a framework to complete this assessment.

5.6 Recommendations

Careful consideration of the likely uptake by farmers is required prior to proceeding with a VGGR, particularly in relation to the existence or otherwise of financial incentives.

If a decision is made to pursue a VGGR, design of the system should aim to maximise the incentives and minimise the disincentives outlined in this section.

Section 6 VGGR design options

6.1 Introduction

This section describes options to provide a VGGR system for New Zealand pastoral agriculture. The first part of this section describes a 'core' VGGR option which would deliver MAF's stipulated VGGR requirements at the lowest cost to government. The next part provides an assessment of the likely uptake of the core option by farmers, followed by an estimate of the costs to government to develop the core option.

The second part of this section describes variations to the core option, each capable of delivering different outputs to farmers or government. For each variation an assessment of likely uptake by farmers is provided along with estimates of the cost to government (where applicable).

This section concludes with a summary of all design options described and their estimated cost.

URS subcontracted software development company Fronde to cost out the IT components of each option. Appendix A contains a copy of Fronde's report.

6.2 VGGR requirements

MAF has stipulated that any VGGR option should include:

- a system to report emissions from individual farms, or aggregations of them, to farmers, government and the public
- a registry to receive reports of farms' emissions
- a system for auditing the reports of on-farm emissions, including options for contracting this activity to third parties
- a system to provide advice to farmers to help them with operating the VGGR system and to enable them to reduce emissions

The core VGGR option described in this section provides the most cost effective method to government of meeting these requirements.

The additional VGGR options outlined in section 6.7 also meet the VGGR core requirements listed above, but provide additional outputs, at increased cost to farmers and/or government. We identified the possible additional outputs from recommendations made earlier in this report (sections 2-5).

6.3 Core VGGR option

This section outlines the core VGGR option. The first part of this section describes the high level concept of the core VGGR option. The remaining parts of this section then describe the core option in more detail including participation, scope, data requirements, the database, reporting, verification, technical assistance and administration.

6.3.1 Overview of concept

The core VGGR option outlined in this section provides the most cost effective method to government of meeting MAF's VGGR requirements.

The core VGGR option will focus on enteric CH_4 emissions and N_2O emissions from soils, and on the dairy, sheep and beef cattle sectors.

The core VGGR option contains the following key components:

- participating farmers will collect and provide information on their farming operations (such as stock numbers, types, weights, feeding practices, and waste management practices)
- participating farmers will submit that data into a system that, using a prescribed methodology and fixed parameters, can estimate their greenhouse gas (GHG) emissions
- farmers, the government, and to a lesser extent the public, will be able to access the information stored in, or calculated from, the database

This core VGGR option requires the following four key computing components:

- a data entry module – allowing farmers to input data into the system
- a calculation module – converting the data farmers input into the system into GHG estimates
- a central database -which stores the data provided by farmers
- a reporting module – which farmers and other parties can use to get GHG data from the database

Figure 6-1 illustrates the key components of the core VGGR option.

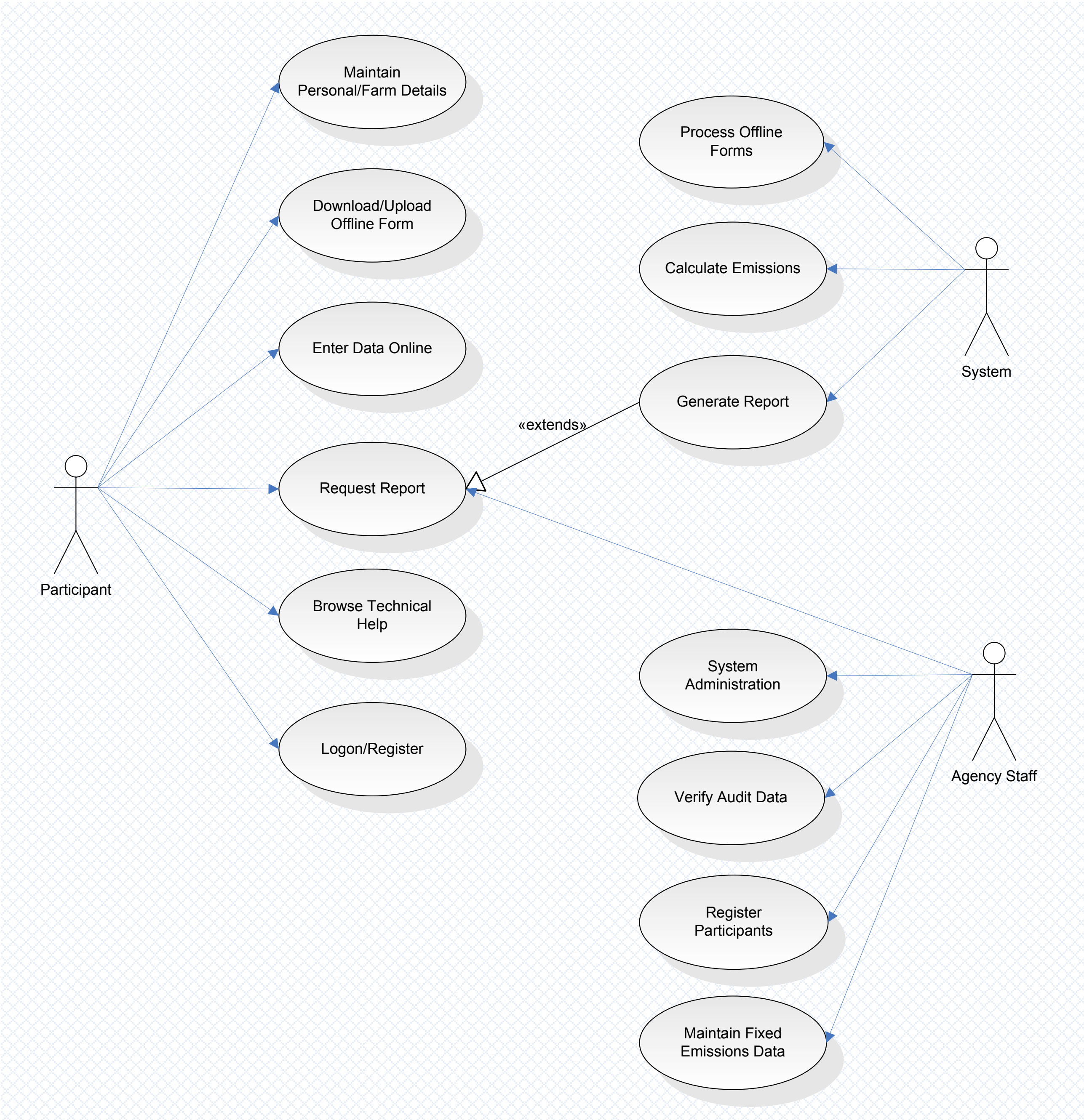

Figure 6-1 Key components of a core VGGR option

6.3.2 Participation

To develop the core design option we have assumed that there will not be any direct government incentives for farmers to join the VGGR scheme, and that it would be open to any farmer based in New Zealand.

We expect that participation rates in this situation would be relatively low (see discussion in Section 6.4.4). We would not expect representatives of more than 1-5% of New Zealand's 45,000 farms to participate; leading to a maximum number of participants of 450 – 2,250. We note that there is considerable uncertainty at this early stage around likely participation levels. Participation could be increased relatively substantially through the use of government incentives.

There would be little or no cost impact if the software components of the system were designed from the outset to cope with much higher participation rates than we currently expect. However, increased participation levels would most likely lead to higher hosting costs, such as increased Central Processing Units (CPUs) to handle extra traffic or extra memory for the database.

If the government pursues the core option, we recommend that the software components of the system be built from the outset to cope with a capacity of 50,000 – 55,000 participants; ensuring that it would be able to cope with all feasible participation outcomes over the next 10-15 years. However, ongoing hardware and staff resources devoted to hosting the system should initially be based on much more conservative participation rates. This approach would give MAF the flexibility to introduce policies to expand participation levels at a later date without undermining the cost effectiveness of the system during the initial years of its operation.

6.3.3 Scope

MAF have directed us to limit the scope of the core VGGR system to the estimation and reporting of agricultural sector emissions of methane and nitrous oxide.

As outlined in Section 3, the simplest way of doing this is to estimate the total methane and nitrous oxide emissions at the level of each participant's farm and use New Zealand's national inventory methodology (refer to Figures 6-2 and 6-3). Developing a new model based on the existing national inventory methodology is expected to be simpler and therefore more cost effective than adapting an existing model (e.g. Overseer), and is therefore included in this core option.

The vast majority of New Zealand's agricultural emissions of methane and nitrous oxide come from three sources:

- methane emissions from enteric fermentation;
- nitrous oxide emissions from animal wastes (manure); and
- nitrous oxide emissions from fertiliser use.

Computer models for estimating emissions from these sources already exist and would be available to any party tasked with developing the software necessary to run a VGGR (see Section 3). This will make it relatively straight forward to re-create the calculations required. In order to minimise costs we have therefore included these three emissions sources only.

6.3.4 Data requirements and data entry arrangements

The level of time and effort required of participants in the VGGR scheme is likely to have a significant impact on participation rates (refer Section 5). We have therefore based our core option on the assumption that the information required from participating farmers will be kept to a minimum; only that information needed to estimate each participants farm-level emissions (using the national inventory methodology) and to manage the VGGR system.

While our core option is based on the IPCC methodology, we also propose to include the requirement to enter local condition information (soil type and climatic information). The addition of this information will increase the data entry requirement for farmers but will significantly increase the accuracy of N_2O estimates.

Some information variables (e.g. soil type) will require entry only once as they are unlikely to change significantly over the participation period. We have identified this information as 'baseline' and will require farmers (or their agents) to enter this information once only.

Based on these assumptions, farmers would need to provide the data listed below:

Participant information

- the name and role of the person submitting the information
- the name of the owner of the farm
- a farm identifier(s) (for example the valuation roll number, and/or the LINZ certificate(s) of title reference
- the farm address
- location (e.g. GPS or map coordinates)

Baseline information

Soil type – this information could be supplied by the individual farmer (e.g. data taken from representative paddocks on the farm) or taken from soil information held by Landcare.

Climatic factors (rainfall and temperature) - this information could be supplied by the individual farmer if available or taken from the nearest meteorological station (data held by NIWA).

Emissions information

Farmers would need to provide the following information to enable the system to estimate methane and nitrous oxide emissions. For each requirement listed below, farmers would be requested to enter specific information where this is available (e.g. average weight of mature adults by herd). However, it is possible that for some variables some farmers may not easily have access to this information. For data requirements that may not be readily available or easily calculated at the individual farm level (for example diet characteristics) default options would be provided to allow a farmer to enter alternative information. Conversion factors built into the model would then convert the information entered into the required entry information. For example, for diet characteristics, a menu choice of options describing the makeup of the diet (good quality pasture, maize, silage etc) may be offered as a default, and entry of this information then automatically calculates a figure for diet characteristic based on built in conversion factors.

Also, farmers would be requested to report information by monthly variables, but options would be provided to report annual figures if monthly figures are not available.

Methane

- Animal numbers – minimum requirements are annual totals at a specific point (could be taken from June census/survey) broken down by age, sex and reproductive state (use categories in June census/survey). It would be preferable if animal numbers were available at a monthly time scale to avoid having to construct monthly population models.
- Performance characteristics (weight of mature adults, weights at slaughter of growing animals (can be carcass weight), annual milk yield of dairy cattle (information to be provided by average for group e.g. herd), including timing of important events e.g. average calving date, average lambing date, average slaughter date. These data need to be provided at a minimum on an annual basis. As with animal numbers monthly data would avoid the need to construct monthly models of animal weight etc.
- Diet characteristics (digestibility, metabolisable energy content)[20] – needed on a monthly basis; values can be taken from individual farm feed analyses or default values can be assumed.

Nitrous Oxide

- All of the above plus
- Diet characterisation to obtain a representative N content of the diet; this is available nationally as an annual average at present but more accurate estimates will result from the use of monthly data
- Quantities of fertiliser applied and quantities of manure applied (not wastes directly deposited by animals) and date of application
- Quantities of nitrification inhibitors applied and date of application.

Information entry

Participants would be required to enter this data annually, through electronic submission in a standardised template. Due to the low internet connection speeds experienced by many farmers, the system should be designed to allow this data entry to be undertaken either:

- online;
- by downloading a software programme containing all entry fields required by the model, filling in the required fields and submitting the file when completed; or
- by downloading a manual form, filling it in, and submitting it by post or email when ready.

Due to possible slow internet connection speeds, the internet pages and downloadable templates should be kept simple, and as small as possible.

Where a farmer has farming operations in more than one area, we recommend that he/she be allowed to decide whether to submit a single return for all of their operations, or two or more separate returns.

