BEFORE THE ENVIRONMENT 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	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**DAY, MR ANDREW** **ENV-2010-WLG-000158**
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 PLANNING EVIDENCE BY IAIN LACHLAN GRANT ON THE TOPIC OF SURFACE WATER QUALITY – NON-POINT SOURCE DISCHARGES ON BEHALF OF MANAWATU-WANGANUI REGIONAL COUNCIL

Dated: 31st January 2012

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Introduction

My qualifications/experience

1. My full name is Iain Lachlan Grant. I have a Masters of Agricultural Science with honours (specialising in land resources, erosion processes and soil mechanics) from Massey University, Palmerston North. I also hold a Bachelor of Agricultural Science Degree (specialising in soils, nutrient management, agricultural engineering and farm management) from Massey University.

2. From 2005 to present I have worked as the director of the land management consultancy company LandVision Ltd specialising in soil, land resources and LUC mapping, whole farm planning, effluent and nutrient management, and sustainable land resource management.

3. LandVision Ltd is based in Wanganui and works throughout the North Island and upper South Island. LandVision Ltd has produced in excess of 300 whole farm plans for Horizons Regional Council under SLUI (Sustainable Land Use Initiative), and in excess of 100 other farm plans, nearly 30 nutrient management plans or FARMs strategies (Farmer Applied Resource Management), written numerous articles on sustainable land management and resource management, and presented many papers on land management and farm planning.

4. From 2002-2005 I headed the Land Management Department of the Taranaki Regional Council where the focus was sustainable land management through comprehensive farm planning and riparian planning.

5. From 1996-2002 I worked as a Land Management Officer for Horizons Regional Council based in Wanganui. During this time I was involved with land management programmes, oversaw the Whanganui Catchment Strategy, involved in the Wanganui and Taumarunui

Sustainability groups, numerous SUBS (Soils Underpinning Business Success) programmes, farm planning and resource consents. I was also involved in the Green Tick or Farmsure quality assurance programme as an expert for the land management component.

6. From 1992-1996 I worked as a Soil Conservator for Manawatu-Wanganui Regional Council based in Marton with a focus around the Rangitikei, Manawatu and coastal sand country. Work included farm planning, sustainable land management programmes and erosion control planning for individual landowners, and land use resource consents. I also managed the Rangitikei District Council forestry estate.

7. I am a member of the New Zealand Association of Resource Management.

Scope of Evidence

8. My evidence to the Court is to explain the landuse capability classification system (LUC) which is used for setting nitrogen leakage limits in Table 13.2 of the Proposed One Plan as amended by decisions. I have also examined the LUC system as it currently applies to the coastal sand country and refined its application for both re-contouring and irrigation.

Executive Summary

9. The landuse capability system (LUC) is a easily applied but sophisticated classification system that groups land into eight different classes according to their versatility and physical limitations present. Within these LUC classes the land is differentiated into subclasses according to the major limitation or hazard present. The types of limitations or hazards include erosion, wetness, soil or climate. The land resource inventory factors of rock type, soil type, slope, erosion type and severity and vegetation type along with the LUC class and subclass are used to form the LUC unit. The LUC unit and subclass system was not originally designed for the purpose of setting nutrient

limits but to establish a rigorous classification system for creating an inventory of the rural land resource. The scientific basis for using LUC as a tool to differentiate nutrient limits for land types is set out in the scientific analysis of scientists from the relevant Crown Research Institutes, including Dr McKay.

10. The existing suite of Land Use Capability Units (LUC) for the sand country is adequate for regional mapping at the 1:50,000 scale. Mapping at this scale allowed for the grouping of a multitude of landforms as these varied significantly over a very short space. The assignment of land use capability units (LUC units) was usually according to the poorest quality LUC unit present, or if this was insignificant, to the most dominant LUC unit present. As a result there is only a limited amount of LUC units assigned to the sand country. When the sand country is mapped at the paddock scale (1:7,000) there is a need for additional LUC units that differentiate all the landforms present.

11. Farming practices in the sand country have changed significantly over the last fifteen years from extensive pastoral farming to intensive dairying and beef finishing. This has come about through the introduction of large scale irrigation systems and the development of sand plains by re-contouring sand dunes. Fertiliser application rates have increased significantly as a result. Irrigation has significantly reduced the severity of wind erosion and made more water available for plant growth thus overcoming those inherent limitations to arable production.

12. The LUC classification of irrigated land under a community based irrigation system is treated differently to privately-owned individual irrigation systems. If there is a community based irrigation system available then the land is classified as if the improvement has been made even if it has not. If a private irrigation system exists on a property (and it is not a community based system), then the land is classified under the LUC system as having no irrigation improvements available. The logic behind this was that community based schemes would be maintained and privately owned schemes may not be. The practical solution to this is to have two LUC units for the same piece of

land – one for when the land is irrigated and one for when it is not. As a result of irrigation, some additional LUC units are proposed for the coastal sand country when undertaking mapping at the paddock scale (1:7,000).

13. LUC classification of land for drainage is treated as if the drainage has been undertaken, irrespective of whether it has been or not.

