BEFORE THE ENVIROMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region.
between	**FEDERATED FARMERS OF NEW ZEALAND ENV-2010-WLG-000148**
and	**MERIDIAN ENERGY LTD** **ENV-2010-WLG-000149**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**PROPERTY RIGHTS IN NEW ZEALAND** **ENV-2010-WLG-000152**
and	**HORTICULTURE NEW ZEALAND** **ENV-2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157**
	Appellants
and	**MANAWATU-WANGANUI REGIONAL COUNCIL** *Respondent*

STATEMENT OF TECHNICAL EVIDENCE BY MR NORM IAN NGAPO ON THE TOPIC OF SUSTAINABLE LAND USE AND ACCELERATED EROSION

ON BEHALF OF WELLINGTON FISH & GAME COUNCIL

Dated: 17 February 2012

QUALIFICATIONS AND EXPERIENCE

1. My full name is Norman Ian Ngapo. I have a Bachelor of Agricultural Science degree (specialising in soils) from Massey University, Palmerston North. I hold a Certificate in Sustainable Nutrient Management in New Zealand Agriculture from Massey University (2009). I also hold a Certificate in Maori Studies from the University of Waikato (1990).

2. I have been involved with the management of natural and physical resources for over 36 years as a professional Soil Conservator. I have worked as a Soil Conservator for Hauraki Catchment Board (1975 – 1980), Bay of Plenty Catchment Commission and Catchment Board (1980 – 1989), and was Senior Soil Conservator for the Bay of Plenty Regional Council (1989 – 1998). In June 1998, I left the Bay of Plenty Regional Council and formed my own soil conservation consultancy business (Waiora Soil Conservation Ltd).

3. Over the last 13 years as a soil conservation consultant, I have undertaken a variety of projects for local, regional and central Government as well as for private landowners and organisations. I have been involved with assisting with policy development of regional plans in the Bay of Plenty Region. I have also helped prepare and review environmental guidelines for the Bay of Plenty Regional Council on earthworks, forestry operations, as well as rivers and drainage works. I have been involved with the development and reviews of the New Zealand Environmental Code of Practice for Plantation Forestry, from its original inception in 1989 through to its latest review (2007). Most of my soil conservation work has been within the Bay of Plenty and Waikato regions. For over twenty years, I was directly involved one on one, working with farmers preparing and implementing farm plans and environmental property plans. From 1989 to 1998 this work included co-ordinating all of the soil conservation works programmes for the Bay of Plenty Regional Council. The majority of this work involved voluntary plans at landowner's request. However, I also worked with farmers on mandatory catchment plans under the Waihou Valley Scheme, and mandatory farm plans under the Lake Okareka and Kaituna Catchment Control schemes. I have undertaken a range of soil conservation work throughout the

North Island of New Zealand, including delivering workshops on land use capability and erosion control to farmers and regional council staff. As riparian management is a key element of soil conservation work in the Bay of Plenty, I have extensive experience in riparian management. I was involved in a project for the Ministry for the Environment (MfE) in 2002/2003 delivering (with another consultant) six riparian training workshops throughout New Zealand. In a follow up project, I was a member of the project team for developing and delivering riparian training workshops for a combined MfE/Ngai Tahu project, tailored to Tangata Whenua. I have lectured at Te Whare Wananga O Awanuiarangi for two papers; Water and Soil in Land Management (2008 and 2009) and Wetlands in New Zealand (2009). I am also familiar with the different types of Environmental Farm Plans that are used by Regional Councils throughout New Zealand, and was joint author with Dr P Blaschke for the MfE project "Review of Environmental Farm Plans" (2003).

4. I am a member of the International Erosion Control Association (Australasian Chapter), and I am also an Executive Committee member of the New Zealand Association of Resource Management (NZARM). I hold the NZARM Professional Certificate and Practising Certificate.

5. I am familiar with the evidence of those witnesses relevant to my area of expertise which is contained in the "Technical Evidence Bundle" lodged with the Court by the respondent, which includes the s42a report of Dr Roger Parfitt lodged for the water quality hearings, together with the additional evidence of Mr P Hindrup, Dr J Quinn and Mr A Kirk dated 31 January 2012

6. I attended expert witness conferencing on 7 February 2012. At the time of writing this evidence no agreed record of that conferencing has been produced.

7. I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief are within my areas of expertise.

8. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

9. My evidence will deal with the following:

- General comments on soil conservation and its history in New Zealand.
- Discussion of accelerated erosion and natural erosion, and how the land use capability classification addresses the erosion factor.
- The importance of land use capability mapping as a first step in working towards sustainable land management
- Reducing the potential for erosion by increasing the resilience of land – prudent land use coupled with careful land management.
- Best practice options for reducing erosion and sediment loss from pastoral agriculture as well as from other land uses.
- Comments on the delivery of Whole Farm Business Plans (WFBPs) through the SLUI approach within the Manawatu – Whanganui region.
- On-site and off-site effects of erosion.
- The importance of riparian management in achieving both on site and off site benefits.
- The advantages of controlling phosphorus losses from farming through erosion control of critical source areas.
- Land disturbance activities; earthworks, cultivation and vegetation clearance.

EXECUTIVE SUMMARY

10. Erosion can be influenced both positively and negatively, by land use as well as land management practices. When land use is matched to land capability, and management systems follow best practice advice, the resilience of the land to erosion is increased. On the other hand, unwise land use and/or poor

management practices can result in elevated rates of erosion which result in a number of off-site problems.

11. Elevated rates of erosion can result in the deposition of sediment into receiving waters which can have adverse ecological effects on instream aquatic values including: physical changes to channel hydraulics; smothering or abrasion of in-stream fauna and flora; reduction of water clarity; effects on food sources and interruption of life cycles. Localised flooding can result from sediment deposition, and suspended sediment can also provide a carrier mechanism for other contaminants such as phosphorus. In addition to this, there are potential problems of damage to assets such as pumps, flood control schemes and other infrastructural assets.

12. While the concept of natural erosion and accelerated erosion is readily understandable, in practice it is generally extremely difficult to differentiate between the two in the field. This is because so much of our land has been influenced by human activity. I recommend that the term ‘erosion’ be used instead of accelerated erosion. Alternatively the terms ‘present erosion’ and ‘potential erosion’ can be used to classify erosion, following the process described in the Land Use Capability Survey Handbook.

13. The LUC mapping exercise results in the identification of land management units over the property which are based on the versatility of the land for sustainable production – or conversely, on the physical limitations of the land for sustainable production. The LUC system is therefore a very important tool when undertaking planning for sustainable land management. Depending on the scale of mapping, it can be used for broad based national and regional planning purposes, or for detailed property management purposes. I believe that effective land management should be based on the identification of the natural capabilities and limitations of the land.