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20 Performance characteristics & diet characteristics are available nationally at present

6.3.5 Central database and calculation module

The calculation module will be stored centrally containing fixed inputs (such as emission factors) and formulae that are needed to estimate farmers' emissions. This would ensure that participating farmers only need to enter data on their farming operations and could do so either manually or online. It would also make it easier to update the estimation methodology or inputs at a later date if necessary.

However, we also recognise the importance of enabling farmers to view how their data entry affects their total emission levels. We therefore propose that farmers are given the option of downloading software from the VGGR website, for automatic storage on their computer's desk top. This will allow the participant to enter information over a period of time, view how their data entries affect their total emissions, then submit the information into the central database once satisfied that all data requirements have been met.

The IPCC methodologies for estimating methane and nitrous oxide emissions are shown in Figures 6-2 and 6-3 below. Nitrous oxide emissions resulting from fertiliser applications are also fed into the IPCC methodology pathway model. As noted in Section 3 computer models already exist which undertake these calculations. It should therefore be relatively straightforward to build them into a new calculation module.

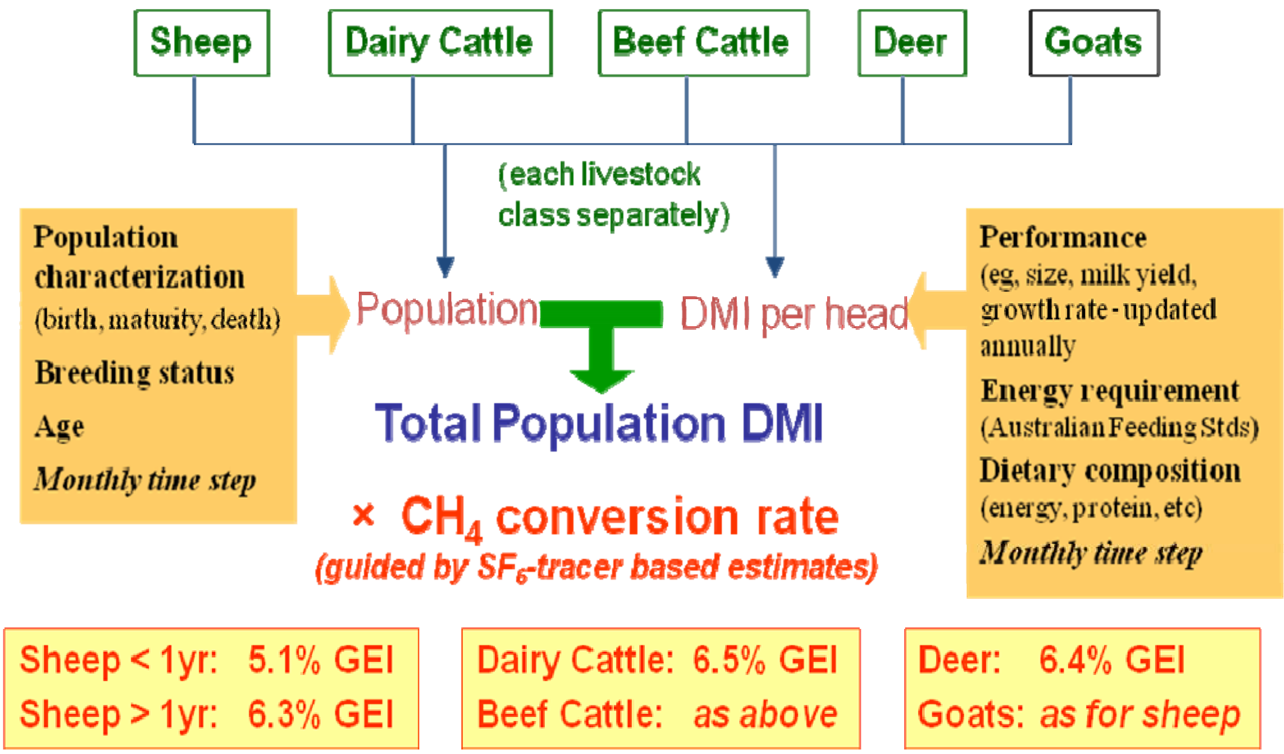

Figure 6-2 IPCC Methodology for Estimating Methane Emissions (Source: Ministry for the Environment, 2006)

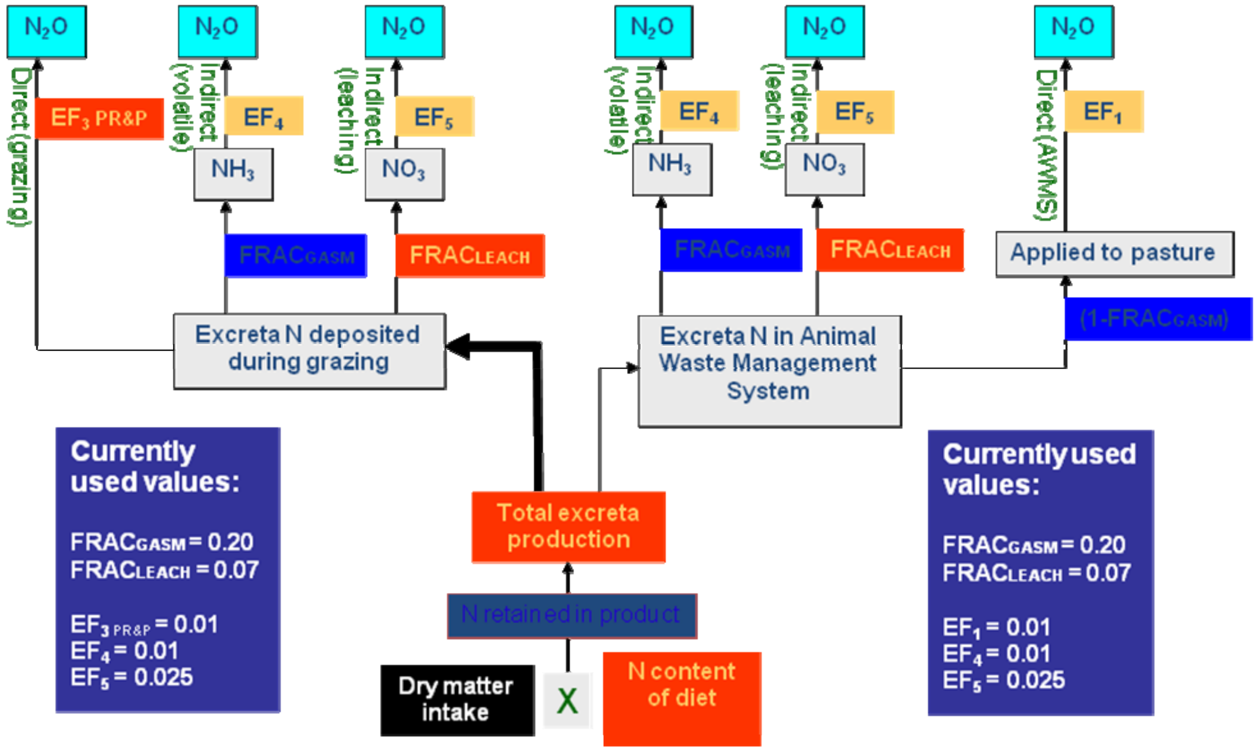

Figure 6-3 IPCC Methodology for Estimating Nitrous Oxide Emissions (Source: Ministry for the Environment, 2006)

6.3.6 Reporting

Farmers

Participation levels will increase if the scheme is useful to participants. A key benefit identified in both the review of voluntary reporting systems in place internationally and incentives for farmers was the ability to build capacity in terms of estimation and mitigation technologies. We therefore recommend that the system be developed to enable farmers to access the following reports on-line:

- emissions at the level of: each participant's farm or group of farms; each region of NZ; and the country as a whole
- the emissions of a participant relative to a benchmark of the best, worst, or average level of emissions per hectare in the relevant region, or nationally
- emissions through time
- individual emission sources, or total emissions
- individual GHG gases or total emissions of all gases

For those farmers who choose to download the software themselves and enter the information into the downloaded module, the reports identified above, will be available for them to review at any stage during their entry process and following submission of their module into the central database.

At a minimum, participants would need to be able to generate onscreen data reports with these types of information. However, our software development experts' analysis suggests that the cost of providing more sophisticated reporting functionality, such as the ability to prepare graphs and download the underlying data onto the viewer's computer, would be relatively modest at around $15,000. Given that the ability of users to access data and benchmark their emissions is one of the key benefits offered by a VGGR, we recommend that this more comprehensive reporting functionality be provided.

For confidentiality reasons we also recommend that only the farmer concerned, and the relevant government agencies, would be able to access reports at the individual farm or farm owner level.

Regional data would be provided only in relation to minimum sample sizes to protect the anonymity of other participants.

Public

In order to preserve business confidentiality, the public would only be able to view reports at a regional level, and would not be able to view an individual farm or farm owner level report.

Government

The administering government agency would have access to data at an individual farm level. Other relevant government agencies (such as the Ministry for the Environment) would have access to the data at the farm level if required (e.g. to contribute to verification of IPCC estimations) however this data would be anonymous and would not be identifiable against a specific farmer or farm unit. All other government agencies would have access to the regional average data only. The confidentiality of farm level information would require assessment in terms of the Official Information Act during the design stage.

Verification

MAF have requested that VGGR options include a system for auditing the reports of on-farm emissions, including options for contracting this activity to third parties.

We recommend that MAF adopt two methods for identifying errors in the data submitted. The first method is aimed at reducing the level of data entry errors made by farmers. We recommend that MAF require the software developers to build a series of basic data checks into the data submission forms used by farmers, which would immediately identify any clear inconsistencies between the different pieces of data entered. Where different aspects of the data provided appeared inconsistent, farmers would be prompted with a warning message and asked whether the data is in fact correct.

In addition we recommend that MAF audit the returns of a small, fixed proportion of scheme participants each year. The purpose of these audits would be to identify any more systemic problems with data collection and any deliberate mis-reporting. If errors are found, the administrative agency would be able to amend the data in question, or if necessary, delete the farmer's entry for the year in its entirety. These audits could possibly be undertaken by the same people engaged to provide technical on-farm assistance (see 6.3.8 below).

6.3.7 Technical assistance

Technical assistance will be important for ensuring adequate participation by farmers in the VGGR scheme, and in helping participants to meet their reporting obligations and reduce their greenhouse gas emissions more generally. We recommend that this assistance be provided in a number of ways:

- web-based technical instructions and a set of questions and answers to act as a first port of call for participants facing technical difficulties
- a toll free, phone based help desk
- a number of farm consultants trained in the use of the system that could visit participating farmers to:
  - address any problems around data collection and data entry
  - educate and inform participants about their emission levels (in absolute terms and relative to their peers)
  - advise on the causes of GHG emissions and possible mitigation measures
  - advise on nutrient management / budgeting and options for improving farm productivity
- the provision of occasional seminars and workshops open to all scheme participants that address options for improving nutrient management and reducing greenhouse gas emissions (again run by selected farm consultants)

Farmers would also be free to engage their own agents or consultants to assist them in meeting their requirements under the scheme.

We recommend that MAF contract out the provision of the phone-based help desk service. It is likely that the organisation that wins the tender to develop the overall VGGR system will be well placed to provide that help desk service. We therefore recommend that MAF require tenderers to submit bids for providing a help desk service as part of their overall tenders, but that MAF retain the option of using a different provider if that appears likely to be more cost effective.

We also recommend that the specialist agricultural assistance be provided by a team of government funded, designated farm consultants based around the country, who have received training on use of the VGGR system and ways of reducing GHG emissions more generally. It is likely to be most cost effective to contract with existing, independent farm consultants to provide this service. Our preliminary analysis indicates that on-site farm visits would involve a 2-3 hour engagement with the farm, and travel time, making each consultation a half day exercise. A network of consultants around the country would be needed to minimise travel times. By our estimation this would require a minimum of 12 agents in the North Island and 8 in the South Island. These consultants could also be required to assist farmers to collect specific farm level information required for baseline information entry, e.g. soil type and climatic factors.

Seminars and workshops would also provide a useful adjunct to on farm consultations. Such events can help to:

- raise awareness, and thereby help to encourage farmer engagement
- explain the concepts and science behind agriculture sector GHG emissions and
- develop the modelling and reporting capability within the rural community.

Experience would suggest that in addition to participating farmers, these seminars and workshops be targeted at the people who advise and influence farmer behaviour, such as the rural press and broadcasters, consultants and the servicing sector.

6.3.8 Administration

To protect the accuracy of the data in the system, it will be necessary to require each participating farmer to apply for a secure logon and password to enter or amend data. They would also need to be logged on to access reports with information on their individual farm, or farms.