14. Irrigating the dry sand plains or dunes of sand country can either remove or significantly reduce the erosion limitation that is present. If the erosion limitation is eliminated through irrigation then the new dominant limitation will be a soil limitation (i.e. a low soil moisture holding capacity). If the irrigation only reduces the wind erosion potential then the dominant limitation would either be erosion or soil and would be dependent on which limitation is greater to production. Applying irrigation to land with 'soil' as the dominant limitation should reduce the limitation providing the soil limitation is low moisture holding capacity. If the physical limitation is reduced, then the LUC class will also be improved.

15. Applying irrigation to land with a wetness limitation will have no effect on the LUC class or LUC unit that it has been classified as, as the irrigation is doing nothing to improve the limitation present. The incorporation of drainage of such land has already been taken into consideration when the LUC class was first classified.

16. Re-contouring results in a change in landform and the area should be remapped at the farm scale according to the proposed LUC units. Decisions as to LUC units will be dependent on soil depth, the depth to the water table and slope.

The Land Use Capability Classification System

17. The **land use capability system** (LUC) is a classification system that differentiates land according to physical limitations or hazards. It comprises of eight different classes of land (called LUC classes) and each is described below. The LUC class is further subdivided into LUC subclass according to the major limitation present. The LUC class and

subclass are then further divided into the LUC unit where landforms with similar properties are grouped together. These three components are described in Sections 4.1-4.3 below.

18. To make a LUC classification down to the unit level, a **land resource inventory** survey needs to be undertaken first. A land resource inventory survey is the field mapping of the geology or rock type, the soil type, the slope, the erosion types and severity and the vegetation type present. These five factors (rock type, soil type, slope, erosion type and severity and vegetation) are termed the land resource inventory factors. When any one of these resource inventory factors change then a new map unit or polygon is required. These land inventory factors are important for determining the LUC classification and this discussed further in Section 4.3.

LUC class

19. Land is classified into eight different LUC classes and the definitions of each of these is summarised below.

Class 1 land

20. Class 1 land is the most versatile multiple-use land, with minimal physical limitations to arable use. It is flat or undulating, has deep resilient and easily worked soils and there is minimal risk of erosion. The soils are characterised as being fine textured, well drained, not seriously affected by drought, well supplied with plant nutrients and responsive to fertilisers. Climate is favourable for the growth of a wide range of cultivated crops, pasture or forest.

21. Land which has a slight limiting physical characteristic such as wetness, risk of flooding, or drought can be included in class 1 where the limitation can be removed by permanent works. The extent of class 1 land is limited, and is confined almost entirely to areas of deep, well drained alluvial soils located mostly on the flood plans of the larger rivers, or tephric and recent loess soils on terraces, or inland in frost free localities where climatic conditions are favourable for good crop growth. In the North Island, class 1 land normally occurs below 350 m

and 200 m in the South Island. Rainfall is normally between 650 and 1500 ml annually.

Class 2 land

22. Class 2 land has only slight physical limitations to arable use, which is readily controlled by management and soil conservation practices. Most class 2 land is flat or undulating. When cultivated, there may be a slight susceptibility to wind erosion and surface wash on more undulating land. Slight streambank erosion may be present around waterways. Unfavourable soil characteristics include loamy sand and clay-textured soils. The soils are generally developed from alluvium and recent loess, although some in the North Island may be developed on fine-textured, andesitic and basaltic ash. Class 2 land normally occurs below 400 m (South Island) and 500 m (North Island), and where the annual rainfall is between 800 and 2,000 mm in the North Island and less than 1,500 mm in the South Island.

Class 3 land

23. Class 3 land has moderate physical limitations to arable use. These limitations restrict the choice of crops and intensity of cultivation, and/or require special soil conservation practices. Some common limitations include; moderate susceptibility to erosion under cultivation, rolling slopes, shallow or stony soils, wetness or water-logging after drainage, low moisture holding capacity, moderate structural impediments to cultivation, low natural fertility, and moderate climatic limitations. Class 3 land occurs on undulating to rolling country, flat pumice country, slow draining soils, and across extensive areas of shallow and stony plains. Distribution is generally confined to below 650 m (South Island) or 750 m (North Island), and where annual rainfall is between 800 and 2,500 mm in the North Island or below 2,400 in the South Island.

Class 4 land

24. Class 4 land has severe physical limitations to arable use. These limitations substantially reduce the range of crops which can be grown, and/or make intensive soil conservation and management necessary.

In general, class 4 land is suitable for occasional cropping (eg once in five years or less frequently) and is most suitable for pasture, tree crops or production forestry. The most common limitations which may occur in class 4 land are; moderate to high susceptibility to erosion under cultivation, strongly sloping, very shallow soils and/or stony or very stony soils, excessive wetness after drainage, frequent flooding, very low moisture holding capacity, severe structural impediments to cultivation, low fertility difficult to correct, and severe climatic limitations.

25. Class 4 land ranges from flat to strongly rolling. When cultivated there may be severe susceptibility to wind erosion, and to sheet, rill and gully erosion. Unfavourable soil characteristics include clay, loamy sand and sand textures, and very stony soils on terraces. Distribution normally occurs below 800 m (South Island) or 1000 m (North Island) or where rainfall is between 800 and 3,000 mm in the North Island or below 3,000 mm in the South Island.

