

Farm-scale Land Use Capability Classification for Auckland

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Executive summary

FARM LUC (farm land use capability) is a land use capability classification for farm-scale maps (up to 1:10,000). It provides more detail than, though remains interchangeable with, the regional-scale (1:50,000) NZLRI (New Zealand Land Resource Inventory) LUC layer in Auckland Council's GIS.

The rationale for FARM LUC is to provide a map format which landowners find easier to understand, and more information as an aid for land management, than the existing NZLRI LUC sub-classes and units. It retains existing LUC classes 1 to 8, replaces four sub-classes (indicating general limitations to land use) with 20 specific sub-classes, and replaces unit numbers (denoting different kinds of land but three inconsistent number sets) with a single set of character suffixes.

When preparing a FARM LUC map, land inventory recording and land use capability classification remain consistent with standard procedure as described in the Land Use Capability Handbook (Lynn et al 2009).

This report documents how FARM LUC has been developed and trialled on farm-scale maps prepared by Auckland Council between 2011 and 2015. The classification has also been used on a number of maps prepared privately for Auckland landowners. The maps are currently used to advise landowners about sustaining current use, reducing environmental impact, or changing it. Examples are adjustments to fertiliser application or grazing management, identifying sites for land application of dairy effluent, erosion control plantings, and riparian retirement.

A region-wide NZLRI – FARM LUC conversion layer was entered into GIS in 2016 by examining inventory recorded for each 1:50,000 NZLRI LUC polygon, and identifying a corresponding FARM LUC classification. The conversion layer is regional scale (1:50,000), so any map printed from it will only be suitable for illustrative purposes. Such a map must never be used in planning procedures which relate to a particular property because:

- it depicts the main FARM LUC class/sub-class/suffix which would be recorded, if a 1:50,000 NZLRI LUC polygon were to be remapped at farm-scale,
- other FARM LUC classes/sub-classes/suffixes are present inside each polygon's boundary, but the conversion layer does not indicate their location or extent,
- to find out for a particular property, it is necessary to field-map FARM LUC at a scale appropriate for the current or intended land use.

When preparing the farm-scale maps, land inventory recording and land use capability classification remain consistent with standard procedure as described in the Land Use Capability Handbook used by regional councils nationwide.

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1. Background

Land use capability is a classification of land according to properties that determine its capacity for sustained primary production. Farm-scale land use capability (LUC) maps are one of the tools used by rural land management advisors when helping farmers and communities achieve sustainable land management on individual farms and within whole catchments. Regional-scale LUC maps are also one of the tools historically and currently used by researchers, rural industry representatives, and local authority planners when formulating policy, preparing plans, and advising decision makers about the region's productive capability (Curran-Cournane et al 2014).

The Land Use Capability (LUC) classification was first developed in the USA, applied in many other countries, and adapted for use in New Zealand by the Soil Conservation and Rivers Control Council (SCRCC, later National Water and Soil Conservation Authority, NWASCA). New Zealand mapping and classification procedures are described in the third edition of the Land Use Capability Handbook (Lynn et al 2009). Land is categorised into eight classes according to its long-term capability to sustain one or more productive land uses. LUC class 1 is defined as being the most versatile (multiple-use) land with minimal physical limitations. Versatility decreases, and limitations increase, moving from LUC classes 1 to 8. LUC class 8 is land with extreme limitations that preclude productive use. Each LUC class is divided into sub-classes which identify the main limitation to use. Just four are recorded in New Zealand: e = erosion, w = wetness, s = soil and c = climate. More specific (and numerous) sub-classes are recorded in other countries' classifications (Klingebiel and Montgomery, 1961). Classes and sub-classes are divided into units. Units group areas of land which have the same geology, soils and slope. Underlying assumptions are that each LUC unit is suitable for the same crops, pasture or forestry species; produces similar yields; and will require the same kind of land management or conservation treatment.