It will therefore be necessary for MAF to provide administrative support for the system. This would involve tasks such as registering new users, resetting passwords, maintaining the information required to operate the system (such as security permissions), and updating and deleting information stored in the database.

In addition, it is likely that MAF will want to undertake activities to promote the scheme (refer Section 9), and staff may occasionally need to travel in relation to the establishment and operation of the scheme.

6.3.9 Co-location with NZEUR

The Ministry of Economic Development (MED) currently hosts around ten different registries, including the NZ Emissions Unit Registry (NZEUR). This section describes the potential benefits and costs of utilising the software application and/or infrastructure arrangements put in place for the NZEUR[21].

Software

The registry software used by the NZEUR was developed by an American company, Perrin Quarles Associates (PQA). The system provided by PQA is based on an emission allowances trading system (EATS) originally developed for the U.S. Environmental Protection Agency. That system has been used by the EPA in America to run its NO_x and and SO_2 trading systems, and more recently by the UNFCCC Secretariat to run its Clean Development Mechanism (CDM) Registry.

The NZEUR advise that the software developed by PQA is unsuitable for the purposes of an agriculture sector VGGR without substantial modification. The software does not currently have the capacity to: store data on farm practices (as opposed to emissions); estimate emissions from other data stored in the system; allow online data entry by users; or allow users to access online reports. Further, the NZEUR software contains many functions relating to the operation of an emissions trading system that would not be needed for a VGGR (such as the ability to store information on permits as well as emissions; and the ability to reconcile emissions against permit holdings and remove permits from individuals accounts). There is unlikely to be any clear benefit in seeking to modify the existing NZEUR software, instead of commissioning the development of a new bespoke VGGR system.

Consideration should also be given to the any benefits of ensuring that the system used to run the VGGR is capable of transferring emissions data to the emissions registry, and if so to stipulate that requirement in its tender documents.

Infrastructure and Systems

As noted, MED runs a number of different registries in addition to the NZEUR. We understand that MED provides a number of the administrative functions supporting these registries jointly, rather than individually for each registry. For example there is one help desk (based in Christchurch) which provides phone assistance for all of the registries, and one 'revenue team' which undertakes basic background checks on participants where necessary (such as ensuring they are not bankrupt and do not have any outstanding tax debts).

[21] The information provided in this section is based on a telephone conversation with Tony Offord, NZEUR, March 2007

More generally, even where functions are provided separately for each registry, such as system administrator roles, the economies of scale of providing more than one registry allow MED to manage its human resources more effectively. This is especially important where a task for each individual registry would require substantially less than one full time equivalent position.

For these reasons, we recommend that MAF consider placing some or all of the administrative functions associated with operating a VGGR within MED.

6.3.10 Compatibility with E-Govt. initiative

The E-government Strategy sets out the government's approach to transforming how public service departments use technology to deliver services, provide information, and interact with people, as they work to achieve the outcomes sought by government.

The E-government vision (at November 2006) is:

New Zealanders will be able to gain access to government information and services, and participate in our democracy, using the Internet, telephones and other technologies as they emerge.

The use of technology will enable a transformation of government as the operation of government is transformed by government agencies and their partners using technology to provide user-centred information and services and to achieve joint outcomes. Further, people's engagement with the government will be transformed as increasing and innovative use is made of the opportunities offered by network technologies.

This report recommends the use of web and email-based user interfaces to allow participants to input data and request information. As such our recommendations are fully consistent with the E-government vision.

The E-Govt. website sets out both mandatory and discretionary requirements for public service departments (State Services Commission, 2005). At this stage, there is nothing in core design that would prove incompatible with the checklist. It should be noted that the core design provides high level indicative information only while the checklist provides much lower-level information that would typically be included within a detailed requirements specification. If the government decided to pursue a VGGR, the next stage of the process would be to provide a complete and detailed list of functional and non-functional requirements for the system. The functional requirements would describe how the system will behave at a detailed level, while the non-functional requirements describe the kind of information provided in the checklist. For example, detailed requirements might specify that the system should be compliant with NZ e-GIF standards or more importantly, which of the specific standards should be adhered to based upon the functional content. The output from the detailed requirements analysis would then feed into the next stage of the process and allow a detailed design to be produced along with an accurate cost analysis.

6.4 Likely uptake by farmers of core VGGR option

This section contains an assessment of the likely uptake by farmers of the core VGGR option using the assessment framework outlined in Section 5.5. The information provided in this section is based on the professional experience and knowledge of the AgriBusiness Group, a sub consultant to the project team. The project team did not consult directly with farmers to complete this section.

Table 6-1 below indicates that in the absence of a financial incentive, incentives for farmers to participate in the core VGGR option are largely limited to the provision of information the VGGR will provide to a farmer around their emissions profile and mitigation opportunities. The core VGGR option largely avoids most of the possible disincentives for farmers to participate.

Section 6 VGGR design options

The majority of farmers in New Zealand are owner / operators. A very high level of concentration of their time and thought goes into operational activities with some time in managerial and very little time in strategic thinking. Any activity, technology or practice that has little to do with operational or managerial thought processes therefore has little chance of coming into the decision making framework of farmers without strong external drivers.

Overall, it would appear that the incentives that do exist would not be strong enough on their own to create a high uptake. Based on knowledge of the farming industry and assessment of similar programmes (e.g. DairyBase and nutrient budgeting), farmer uptake of the core scheme would therefore be expected to be between 1 to 5% of potential participants.

Table 6-1 Assessment of drivers for uptake of core VGGR option

Subject	Key Questions	Comment	Assessment*
Possible incentives			
Financial incentives	Do any financial incentives exist for a farmer to participate (e.g. an emissions trading regime?)	Not currently	X
Demonstrate stewardship	Does the VGGR enable a farmer to both increase and demonstrate an increase in on farm stewardship?	No (certification and auditing provided but no branding/advertising etc).	X
Respond to market	Does the VGGR provide an ability to respond to market concerns around climate change?	No	X
Protect baseline emissions	Does the VGGR allow a farmer to record emissions baselines and subsequent reductions to protect early reducers against future emission allocations?	With regard to the use of nitrification inhibitors only	½ X
Provision of information	What information is provided to farmers about their emissions, mitigation opportunities and offset ability?	Emissions profile, information about mitigation provided by roving technical advisors. No offset information.	✓
Ability to improve nutrient management or productivity	Does the VGGR provide a co-benefit in terms of the ability to also manage nutrients or improve productivity?	No nutrient budgeting capability. Could improve productivity indirectly, but no specific capability.	X
Ability to use third parties	Can a farmer use a third party to collect, model or enter information (as required)?	Yes	✓
Increase understanding	Does the VGGR provide information in such a way that through participation, farmers will be better able to understand the science of greenhouse gas emissions and reductions?	Yes	✓

Subject	Key Questions	Comment	Assessment*
Possible disincentives			
Mitigation opportunities	Do opportunities exist for a farmer to mitigate emissions?	Currently mitigation limited (e.g. nitrification inhibitors , feed pads)	½ X
Direct costs	Will a farmer have any direct costs (e.g. purchase of a computer)?	Farmers would have minimal direct costs as most would already own a computer and have internet access.	✓
Time and effort	How complex are the data input requirements?	Simple, with options to use emission factors if required.	✓
	Does the system provide a farmer with flexibility around the level at which he/she can report (i.e. entity level or whole business level?)	Yes, can submit a single report for all operations or separate reports for each.	✓
	Is a farmer required to report a full set of information every year, or do requirements decrease in subsequent years and/or does the frequency of reporting decrease?	Use of baseline information means information requirements decrease. Frequency of reporting does not decrease.	½ ✓
Perception of reduced competitiveness	Will the VGGR enable others to access individual farm level information potentially reducing an individual farmer's competitiveness? Is confidentiality ensured?	No	✓
Suspicision about motives	Is the government being clear information about the current and future use of the system?	Suspicious about motives as no clear decision on purpose of VGGR.	X

*✓ indicates a positive influence on farmer uptake
X indicates a negative influence on farmer uptake

6.5 Indicative cost of developing core VGGR option

IT sub consultants Fronde developed an indicative cost estimate for developing and operating the recommended core VGGR option. The cost figures provided by Fronde are based on high level scheme requirements, and it has been necessary for Fronde to make assumptions in order to derive those estimates. The cost figures should therefore be seen as indicative only. Detailed analysis will be required before more accurate cost information can be provided, which we recommend be undertaken during the procurement process. Appendix A contains a copy of Fronde's report. We have summarised the costs below in this section.

6.5.1 Establishment costs

One off software licence costs

With the exception of the user interface, Fronde considers that a number of technology options are possible for developing a VGGR system. The various options are, by and large, cost neutral from a financial perspective. The choice of platform is therefore likely to be driven by MAF's technology history, preferences, standards and desired future direction. Table 6-2 provides a summary of technologies that will fulfil MAF's high level requirements.

Table 6-2 Platform architecture options

Component	Implementation Options
User interface (what the users see)	HTML. HTML is generally used to provide web user interfaces.
Programming Language	Microsoft .NET or Java. Either programming language can fulfil the non-visual part of the business requirements.
Web and Application server	This is where the user, using an Internet Browser, would submit requests. Good, free and security conscious implementations of these are available and will satisfy your requirements.
Database	Microsoft SQL Server Standard Edition or Oracle Standard Edition or any other entry-level enterprise database system.

Fronde recommend that the core VGGR option uses a large vendor's entry-level database such as Microsoft SQL Server Standard Edition or Oracle Standard Edition. Smaller free database systems are available. Supporting smaller databases may be more expensive in terms of support, performance tuning, backup and recovery as less people are experience in using these smaller systems. Table 6-3 below provides a summary of the likely licence costs of acquiring suitable software.

Table 6-3 One-off software licence costs

Component	Cost
HTML There is no license cost associated with this component. HTML Interfaces are also generally cheaper to build than other options.	$0
.NET or Java. There is no license cost associated with these languages. Both have merits and can be more or less cost effective for different reasons. Choosing one would be best done after further analysis.	$0
Microsoft SQL Server Standard Edition or Oracle Standard Edition. There are additional support costs per year that have been included in the 'Cost of ownership' section below.	*$9,000
Operating System Licences	**$3,500

* Indicative cost based on Microsoft SQL Server Standard Edition. Oracle Standard Edition is approximately the same price.

** Based on Windows Server 2003 Standard Edition licenses for two servers.

Development costs

The following table provides a breakdown of the total estimated development cost. The software development effort has been estimated in most detail, and is used as the base value. The other activities are expressed as a relative percentage of that software development effort, based upon standard industry figures. These development costs are based on a review of the algorithms contained within Overseer.

It is important to note that the actual costs for these other activities will vary on a project-by-project basis. The effort figures shown here are used only as a method of calculating an indicative cost, and do not constitute a project plan or measure the elapsed time it would take to implement a system of this nature.

Table 6-4 Software development cost

High-level Project Task	Percentage of project	Days Effort
Analysis and Design	25%	72
Software Development	40%	115
System Testing	30%	86
Implementation (Delivery)	5%	15
Sub Total		288
Project Management	10%	29
Total		317
Taking a blend rate of $1200 a day to calculate the overall development project cost.		$380,000

Other establishment costs

We have costed the development of a VGGR on the assumption that the system, once up and running, will be hosted by an appropriate organisation. As noted, this requirement could be included by MAF in the broader contract to develop the VGGR system.

This approach negates the need to purchase physical hardware, other than one or two internet enabled computers needed for MAF to undertake its administrative role. We have estimated this cost at $3,500 per computer.

6.5.2 Ongoing costs of ownership and operation

Hosting and licence costs

As noted, we have costed the development of the VGGR on the assumption that the system will be hosted by a suitable external organisation (e.g. Ministry of Economic Development). This negates the need to purchase physical hardware, other than one or two internet enabled computers needed for MAF to undertake its administrative role. However, if MAF preferred it could undertake this role internally for a broadly equivalent cost.

The indicative hosting and licence costs are set out in Table 6-5 below.

Table 6-5 Cost of ownership*

Requirement	Cost per Year
Hosting	$50,000**
Database license support ~20%	$2,000

* reflects the on going costs of hosting, supporting and licensing the system

**Indicative cost for two virtual servers hosted externally. This includes helpdesk and maintenance support.

Technical assistance costs

We have recommended (see Section 6.3.8) that technical assistance be provided through a number of farm consultants trained in the use of the VGGR system. We also recommended that MAF organise occasional seminars and workshops, open to all scheme participants. We would envisage these seminars also being run by farm consultants.

We consider that it is likely to be most cost effective for MAF to provide this technical assistance by contracting with existing farm consultants, rather than attempting to employ suitable staff directly. MAF could enter into an agreement with a number of consultants in different regions around the country, paying for the work they undertook providing technical assistance to VGGR participants, and for any training they needed.