Class 5 land

26. Class 5 land is high producing pasture with physical limitations that make it unsuitable for arable cropping, but only negligible to slight limitations or hazards to pastoral, tree crop or production forestry. It is generally restricted to the pumice country where it is flat enough to cultivate but the soils are too erosion prone to turn over.

Class 6 land

27. Class 6 land is defined as land which is not suitable for arable use, and has slight to moderate physical limitations and hazards under a perennial vegetative cover. Some class 6 land may be suitable for cultivation but for pasture renewal only (ie less than once in ten years).

Class 7 land

28. Class 7 land is defined as land that is unsuitable for arable use and has the potential for severe physical limitations or hazards under perennial vegetation.

Class 8 land

29. Class 8 land has the potential for very severe to extreme physical limitations which make it unsuitable for arable, pastoral, or commercial forestry use. In the sand country class 8 land occurs within 400 m of the coast and is generally restricted to the coastal foredune. It is not suitable for productive use.

Summary Table

30. In summary, the limitations or hazards for land use increase and the versatility of uses decreases as you move from class 1 to class 8 land. This is shown in Table 1 below.

Table 1: Summary table of limitations to LUC Classes.

<table>
<tr><th>LUC Class</th><th>Arable cropping suitability</th><th>Pastoral grazing suitability</th><th>Production forestry suitability</th><th>General suitability</th></tr>
<tr><td>1</td><td rowspan="4">High
↓
↓
Low</td><td rowspan="4">High
↓
↓
↓
Low</td><td rowspan="4">High
↓
↓
↓
Low</td><td rowspan="3">Multiple land use</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td><td rowspan="3">Unsuitable</td><td rowspan="2">Pastoral or forestry land</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td rowspan="2">Unsuitable</td><td rowspan="2">Unsuitable</td><td rowspan="2">Conservation land</td></tr>
<tr><td>8</td></tr>
</table>

LUC subclass

31. The LUC subclass identifies the main kind of physical limitations or hazard to use. Four kinds of limitation or hazard are recognised and include erosion (e), wetness (w), soil (s) and climate (c). Further to this the limitations are always determined in this order. Hence, for example, climate will only be a limitation if there is no erosion, wetness or soil limitation present. Conversely there will only be a wetness limitation if there is no erosion limitation.

32. In the sand country, the erosion limitation is usually the most dominant limitation on the dry sand plains and sand dunes. The potential severity for wind erosion is dependent on vegetative cover, soil depth and soil moisture holding ability present.

33. LUC classes in the sand country with wetness as their dominant limitation are restricted to the wet sand plains. The water table will be high for part of the year, and as a result, this eliminates the erosion potential. The drainage of land with a wetness limitation is always taken into consideration when determining the LUC class.

34. Where soil is the dominant limitation in the sand country it is usually due to the poor moisture holding capability of the soil present. Where soil is the major limitation then the erosion and wetness limitations are always insignificant.

LUC unit

35. The LUC unit groups land of similar resource inventory factors together. Land with the same LUC units will require essentially the same kind of management, the same kind and intensity of conservation treatment, and are suitable for the same kind of crops, pasture or forestry species with similar yield.

36. The grouping together of the LUC class and subclass into LUC units requires comparing the surveyed land resource inventory factors (i.e. rock type, soil type, slope, erosion type and severity) with those on the Land Inventory Worksheets. Using the following table (Table 2) as and example – if the land was determined as having slight to moderate physical limitations to pastoral farming and not suitable for arable farming then it is classified as class six land. If the dominant limitation recorded was erosion then the LUC classification down to the subclass is 6e. Now if the land resource inventory factors were banded mudstone (the rock type), the Atua silt loam soils (the soil type), a slope of 20-25 degrees, and the erosion is slight soil slip and earthflow erosion then the LUC unit is 6e3 from Table 2 below. If the rock type was sandstone and the soil type was a Wilfred sandy loam while the other three resource inventory factors were the same (i.e. erosion type and severity, slope and vegetation), then the LUC unit would be 6e9 rather than 6e3.

37. The LUC Unit does not affect the LUC class as the LUC unit is the last part of the LUC classification chain. As a result, the LUC unit has no

bearing on the nutrient limits proposed in Table 13.2 of the Proposed One Plan.

Table 2: Part of the land resource inventory worksheet showing three LUC units.