14. In my opinion, the implementation of a Whole Farm Plan is the cornerstone of any management approach adopted by a regional council to achieve sustainable land management on hill country farms. This is because they are based on LUC as a pre-requisite which matches land use to land capability. In this way, the

programme is custom made to the property. Critical areas such as very steep slopes, waterways, wetlands, and highly erodible areas are identified, delineated and a programme of management put in place to remediate present erosion and reduce the potential for future erosion problems as far as possible. As a consequence of this approach, the programme increases the resilience of the property to erosion.

15. Management practices such as earthworks, vegetation clearance, forest harvesting, and cultivation are capable of having adverse off site effects, particularly when stormwater discharges from the land based activity are contaminated with sediment from erosion. The off-site effects of erosion on downstream water resources are of particular importance, as water is a public asset. Therefore, contamination of clean water from sediment as a result of erosion is a community issue. When that contamination has been aggravated or caused by poor management practices or unwise land use, then it is appropriate to use regulation to address the source of the problem.

16. Riparian buffers are able to fulfill specific functions and provide a number of benefits including: controlling contaminants such as nitrogen, phosphorus, sediment and pathogens in faecal matter; stabilizing stream banks and reducing erosion; maintaining and increasing biodiversity; and maintaining both terrestrial and aquatic ecological functions. There are also a range of other benefits that can be enhanced by specialised management of riparian buffers such as downstream flood control, and the protection of cultural values and amenity values. Activities, such as land disturbance including cultivation, and vegetation clearance within buffer zones should be strictly managed to retain the integrity of the riparian buffer zone (ability to assimilate pollutants, reduce contaminant loadings to surface water and retention of stream bank stability) and its terrestrial and aquatic ecological functions.

INTRODUCTORY COMMENTS IN RETLATION TO SOIL CONSERVATION AND REDUCING THE RISK OF EROSION

17. Soil conservation is often equated with erosion control measures such as tree planting of erodible slopes. Although erosion control is a major method of implementing soil conservation, the subject is much wider than that, and it cannot be separated from water conservation. The term soil conservation embraces the care of the land while using the land for its widest range of uses, including production. In this sense, soil conservation recognises both the on-site versatility as well as the limitations of the land resources. In addition, soil conservation is undertaken in full understanding of the potential off-site effects of activities. In fact the birth of soil conservation in New Zealand (leading to the Soil Conservation and Rivers Control Act 1941) was largely as a result of the off-site effects of severe storm damage from the East Coast floods in 1938 (McCaskill 1973). Throughout New Zealand's history, soil conservation programmes in the upper headwater areas has been seen as an important component of catchment management to help protect flood control works in the lower reaches of the catchment systems. It is important to observe that soil conservation is not confined to preservation, although it may include that as a component.

18. In the RMA, soil conservation is interpreted as "avoiding, remedying or mitigating soil erosion, and maintaining the physical, chemical and biological qualities of the soil". In my opinion, this can be also taken as safeguarding the life supporting capacity of the soil resource.

19. Historically, soil conservation staff of Catchment Boards, and more recently, land management staff of Regional Councils, have worked very closely with land owners (predominantly farmers) to develop and implement Farm Plans to control soil erosion on their properties. Having undertaken this work myself, I consider that this close working relationship is successful because the soil conservator not only provides expertise in sustainable land management, but also builds up a high degree of trust with the farmer, who takes responsibility for the problems and the solutions.

20. In my experience from working under both mandatory catchment scheme approaches, and voluntary Whole Farm Plan approaches, there are inherent problems in dealing with landowners where soil conservation programmes are imposed on them. Therefore, it is important to have a strong voluntary component associated with any soil conservation programme. On the other hand, if erosion problems are so severe that they affect downstream water resources, then there is an obligation for farmers to act responsibly to address the source of pollution problem associated with the downstream impacts of erosion. This is discussed further in my evidence – where I support the use of a permitted activity rule providing for the uptake of a Whole Farm Plan as an option to undertake land disturbance (including earthworks and vegetation clearance) activities.

21. There is the added responsibility of landowners being caretakers of the soil resource. In my opinion it is unreasonable for landowners to knowingly undertake poor management practices that are likely to result in soil erosion. Erosion can be influenced both positively and negatively, by land use as well as land management practices. When land use is matched to land capability, and management systems follow best practice advice, the resilience of the land to erosion is increased. On the other hand, unwise land use and/or poor management practices can result in elevated rates of erosion that are unacceptably high.

22. The loss of topsoil through these elevated rates of erosion is effectively a depletion of a resource that in New Zealand has taken hundreds of years (if not thousands of years) to form. The effects of this erosion from upper catchment areas on downstream receiving environments can be wide ranging as discussed below.

23. The effects of sediment laden runoff, particularly from fluvial erosion (rill, gully and streambank erosion) can result in a number of off-site problems. The deposition of sediment into receiving waters can have adverse ecological effects on instream aquatic values; physical changes to channel hydraulics, smothering or abrasion of in-stream fauna and flora, reduction of water clarity, effects on

food sources and interruption of life cycles. Recovery time for in-stream communities can be long term, ranging from months to years. An injection of sediment into a stream system is capable of initiating an erosion cycle that is difficult to control. Localised flooding can result from sediment deposition, and suspended sediment can also provide a carrier mechanism for other contaminants such as nutrients or pathogens. In addition to this, there are potential problems of damage to assets such as pumps, flood control schemes and other infrastructural assets. (Greater Wellington Regional Council 2006 – Erosion and Sediment Control Guidelines for the Wellington Region).

24. While erosion can occur as a natural process particularly under major storm events, it can be greatly increased by poor management practices which may be common for that time, or unwise land use as evidenced by the East Coast floods of 1938. Also, as shown in the 2004 floods in the Manawatu, land use and vegetation cover can have a direct influence on the severity of erosion (Hancox & Wright 2005).

25. In my experience, fluvial erosion processes (rill erosion, gully erosion and stream bank erosion) can be easily exacerbated by relatively smaller storm events once the erosion process has been initiated – particularly if no remedial action is undertaken. Therefore, I consider that sustainable land management includes ensuring that as far as practicable, all soils (including the more highly productive as well as the less productive) are retained on our farmland. The retention of riparian setback zones is crucial to this goal. This reduction in soil loss will reduce the impact of erosion on downstream water bodies.