We anticipate that the costs of providing technical assistance would be in the order of $170,000 for the first year with an ongoing per annum cost of $100,000.

We have derived this figure as follows:

- We consider that farm visits by accredited farm consultants would need to involve a 2 to 3 hour engagement. This would mean that each visit would effectively be a half day exercise (from office to office). It would be necessary to have accredited agents in the majority of the major rural servicing centres in New Zealand. We therefore estimate that a minimum of 12 agents would be required in the North Island and 8 in the South Island creating a minimum total of 20 agents.
- We have assumed that all agents would be required to attend a three day centrally provided training exercise to gain accreditation. We have assumed that all of the costs associated with that accreditation process would be met by the scheme. On that basis direct agent training costs would most likely be around $3,500 per farm consultant, leading to an overall accreditation cost of $70,000.
- We estimate that the cost per visit is likely to be around $500, based on 4 hours per visit
- We have assumed that up to 200 visits would be required per year (based on each of the 20 agents carrying out 10 visits)

  These figures are summarised in Table 6-6 below.

Table 6-6 Costs for technical assistance

Component	Cost
Agent training	$70,000
200 visits per year @ $500/visit	$100,000
Total	**$170,000**

Staff costs

As discussed, we have costed the development and operation of the VGGR on the assumption that MAF would contract out the hosting of the system, and would provide the technical assistance required through the use of independent accredited farm consultants.

As a result MAF would only need to provide the core administrative service in-house. Drawing on the experience of MED in providing its range of registry services, we consider that this is likely to require only around half a full time equivalent staff position. We estimate the cost of providing that half time position at $30,000. This does not include further policy development costs.

Other administrative costs

It is very difficult to predict what other administrative costs MAF might face in running a VGGR scheme at this early stage. But it seems likely that MAF would want to undertake some form of promotional activity, and may need to travel in relation to the establishment and operation of the scheme. Drawing on the budget for the NZEUR, we recommend that MAF set aside an indicative budget of $20,000 for publicity and promotions, and a further $10,000 to cover travel and basic office costs such as phone costs, photocopying services, and postage.

6.6 Summary of core VGGR option

The core VGGR option would provide MAF's requirements of:

- A registry to receive reports for farmer's emissions
- A system for auditing the reports of on farm emissions, including options for contracting this activity to third parties
- A system to report emissions from individual farms or aggregations of them, to farmers, government and the public
- A system to provide advice to farmers to help them with operating the VGGR system and to enable them to reduce emissions

The core option requires farmers to collect information on their farming operations and annually enter this data online or via email. A central database and calculation system would calculate emissions at a farm level and enable farmers to access this information.

The scope of the core option is limited to methane emissions from enteric fermentation and nitrous oxide emissions from animal wastes and fertiliser application. Farmers would be required to collect information on animal numbers, performance characteristics and diet characteristics.

The central database and calculation module would be based on the existing IPCC methodology for estimating methane and nitrous oxide emissions from agriculture, with updates included to allow for inputs of farm level information for nitrous oxide calculations.

The system would enable farmers to access emissions at their farm level, New Zealand regions and the country as a whole. The system would also provide benchmarking information, individual or total emissions sources, individual GHG or total gases and data on farm management practices provided by other farmers.

The system would be verified via annual audits of a small fixed proportion of scheme participants. Technical assistance would be provided via a help desk, web based instructions and roving technical advisors.

Benefits to farmers are limited to capacity building and the ability to benchmark performance. Direct costs to farmers would be relatively low but time would be required to collect and input the data. Based on uptake of similar programmes in New Zealand and the potential benefits and costs to farmers we anticipate that only 1-5% (450-2,250) of New Zealand farmers would participate in this option.

Table 6-7 summarises establishment costs to government of implementing the core system. These costs are expected to be in the order of $470,000.

Table 6-8 summarises costs to government of operating the VGGR, expected to be in the order of $162,000-$212,000. Note that annual operating costs referred to in Table 6-8 provide only $30,000 for administration costs for MAF staff and $20,000 for publicity and promotion. Section 7 outlines indicative consultation costs. Other costs to MAF may include costs involved in the tendering process, overall project management required to establish the VGGR system.

We stress that the cost estimates provided here are indicative, 'ball-park' estimates only. It will not be possible for MAF to develop more robust estimates until further more detailed policy work has been undertaken, and the detailed requirements of the system have been developed. These cost estimates were mostly derived from advice by Fronde, and by drawing on MED's experience in establishing the NZEUR.

Table 6-7 Estimated establishment costs for core scheme

Item	Estimated Cost
Initial (one-off) software licence costs	$12,500
Software Development	$380,000
Computers (for Administrative Functions)	$7,000
Training of Initial Tranch of Technical Advisors	$70,000
Total	**$470,000**

Table 6-8 Estimated annual operating costs

Item	Estimated Cost
Hosting of System (incl. phone based help desk)	$50,000
Ongoing Licence Costs	$2,000
Technical Assistance Visits (assuming 100 – 200 visits per year)	$50,000 - $100,000
Administrative Staff	$30,000
Publicity and Promotion	$20,000
Other operating expenses	$10,000
Total	**$162,000 - $212,000**

6.7 Design options and their cost implications

This section outlines additional VGGR design options and describes these options in terms of variations to participation, scope and data requirements and entry arrangements. A description of the likely impact of each variation on farmer's likely uptake and costs to government is provided.

6.7.1 Participation

Delegation of responsibility to a third party

The government could choose to encourage or contract with another key organisation in the agriculture sector, such as Fonterra, to establish and operate the VGGR system. The advantage of this option is that it would reduce, and possibly remove entirely, the establishment and ongoing operational costs facing the Crown. A key agriculture sector agency such as Fonterra might also be able to encourage greater levels of participation.

The change of status of the promoter of the scheme from government to an industry organisation would increase uptake by farmers because there would be less suspicion about the possible motives of the promoter and potential future use. Farmers tend to respond better to industry good motives rather than national public good motives, particularly where there is potential conflict between the two. Uptake would be further increased if the promoter combined the existing benefits of the scheme with a method to respond to market signals around climate change (e.g. promotion of participant achievements through branding).

However, by ceding control of the VGGR scheme to another party, the government might lose confidence over the accuracy of the information provided through the scheme. This option might also limit how the information provided through the scheme could ultimately be used, for example a future regulatory system.

Farm block or paddock level reporting

The government could choose to further 'future proof' the system by designing it with the capability to be expanded to allow separate reports for different farm blocks or paddocks. This would require the system to have the capacity to store an even greater number of records. It would also require modification to the data entry modules (as some data would remain consistent across all paddocks) and the ability to link different reports from a single farm together.

This option would provide greater flexibility to farmers and improve the quality of feedback to farmers who selected this option, potentially increasing farmer uptake.

This option would only impose a moderate cost increase on the software development task – in the region of $15,000. In addition, the extra volume of data arising from a greater number of reports could lead to increased hosting costs. However, the size of that impact is not possible to estimate at this early stage.

Direct participation incentives

The government could also provide direct participation incentives to farmers to encourage greater levels of participation. These incentives could take the form of:

- direct financial payments
- other incentives, for example payment by government for technical advisors to take soil samples to provide specific farm information
- participants receiving exemptions from other climate change policies
- participants historic emission reductions efforts being recognised when applying policies in the future (such as when deciding how many permits to allocate to individual farmers under a tradable permit regime)

The impact of any incentives to engage on uptake levels would depend on the design and nature of the incentive. Exemptions and recognition of historic reduction efforts would be expected to greatly enhance uptake levels as farmers would see that it is in their own personal interests to be involved in that activity in order to secure any personal advantage that could result. Direct financial payments would probably have little impact as time is the potentially limiting resource rather than finance.

The primary cost impact of this option would lie in the financial cost to the government of providing the incentive. If the incentive was very successful, this option could also lead to increased hosting costs. It is not possible for us to assess the likely cost impact of this option at this early stage.

Maximisation of market benefits

The government could also help to maximise indirect 'market' incentives to participate by establishing a scheme certification regime and branding system. This would ultimately allow farmers to market their product as being more environmentally friendly.

Considerable further work would be needed before deciding to pursue this option. Most importantly it would be necessary to assess whether the act of participating in a VGGR scheme would be enough to establish an effective 'green brand'. The Australian Greenhouse Challenge Plus programme provides participants with recognition for their reductions through the use of Challenge Plus logos and marketing material. Participants note that this is key driver for their participation (Section 4). Further review of work done internationally (including Greenhouse Challenge Plus) would be useful in this regard, particularly with relation to costs to governments, market perception and resulting impact on uptake. It is not possible for us to assess the likely cost impact of this option at this early stage.

Section 6 VGGR design options

Expansion to other sectors

In the longer term the government may also want to expand the VGGR scheme to include GHG emissions from completely different sectors, such as manufacturing. This would almost certainly require the reporting of different types of data (e.g. CO_2 from industrial activities) in addition to increasing the number of participants in the scheme.

It is very difficult to determine what changes to the VGGR system this would require in the absence of a clear understanding of the types of sectors that might be included, and the numbers of participants that are likely. A high level cost estimate of the changes required to the core design, to provide flexibility to allow for the addition of capability to enable other sectors to report is in the order of a 50% increase to the development cost of the core system.

6.7.2 Scope

More accurate estimation methodology

The government could choose to increase the accuracy and completeness of the GHG emission estimates provided through the VGGR system by:

- including a greater number of agriculture sector emission sources (such as the burning of crop residues and tussock)
- including farm's indirect emissions (such as through electricity and fuel use)
- adopting a more detailed, and therefore more accurate, estimation methodology than currently required by the IPCC for the national inventory.

The first and second changes outlined above would require more farmer inputs and a more complex calculation module. They would also require additional output reports.

The degree of complexity of data requirements could have a negative impact on uptake unless greater value of feedback or output information resulted from it.

It is not possible to estimate the likely cost impact of these changes at this early stage. However, it is likely that those costs would be relatively substantial. Equally importantly, there is a clear risk that the requirement to provide a greater number of inputs could lead to reduced participation rates by farmers.

Choice of estimation methodology

The government could also consider giving farmers a choice over the estimation methodology used to calculate their emissions; giving them flexibility over the number of data inputs they provide (for example as currently provided in the Voluntary Reporting of Greenhouse Gases (Section 4.2.2). This would require the calculation module to include several estimation approaches and have the ability to switch between them as appropriate, increasing complexity. Costs to provide additional estimation methodologies are expected to be in the order of $48,000 per additional methodology.

Incorporate nutrient budgeting

One obvious option in this area would be to give farmers the choice of including all of the data inputs and calculations used in the existing Overseer® model, so that the VGGR could be used for nutrient budgeting purposes as well as for estimating farm-level GHG emissions. In addition to a greater number of inputs, this would require a more complicated calculation module (although an existing model already exists which could be used to develop the new model from) and more complicated reporting arrangements.

Section 6 VGGR design options

The dual capability of the register would add significantly to uptake rates as nutrient budgeting is a much more attractive exercise for farmers in terms of positive drivers. It may be that the register could actually be promoted as a means of calculating and verifying a nutrient budget with greenhouse gas reporting as a secondary benefit.

Fronde estimates that this option could add an extra 5%-10% ($16,500 - $33,000) to the cost of developing a VGGR. Given this cost and the extra reporting burden this option would place on participating farmers, and the fact that the existing Overseer model is already freely available, we question whether there is sufficient benefit to warrant expanding the VGGR to include the full Overseer functionality.

An alternative option would be to add the VGGR capability on to the current Overseer model. This would require redesign of the model to add in the GHG data entry requirements, and modifications to the Overseer model (which is stand alone) to link it up with the central database and calculation module. Costs for this option are likely to exceed costs for development of a new model.

Reporting of emissions reduction projects only

Another option would be to give farmers the right to only report specific emission reduction ‘projects’ rather than the full set of data required to estimate their overall level of emissions. These projects would fall into two types:

- ‘offset’ or ‘sink’ activities; such as tree planting
- ‘mitigation’ activities; such as improved waste management practices

This second project reporting option might prove attractive to farmers wanting to ensure that any efforts they took to reduce emissions would be recognised if the sector was subject to broader climate change controls at some stage in the future. Reporting emission reduction projects only allows a farmer to do this while at the same time minimising data input requirements (i.e. farmers are not required to report all their emissions information, only information required around emission reduction projects)

Fronde’s analysis suggests that this option could be implemented for around $50,000.

6.7.3 Data requirements and data entry arrangements

Third party data sources

The government could choose to design the VGGR system so that some of the data required could be collected from existing third party sources and databases, such as Fonterra, the LIC and the national soils database. The obvious benefit of this option is that it would help to reduce the size of farmer’s reporting obligations. The downsides are that it would make it impractical to hold farmers accountable for the accuracy of all of the data used to estimate their emissions, and that it could make the data reporting process more complex.