Since 1980 users of LUC classification in New Zealand have referred to 1:63,360 land use capability maps, prepared nationwide between 1969-1979 by Ministry of Works and Development (MWD) who provided technical services to NWASCA. Since the demise of these organisations in 1988, and subsequent to a brief period of maintenance by Department of Scientific and Industrial Research (DSIR) 1989-1992, the maps have been revised at 1:50,000 in some parts of the country including Auckland by the crown research institute Landcare Research (LCR). In recent years they have been made available as geospatial layers on its Land Resource Information Systems (LRIS) portal. For rural parts of Auckland the maps help underpin land use planning decisions whether it be for resource consents, plan change procedures (often supplemented by LUC site inspection and mapping) or whilst preparing district, regional or unitary plans.

In Auckland three of the limitations with using and interpreting existing LUC maps are:

- Class 1 (the best arable land) and Class 5 (the best non-arable land) appear limited in extent on 1:50,000 maps, a scale which does not permit many small areas to be separated from surrounding land of lower land use capability. 1:5,000 - 1:10,000 maps enable separation. They show Class 1 and Class 5 land to be more extensive, occupying a greater percentage of regional area.

- Different LUC units are mapped on similar soils, north and south of the city. This is a historical artefact of 1969-1979 mapping, when separate classifications were used for different parts of the country instead of a uniform national classification.
- A perception on the part of landowners that LUC map labels are difficult to comprehend. LUC classes (1 to 8) are easily grasped, but LUC sub-classes (c, w, s, e) are so general that rural advisors have to provide additional explanation (verbal or written) about the nature of the limitations, when discussing any particular area on a farm-scale map. LUC unit numbers (for instance the 1 in 6e1) are a source of confusion. They can be explained as a label denoting areas of land with similar physical properties, and as having no numerical significance; but because they convey no information about physical properties, it remains difficult for a farmer to grasp exactly what “the 1 in 6e1” denotes.

In response to these issues, Auckland Council asked one of the authors (Douglas Hicks, DLH) to develop a better map format, when preparing farm-scale land use capability maps for supply to landowners by the other author (Vanessa Vujcich, VV) between 2011 and 2015. This report documents key elements in the new map format:

- retention of existing classes (1 to 8),
- twenty new sub-classes to indicate the nature of limitations,
- sub-classes (singly, combined, or with character suffixes) replace unit numbers,
- the same classification appears on farm-scale maps anywhere in the region.

Auckland’s new farm-scale classification (FARM LUC) remains interchangeable with the combinations of sub-class and unit in New Zealand Land Resource Inventory (NZLRI), LCR’s revised version of the old MWD regional-scale land use capability map series, which appears as a layer in Auckland Council’s Geographic Information System, and which is referred to by the council’s planners as an aid for planning activities.

When preparing the farm-scale maps, land inventory recording and land use capability classification remain consistent with standard procedures as described in third edition of the Land Use Capability Handbook (Lynn et al 2009).

2. Method

2.1 Land use capability (LUC) class

2.1.1 Existing classes

Land's capability for productive use is indicated by assigning it to one of eight classes. Class definitions have not changed through successive editions of the Land Use Capability Handbook (LUC Handbook), the most recent of which is Lynn et al 2009. Briefly, classes 1 to 4 are arable, capable of a range of uses – vegetable growing, orchards, vineyards and berry fields, grain and fodder cropping, pastoral grazing and production forestry. However physical limitations for arable farming increase, and versatility for sustained production decreases, moving from class 1 to class 4. Classes 5 to 8 are non-arable. Physical limitations for non-arable farming and forestry likewise increase, and versatility for sustained production decreases, moving from class 5 to class 8. Class 5 land is capable of orchards, vineyards and berry fields; classes 5 to 7 of dairy or drystock farming and production or conservation forestry; and class 8 of conservation for watershed protection, biodiversity and recreation.