ACCELERATED EROSION AND NATURAL EROSION

18. I have read the comments made by Mr G Eyles in terms of accelerated and natural erosion, and agree with them.

19. While the concept of natural erosion and accelerated erosion is readily understandable, in practice it is generally extremely difficult to differentiate between the two in the field, unless the accelerated erosion is associated with an

easily identifiable cause such as poor earthworks practice. This is because so much of our land has been influenced by human activity. However, a trained practitioner is able to identify areas with a higher erosion potential, and plan appropriate soil conservation measures to reduce the risk of erosion.

20. As a consequence of this, the 3rd Edition of the "Land Use Capability Survey Handbook – A New Zealand handbook for the classification of land" did not attempt to differentiate between accelerated and natural erosion. Instead, it describes how to assess the present and potential erosion for the area of land being mapped.

21. The use of the term 'accelerated erosion' in the Regional Plan is therefore unfortunate, because it is difficult to assess in practice. The term 'erosion' can be used instead of accelerated erosion. For more specific detail, the terms 'present erosion' and 'potential erosion' can be used to classify erosion, following the process described in the Land Use Capability Survey Handbook (Lynn et al 2009).

THE IMPORTANCE OF LAND USE CAPABILITY (LUC) MAPPING

22. I have read the comments made by Mr G Eyles in terms of LUC mapping and agree with him. I have the following comments to add.

23. LUC mapping provides a valuable land resource database that can then be used to make informed decisions regarding the future use and management of land. LUC mapping (at farm scale of approximately 1:10,000) is normally accepted as the first step in undertaking any farm based planning, such as preparing a Whole Farm Business Plan.

24. As with any map, it is important to understand that the scale of mapping determines its ultimate use. LUC mapping carried out at 1:50,000 is ideal for regional planning purposes – however, it is not suitable for detailed farm planning purposes. As an analogy, a map of the world is not suitable for finding your way around Wellington.

25. The LUC map of the farm (at a scale of 1:10,000 approximately) provides detailed factual data on rock type, soils, slope, erosion and vegetation, as well as an assessment of the long term capability of the land for productive use. The fact that the LUC system has been used in New Zealand for decades is testament to its usefulness and robustness.

26. The LUC mapping exercise results in the identification of land management units over the property which are based on the versatility of the land for sustainable production – or conversely, on the physical limitations of the land for sustainable production. The LUC system presumes that currently accepted good land management practices will be undertaken. The LUC system is therefore a very important tool when undertaking planning for sustainable land management. Depending on the scale of mapping, it can be used for broad based national and regional planning purposes, or for detailed property management purposes.

REDUCING THE POTENTIAL FOR EROSION FROM POOR LAND MANAGEMENT PRACTICES

27. Prudent land management is essentially about risk management. The implementation of soil conservation programmes on farms is often described as increasing the resilience of land to climatic events that cause erosion problems. This same approach can also be applied to more intensive land uses, land development, and cultivation practices.

28. The potential for erosion on any particular parcel of land will depend on a range of factors, including rock type, soils, climate, slope, or vegetation. We have little or no control over many of these factors. However, through wise land use and prudent land management, we can have a major influence on reducing the risk of erosion problems occurring under any given set of circumstances. If the land use is not matched to the land capability, and/or poor land management practices are being followed, then the trigger point where erosion problems occur, is reduced.

29. When we are dealing with land that has an inherently higher potential for erosion (such as highly erodible Class 7e or 8e land), then the more severe those

erosion problems are likely to be. In worst case scenarios, if the land is misused and mis-managed, the land capability can be irreversibly changed for the worse, such as occurred in the American and Canadian prairies in the 1930's.

30. Historical land use patterns and successive government programmes supporting land development have resulted in a legacy of land use that we now consider may be less than ideal. Therefore, it is entirely appropriate that incentives are available for farmers to address historical land uses and practices that may not be acceptable given the knowledge that we have today. In my opinion, we have the ability to reduce the risk of erosion, particularly on more marginal steep land. Therefore, I consider that the argument that we should not do anything (because erosion will occur regardless), is irresponsible. Preventative methods are generally preferable to curative methods – so I recommend that we manage the erosion risk, using all reasonable means at our disposal, to reduce it to an acceptable level. Implicitly, this means that we must assess the erosion potential of the land, reconsider recommended land use in light of that erosion potential, and undertake appropriate land management accordingly.

31. For a pastoral farming situation, one proven successful method to reduce the risk of erosion problems is to implement a planned programme of soil conservation works and management systems under a property plan approach. In simple terms, these programmes are based on the identification of different land management units on the property (using LUC mapping), and designing specialised treatment of the different types of land according to their physical limitations for sustained production. In this way, the programme is unique to that property. Critical areas such as very steep slopes, waterways, highly erodible areas etc are identified, delineated and a programme of management put in place to remediate present erosion and reduce the potential erosion problems as far as possible. However, because the farmer is part of the process, the final programme will depend on the individual farmer's financial circumstances and preference for different farming / forestry systems.

32. As covered in Mr Eyles evidence, Farm Plans were financially supported by Central Government up until 1987. Following the removal of government grant

assistance, some regions stopped their Farm Plan programmes, while others continued or modified their approaches. As each region developed their own soil conservation programmes, they became identified under a wide range of names such as Farm Plans, Property Plans, Whole Farm Plans, Environmental Farm Plans, etc. Historically, the Farm Plan approach only dealt with erosion control. Since 1987, they have become more holistic, and now address a wide range of environmental issues, including nutrient management, riparian management, animal and pest control, heritage values and biodiversity. I will use the term Whole Farm Plans to describe these more holistic programmes. At the same time, the term 'soil conservator' was generally phased out in favour of Land Management Officer (LMO) reflecting the wider range of their workload.

33. The approach developed and adopted by Horizons Regional Council under the Sustainable Land Use Initiative (SLUI) advocates the implementation of Whole Farm Business Plans (WFBPs). This approach goes a step further than many other types of Whole Farm Plan, in that it includes a farm business component, to identify the initial economic viability of the property and the subsequent effect of the programme of works on the resultant economic viability of the property.

34. It is implicit in best practice for farming that land use is matched to land capability. Because they are based on LUC as a pre-requisite, the implementation of a Whole Farm Plan (or WFBP in the Horizons Region), will ensure that this occurs. As a consequence of this approach, the programme increases the resilience of the property to erosion. In my opinion, the implementation of a Whole Farm Plan is the cornerstone of any management approach adopted by a regional council to achieve sustainable land management on hill country farms.