It is not possible to cost this option at this early stage; however it is unlikely that this option would reduce costs.

Reduced regularity of reporting

The government could choose to reduce the regularity of participants’ reporting requirements to once every 2 or 3 years. This might be attractive to farmers, as it would reduce their reporting burden. However, this option would not impact on the cost of developing the system, would only have a modest impact on the ongoing hosting costs, and may reduce the level of benefit in terms of capacity building, farmers would receive through participation.

Data entry could also be reduced by the system bringing up the last return and prompting farmers to update the form with changes. This would reduce farmer effort but may mean farmers would be tempted to re-submit old information instead of providing updated information.

6.8 Summary of VGGR design options

A number of VGGR design options exist that would deliver different outputs to the core option. Each option has implications on cost or likely farmer uptake.

Options around participation that are likely to increase farmer uptake include delegation of responsibility for the system to a third party (i.e. industry driven rather than government driven), provision of direct incentives and maximisation of market benefits.

In terms of changes to scope, an ability to allow farmers to complete nutrient budgeting and GHG emission estimation would increase uptake, as would an ability to report specific emission reduction projects (e.g. tree planting).

Allowing a third party to enter information, reducing the regularity of reporting requirements and improving the information feedback to farmers are all also likely to result in increased uptake.

It is not possible to assess cost implications for each option; however options that would increase cost to government include the option to allow reporting by farm block, allowing a choice of estimation methodology, incorporating a nutrient budget ability, allowing reporting of specific emission reduction and improving information feedback to farmers. Increased costs for each of these are listed in Table 6-9 below and are expected to be in the range of $15,000-$50,000. These cost estimates are indicative only.

Table 6-9 Estimated establishment costs for optional additional functionality

Item	Estimated Cost
Participation Options	
Delegation to third party	Unknown but reduction in cost likely
Allow report by farm block	+$15,000
Direct participation incentives	Unknown but increase likely if successful
Maximisation of market benefits	Unknown
Expansion to other sectors	Unknown
Scope Options	
More accurate estimation methodology	Unknown
Allow choice of estimation methodology	+$48,000 (for each additional methodology)
Incorporate full functionality of Overseer model into VGGR	+$16,500 - $33,000
Allow reporting of specific emission reduction projects only	+$50,000
Data Requirements and Entry Options	
Third party data sources	Unknown
Reduced regularity of reporting	Unknown but expected to be minor
Provide modelling facility	+$15,000

Section 7 Consultation guidance

7.1 Introduction

This section provides advice to MAF on how to consult with farmers and the agricultural sector prior to the implementation of a VGGR. The information provided in this section is based on the professional experience and knowledge of the AgriBusiness Group.

The New Zealand pastoral industry's contribution to climate change is an emotive and political issue amongst the industry. Farmers are aware of the subject area but their attitudes and responses are not strongly formed and not always well-informed. Some representatives in the sector express opposition to the Kyoto Protocol and repeat concern about the impacts on New Zealand's competitiveness as a result of regulation. With relation to a VGGR, farmers are liable to be influenced by the attitudes and responses of their industry leaders and spokespeople and will rely on advice from professional advisors and peers.

We recommend a staged consultation approach designed to engage leadership and influencers first (stage one) and, as feedback from them is received, refine the consultation approach to a point where it can be taken to the farming community (stage two). MAF may also consider forming a partnership with the leadership organisations to take the consultation to the farming community.

We also recommend that MAF use the initial industry consultation stage (stage one) to assess the feasibility of the VGGR and finalise the high level design requirements of the system prior to wide scale consultation with farmers. We recommend that MAF allows time and resources to make changes to the VGGR design following consultation during stage one and stage two. This will enable MAF to make changes to the system to increase participation, increasing the value of the system to both government and farmers. Section 9 outlines how we propose consultation could be integrated into VGGR design and implementation. We have outlined this two stage approach in more detail below including the objective, target audience and proposed strategy for each stage.

We make the general observation that the ideal approach for consultation on the VGGR system would be as part of consultation on a wider strategy for the pastoral sector on addressing greenhouse gas emissions and the issue of climate change. The government released a discussion document *Sustainable Land Management and Climate Change* in November 2006 and invited comments until March 2007. This document included a VGGR system as one of a range of policy options. If the government decides to explore the VGGR option further, it could be included in any further consultation exercises. The concept of a VGGR system as a stand alone issue without an overall greenhouse gas framework and response may be a difficult topic to gain a significant amount of traction for. However if the VGGR was part of development of an overall industry wide accord (similar to the Clean Streams Accord) that addressed a staged industry response to addressing greenhouse gas emissions then it would be a much easier method to engage widespread consultation. The consultation guidance outlined in this section provides an approach to consult on the VGGR alone, but if MAF could incorporate this consultation into a wider strategy, this would increase engagement and participation.

Our consultation approach favours discussions with industry leaders, influencers and farmers at one on one meetings and at agricultural forums, with practical demonstration where possible. We have not suggested any quantitative survey of farmers at this stage, as we feel that the farmers' current lack of understanding of the purpose of a VGGR and the wider climate change context would result in a low survey response and lack of meaningful feedback. Discussions, with information provided and ideally leadership via an industry organisation will provide a more useful result. A quantitative survey could be considered at an early stage of the VGGR implementation process (1-2 years after commencement) if required to better understand participation rates and benefits to farmers.

Section 7 Consultation guidance

7.2 Stage one

The first stage of consultation would be designed to:

- inform industry groups about the VGGR concept
- consult with these groups to gain feedback about the feasibility of a VGGR and firm up high level design
- achieve early engagement of leaders and influencers
- en-list the help of these organisations during stage two.

The target audience for stage one consultation are industry leaders and industry influencers. We recommend a different consultation approach for each group, outlined below.

Industry leaders

Industry leadership will encompass industry political organisations and sector leaders including:

- Federated Farmers National Office (including National office bearers of Meat and Wool section and Dairy Farmers of New Zealand). Preference would be to consult at an individual level rather than at an executive or group meeting.
- Levy Funded Industry Organisations (Meat and Wool NZ, Dairy InSight, Deer Industry New Zealand)
- Processors and Marketers (Dairy Co operatives Association NZ, Meat Industry Association), key co operative processor / marketers).

Consultation with industry leaders should be in the form of one to one discussions with key industry leaders within the organisations. Consultation would take the form of explaining the purpose and operation of the VGGR system and gauging feedback on the attitude to the initiative and how it may or may not be complimentary to the organisations response to wider greenhouse gas and sustainable agricultural systems initiatives. Feedback as to the organisation's view of the initiative and possible responses and improvements that could be made to improve farmer uptake should be sought.

Industry influencers

Industry influencers will include agricultural consultants, science information providers, the servicing sector and professional advisors such as accountants, banking and other advisors, including:

- New Zealand Institute of Primary Industry Management
- Dexcel Consulting Officer Service
- New Zealand Institute of Agricultural Science
- NZ Greenhouse Gas Consortium
- Agricultural Accounting section NZ Institute of Chartered Accountants.

Consultation with industry influencers should be of a more general nature and should be carried out at group functions and field days that involve a wider range of group members. Consultation would take the form of explaining the purpose and operation of the VGGR system and gaining feedback on ways that it could be presented to farmers as part of the normal engagement processes of those organisations with farmers. Identification of how uptake could be incorporated into normal strategic business thinking at the farm level should be sought.

7.3 Stage two

Following changes to VGGR design resulting from stage one, the second stage of consultation would be with farmers and would be designed to:

- inform farmers about the system purpose and concept and the likely costs and benefits
- consult with farmers about likely participation and changes required to increase participation
- promote a positive response and farmer involvement

This stage could be considered as bridging the transition between consultation and implementation of the VGGR and therefore will have elements of both consultation and early implementation activities.

We do not believe that the VGGR system itself would promote sufficient interest to attract farmer attendance at consultation meetings. It would therefore be best to consult with farmers on this issue as part of normal group activity during other industry initiatives. Consultation on VGGR would fit well into a number of existing farmer forums, e.g.

- dairy discussion groups
- other livestock discussion groups
- meat and wool and deer monitor farm community group meetings.

As mentioned previously, MAF should aim to enlist the help of industry leaders to promote and support consultation during stage two.

The consultation approach would include both provision of information and feedback. Information provided to farmers should include an explanation of the purpose and operation of the VGGR system, the information and support that farmers would receive and the benefits and costs to farmers. MAF should then seek feedback on farmer reaction to the system and how it could be promoted to increase the level of uptake and interest.

The ability to show case the system on an example property would be an advantage at this level of consultation as it would take the concept from the abstract or conceptual level to the practical, increasing understanding and enabling improved feedback. This will depend on the specific timing of and detailed design. It may be possible to run a prototype based on high level design requirements at this stage. Alternatively, practical demonstration could be implemented as part of the promotional strategy (refer Section 9.4).

MAF should then use the results of the stage two consultations to fine tune the VGGR to maximise participation and benefits to farmers.

7.4 Key cost components

Table 7-1 below summarises the key cost components required to implement the consultation approach described in this section. This table should be considered indicative only and is based only on the high level consultation guidance outlined in this section.

Table 7-1 Key cost components for consultation

Task	Possible hours	Possible labour cost (@$150/hr)	Other costs
Design and confirm consultation approach	24-32 hours	$3,600-$4,800	N/A
Preparation of consultation materials (prototype model for demonstration, brochures, website)	80-120 hours	$12,000-$18,000	Graphic design Printing Website
One on one meetings with industry leaders	6-10 meetings @ 4 hours per meeting (including travel) 24-40 hours	$3,600-$6,000	Travel to meetings, accommodation, room hire, meals
Attendance at group functions and field days to consult with industry influencers	2-4 meetings @ 4 hours per day (including travel) 8-16 hours	$1,200-$2,400	Travel to meetings, accommodation, room hire, meals
Attend existing farmer forums to consult with farmers	6-10 meetings @ 8 hours per day (including travel) 48-80 hours	$7,200-$12,000	Travel to meetings, accommodation, room hire, meals
Total		**$27,600-$43,200**	Based on above

Section 8 Risk identification and mitigation

This section contains a review of the key risks and challenges that are likely to arise in implementing the core VGGR design and contains recommendations for managing and mitigating those risks.

Section 9 provides a recommended project plan to implement the core VGGR option. Measures to mitigate risks identified in this section are included in the project plan.

Table 8-1 below summarises the source of any potential risks, the possible consequence of each risk and recommended mitigation measures for key stages during the development, engagement and operational stages of VGGR implementation. The table does not include any assessment of likelihood as it is difficult to quantify likelihood without more detailed understanding of how the VGGR would be developed and implemented. This table provides a high level risk assessment for the core VGGR option only. This assessment could be expanded and used to complete a detailed risk assessment (including detailed assessment of likelihood and consequence) of any future detailed VGGR option proposed.

Table 8-1 Key risks and mitigation

Risk Source	Consequence	Mitigation
Failure to maximise participation during design process	The system is not effectively designed to maximise participation. Farmers and/or industry representatives do not engage in the project or take any ownerships	Section 7 outlines consultation guidance and Section 9 a project implementation plan. We have recommended that MAF carry out consultation both with industry groups and farmers to identify participation levels and methods to increase participation. Care is required to ensure timeframes and resources allow for further design changes to be made after consultation aimed at maximising participation.
Barriers to participation as a result of system design.	System design that creates barriers to participation by creating complexity of operation or slow information transfers will reduce the motivation for farmers to participate.	Allow time and resources to fully understand rural IT access and engagement issues during system design. System design will need to incorporate an understanding of the unique range of IT skills and IT access difficulties experienced by the rural community.
Unrealistic scope, timelines or resources	Project being delivered late, outside of budget or not to the government's specification	Early and firm definition of the desired scope. This will require sufficient MAF resources being devoted to that task, close sector involvement, and the subsequent involvement and support of management to resist arguments for unreasonable increases in scope during the development phase.
Poor relationship between MAF and the contractor	Project not being delivered to the government's specification.	It will be important for MAF to ensure that it remains closely involved in the development process, and has sufficient in-house technical understanding to be able to communicate its requirements to the contractor, and discuss how to address any technical issues that arise.
Poor quality and track record of contractors	Difficulties can arise if contractors are selected that do not have previous experience implementing public service projects, or have placed emphasis on cost rather than quality.	In deciding who to award the development contract to we recommend MAF place considerable emphasis on the track record of the different bidders in working successfully on public sector projects of this nature. Above all else it is the quality of their staff who will work on the project and their ability to work with MAF and any sector representatives that will determine whether it is successful.