LUC unit	Resources information	Parent material	Dominant soil type	Slope (degrees)	Dominant vegetation	Erosion degree & severity	
						Actual	Potential
VIe3	Moderately steep to strongly rolling fertile mudstone and siltstone hill country. Unit has a moderate potential for shallow earthflow and sheet erosion and slight potential for soil slip erosion.	Jointed mudstone (Mj) Banded mudstone and siltstone (Mb)	Atua silt loam	16-25	Pasture	Slight to moderate soil slip erosion Slight earthflow erosion.	Moderate earthflow & sheet erosion Slight soil slip and sheet erosion.
VIe7	Moderately steep to steep fertile mudstone and siltstone hill country with a moderate potential for shallow earthflow and soil slip erosion.	Jointed mudstone and siltstone (Mj) Banded mudstone and siltstone (Mb)	Atua hill soil	21-35	Pasture	Slight to moderate earthflow and soil slip erosion.	Moderate earthflow and soil slip erosion.
VIe9	Moderately steep to steep sandstone hill country with a moderate soil slip and tunnel gully erosion potential.	Massive sandstone and siltstone. Banded sandstone.	Wilfred sandy loam	20-35	Pasture	Slight to moderate soil slip erosion. Slight gully, tunnel gully and sheet erosion.	Moderate soil slip & tunnel gully erosion. Slight gully & sheet erosion

38. Whilst, in this example, the subclass varies because the land resource inventory factors change, the land is still class six land and it has slight to moderate erosion limitation to pastoral farming.

39. Within this evidence, LUC class refers to land classes one to eight. The LUC subclass refers to not only the classes one to eight but also the dominant limitation present (e.g. 2w – class two land with a wetness limitation). **Where this evidence details down to the LUC unit level it refers to the LUC class, subclass and the unit number combined** (e.g. 6e24 – class six land with an erosion limitation).

Current farming practices in the sand country

40. Significant land development for intensive pastoral farming has occurred in the sand country over the last fifteen years. The introduction of irrigation with large pivot irrigation systems has increased the value of flat sand plains and promoted opportunities to re-contour sand dunes into sand plains. As a result, land use has changed significantly from extensive dry stock farming of the wet and dry sand plains and production forestry on the sensitive dunes, to large scale dairying or beef finishing.

41. Irrigation has enabled a significant reduction in the wind erosion potential by maintaining a vegetative cover. It also reduces the soil moisture deficit over the dry summer months. Production capabilities on the drier sand plains has increased from less than three to five tonnes of dry matter per hectare per year to excess of 15 tonnes. These areas under irrigation are also capable of growing maize with similar yields to those achieved on the alluvial plains. The production increases have been helped with significant increases in fertiliser applications. Due to the nature of the sand country soils the fertiliser inputs required are usually much higher than the alluvial plains to achieve the same yields.

42. In order to maximise the area suitable for irrigation there has been significant re-contouring of dune land into sand plains. This usually involved stripping the little topsoil present from the dunes and then bulldozing the dunes to a more suitable contour. Once this contour is achieved the stripped topsoil is then spread back over the re-contoured land. Irrigation reduces the erosion potential by promoting a vegetative cover with plant growth or by keeping bare sand moist enough so it will not blow.

Recommended sand country LUC units for the Horizons Region

43. The coastal sand country in the Horizons Region straddles two LUC regions – the Taranaki-Manawatu Region and the Wellington Region.

Harnsworth and Page 2009[1] correlated these two mapping regions to form the Horizons Regional Council Classification naming system.

44. The current LUC units were devised for mapping at the regional scale ie. 1:50,000. For regional mapping of the sand country the shape of the landforms present are generally long narrow sand dunes with sand plains in between. When these landforms are mapped at the regional scale it often meant that two landforms would be clumped together. The LUC used when this clumping occurred was usually either the poorer LUC class present or if the poorer LUC class present was insignificant, then the dominant (by area) land LUC class present.

45. Mapping at the regional scale also meant that the smallest mapping unit or polygon is at about the size of the old 'one cent' piece on a 1:50,000 map. This is actually about the polygon size at any scale mapping. As a result for regional scale mapping in the sand country detailed LUC units are not used despite the landforms and soil types changing rapidly. When mapping at the paddock scale (i.e. 1:7,000), the smallest mapping unit is still the size of a one cent piece on the map and as a consequence the polygons will pull out the different landforms and soil types that would have been grouped at the regional mapping scale. To define the landforms more precisely at the paddock scale in the sand country several additional LUC units over and above the existing ones are recommended and these are shown in Table 3 below. Table 3 also details the proposed units under the Horizons Region naming system and the correlation with the existing units found in either the Taranaki-Manawatu or Wellington LUC Regions. Where there was not a good match for a land type and LUC unit, a new LUC unit is proposed. These recommendations do not mean the LUC units are not useful for mapping at the farm scale but are simply refinements. These recommendations do not necessitate any changes to the rule framework in the POP as these matters will be addressed in the nutrient management plans prepared for each farm.

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[1] Harmsworth, GR, Page, MJ. 2009: Correlation of Land Use Capability (LUC) Units into a single LUC Classification for the Horizons Regional Council area. Landcare Research Contract Report LC0809-082.

46. The issue of the sand country of not having enough LUC units does not occur in other LUC suites in the Horizons Region as other landforms do not change as rapidly as they do in the sand country.

47. In Table 3 below the LUC class for both the Taranaki-Manawatu and the Wellington LUC Regions are in Roman Numerals while the LUC classes change to normal numerals when referring to the Horizons Regional Classification. This is for ease of knowing what classification system is being used.

Table 3: LUC units for the coastal sand country.