BEST PRACTICE OPTIONS FOR REDUCING EROSION AND SEDIMENT LOSS FROM PASTORAL AGRICULTURE AS WELL AS FROM OTHER LAND USES

35. The term 'land use' should not be confused with the term 'land management' – they are not the same. Pastoral farming is a land use. It can be broken down

into more detailed land uses such as sheep and cattle farming, deer farming, dairying etc. It can include a combination of these. On the other hand, land management involves the different ways that individual farmers manage their particular land use. Land management can be quite pronounced, such as set stocking versus rotational grazing. Alternatively, it can be quite subtle, such as grazing young stock on particular classes of land at certain times of the year to reduce the risk of surface erosion problems. Land management is influenced by the individual farmer's personal preferences to risk, to running particular classes of stock, to particular types of farming systems, and other personal traits. Land management is also influenced by the physical limitations of the property (rock type, soils, topography, local climate) and the farm infrastructure (such as fencing, water supply, access tracks, location of stockyards, etc).

36. As noted earlier in my evidence, it is implicit in best practice for farming, that land use is matched to land capability. For sustainable land management, it is also necessary that each hectare of land should be managed according to its particular needs.

37. In my opinion, one of the most successful ways to achieve sustainable land management in a farm situation is to adopt appropriate soil conservation measures as set out in a Whole Farm Plan or similar type of plan developed specifically for that property. In most circumstances, this will result in identifying areas of the farm that have a higher erosion risk (critical sediment source areas) and applying some type of soil conservation treatment to reduce that risk. This will vary from farm to farm, but the final programme will depend on the physical attributes of the property, the existing farm infrastructure, as well the financial position and personal preferences of the farmer.

38. In New Zealand, many industries have developed Codes of Practice or Guidelines to address environmental concerns. In some cases, this has resulted in specific Codes of Practice (fertiliser use, forestry, market gardening etc). The farming industry has also been involved in the production of Guidelines and Codes of Practice. NOSLaM (North Otago Sustainable Land Management Group) is a farmer led initiative that resulted in the production of guidelines for

the sustainable management of down lands in North Otago. The publication of the New Zealand Deer Farmers Landcare Manual (2004) is another example of an industry led approach to addressing environmental concerns. In the Bay of Plenty, lobbying by farmers in the Taupo / Rerewhakaaitu areas in the early 1990s, led to the development of Environmental Programmes, which were adopted by the Bay of Plenty Regional Council as the primary method of delivering sustainable land management to farmers in the Bay of Plenty.

39. All of these guidelines or codes produced by New Zealand farmers have one thing in common; they provide a blueprint for the development of a property based programme of management practices. The process behind each is very similar. As a first step, they carry out an inventory of the property. They then identify critical issues or problem areas, and develop a programme of management to address those issues. Not surprisingly, the LUC system is often used as the first step to provide an inventory of the land resources on the property.

40. The SLUI programme and delivery of WFBPs to farmers by Horizons Regional Council is effectively a Code of Practice. As such it provides a suite of best practice options in one package, tailored to the property, and developed in close liaison with the landowner.

WHOLE FARM BUSINESS PLANS (WFBP) AND SUSTAINABLE LAND USE INITIATIVE (SLUI)

41. This evidence is in addition to comments made by Mr G Eyles.

42. I have followed the progress of the SLUI programme over the last few years and I am a supporter of the approach adopted by the Horizons Regional Council using the WFBPs. I believe that the use of a farm business component as part of the process makes the programme more robust, and will help in achieving the intended outcomes for each WFBP.

43. In many rural communities around New Zealand, the more traditional rural soil conservator or Land Management Officer (LMO) works closely on a one to one basis with farmers and other rural landowners. Over time, a sound working relationship is built up, whereby the LMO is seen by rural landowners as the "face of the council". As such, through that relationship, the officer is able to influence long term sustainable land management decisions made by landowners in a positive environment.

44. In my opinion, the importance of the relationship between the farmer and the LMO cannot be overstated. In essence, this relationship is critical to the success of sustainable land management. This is because ultimately, the success of soil conservation works on the ground (including riparian protection, erosion control plantings, and protection of areas with a high erosion risk) will depend on how they are managed in the long term. From my experience, implementing the initial capital works is the easy part. In the long term, the landowner needs to manage these works so that they remain in good condition in accordance with their design function. This requires farmers to take ownership of the problems that the works are designed to control. This is not an easy task – it requires that landowners understand the reasons why works are necessary, and acceptance that they will take the responsibility for looking after the works in the long term. This is also why it is important to retain a 'voluntary' aspect as to whether works are undertaken in the first place – as it ensures recognition that there is a problem, followed by ownership of the problem and the solution.

45. While I am a strong advocate of having the whole farm plan system being voluntary, I also believe that when there is a clear issue such as hill country erosion, resulting in both on-site and off-site effects, it is reasonable to consider the appropriate mix of both regulatory and non-regulatory approaches to address the problem.

46. In my experience, non regulatory approaches (such as education) have the ability to achieve very good results over the long term. Regulatory approaches are appropriate for specific activities and tend to ensure that minimum standards

can be met, but the likelihood of rising well above those standards, or adopting integrated management approaches, is unlikely in a solely regulatory regime.

47. When it is evident that the adverse effects of hill country erosion are both on-site and off-site, there is an added responsibility on landowners to ensure they are a 'good neighbour' in terms of their land use and land management practices. In my opinion, if erosion problems are in high risk areas, it is then entirely appropriate to adopt a combination of regulatory and non regulatory approaches to address the issue of reducing the risk of hill country erosion. To rely on a non regulatory approach alone, does not give any recognition to potential adverse off-site effects of hill country erosion on downstream water resources.

48. I consider that linking the adoption of a WFBP to a permitted activity rule, backed up by the establishment of a strong regulatory framework which manages specific activities is an appropriate way to ensure that land is managed sustainably and the adverse impacts of activities on the environment are appropriately addressed. The "carrot" of a WFBP has the advantages of incentives and long term certainty to farmers, as well as providing valuable resource information for their property. If a WFBP provides for and allows them to undertake specific activities without the need for a resource consent, then that is an added incentive. However, the farmer must also have an alternative option to enable them to opt out of undertaking a WFBP, if that is their wish. This can be provided by way of having a robust regulatory framework which sets out clear performance standards (the "stick") that need to be met to ensure that the farming activities do not adversely impact on downstream receiving environments. The activity classification (permitted, controlled, discretionary) would depend on the potential magnitude of any adverse effects.

49. This allows farmers to choose which option they want to take. Either the farmer chooses not to undertake a WFBP, but has to comply with minimum performance standards, or else the farmer opts for undertaking a WFBP, which results in a management programme tailored to the specific needs of the property, and provides the opportunity to include activities that would be assessed as part of

the WFBP approach. In this way, activities that would normally be subject to a consent process can be included as permitted activities under the WFBP.