Section 8 Risk identification and mitigation

Risk Source	Consequence	Mitigation
Inappropriate risk sharing around delivery cost, and performance of the IT system between the procuring agency and the contractor	Non performance if the contractor is constrained by time or financial delivery requirements	We recommend MAF take a pragmatic approach to addressing any unforseen difficulties that arise in the development of the necessary IT systems. While an initial fixed price bid is appropriate, MAF should set up the contract so that changes can be negotiated to the price in response to changes in the required scope or unforseen technical challenges. To do so, MAF will again need sufficient in-house technical understanding.
Unsatisfactory tender process	Unsatisfactory outcomes can occur if MAF does not receive comprehensive information on the proposed approach each tenderer intends to take in relation to system design and development.	Ensure that the initial RFP require all of the information MAF is likely to need to undertake its bid evaluation. Information on the proposed methodology of tenderers, and their proposed approach to software development, can be used at the evaluation stage to assess the risks faced by the government.
Lack of industry support	Not understanding or addressing sector drivers meaning industry drivers do not positively influence farmers' decision making around participation.	As outlined in Section 7, we suggest that industry support for the VGGR concept could be enhanced by adopting a staged approach to consultation. In the first stage, we recommend MAF consult with industry leaders and influencers and seek to enlist their support, in the second stage MAF consult with the wider farming community. During both stages, MAF should specifically seek to understand likely participation levels and drivers and to identify any changes required to increase support and participation.
Lack of farmers attention	Farmers fail to participate because they can not clearly see its relevance to a wider policy initiative (i.e. climate change).	If possible, carry out consultation around the VGGR in the context of a wider suite of measures around climate change, so farmers can clearly see the role of a VGGR in overall methods to reduce pastoral emissions.
Lack of farmers participation	Farmers fail to participate if no clear drivers (e.g. emissions trading) exist.	Careful consideration of the likely uptake by farmers is required prior to proceeding with a VGGR, particularly in relation to the existence or otherwise of financial incentives.

Section 8 Risk identification and mitigation

Risk Source	Consequence	Mitigation
		If farmers are driven to participate, there are key elements of VGGR design which should be taken into account to maximise benefits, as follows: • farmers are able to easily understand the information provided and it helps them to 'demystify' the science of climate change • the information farmers receive could also help them improve productivity or nutrient management • the VGGR allows farmers to respond to market concerns over climate change or demonstrate stewardship • the VGGR provides a mechanism for farmers to protect baseline emission levels against future grandfathering. • Direct costs (for data gathering and entry) are minimised; • Confidentiality provisions are included in the VGGR;
Inadequate user testing	If the system is not adequately tested there are risks of the system: • not being user friendly for farmers, • containing glitches in it that frustrate data entry, • not easily and effectively providing reports to farmers or government, • being difficult to manage or administer, • being incompatible with NZEUR	MAF should therefore ensure that the Contractors are able to effectively test the system from a user point of view (i.e. farmers) and from an administration and management point of view (MAF). Appropriate time should be allowed to carry out testing and the contract and system should be flexible enough to ensure that the contractors are able to effectively fine tune the system if required, following testing.
Not resourcing the promotion of the system adequately	If the system is not properly promoted, farmers (and the industry) may not clearly understand the VGGR purpose and benefits leading to low participation	We recommend MAF ensures that adequate resources are committed to system promotion and sector engagement.
Not resourcing consultation appropriately	Lack of appropriate funding/resourcing may jeopardise effective consultation leading to system design that does not maximise the government's objectives for the system	It would be useful for MAF to firm up this strategy prior to development and implementation of the system, and ensure that roll out of the strategy is appropriately resourced, either from MAF or contracted out.
Inadequate funding	Promotion of the system will be essential in order to ensure farmers and the industry clearly understands the VGGR purpose and benefits.	Ensure comprehensive business plan prepared once VGGR objectives and concept confirmed.

Section 8 Risk identification and mitigation

Risk Source	Consequence	Mitigation
Failure to engage farmers	If farmers fail to understand how the system functions, the support available to them and how they can use the information to mitigate emissions, the benefit of capacity building may not be realised.	We recommend MAF include periodic review and evaluation of the system during implementation to identify any changes necessary to increase value to farmers (and government). It is also important that MAF allows appropriate resourcing to provide the support and advice required to farmers during implementation. As outlined in Section 5 this should include a phone line, seminars and visits from roving technical advisors.
Unsatisfactory advisory services	If the advisory service proposed to be provided by roving technical advisors is not appropriately targeted, farmer participation may wane, and additional uptake not materialise.	We recommend that the periodic review outlined above includes review of the technical advisors and their information provision. Also, care is required during the start up stage to ensure technical advisors are appropriately trained along with those manning the help desk and the information provided on the web. MAF should ensure appropriate budget is provided to deliver this service to a high standard.
Unsatisfactory management of initial system operational failures and regular changes to system	Farmers will become disillusioned and may pull out if the system experiences regular operational failures or if regular changes are made to the VGGR once they are experienced or comfortable with the system.	Robust pre launch system testing will be required before the system goes live. We recommend MAF build in suitable change management systems into the design and implementation of a VGGR so any changes that are made are appropriate assessed, streamlined, and effectively communicated to farmers.
Inadequate promotion/advertising	Inadequate promotion and advertising may mean farmers aren't encouraged to participate, industry leaders do not support the process or other parties do not understand the benefits of the system	Allow for and develop (or contract) an ongoing promotional and advertising strategy for the project during the implementation period.

Section 9 Project plan

9.1 Introduction

This section provides a recommended project plan to implement the core VGGR option. The project plan contains only the elements of the core VGGR option. We recommend MAF review and enhance the project plan once the specifics of the system are finalised. This section also contains an overall timeline summarising recommended actions and suggested timeframes.

9.2 Consultation

Section 7 of this report provides guidance to MAF on a possible consultation approach prior to implementation of the VGGR. It would be useful for MAF to firm up this strategy prior to development and implementation of the system, and ensure that roll out of the strategy is appropriately resourced, either from MAF or contracted out.

We recommend that consultation is carried out at various stages of system design. Consultation with industry leaders (stage one) should be carried out during finalisation of high level requirements, and consultation with farmers (stage two) should be carried out prior to detailed design. We have indicated in the relevant sections below, where we recommend each stage of consultation should be completed.

9.3 Development

Overview

The procurement and development process will need to occur in a number of distinct phases, listed below, and described in more detail in the remainder of this section:

I. Finalisation of high level scheme requirements
II. Running the Tender Process
    a) Optional: release of a call for expressions of interest (EoI)
    b) Release of a request for tenders (RFT)
    c) Evaluation of bids and engagement of successful tenderer
III. Completion by the successful tenderer of the tasks required under their contract:
    a) developing more detailed requirements and design specifications
    b) building the system
    c) testing the system

I. Finalisation of high-level scheme requirements

The first step MAF will need to take to develop a VGGR will be to finalise its high-level system requirements. This specification of the scheme requirements is not a task the government can transfer to a third party; it is not possible for the government to purchase a product or service unless it is clear what it wants.

To do this, MAF will need to work through the core recommendations and design options set out in this paper, further developments in climate change policy (such as the development of price-based mechanisms, and produce a preferred outline design. This should then be tested through a consultation process with industry leaders and influencers and amendments made to the system where possible aimed at increasing farmer participation. Section 7 outlines our recommended pre-implementation consultation strategy.

Also MAF will need to consult further with the NZEUR Office and managers of the E-Govt. initiative at this stage to ensure compatibility of the VGGR with both projects.

II. Running the tender process

Release of a call for expressions of interest (EoI)

In our view there is no need for MAF to release an initial call for expressions of interest (EoI) in this instance. The extra step is not warranted given that MAF should be able to provide a clear set of high level scheme requirements, and that the VGGR should be a relatively straightforward system to develop.

Release of a request for proposal (RFP)

We therefore recommend that MAF initiate the procurement process with the release of a Request for Proposal (RFP). The RFP should include a relatively comprehensive outline of the VGGR's scheme requirements, while still allowing for innovation and design from the contractor.

During the evaluation and award stage, it is likely to be desirable for MAF to increase its understanding of the tenders that have been received, and possibly to work to improve the quality of those offers. We would therefore encourage MAF to adopt an interactive bid process, to ensure a continued flow of information between it and likely bidders during the tender preparation phase.

Evaluation of bids and engagement of successful tenderer

Bidders should be encouraged to seek clarifications on the RFT document where useful (with appropriate open disclosure arrangements to ensure no one bidder gains a competitive advantage). There may also be a case for attempting to further improve any bids received through post-contract negotiations.

In large IT projects the different stages of developing the system are sometimes contracted for separately. In particular, the process of developing the detailed system requirements is sometimes contracted for prior to tendering for the development of the system, in order to allow the design and build job to be scoped more effectively. However, in this case we recommend that all of the different design and maintenance jobs be tendered jointly, due to the relative small size and simplicity of the project.

III. Completion by the successful tenderer of the tasks required under their contract

Development of detailed requirements specification, and detailed design

IT projects are typically not fully defined when they are tendered. This is particularly true for customised rather than commoditised systems. The ability of the system to deliver requirements, and the costs of doing so, will only become completely clear once the system is developed. The first step the successful tenderer will need to take will therefore be to develop a more comprehensive understanding of the detailed business requirements and recommend a detailed design specification.

In developing the detailed scheme requirements and design it will be important for the successful developer to work closely with MAF and farmers to ensure that their needs are understood, and will be met by the system. We suggest that the stage two consultation process recommended in Section 7 (consultation with farmers) is completed prior to development of detailed design, so that the results of farmer consultation can be used to inform the detailed design.

Building the system

Once the detailed system requirements and design have been agreed with MAF and stakeholders, the Contractor would turn to building the system. This stage of their work is not likely to require significant input from MAF.

Testing the system

Once developed, the system would need to be comprehensively tested. The system should be tested from a user point of view (i.e. farmers), from a data management point of view (MAF), and in relation to the information MAF and the farmers will receive. This testing process should ideally involve farmers and MAF staff.

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It may be valuable to establish a small user reference group during the design and implementation stage of the project. This group can be used as an information source for the designers during early system design and as a beta testing group of the system pre release. Members of this group would include farmers as well as members of the advisor community (agricultural consultants, accountants etc) who understand how farmers think and would operate the system. Once this initial testing has been carried out and the system refined as a result it will be valuable then to do real life testing in a selected wider set of farmers across the country. This may incorporate dairy discussion groups, monitor farms etc to get a wider range of operational issues and problems identified. The main focus of this testing should be ease of operation of the system. This has not been costed in our establishment cost estimates provided in section 6.

Following testing, the Contractor should report back to MAF on test results, with recommendations for any fine tuning required.

9.4 Promotion

During development of the system and prior to system rollout, MAF will need to promote the system to the industry, farmers and other affected parties, to increase understanding and participation. Some promotion and engagement will occur via consultation; however additional targeted promotion will be required following design to ensure all parties have a very clear understanding of the system, its purpose and benefits.

MAF should aim to promote the system to the industry leader and influencer's groups identified in Section 7, to farmers and to other affected parties such as Central Government, Regional Councils, fertiliser companies and trading partners.

It would be worthwhile to target early promotion to groups that are most likely to be inclined to participate. These would be farmers with a high degree of computer literacy and competency as well as farmers that are already engaged in activities focussed on climate change or the wider area of sustainable agricultural initiatives. For example, a number of the monitor farm initiatives in the pastoral livestock sector have a sustainability module incorporated into them. It would be sensible to have the VGGR system incorporated into that module and adopted on the monitor farms if possible. Incorporation of VGGR activities into NZ Landcare Trust groups would be sensible as participants are already sensitive to the impacts of farm management practices on the environment and so are more likely to be inclined and interested in recording greenhouse gas emissions. MAF may also consider specifically targeting likely sceptics, to ensure that, at least such groups are supplied with enough information to make informed decisions.

It may be worthwhile to target early promotion to sectors that are incorporating sustainable agriculture accreditation into brands or marketing campaigns of produce. This could include the organic farming community or producers that are involved in supply to markets where environmental performance claims are made (e.g. carboNZero[22]).

[22] The carboNZero programme is administered by Landcare Research and encourages and supports individuals and organisations, to minimise their impacts on climate change by providing them with tools to measure, manage and mitigate their carbon dioxide (CO_2) emissions.

9.5 Technical guidance

We have recommended that farmers are provided with ongoing support during implementation (refer Section 6.3.8). Prior to system roll out and implementation, MAF will need to:

- Develop the web-based technical instructions and a set of questions and answers to act as a first port of call for participants facing technical difficulties (or commission the Contractor to complete this)
- Contract out the toll free, phone based help desk.
- Train the roving farm consultants in the use of the system (or contract this out)
- Provide any services necessary to enable other agents or consultants to assist farmers in meeting their requirements under the scheme.

  MAF will also need to commission training for the MAF staff responsible for administering the system during implementation.