LUC Units	**Correlation**	
	Taranaki-Manawatu Region	**Wellington Region**
2s3 Flat to undulating medium height terraces overlain by slightly consolidated Aeolian sands. Soils are sandy in texture and well drained, tending to dry out in summer. Occurs around Levin and south.		IIs2
2s9 (new) Irrigated sand plains with greater than 40 cm of soil development.	IVe10	
3e13 (new) Non irrigated dry sand plains with greater than 40 cm of soil development.		
3e14 Rolling to undulating downlands of slightly consolidated Aeolian sands over older terraces. Soils are sandy textured and well drained. There is the potential for slight to moderate sheet, rill and wind erosion when cultivated. Occurs in the southern part of the Region.		IIIe2
3w5 Flat, wet sand plains with gleyed yellow-brown sands and gley soils. High water table in winter and spring limits cropping versatility.	IIIw4	IIIw3
3w7 Poorly drained flat land in the interdune depressions with greater than 40 cm of peat and the water table is at or near the surface during the winter and spring.		IIIw2
3s8 (new) Irrigated sand flats with 20-40 cm of soil development.	IVe10	IVe4
4e12 Sand plains with yellow-brown sand soils with a potential for severe wind erosion when cultivated.	IVe10	IVe4
4e24 (new) Low level sand dunes with greater than 20 cm of topsoil development under irrigation.	VIe24 VIs4	VIe5 VIs4
4w6 Poorly to very poorly drained flat land in the interdune depressions with greater than 40 cm of peat and a permanently high water table.		IIIw3
6e38 Undulating to moderately steep stabilized sand dunes with weakly developed yellow-brown sand soils. Soils are free draining with frequent periods of soil moisture deficiency. Potential for moderate wind erosion.	VIe24	VIe5

LUC Units	Correlation	
	Taranaki-Manawatu Region	**Wellington Region**
6w2 Very poorly drained flat land in the interdune depressions and a permanently high water table and surface water for some of the year.		VIw1
6s4 Flat sand plains with yellow-brown sand soils that are free draining, of low to medium natural fertility and have frequent periods of soil moisture deficit. Potential for slight wind erosion.	VIs4	VIs4
7e26 Rolling to moderately steep sand dunes with a potential for extreme wind erosion under grassland.	VIIe15	VIIe3
8e1 Coastal foredune and dunes within 200 metres of the foredune.	VIIIe1	VIIIe1
8w2 Coastal lakes.	VIIIw1	VIIIw1

Decision pathway for proposed LUC Units for the sand country

48. The following table provides a decision pathway for determining the LUC unit present. Land has been divided into five sub-suites for the sand country:

- coastal dunes within 200 metres of the coastline,
- sand dunes beyond 200 metres,
- sand plains formed from windblown sand,
- plains formed from peat overlying windblown sand, and
- windblown sand over older terraces.

49. The landform present dictates the sub-suite irrespective of whether it has been re-contoured. Sub-suites in combination with the depth of soil development, and whether the land is irrigated or not, will determine the appropriate LUC unit present.

A. is the land sand dunes within 200 metres of the coastline?	
Yes – go to A1	No - Go to B
B. Is the land on wet sand flats formed from peat?	
Yes – go to B1	No - Go to C
C. Is the land inland sand dunes?	
Yes – go to C1	No - Go to D
D. Is the land on sand plains?	
Yes – go to D1	No - Go to E
E. Is the land slightly consolidated sand overlying terrace deposits and border the inland margin of the sand country?	
Yes – Go to E1	

A. Sand dunes within 200 metres of the coastline	
A1. Are the dunes within 200 metres of the coastline and are unstable with little to no soil development or are the dunes between 200 and 400 metres inland with greater than 30% bare sand present?	
Yes – 8e1	

B. Sand flats formed from peat	
B1. Does the land consist of greater than 40 cm of peat which occurs in interdune depressions?	
Yes – go to B2	Go to D1
B2. Is the peat poorly drained with the water table near the surface during winter and spring?	
Yes – 3w7	No – go to B3
B3. Is the peat poorly to very poorly drained with a permanently high water table?	
Yes – 4w6	No - go to B4
B4. Is the peat very poorly drained with the water table at the surface for part of the year?	
Yes – 6w2	

C. Sand dunes beyond 200 m of the coastline	
C1. Do the dunes have greater than 30% bare sand exposed and little or no topsoil development where it is vegetated?	
Yes – 8e1	No – go to C2
C2. Are the dunes unstable with little or no topsoil development, and has evidence of greater than slight to moderate wind erosion present (less than 30% bare ground)?	
Yes – Go to C3	No – go to C4
C3. Is the land irrigated?	
Yes – 6e38	No – 7e26
C4. Do the dunes have greater than 20 cm of soil development and slopes 8-15 degrees?	
Yes – go to C5	No – go to C6
C5. Is the land irrigated?	
Yes – 4e24	No – 6e38
C6. Are the dunes relatively stable with greater than 20 cm topsoil development and a slope greater than 15 degrees?	
Yes – 6e38	