50. In my opinion, the SLUI programme and WFBPs adopted by the Horizons Regional Council is one of the most comprehensive programmes of its type in New Zealand. It is able to ensure that all appropriate best practice options are considered for each individual property. The inclusion of a farm business component into the process is an excellent initiative that other Whole Farm Plan models around New Zealand would do well to emulate.

ON SITE AND OFF SITE EFFECTS OF EROSION

51. Erosion is a natural process – our floodplains are formed from alluvial sediments that have washed down from the hills over time. However, both present and potential erosion can be strongly influenced either positively or negatively, by land use and land management practices.

52. The LUC handbook classifies thirteen erosion types and one deposition category. There are four major categories recognised; surface erosion; mass movement; fluvial erosion and deposition.

53. Following a number of studies over the years, it is now accepted that following soil slip erosion on New Zealand hill country, pasture production takes around 20 years to recover to within 70-80% of its pre erosion levels, (and it will probably never recover to the uneroded production level) providing no further erosion occurs (Basher et al 2008). While the actual levels of production loss may vary depending on region, soil type, slope, climate and management, it has been clearly established that the loss of production is substantial and ongoing. Pastoral farming in New Zealand relies on the quality of the topsoil – loss of that topsoil through erosion is effectively a loss of capital. The on-site effects of erosion have a direct and ongoing impact on farm production.

54. There is also the issue of the potential off-site impact of hill country erosion. The off-site effects of hill country erosion can vary, depending on a number of factors

including the rock type, slope, type of erosion and the proximity to waterways. Some erosion categories (such as fluvial erosion; including rill, gully and streambank erosion) will have the potential for a greater impact downstream. The impacts can include deposition, contributing material to moving bedload, and suspended sediment in waterways. In essence, elevated levels of sediment from erosion become a contaminant in waterways. As noted earlier in my evidence, sediment-contaminated stormwater is capable of having wide ranging effects on aquatic habitat as well as on downstream assets.

55. Management practices such as earthworks, vegetation clearance, forest harvesting, and cultivation are capable of having adverse off site effects, particularly when stormwater discharges from the land based activity are contaminated with sediment from erosion. The off-site effects of erosion on downstream water resources are of particular importance, as water is a public asset. Therefore, contamination of clean water from sediment as a result of erosion is a community issue. When that contamination has been aggravated or caused by poor management practices or unwise land use, then it is appropriate to use regulation to address the source of the problem. Unfortunately, identifying the source of contamination (whether it is sediment or other contaminants) when it is not from a point source, can sometimes be difficult. Therefore, any regulation needs to be well considered to ensure that the source of the problems, including cumulative effects, are addressed.

IMPORTANCE OF RIPARIAN MANAGEMENT

56. Poor riparian management can impact adversely on aquatic ecosystems. Conversely, riparian management can be tailored in a positive manner, to address a range of objectives, depending on the particular issues that are of concern.

57. Protected riparian areas are referred to as riparian buffers. Riparian buffers are able to fulfill specific functions and provide a number of benefits. Riparian buffers can control contaminants (such as nitrogen, phosphorus, sediment and

pathogens in faecal matter), Sediment discharges to surface waterbodies are controlled by reducing the amount of sediment that reaches a stream through overland flow pathways (grass or low vegetated filter strips) and also by helping to stabilise streambanks (vegetated buffers, and grassed buffers) which reduces stream bank erosion. Riparian buffers can also increase biodiversity and maintain ecological functions (both aquatic and terrestrial). There are also a range of other benefits that can be enhanced by specialised management of riparian buffers such as downstream flood control, cultural values and amenity values.

58. The adverse effects of pastoral farming on waterways resulting from inputs of contaminants such as sediment, phosphorus and faecal matter can be reduced by specialized riparian management, as part of an overall suite of soil conservation measures. The type of riparian management undertaken will depend on the objectives. For instance, if the primary objective is to reduce faecal contamination from stock, then this can be achieved by fencing the stream banks and providing an ungrazed grass buffer strip. Stock will be excluded (preventing direct input of faecal material), and any faecal material carried in runoff from the paddock will be trapped in the grass buffer strip and broken down by sunlight over time. If the purpose is to control stream bank erosion, this can be achieved by retaining currently vegetated buffer zones or by establishing soil conservation planting (including ground cover, tree and shrub plantings), Stock exclusion is also recommended, along with animal pest control. Retention or establishment of native planting of riparian areas is often advocated, as the long term management of riparian areas is critical to their success. Once a native regime is established, it requires less maintenance in the long term. On balance therefore, retention of native buffer strips or the establishment of native plantings for riparian zones is generally preferable, except in very high energy riparian environments such as active river fans or very erodible river banks, where retention or establishment of specially bred willow species is recommended.

59. Land disturbance activities, such as earthworks, cultivation, and vegetation clearance within buffer zones should be strictly managed to retain the integrity of

the riparian buffer zone (ability to assimilate pollutants, reduce contaminant loadings to surface water and retention of stream bank stability) and its terrestrial and aquatic ecological functions. Figure 1 below shows an example of poor operational practice when clearing a fence line in a riparian environment.

Figure 1: Poor operational practice in clearing fence line in riparian area

60. There are some important advantages associated with riparian management. In my experience, the benefits that accrue from riparian management are generally greater than the particular objective being targeted. Also, the 'environmental gearing' or benefits that result from managing a relatively small area of land in proportion to the downstream catchment is greater than would be expected.

61. While riparian management is important, it should not be considered to be a panacea for poor land management.

CONTROLLING PHOSPHORUS LOSSES FROM FARMING THROUGH EROSION CONTROL OF CRITICAL SOURCE AREAS

62. Erosion of topsoil by wind and water removes both organic and inorganic Phosphorus (P) on fine soil particles. It is well understood that eroded soil represents the major transfer mechanism of P from terrestrial to aquatic systems (Sustainable Nutrient Management in New Zealand Agriculture). Therefore, targeted erosion control on critical source areas can substantially reduce P losses from farmland. When looking to reduce P losses from farm land to water bodies, regional councils such as Bay of Plenty Regional Council and Waikato Regional Council are targeting **erosion control measures in critical source areas** as a key element in their control programmes.