MAF may also consider running a series of initial seminars around the country to promote the system and provide initial training to farmers in use of the system.

9.6 Governance

We have recommended below that MAF consider contracting out the maintenance and operation of the VGGR to an external provider, and operate an ongoing administrative role only. However, MAF will need to determine and put in place governance arrangements prior to implementation and set up an appropriate governance structure during operation.

A number of organisations may hold a stake in the performance of the VGGR. MAF may therefore consider establishing a steering committee to provide an advisory role during the operation of the VGGR. While the steering committee may be chaired by MAF (to ensure overall direction), organisations represented could include Federated Farmers (to reflect the views of farmers), the organisation(s) responsible for developing and hosting the VGGR, Fonterra and/or meal/wool companies, a representative from the roving technical advisors and any other central government agency dependent on the VGGR data (e.g. Ministry of Economic Development and Ministry for the Environment).

Governance arrangements put in place prior to operation should include lines of accountability, terms of reference, roles and responsibilities, lines of communication with MAF, confidentiality requirements.

9.7 Operation

Managing the system

Once developed and operational, the system will need to be hosted on a suitable server. It is also likely to require ongoing maintenance and occasional further development.

We recommend that MAF include the maintenance and ongoing development tasks in its tender for designing and building the system, but retain the option not to proceed with that aspect of the successful tenderers bid if MAF ultimately concludes that it, or MED, could host the system more cost effectively.

In Section 6, for costing purposes we have assumed that MAF will let a contract to an external organisation to host the VGGR system. In this case, MAF would be required to take only an administrative role in the system operation. Accordingly, MAF would only need to provide a small range of administrative functions, with a total workload of less than one full time equivalent position. Given that, we see no need for MAF to set up a standalone agency. Instead we recommend that MAF, or MED if relevant, provide this function as part of its core operations.

Ongoing advertising/promotion

MAF will need to carry out ongoing advertising and promotion of the VGGR both to farmers and the farming industry and to other interested and affected parties. We recommend MAF develop an ongoing advertising/promotion strategy for implementation during the system. MAF may wish to contract this service out. It is likely to include press releases as required, farmer's surveys to assess participation and usefulness, ongoing communications with interested/affected parties and ongoing communications with farmers and industry groups.

Review and Evaluation

We recommend MAF include periodic review and evaluation of the system during operation to identify any changes necessary to increase value to farmers (and government). MAF should identify a review programme at project commencement and set up a system to ensure reviews are completed and corrective actions are completed. Review and evaluation should be administered by MAF with management by the steering committee (recommended above).

9.8 Timelines

We have developed an indicative timeline for the project plan outlined in this section, based on estimates only. We recommend MAF develop a more comprehensive timeline at project commencement, based on consultation with other government agencies with experience implementing similar projects and IT providers.

Figure 9-1 illustrates the indicative timeline, with a summary of time periods for each key stage listed below.

Consultation

Develop consultation strategy: 1 week

Stage one consultation: 4 weeks

Stage two consultation: 5 weeks (will need to link with industry event timetable / activities)

Development

Specification by MAF of the high level scheme requirements: 6 weeks (including consultation with stakeholders)

Running the Tender Process: 10 weeks

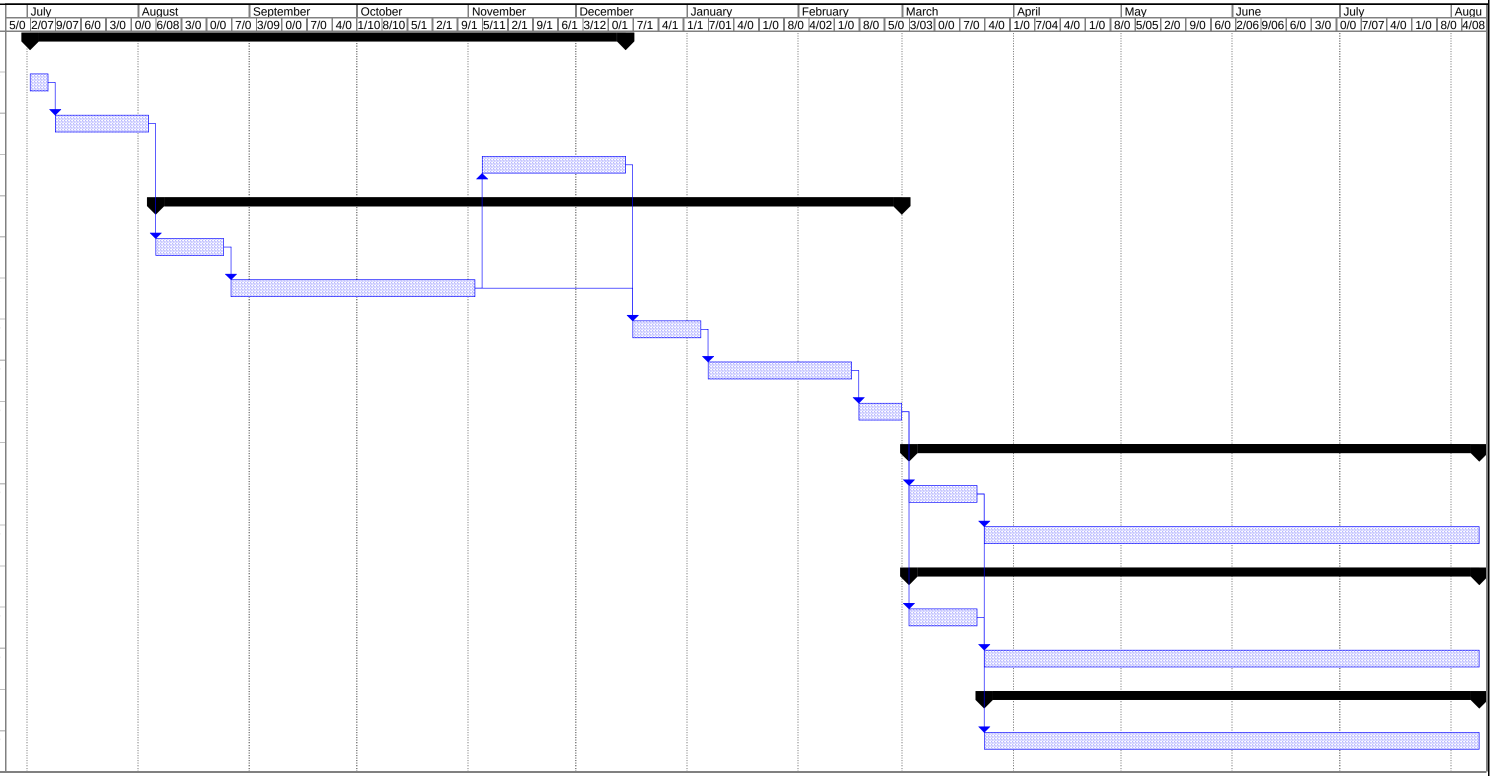
- 5 weeks for parties to respond to RFT
- 5 weeks for MAF to select preferred tenderer and complete contract negotiations

Work Required from Contractor: 11 weeks

- developing more detailed requirements and design specifications (including consultation with stakeholders): 3 weeks
- building the system: 6 weeks
- testing the system: 2 weeks

Figure 9-1 VGGR indicative time frame

ID		Task Name	Duration	Start	Finish
1		**Consultation**	**120 days**	**Mon 2/07/07**	**Fri 14/12/07**
2		Prepare consultation strategy	5 days	Mon 2/07/07	Fri 6/07/07
3		Stage one consultation	20 days	Mon 9/07/07	Fri 3/08/07
4		Stage two consultation	30 days	Mon 5/11/07	Fri 14/12/07
5		**Development**	**150 days**	**Mon 6/08/07**	**Fri 29/02/08**
6		High level requirements	15 days	Mon 6/08/07	Fri 24/08/07
7		Run tender process	50 days	Mon 27/08/07	Fri 2/11/07
8		Detailed design	15 days	Mon 17/12/07	Fri 4/01/08
9		Build system	30 days	Mon 7/01/08	Fri 15/02/08
10		test system	10 days	Mon 18/02/08	Fri 29/02/08
11		**Promotion**	**115 days**	**Mon 3/03/08**	**Fri 8/08/08**
12		Initial promotion	15 days	Mon 3/03/08	Fri 21/03/08
13		Ongoing promotion	100 days	Mon 24/03/08	Fri 8/08/08
14		**Technical guidance**	**115 days**	**Mon 3/03/08**	**Fri 8/08/08**
15		Set up	15 days	Mon 3/03/08	Fri 21/03/08
16		Implementation	100 days	Mon 24/03/08	Fri 8/08/08
17		**Operation**	**100 days**	**Mon 24/03/08**	**Fri 8/08/08**
18		Managing the system	100 days	Mon 24/03/08	Fri 8/08/08



Project: Project plan.mpp
Date: Wed 6/06/07

Task · Split · Progress · Milestone · Summary · Project Summary · External Tasks · External Milestone · Deadline

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Promotion

Initial promotion: 3 weeks

Ongoing promotion: As required throughout operation of VGGR

Technical guidance

Set up: 3 weeks

Implementation: As required throughout operation of VGGR

Operation

MAF administration of the system: Throughout operation of VGGR

Section 10 Conclusion

Introduction

This report contains the results of a technical study to evaluate options to provide a voluntary greenhouse gas reporting system for New Zealand agriculture. This evaluation includes cost implications, advantages and disadvantages and implementation risks.

Agricultural GHG emissions in New Zealand

The ability for NZ farmers to mitigate CH_4 and N_2O is limited. Application of denitrification inhibitors provides the best possibility to substantially decrease N_2O, although costs currently inhibit widespread uptake.

To capture the main drivers of CH_4 emissions, a VGGR system would require, as a minimum, to be able to estimate individual animal feed intake in some way and to record animal numbers. The breakdown of animals by age is desirable.

The minimum requirements for estimating N_2O emissions are animal feed intake, N content of the feed and animal performance. It is highly desirable that soil and climatic information be incorporated into any estimation method as these have major effects on N_2O emissions. Since there are some mitigation technologies available for N_2O (e.g. nitrification inhibitors) it is also important that any VGGR records their use and has routines that quantify their impact.

Estimating GHG emissions

There is no model currently available in New Zealand to specifically estimate GHG emissions at the farm scale.

Farm scale models exist for other on farm purposes that could be adapted to use to predict GHG emissions at the farm scale. Of these models, Overseer, a nutrient budgeting model would appear the most suitable. However Overseer would require significant redevelopment to incorporate a central calculation model and database and would require updating to include new information and to simplify the interface.

New Zealand follows a methodology to estimate GHG emissions at a national level as part of its commitment to the United Nations Framework Convention on Climate Change. A new model could be developed based on the current national inventory model for use at a farm scale. This model would provide valuable CH_4 estimates but less suitable N_2O information. However amendments could be made to effectively capture N_2O drivers at the farm scale and therefore increase the value of the N_2O estimates.

Greenhouse gas reporting systems in other countries

A number of GHG reporting systems exist in other countries, with four that are particularly relevant to a VGGR for NZ agriculture. The purpose of each system varies, but is typically to provide emitters with protection of current reductions against future policy initiatives and/or to allow emitters to receive public recognition for their achievements.

For each system, participation levels are low but are increasing. Participation rates for agricultural producers in all systems are either low or non existent.

A key benefit to participants results from the opportunity to use system resources to calculate emissions and understand mitigation opportunities. This allows participants to prepare for future policy provisions via capacity building and to report their achievements to the public. Online tools simplify the reporting process for participants, provide opportunities for participants to quickly and accurately view their results (i.e. total emissions), and provide opportunities to improve integrity and security of inputs and results.

As none of the systems investigated have a high participation rate from small to medium enterprises and in particular from agricultural businesses, careful consideration of the ability to incentivise farmers or their agents to participate would be required prior to development of a VGGR system.

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Incentives and disincentives for farmers

A range of incentives and disincentives exist that will impact on the likelihood of a farmer participating in a VGGR system. The incentives for farmers to participate in a VGGR are limited in the absence of financial incentives to reduce emissions. Even in such an environment, opportunities for farmers to mitigate emissions are limited. A lack of financial incentive may be countered to some extent by the desire of farmers to improve their stewardship or respond to the market, in line with an increasing focus on sustainability.

If farmers are driven to participate, there are additional incentives that should be taken into account to maximise benefits. These include the provision of information about emissions and mitigation, provision of any co-benefits (e.g. nutrient budgeting), ability to respond to market (or regulatory concern) regarding climate change or stewardship, and a mechanism for farmers to protect baseline emission levels against future grandfathering.

Disincentives would include lack of mitigation opportunities, time costs and level of difficulty required to gather or enter data, concerns about confidentiality, or suspicion about government involvement and motives.