D. Sand plains	
D1. Does the land consist of flat, interdune sand plains?	
Yes – Go to D2	
D2. Are the sand plains low lying and imperfectly to poorly drained (high water table, mottled subsoils) and less than 40 cm of peat present?	
Yes – 3w5	No – go to D3
D2. Are the sand plains low lying and very poorly drained (high water table, mottled subsoils) and less than 40 cm of peat present?	
Yes – 6w2	No – go to D4
D4. Are the sand plains high and excessively drained?	
Yes – go to D5	
D5. Do the sand plains have less than 20 cm soil development?	
Yes – Go to D6	No – go to D7
D6. Is the land irrigated?	
Yes – 4e12	No – 6s4

D7. Do the soils have between 20 and 40 cm of soil development?	
Yes – Go to D8	No – go to D9
D8. Is the land irrigated?	
Yes – 3s8	No – 4e12
D9. Do the soils have greater than 40 cm of soil development?	
Yes – Go to D10	
D10. Is the land irrigated?	
Yes – 2s9	No – 3e13
D11. Is the land coastal lakes?	
Yes – 8w2	

E. Slightly consolidated sand overlying terrace deposits and border the inland margin of the sand country	
E1. Is the land slightly consolidated sand overlying terrace deposits and border the inland margin of the sand country?	
Yes – go to E2	
E2. Are slopes 0-7 degrees?	
Yes – 2s3	No – Go to E3
E3. Are slopes 7-15 degrees?	
Yes – 3e14	

Proposed LUC descriptions

The following table describes the resource inventory factors for the various LUC units recommended for the sand country. There may be some local variations as to the soil types present.

LUC Description	Landform	Parent material	Slope (degrees)	Soil type	Drainage	Erosion degree & severity	
2s3 Flat to undulating medium height terraces overlain by slightly consolidated Aeolian sands. Soils are sandy in texture and well drained, tending to dry out in summer. Occurs around Levin and south.	Sand plains over terraces.	Slightly consolidated sands.	0-7	Yellow brown sands. Koputaroa fine sandy loam Waitawa fine sandy loam Koputaroa sand.	Well to excessively well drained.	Nil.	Slight wind when cultivated.
2s9 Irrigated sand plains with greater than 20 cm of soil development.	Sand plains.	Wind blown sands.	0-7	Yellow brown sands. Himatangi series Awahou series Pukepuke Brown sand	Well to excessively well drained.	Nil.	Slight wind when cultivated.
3e13 Non irrigated sand plains with greater than 40 cm of soil development.	Sand plains.	Wind blown sands.	0-7	Yellow brown sands. Awahou series Pukepuke brown sand	Well to excessively well drained.	Nil.	Slight to moderate wind when cultivated.
3e14 Irrigated low angled (4-15 degrees) dunes with greater than 20 cm of soil development.	Sand dunes.	Wind blown sands.	4-15	Yellow brown sands. Foxton black sand Foxton brown sand	Well to excessively well drained.	Nil.	Slight to moderate wind when cultivated.
3e15 Rolling to undulating downlands of slightly consolidated Aeolian sands over older terraces. Soils are sandy textured and well drained. There is the potential for slight to moderate sheet, rill and wind erosion when cultivated. Occurs in the south.	Sand over older terraces.	Slightly consolidated sands (Us)	4-15	Yellow brown sands. Koputaroa fine sandy loam rolling phase Koputaroa sand.	Well to excessively well drained.	Nil.	Moderate sheet, rill and wind erosion when cultivated.

LUC Description	Landform	Parent material	Slope (degrees)	Soil type	Drainage	Erosion degree & severity	
3w5 Flat, wet sand plains with gleyed yellow-brown sands and gley soils. High water table in winter and spring limits cropping versatility.	Sand plains.	Wind blown sand. Peat less than 40cm over sand.	0-7	Carnarvon brown – Foxton association. Carnarvon black – Foxton association. Pukepuke – Omanuka association. Pukepuke brown peaty fine sandy loam. Pukepuke brown peaty loam. Pukepuke black sandy loam, Carnarvon find sandy loam	Poorly drained.	Nil.	Slight wind erosion when cultivated.
3w7 Poorly drained flat land in the interdune depressions with greater than 40 cm of peat and the water table is at or near the surface during the winter and spring.	Peat over wind blown sand.	Peat over wind blown sand.	0-4	Pukepuke – Omanuka association. Pukepuke brown peaty fine sandy loam. Pukepuke brown peaty loam. Pukepuke black sandy loam,	Poorly drained.	Nil.	Nil.
3s8 Irrigated sand flats with 20-40 cm of soil development.	Sand plains.	Wind blown sands.	0-7	Yellow brown sands. Himatangi series	Well to excessively well drained.	Nil.	Slight to moderate wind erosion when cultivated.
4e12 Sand plains with yellow-brown sand soils with a potential for severe wind erosion when cultivated.	Sand plains.	Wind blown sands.	0-7	Himitangi, Awahou and Mosston series.	Well to excessively well drained.	Nil.	Nil to slight wind erosion. Severe wind erosion when cultivated.
4e24 Low level sand dunes with greater than 20 cm of topsoil development under irrigation.	Sand dunes.	Wind blown sands.	7-15	Yellow brown sands. Foxton black sand Foxton brown sand	Well to excessively well drained.	Nil.	Nil to slight wind erosion. Severe wind erosion when cultivated.
4w6 Poorly to very poorly drained flat land in the interdune depressions with greater than 40 cm of peat and a permanently high water table.	Peat over windblown sand.	Peat over sands.	0-7	Omanuka series Pukepuke series	Poor to very poorly drained.	Nil.	Nil.