63. Phosphorus losses can occur as Particulate Phosphorus (PP), Dissolved Reactive Phosphorus (DRP), or as Dissolved Organic Phosphorus (DOP). Parfitt et al (2007) notes that the majority of P losses (in the Upper Manawatu catchment above Hopelands) occurs as PP attached to eroded soil particles under storm events, with ninety percent of the erosion occurring under pastures on steep land and 10% under forest. These particle P losses could be reduced from 511 to 280 tonnes by erosion management approaches (eg targeted planting of trees) on 10% of farms with land subject to an elevated risk of erosion (Parfitt, 2006). However, DRP which contributes to blooms of periphyton (as discussed by Associate Professor Death) comes from pasture runoff and stream bank erosion between storms and during periods of low flow. I have read and agree with the comments made by Parfitt et al (2007) in reducing phosphorus losses from pastoral agriculture. Parfitt recommends the use of the WFBP and erosion management approaches to reduce levels of particulate phosphorus, and the Farmer Applied Resource Management Strategy (FARM Strategy), along with retention of riparian zones or target planting of riparian zones to address reductions in DRP losses from intensive land uses to help reduce P losses during low flow conditions. Effluent management and careful use of P fertilisers is also recommended. Monitoring of P levels in soil tests (Olsens P), and judicious use

of P fertilisers will ensure efficient utilisation of P, and reduction in losses downstream.

64. The use of the OVERSEER® Nutrients Budgets model allows for efficient fertiliser use in conjunction with nutrient budgeting. Coupled with understanding of the source control options for reducing P losses from erosion, this combined approach can potentially result in a win-win situation for the farmer as well as the environment.

65. In summary, controlling soil erosion from critical source areas such as from hill country erosion, land disturbance erosion, and stream bank erosion, can have a direct influence on reducing losses of P from pastoral farming.

LAND DISTURBANCE ACTIVITIES – EARTHWORKS, VEGETATION CLEARANCE, AND CULTIVATION

66. Land disturbance activities include earthworks, vegetation clearance and cultivation. All of these activities are capable of having significant adverse effects on the environment if not appropriately managed. Adverse environmental effects result from destablising soil, increasing erosion, and discharges of sediment-contaminated stormwater to surface waterbodies from disturbed sites, along with effects on the integrity and ecological function of riparian margins (which has been more fully discussed above).

Earthworks

67. As the sediment yield from earthworks is potentially capable of being up to 100 times greater than from pastoral land use, and potentially up to 1000 times greater than natural forest (Greater Wellington Regional Council 2002), it is entirely appropriate that earthworks, and other land disturbance activities, are regulated to ensure they are properly planned and implemented to avoid, remedy or mitigate offsite effects.

68. However, I also consider that if the earthworks activities are carried out by farmers, and assessed as part of a WFBP, then they could be undertaken in a

manner that ensures any adverse environmental effects are avoided, remedied or mitigated. There would need to be a comprehensive assessment made by an LMO as part of the WFBP, particularly considering potential stormwater discharges from the activity. The assessment undertaken by the LMO would need to conclude that the proposed activity could be undertaken without the likelihood of any stormwater discharge breaching the in-stream water quality standards (Schedule D water quality limits). If this test could not be met, then the activity should not be approved under the WFBP.

69. When considering erosion from an earthworks site, we are concerned with surface erosion problems, some fluvial erosion problems, deposition and the potential for sediment-contaminated stormwater to be discharged off site. This includes the following erosion types; sheet erosion, rill erosion, gully erosion (if the site is poorly controlled) and deposition. The main factors influencing soil erosion in earthworks sites are climate, soil characteristics, topography, ground cover and evapotranspiration. The effects of these factors can be managed by following a purposed designed Erosion and Sediment Control Plan (ESCP) for the proposed earthworks.

70. I strongly support the preparation of an ESCP for all earthworks operations. The document "Greater Wellington Region Guidelines 2002" provides a sound basis for the preparation of an ESCP. The ESCP may be relatively simple for small scale earthworks where the topography is not steep, and the stormwater runoff from the disturbed area can be well controlled. However, for large scale earthworks where there is a greater area of disturbed ground exposed, with the operations continuing over a longer period, the ESCP will be more complex, and may well involve input from a range of disciplines, and multiple staging as the earthworks are undertaken.

71. The situation is compounded when the earthworks are in steeper land and/or in proximity to water bodies. Very large scale operations can continue over months or years, and will likely require specific methodologies to address the risk of problems over the winter period, when soil conditions are wet, sunshine hours are reduced, and the risk of sediment-contaminated stormwater discharge is

higher. In my experience, most regional councils in the North Island of New Zealand that regulate large scale earthworks, require specific management systems to deal with the higher risk of sediment-contaminated stormwater discharge from winter earthworks, with the exception of winter earthworks on some sandy soils. In many cases, this specific management system will include the requirement for a Winter Exclusion Period for earthworks.

72. In my opinion, small scale earthworks (under 2500 square metres in area) can be controlled relatively easily so that adverse environmental effects are minimal. I consider that this could be achieved through robust permitted activity conditions, including the preparation and implementation of a sediment control management plan, and requiring that any stormwater discharge to water does not breach the in-stream water quality standards (Schedule D water quality limits). In extreme circumstances, for small scale earthworks, this could involve providing sufficient storage capacity in the erosion and sediment control measures to prevent any off site discharge.

73. However, large scale earthworks (greater than 2500 square metres in area) have a high potential for causing significant adverse environmental effects if the earthworks and stormwater from disturbed areas, are not well controlled (see Figures 2, 3 and 4 below). I consider that large scale earthworks should be regulated through consents, and a primary requirement would be for an approved ESCP to ensure that there is a low likelihood of any stormwater discharge breaching the in-stream water quality standards. Again the activity should also have to ensure that it does not breach instream water quality standards (Schedule D water quality limits).

74. I consider that the Decision version of the permitted activity conditions for large scale earthworks (Rule 12-1) is inadequate. The reliance on submission of an Erosion and Sediment Control Plan (ESCP) 48 hours prior to commencement of work provides little time to fully assess the adequacy of the ESCP. Furthermore, the conditions do not require approval of the Council for the ESCP, nor do they actually require the activity to meet receiving water standards.

75. In my experience of processing large scale earthworks consents in the Bay of Plenty, it is essential to carry out a site inspection to adequately assess an ESCP. The submission of an ESCP 48 hours prior to works commencing is totally unrealistic. This situation is further compounded by the fact that as earthworks proceed, the ESCP changes as the earthworks modify the landscape. Consent conditions are able to cater for these changes as works proceed, with sign off at critical stages of work completion.

76. When large scale earthworks are regulated by consent, there is provision for a full Assessment of Environmental Effects as covered under the RMA. This means that any problems associated with particular rock type or soils can be adequately addressed. If the soils have a high clay content, and flocculation is required to ensure satisfactory treatment of stormwater runoff from disturbed areas, then robust provisions can be provided for under the conditions of consent.