Careful consideration of the likely uptake by farmers is required prior to proceeding with a VGGR, particularly in relation to the existence or otherwise of financial incentives. Design of any VGGR system should aim to maximise incentives and remove disincentives. An assessment framework is provided in this report to assess likely farmer uptake of any particular VGGR system option.

Design

The benefits to farmers of a core VGGR option that would meet MAF's requirements while providing the lowest cost option to government would be limited to capacity building and the ability to benchmark performance. Costs to farmers would be relatively low. Based on uptake of similar programmes in New Zealand and the potential benefits and costs to farmers we anticipate that only 1-5% (450-2,250) of New Zealand farmers would participate in this option. The establishment cost to government of implementing the core system is expected to be in the order of $470,000. Annual operational costs are expected to be in the order of $162,000-$212,000.

A number of VGGR design options exist that would deliver different outputs to the core option. Each option has implications on cost or likely farmer uptake.

Options around participation that are likely to increase farmer uptake include delegation of responsibility for the system to a third party (i.e. industry driven rather than government driven), provision of direct incentives and maximisation of market benefits. In terms of changes to scope, an ability to allow farmers to complete nutrient budgeting and GHG emission estimation would increase uptake, as would an ability to protect emission reductions via reporting of specific emission reduction projects. Allowing a third party to enter information, reducing the regularity of reporting requirements and improving the information feedback to farmers are all also likely to result in increased uptake.

It is not possible to assess cost implications for each option; however options that would increase cost to government include the option to allow reporting by farm block, allowing a choice of estimation methodology, incorporating nutrient budget ability, allowing reporting of specific emission reduction and improving information feedback to farmers. Increased costs for each of these are expected to be in the range of $15,000-$50,000.

Consultation

Consultation with agricultural leaders, influencers and farmers prior to final design and implementation of a VGGR system will be important to maximise participation.

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We recommend a staged consultation approach designed to engage leadership and influencers first (stage one) and, as feedback from them is received, refine the consultation approach to a point where it can be taken to the farming community (stage two). MAF may also consider forming a partnership with the leadership organisations to take the consultation to the farming community.

The ideal approach for consultation on the VGGR system would be as part of consultation on a wider strategy for the pastoral sector on addressing greenhouse gas emissions and the issue of climate change.

Risks

Risks exist at all stages of the project including the design, procurement, engagement, and testing, resourcing, and operational phases. Key risks include a failure of farmers to participate owing to a lack of incentives, failure to maximise participation via design, inappropriate procurement processes leading to poor system delivery, inability to engage the industry, inadequate resourcing of promotion, consultation or operation of the system and unsatisfactory review and feedback processes. Mitigation measures exist for all risks identified. A more detailed risk assessment should be completed prior at project commencement.

Project plan

A project plan has been prepared for the core VGGR option, identifying project stages including specific actions required to implement the VGGR. These include consultation requirements, VGGR development, promotion of the system, provision of technical guidance and system operation. A detailed project plan should be prepared prior to commencement on any future VGGR option.

Concluding statement

The results of our work suggest that it is feasible for the government to develop and implement a voluntary greenhouse gas reporting system in order to estimate farm level agricultural greenhouse gas emissions. We estimate that the establishment cost of designing and building the core system would be in the order of $470,000, and the annual operation costs in the order of $162,000 - $212,000.

However, for any VGGR option, participation rates are unlikely to be high in the absence of other policy/regulatory initiatives that motivate farmers to reduce emissions. Careful consideration of the likely uptake by farmers is required prior to proceeding with a VGGR.

A VGGR system that is developed and implemented at lowest cost to government is unlikely to maximise participation rates from farmers. Variations to the system may increase participation rates but at increased costs to government. Careful consultation with industry and a well run procurement process will be important for: ensuring adequate participation by farmers; developing the scheme within the indicative budget; and securing the objectives sought by government. Regardless of variations to the system, participation rates may still be low in the absence of financial incentives.

Further assessment of the desirability of a VGGR system should be completed following clearer identification of the required government objectives for such a system.

Section 11 References

Australian Greenhouse Office (AGO) (2005) Greenhouse Challenge Plus Programme Framework 2005. Australian Greenhouse Office in the Department of Environment and Heritage, Commonwealth of Australia.

Blaxter, K.L.; Clapperton, J.L. (1965) Prediction of the amount of methane produced by ruminants. *British Journal of Nutrition* 19: 511-522.

Beukes P, Wastney M, Palliser C, Clark D, Dalley D and Glassey C (2004). Dexcel's Whole Farm Model: A software tool for exploring farm systems and economics. Modelling once-a-day milking. Dexcel Field Day, Hamilton.

California Climate Action Registry (CCAR) (2005) Second Biennial Report to the Governor and Legislature of California, CCAR, Los Angeles.

Clark H., de Klein, C. Newton, P. 2001: "Best Management Practices" and technologies to reduce nitrous oxide, methane and carbon dioxide emissions in New Zealand agriculture. Report to Ministry of Agriculture and Forestry Oct 2001.

(Clark 2006) Emissions from animals. Climate Change and Governance Conference March 28-29th, Wellington University, New Zealand.

Clark, H.; Brookes, I.; Walcroft, A. (2003) Enteric methane emissions from New Zealand ruminants 1990 - 2001 calculated using an IPCC Tier 2 approach. Report for the Ministry of Agriculture and Forestry, March 2003.

Clark, H.; Wright, A.D.; Joblin, K.N.; Molano, G.; Cavanagh, A.; Peters, J.S. (2004) Field testing an Australian developed anti-methanogen vaccine in growing ewe lambs. *Proceedings of the Workshop on the Science of Atmospheric Trace Gases, 2004*. NIWA Technical Report 125, Wellington, New Zealand. Pp. 167.

Clark, H.; Pinares-Patiño, C.S.; de Klein, C. (2005) Methane and nitrous oxide emissions from grazed grasslands. *In:* McGilloway, D.A. (ed). Grassland: A Global Resource. Wageningen Academic Publishers, Wageningen, The Netherlands. Pp. 279-293.

Department of Environment/Energy Information Administration (DOE/EIA) (2006) Voluntary Reporting of Greenhouse Gases 2005-Summary, DOE/EIA, Official Energy Statistics from the U.S Government.

Di, H.J.; Cameron, K.C. (2002) The use of a nitrification inhibitor, dicyaniamide (DCD), to decrease nitrate leaching and nitrous oxide emissions in a simulated grazed and irrigated grassland. *Soil Use and Management* 18: 395-403.

Di, H.J.; Cameron, K.C. (2003) Mitigation of nitrous oxide emissions in spay-irrigated grazed grassland by treating the soils with dicyaniamide, a nitrification inhibitor. *Soil Use and Management* 19: 284-290.

Firestone, M.K. (1982) Biological denitrification. *In:* Stevenson, F.J. (ed.) Nitrogen in agricultural soils. ASA-CSSA-SSA, Madison, Wisconsin, U.S.A. Pp. 289-326.

Giltrap D, Saggar S, Li CS, Wilde H (2006) Nitrous oxide emissions in the Manawatu-Wanganui region modelled using 'NZ-DNDC'. In *implementing sustainable nutrient management strategies in agriculture.* (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand, 8–9 February 2005. pp 151–161.

Hakes J. (2000) Testimony of Jay Hakes, Administrator, Energy Information Administration, US Department of Energy, before the U.S. Senate Committee on Energy and Natural Resources on Senate Bills S.882 and S.1776 and their impact on EIA's programs, March 30, 2000.

Haynes, R.J.; Sherlock, R.R. (1986) Gaseous losses of nitrogen. *In:* Haynes, R.J. (ed.) Mineral nitrogen in the plant-soil system. Orlando, Academic Press. Pp. 242-302.

Section 11 References

Immig, I. (1996) The rumen and hindgut as source of ruminant methanogenesis. *Environmental Monitoring and Assessment* 42: 57–72.

IPCC. (1996) Revised IPCC guidelines for national greenhouse gas inventories. IPCC National Greenhouse Gas Inventories Programme. Published for the IPCC by the UK Meteorological Office, Bracknell.

IPCC. (2000) Good practice guidance and uncertainty management in national greenhouse gas inventories. IPCC National Greenhouse Gas Inventories Programme. Published for the IPCC by the Institute for Global Environmental Strategies, Japan.

Johnson, D.E.; Ward, G.M. (1996) Estimates of animal methane emissions. *Environmental Monitoring and Assessment* 42: 133–141.

Kelliher, F.M.; Ledgard, S.F.; Clark, H.; Walcroft, A.S.; Buchan, M.; Sherlock, R.R. (2003) A revised Nitrous Oxide Emissions Inventory for New Zealand 1990-2001. Report for the Ministry of Agriculture and Forestry, March 2003.

Li C., Aber J., Stange F., Butterbach-Bahl K., Papen H., (2000) A process oriented model of N_2O and NO emissions from forest soils: 1, Model development. Journal of Geophysical Research, 105, 4369-4384.

Miller, T.L. (1995) Ecology of methane production and hydrogen sinks in the rumen. *In:* von Engelhardt, W.; Leonhard-Marek, S.; Breves, G.; Gieseke, G. (eds). Ruminant Physiology: Digestion, Metabolism, Growth and Reproduction. Ferdinand Enke Verlag, Stuttgart. Pp. 317-331.

Ministry of Agriculture and Forestry (2006) Sustainable Land Management and Climate Change; Options for a Plan of Action, MAF Policy, Wellington, New Zealand.

Ministry of Agriculture and Forestry. (2005) Ministry of Agriculture and Forestry Agricultural Merchandise Export Statistics. Available: http://www.maf.govt.nz/statistics/internationaltrade/agriculture/index.htm [11 Jan. 2006].

Ministry of Agriculture and Forestry. (2002) Farms by farm type. Available: http://www.maf.govt.nz/statistics/primaryindustries/land-use-and-farm-counts/index.htm.

Ministry for the Environment (MfE). (2006) New Zealand's Greenhouse Gas Inventory 1990–2004. Ministry for the Environment, Wellington, New Zealand.

Ministry for the Environment (MfE), (2006a) The Dairying and Clean Streams Accord: Snapshot of Progress-2006/2006 (MfE website).

Mosier, A.R.; Duxbury, J.M.; Freney, J.R.; Heinemeyer, O.; Minami, K.; Merckx, R. (1996) Nitrous oxide emissions from agricultural fields: assessment, measurement and mitigation. *Plant and Soil* 181: 95-108.

Murray, R.M.; Bryant, A.M.; Leng, R.A. (1976) Rates of production of methane in the rumen and large intestine of sheep. *British Journal of Nutrition* 36: 1-14.

O'Hara, P.; Freney, J.; Ulyatt, M. (2003) Abatement of agricultural non-carbon dioxide greenhouse gas emissions. A study of research requirements. A report prepared for the Ministry of Agriculture and Forestry on behalf of the Convenor, Ministerial Group on Climate Change, the Minister of Agriculture, and the Primary Industries Council, May 2003. New Zealand Ministry of Agriculture and Forestry, Wellington. www.govt.nz/publications. 171 p.

Saggar, S.; Clark, H.; Hedley, C.; Tate, K.; Carran, A.; Cosgrove, G. (2003) Methane emissions from animal dung and waste management systems, and its contribution to the national methane budget. A report prepared for the Ministry of Agriculture and Forestry, September 2003.

Schmidt, E.L. (1982) Nitrification in soil. *In:* Stevenson, F.J. (ed.) Nitrogen in agricultural soils. ASA-CSSA-SSA, Madison, Wisconsin, U.S.A. Pp. 253-288.

SRC. (1990) Feeding standards for Australian Livestock: Ruminants. CSIRO Publications, Victoria, Australia.

Section 11 References

State Services Commission (2005) E-government agency checklist. E-govt. website (http://www.e.govt.nz/about-egovt/programme/checklist-2005/agency-checklist-2005.pdf)

Ulyatt, M.J.; Lassey, K.R.; Shelton, I.D.; Walker C.F. (2005) Methane emission from sheep grazing four pastures in late summer in New Zealand. *New Zealand Journal of Agricultural Research* 48: 385-390.

Whitehead, D.C. (1995) Grassland nitrogen. CAB International, Wallingford, UK. 397 p.

Wolin, M.J.; Miller, T.L.; Stewart, C.S. (1997) Microbe-microbe interactions. *In:* Hobson, P.N.; Stewart, C.S. (eds). The Rumen Microbial Ecosystem. Blackie Academic and Professional, London. Pp. 467-491.

Section 12 Limitations

URS New Zealand Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Ministry of Agriculture and Forestry. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 13 December 2006 and the letter from MAF to URS clarifying the project way forward dated 26 February 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions.

This report was prepared between 14 December 2006 and 06 June 2007 and is based on the information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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Appendix A IT Cost Estimate for Core VGGR Option