LUC Description	Landform	Parent material	Slope (degrees)	Soil type	Drainage	Erosion degree & severity	
6e38 Undulating to moderately steep stabilized sand dunes with weakly developed yellow-brown sand soils. Soils are free draining with frequent periods of soil moisture deficiency. Potential for moderate wind erosion.	Sand dunes.	Wind blown sands.	3-25	Foxton, Motuiti, Castlecliff, Mosston, Waitarere series.	Well to excessively well drained.	Slight to moderate wind erosion.	Moderate wind erosion.
6w2 Very poorly drained flat land in the interdune depressions and a permanently high water table and surface water for some of the year.	Sand plains.	Wind blown sand and peat over sand.	0-3	Omanuka series	Very poorly drained	Nil.	Nil.
6s4 Flat sand plains with yellow-brown sand soils that are free draining, of low to medium natural fertility and have frequent periods of soil moisture deficit. Potential for slight wind erosion.	Sand plains.	Wind blown sands.	0-3	Hokio series Himatangi series	Well to excessively well drained.	Nil to slight wind erosion.	Slight wind erosion.
7e26 Rolling to moderately steep sand dunes with a potential for extreme wind erosion under grassland.	Sand dunes.	Wind blown sand.	7-25	Yellow brown sands dominantly Motuiti, Castlecliff, Mosston and Patea series. Waitarere series on unstable areas.	Well to excessively well drained.	Moderate to extreme wind erosion.	Severe to extreme wind erosion.
8e1 Coastal foredune and dunes within 200 metres of the foredune or dunes within 200-400 metres of the coastline with greater than 30% bare sand present.	Sand dunes.	Wind blown sand.	7-25	Recent soils. Waitarere series on the dunes and Hokio series on the sand plains.	Well to excessively well drained.	Moderate to extreme wind erosion.	Severe to extreme wind erosion.
8w2 Coastal lakes.	Wetlands.	Peat and wind blown sand.	0-3	Omanuka series	Very poorly drained.	Nil.	Nil.

Justifications of LUC decisions

50. The following sections discuss the justification for each LUC unit proposed for the sand country.

LUC 2s3

51. This unit is an existing unit under the Wellington LUC Region and occurs on old terraces formed from Aeolian sands associated with the Koputaroa dune building phase (about 2-5,000 years old). The soils have good topsoil development and are generally fine sandy loams or sandy textured.

52. This unit will generally be restricted to the areas south of Foxton in the Horizons Region.

LUC 2s9

53. LUC unit 2s9 is a new unit devised for irrigated sand plans with greater than 40 cm of topsoil development. This unit is the same as 3e13 but the application of irrigation has changed the erosion limitation to a soil limitation. The depth of topsoil development means that there is some moisture holding capability and that the land is suited to some arable cropping. The soil textures are sandy loams, loamy sands or sands.

54. Under the current LUC classification system these soils would be classed as LUC unit 4e12 in the Taranaki-Manawatu Region and possibly similar to 2s3 found in the Wellington classification. Furthermore, under irrigation, these soils would have sufficient soil depth to have slight limitation to arable farming, making them class two land.

55. This unit will generally be restricted to the older sand plains.

LUC 3e13

56. LUC unit 3e13 is a new unit derived from 4e12 when mapping at the regional level and all the dry flats are grouped together. The depth of topsoil or soil development means that this unit would only have moderate limitations to arable use rather than severe limitations as for class four land. The soil textures are sandy loams, loamy sands or sands.

LUC 3e14

57. This unit is the same as IIIe2 under the Wellington LUC Classification and generally only applies to land in the southern part of the Region.

LUC 3w5

58. This unit is an existing unit and generally included all the wet sand plains under the current classification system.

LUC 3w7, 4w6, and 6w2

59. These three units are all formed from peat and occur within the interdune depressions. Under the current LUC classification system for the sand country all these units are grouped as IIIw4 or IIIw3 as part of the Taranaki-Manawatu or Wellington Classification Regions respectively. Having significant amounts of peat means these soils should be split out from those wet sand plains. The difference between the three proposed units is on drainage.

LUC 3s8

60. This unit is the same as 4e12 but with irrigation. Applying irrigation has changed the erosion limitation to a soil limitation.

LUC 4e12

61. This is an existing unit – IVe10 in the Taranaki-Manawatu Region and IVe10 in the Wellington Region.

LUC 4e24

62. LUC unit 4e24 are low angled dunes less than 15 degrees and with greater than 20 cm of soil development. Under the current classification system this unit would have been classified as 6e38 solely due to its erosion potential. Under irrigation and at a farm scale survey this land should be classified as class 4e land. Without irrigation it should be classified as 6e38.