77. In my experience, earthworks contractors are generally very optimistic (especially in terms of programme schedules relying on fine weather). Consent provisions are able to deal with contingency plans where site conditions, delays or wet weather become a problem. The permitted activity conditions for large scale earthworks (as set out under Rule 12-1 of the Decision version of the Plan), do not have the flexibility to deal with such issues. I consider that the consequences of having a permitted activity rule to control large scale earthworks will result in an unacceptably high level of enforcement, and frustration on the part of the developers as well as the Council, not to mention a high likelihood of significant adverse effects on receiving waterbodies.

78. While my preference would be for an option of having the choice of either area or volume threshold limits for regulation of earthworks activities, I understand that this is not acceptable, given the plan process to date.

79. I therefore recommend the following:

- Small scale earthworks less than 2500m^2 /per property/year being a permitted activity subject to establishment of appropriate sediment and erosion control methods and meeting in-stream water quality standards (schedule D water quality limits), along with the requirements of the Act in regards to s.15, s70 and s107.

- Large scale earthworks greater than 2500m^2 /per property/year subject to regulation by consent and requiring an Erosion and Sediment Control Plan to ensure that in-stream water quality limits are not likely to be breached. These water quality limits (schedule D water quality limits) should also be placed as standards of consent.
- Earthworks greater than 100m^2 per property/ per year volume and/or greater than 100m^3 per property/ per year on erosion management areas should be regulated.
- Tracking to form access for established river crossing points could be permitted if less than 1000m^2 – vertical to the river or plan view.

Figure 2: Discharge of sediment-contaminated stormwater from poorly managed earthworks operations in the Bay of Plenty

Figure 3: Rill erosion on slope over 20 degrees following conversion of forest to pasture

Figure 4: Fence line construction and soil disposal directly into a watercourse in association with forest to farm conversion

Culivation

80. Cultivation involves land disturbance activities and if not carried out in an appropriate manner, is capable of resulting in adverse effects off-site. When cultivation is carried out on steeper slopes and/or close to water bodies, there is a risk of sediment wash discharging into water, particularly if the discharge is channelised flow rather than sheet flow.

81. Under the LUC system, land classes 1 to 4 are arable, and classes 5 to 8 are non arable. It is therefore reasonable to expect that cultivation on land classes 1 to 4 should be able to be undertaken following normal best practice, with a low risk of off-site effects, but still subject to appropriate setback distances as discussed in the evidence of Associate Professor Russell Death. Set back distances should be of an absolute minimum of 5 metres from river beds <3m width, and greater for larger rivers or rivers and wetlands with high or sensitive values.

82. If rules are unable to use the LUC system to identify land, then a slope limit could be used. However, slope is a poor substitute for LUC. Some Class 4 land in this region is up to 20 degrees in slope. However, in my experience, I have known fine textured soils such as loess, volcanic ash or alluvial soils to be subject to sheet and rill erosion on slopes as low as 7 degrees, and very finely worked soils can erode on slopes as low as 3 degrees.

83. If cultivation is undertaken on classes 1 to 4 following normal best practice on slopes up to 20 degrees, and adhering to appropriate setback distances, then I believe it could be permitted subject to robust conditions, which include the requirement to meet water quality standards and requirements of the RMA (1991) s15, s70, and s107. Having a paddock assessment undertaken in accordance with the Code of Practice for Commercial Vegetable Growing in the Horizons Region (Horticulture New Zealand) Version 2010/2 would be demonstration of good practice. However, I recommend that for slopes greater

than 20 degrees that the cultivation should be regulated through the consent process due to the potential for significant adverse effects.

84. However, where the activity has been assessed and included in the approved works programme by an LMO under a WFBP, then cultivation could be a Permitted activity on slopes above 20 degrees. The WFBP should detail the areas that can be cultivated using appropriate practices so that there is a low likelihood of a discharge to water breaching water quality standards.

Vegetation clearance

85. Vegetation clearance is a general term that can apply to a wide range of practices. Depending on the type of vegetation cleared and the type of practice used, there is potential for a range of adverse effects from minimal and temporary to severe (more than minor adverse effects).

86. If the vegetation being cleared is indigenous forest cover (either regenerating or relatively pristine), it is very likely that the potential adverse effects could be significant. The effects would include increased rates of erosion as a result of the loss of protective forest cover, as well as changes in patterns of runoff (more flash flooding) as a result of the change in land use. The effects would be long term.

87. Using the definition of vegetation clearance in the glossary of the One Plan, there is a wide range of possible practices including desiccant spraying, roller crushing, felling/scrub clearing, root raking, stump removal, as well as burning. Any vegetation clearance that also involves physical disturbance of the soil (such as root raking or stump removal) is likely to have potentially greater adverse effects than no soil disturbance. I have seen the results of stump removal on slopes greater than 15 degrees in the Bay of Plenty and Waikato (associated with conversion of forest to pasture). This practice can result in severe surface erosion problems, and subsequent loss of topsoil (see Figures 5 and 6 below which show both earthworks and stump removal undertaken in early winter period). I have also witnessed roller crushing of scrub on quite steep slopes, with

little or no soil disturbance. The subsequent immediate erosion problems from these operations were minimal.

88. I would therefore err on the side of caution, when recommending rules for vegetation clearance. I consider that any vegetation clearance assessed and approved under a WFBP should be permitted. The assessment should include whether there is a likelihood of a discharge to water, and the risk of any discharge breaching the water quality standards. The assessment would therefore look at the LUC of the activity site, the proximity to water, the proposed methodology, the proposed land use and any recommended soil conservation measures. As the assessment would be part of an overall Whole Farm Plan, the proposed vegetation clearance could be viewed in the context of the cumulative effects of the soil conservation programme over the whole property.

89. Of particular concern is the clearance of established vegetation on land which has been identified as highly erodible (also classified as Erosion Management Areas), as the retention of vegetation is necessary to reduce the erosion potential of this land. Horizons has identified that the total area of highly erodible land in the region is estimated to be 661,359 hectares, while the total amount of highly erodible land currently protected by vegetation cover is estimated to be 387,832 hectares (Roygard 2008). Removal of vegetation from highly erodible land will increase the risk of erosion, and is likely to negate any reduction in erosion achieved from retiring / planting erosion prone areas, and implementation of WFBPs. For this reason, a robust regulatory approach needs to be developed to ensure that vegetation clearance activities are undertaken sustainably, do not impact on land that is highly erodible, and are managed in a manner that conserves soil and minimises impacts on water bodies. The recommendation of clearing no more than 100 square metres of highly erodible land is therefore supported, if not covered under a WFBP.

90. If the identification of highly erodible land is difficult, then regulation could apply to slopes over 20 degrees. This would then include land that is prone to earthflow erosion, gullied earthflow, as well as landslide erosion. However, I consider that the slope threshold for identifying highly erodible land is not as precise as the

system set out by Page et al (2005), which relies on specific LUC units and potential erosion.

Figure 5: Erosion and debris problems as a result of undertaking large scale earthworks in association with forest to farm conversion operations in early winter

Figure 6: Removal of stumps while undertaking conversion of forest to pasture

CONCLUSIONS

91. Erosion can be influenced both positively and negatively, by land use as well as land management practices. When land use is matched to land capability, and management systems follow best practice advice, the resilience of the land to erosion is increased. On the other hand, unwise land use and/or poor management practices can result in elevated rates of erosion which result in a number of off-site problems.

92. Elevated rates of erosion can result in the deposition of sediment into receiving waters which can have adverse ecological effects on instream aquatic values, cause localised flooding, provide a carrier mechanism for other contaminants such as phosphorus, and cause damage to assets such as pumps, flood control schemes and other infrastructural assets.

93. While the concept of natural erosion and accelerated erosion is readily understandable, in practice it is generally extremely difficult to differentiate between the two in the field. This is because so much of our land has been influenced by human activity. I recommend that the term 'erosion' be used instead of accelerated erosion.

94. The LUC mapping exercise results in the identification of land management units over the property which are based on the versatility of the land for sustainable production, or conversely, on the physical limitations of the land for sustainable production. The LUC system is therefore a very important tool when undertaking planning for sustainable land management. I believe that effective land management should be based on the identification of the natural capabilities and limitations of the land.

95. In my opinion, the implementation of a Whole Farm Plan is the cornerstone of any management approach adopted by a regional council to achieve sustainable land management on hill country farms.

96. Management practices such as earthworks, vegetation clearance, forest harvesting, and cultivation are capable of having adverse off site effects,

particularly when stormwater discharges from the land based activity are contaminated with sediment from erosion.

97. As the sediment yield from earthworks is potentially capable of being up to 100 times greater than from pastoral land use, and potentially up to 1000 times greater than natural forest, it is entirely appropriate that earthworks, and other land disturbance activities including cultivation, are managed/regulated to ensure they are properly planned and implemented to avoid, remedy or mitigate offsite effects.

98. In my opinion, small scale earthworks (under 2500 square metres in area) can be controlled relatively easily so that adverse environmental effects are minimal. I consider that this could be achieved through robust permitted activity conditions, requiring that any stormwater discharge to water does not breach the in-stream water quality standards. However, large scale earthworks (greater than 2500 square metres in area) have a high potential impact for adverse environmental effects if the earthworks and stormwater from disturbed areas, are not well controlled. I consider that large scale earthworks should be regulated through consents.

99. If cultivation is undertaken on LUC classes 1 to 4 following normal best practice on slopes up to 20 degrees, and adhering to riparian setback distances from the bed of a wetland, water body or river, then I believe it could be permitted subject to robust conditions, which include the requirement to meet water quality standards and requirements of the RMA (1991) s15, s70, and s107. In erosion management areas, and in the absence of a WFBP, I suggest that cultivation should be a regulated by consent on slopes greater than 20 degrees.

100. I consider that any vegetation clearance assessed and approved under a WFBP should be permitted. If not covered under a WFBP, vegetation clearance of scrub (defined as up to 70% canopy cover of woody vegetation) should be regulated by consents on areas greater than 100 square meters on land which has been identified as highly erodible land (also classified as Erosion Management Areas).

101. Riparian buffers are able to fulfill specific functions and provide a number of benefits including: controlling contaminants such as nitrogen, phosphorus, sediment and pathogens in faecal matter; stabilizing stream banks and reducing erosion; maintaining and increasing biodiversity; maintaining both terrestrial and aquatic ecological functions; protection of cultural values and amenity values; and providing downstream flood control. Activities, such as land disturbance including cultivation, and vegetation clearance within buffer zones should be strictly managed to retain the integrity of the riparian buffer zone and its terrestrial and aquatic ecological functions.

Mr Norm Ian Ngapo

REFERENCES

Basher LR, Botha N, Dodd MB, Douglas GB, Lynn I, Marden M, McIvor IR and Smith W, 2008. Hill country erosion: a review of knowledge on erosion processes, mitigation options, social learning and their long term effectiveness in the management of hill country. Landcare Research Contract Report: LC0708/081. Prepared for MAF Policy (POL/INV/0708/03).

Fletcher JR, 1987. Land Use Capability Classification of the Taranaki-Manawatu Region: A bulletin to accompany the New Zealand Land Resource Inventory Worksheets. Water & Soil Miscellaneous Publication No. 110.

Grant L, 15 May 2008. Section 42A Report for Horizons Regional Council for Hearings on Proposed One Plan.

Greater Wellington Regional Council 2002 (Reprinted 2006). Erosion and Sediment Control Guidelines for the Wellington Region.

Dymond, J., Shepherd, J. 2006. Highly erodible land in the Manawatu/Wanganui region. Landcare Research contract report 0607/027 (September 2006).

Kirk A 2008. Section 42A Report for Horizons Regional Council for Hearings on Proposed One Plan.

Kirk A (4 November 2008). Section 42A Report for Horizons Regional Council for Hearings on Proposed One Plan (Supplementary Report).

Lynn I, Manderson A, Page M, Harmsworth G, Eyles G, Douglas G, Mackay A, Newsome P, 2009. Land Use Capability Survey handbook- a New Zealand Handbook for the classification of land. 3rd ed AgResearch Lincoln.

McCaskill LW, 1973. Hold This Land. A history of soil conservation in New Zealand.

McKay A, (28 May 2008). Section 42A Report for Horizons Regional Council for Hearings on Proposed One Plan.

Page, M., Sheppard, J., Dymond, J., and Jessen, M. 2005. Defining highly erodible land for

Horizons Regional Council. Landcare Research Contract report: LC0506/050.

Parfitt R., Dymond J., Ausseil A-G., Clothier B., Deurer M., Gillingham A., Gray R., Houlbrook D., McKay A., McDowell R. 2007. Best practice phosphorus losses from agricultural land. Landcare Research Contract Report: LC0708/012, prepared for Horizons Regional Council.

Roygard J, (3 June 2008). Section 42A Report for Horizons Regional Council for Hearings on Proposed One Plan.

Schierlitz C, Dymond J, Shepherd J 2006. Erosion/sedimentation in the Manawatu catchment associated with scenarios of Whole Farm Plans. Landcare Research Contract Report 0607/028.