LUC 6e38

63. This unit is equivalent to the existing class VIe unit.

LUC 6s4

64. LUC class 6s4 is an existing unit for sand plains with a soil limitation. The depth of topsoil and the potential for severe wind erosion under cultivation means that this unit is not suitable for arable use. Hence the classification of class six land. Under a pastoral vegetation cover the erosion potential is eliminated, hence the major limitation is soil, specifically soil moisture holding capability. Reducing the soil moisture holding limitation through irrigation means that this unit could be turned over, but with severe limitations for arable use. The limitation would change from a soil limitation to an erosion limitation under irrigation.

LUC 7e26

65. This is an existing LUC unit. Under irrigation the potential for erosion would be lowered but the major limitation would still be wind erosion.

LUC 8e1

66. LUC unit VIIIe1 in the past has included all dunes within 400 metres of the mean high water mark. The proposed classification system has reduced this to 200 metres to make it consistent with the Proposed One Plan as amended by decisions of the coastal foredune definition. LUC unit VIIIe1 also includes sensitive dunes where there is greater than 30% bare sand present. These would mostly be confined to the 200-400 metre mark inland from the coast.

67. The area within 200 metres of the coastline is an extremely harsh environment with the potential for extremely severe wind erosion, the exposure to salt laden winds, very weak soil development, severe moisture deficiencies and high nitrogen deficiencies. Dunes between 200-400 metres with greater than 30% bare sand are prone to similar limitations to those within the 200 metre zone.

LUC 8w2

68. This unit comprises of coastal wetlands. They differ from other wetlands throughout the Region and there are advantages for monitoring if they are differentiated from other wetland types by having their own LUC unit.

Discussion

69. The LUC classification system has been around since the 1950's. Recently the 3rd edition of the LUC survey handbook was published by AgResearch and this provides a national standard for land use capability assessment and land resource inventory mapping. Generally the philosophies and concepts of this edition are the same as the previous editions. The mapping approaches and LUC Unit classification outlined in this evidence are consistent with the LUC survey handbook.

70. Land classification of irrigated land under the LUC system treats community based irrigation systems differently to privately owned individual irrigation systems. If there is a community based irrigation system available then the land is classified as if the improvement has been made even if it has not. If a private irrigation system exists on a property (and it is not a community based system), then the land is classified under the LUC system as having no irrigation improvements available. The reason only community based schemes were only considered as acceptable for reclassification was because it was thought these would be maintained irrespective of whether the commodity prices were high or low. Under private systems, however, it was considered that they would only be maintained during the good years and not the poor year.

71. In the sand country, a community based irrigation scheme has never been available and as a consequence the land has never been classified with this in mind. Private irrigation systems did not classify as a community based scheme. Hence there was no need for a suite of LUC Units that incorporated land that was irrigated.

72. In the last fifteen years the introduction of pivot irrigators has been brought about by a significant investment by the land owner. This investment is such that it is considered that they would be maintained, irrespective of commodity prices, just because the land owner needs to get a return on his/hers investment. As a consequence there is now the need for LUC Units that incorporate irrigation. Since any irrigation in the sand country would be on a private basis there is also a real need to have two LUC units for the same type of land – one when it is

under irrigation and the other when it is not irrigated. This approach would remove problems associated with the irrigation not being maintained or that that is never considered or installed for irrigation.

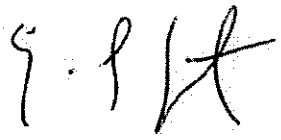
73. The reversion from an irrigated LUC unit to a non irrigated unit would occur when the irrigation system is either decommissioned or not used as a result of the farmer's decision. It should not be by forces outside the farmer's control such as the halting of water-takes during dry periods.

74. Irrigating the dry sand plains or dunes of sand country can either remove or significantly reduce the erosion limitation (LUC Subclass "e") that is present. If the erosion limitation is eliminated then the new dominant limitation will be a soil limitation (Subclass "s"). The specific soil limitation would be a low soil moisture holding capacity. The addition of 'rainfall' through irrigation will provide soil moisture and as a consequence it will improve plant vitality. This in turn will eliminate or reduce the wind erosion potential. If, under irrigation, the wind erosion is only reduced and not eliminated then the dominant limitation will still be erosion. Applying irrigation to land with 'soil' as the dominant limitation should reduce the limitation providing the soil limitation is low moisture holding capacity. If the physical limitation is reduced, then the LUC class will also be improved.

75. Where the land has a wetness limitation (i.e., it requires drainage) it is always classified as having the improvement (drainage) being done irrespective of whether the drainage is part of a community scheme or not. Hence if you had some 3w land, the classification of it being class three was made because it was considered to have moderate limitation to arable production, due to poor drainage. This classification of 3w was made as if the landowner had improved the land with drainage, even if he had not undertaken the drainage. Consequently there have always been adequate LUC units available for classifying the land.

76. Applying irrigation to land with a wetness limitation (Subclass "w") will have no effect on the LUC class that it has been classified as, as the irrigation is doing nothing to improve the limitation present. The incorporation of drainage of such land has already been taken into consideration when the LUC class was first classified.

77. Re-contouring results in a change in landform and the area should be remapped at the farm scale according to the proposed LUC units. Decisions as to LUC units will be dependent on soil depth, the depth to the water table and slope.



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