Table 1. NZLRI and FARM LUC land use capability classes

NZLRI	FARMLUC	Description
<i>Arable</i>		
1	1	negligible limitations to productive use
2	2	with slight limitations
3	3	with moderate limitations
4	4	with severe limitations
<i>Non-arable</i>		
5	5	with slight limitations
6	6	with moderate limitations
7	7	with severe limitations
8	8	limitations preclude productive use

2.1.2 Reasons to retain existing classes

There are strong reasons to retain the existing eight LUC classes (Table 1) on farm-scale maps:

- Consistent use since 1945 has ensured they are widely understood as rankings of land's capability for productive use; accepted as input for planning procedures; with interpretations either upheld or rejected by a body of Planning Tribunal/Environment Court decisions (Robertson and Williams 1996, Jessen and Harmsworth 1997, Curran-Cournane et al 2014).
- They appear on over 15,000 farm-scale maps prepared by catchment boards for landowners between 1945-1988, (NWASCA 1988), plus an unknown number of farm-scale maps prepared by regional councils between 1989-2015.
- They appear on nationwide regional-scale maps prepared by MWD for planners' use 1969-1979 (NWASCA 1979), partly updated by MWD or successor agencies 1980-2004, and maintained by LCR at the present day.

The classes need to be changed in just two respects – the cartographic depiction of class 1 and class 5 land, – and the definition of extra units within classes 1 and 5.

2.1.3 Cartographic depiction of class 1 land

The NZLRI LUC classification identified just one class 1 LUC unit in Auckland: 1w1 on small areas of Patumahoe or related granular soil, on flat land with a negligible to slight wetness limitation. More extensive areas of granular or allophanic soil on flat to undulating land were classed as 2s1 and 2s2 north of Auckland, or 2s3 and 2s4 south of Auckland i.e. as having slight soil limitations.

The authors (DLH and VV) are aware of many properties on the outskirts of Auckland where high-value food production – vegetable, fruit and vine crops – has been sustained for many years on such land, without any soil management other than the cultivation and fertilisation which would normally be expected. These areas meet the LUC Handbook's existing definition of class 1. Soil limitations are negligible, and local climate is the only physical constraint on yield.

Although not done when preparing farm-scale maps for such properties 1995 – 2015, the establishment of LUC class 1 equivalents for the better components of these regional class 2 units is now recommended by the authors. Appendix 1 of this report contains provisional class 1 units alongside the existing class 2. These may be quickly brought into use for future farm-scale mapping.

2.1.4 Cartographic depiction of class 5 land

Class 5 – the best class of non-arable land – appears widely on farm-scale maps prepared between 1945 and 1969. Very little appears on regional-scale maps prepared between 1969 and 1979. The LUC Handbook's 2nd edition (SCRCC 1974) requirement of “virtually no erosion hazard under grazing or forestry use” was the criterion that excluded most land from class 5. (pp 62-63 of Lynn et al 2009). This had three “down-sides”:

- Regional-scale NZLRI maps suggest that class 5 land is less extensive than is actually the case,

- Accompanying documents (extended legends and bulletins) contain few definitions for class 5 LUC units, just ten in the North Island and seventeen in the South Island.
- For 20 years 1969-1989, catchment boards adopted NZLRI's class 5 LUC unit definitions for farm-scale use.

A consequence was that most 1969-1989 farm-scale maps “forced” areas of class 5 land into class 6 units because they didn't fit the limited number of NZLRI definitions. This was a defect which caused ongoing debate with landowners, who knew that these parts of their farms were not subject to the limitations implied by class 6 unit definitions, and were capable of more intensive use. The authors (DLH and VV) have often had the experience, on stable parts of Auckland's hill country, of having to agree with the landowners.

Since 1989 several regional councils (Northland, Auckland, Hawkes Bay, Taranaki, Wellington, Marlborough) responded to landowners' concerns by re-introducing locally-defined class 5 units on farm-scale maps (pp 117-131 of Lynn et al 2009). This is done to differentiate areas mapped as class 6 by 1:63,360 or 1:50,000 NZLRI, but where at farm scale, limitations (whether erosion or other) to pastoral use are slight. The simplest way (which maintains consistency with NZLRI unit numbers) is to create an equivalent class 5 unit where needed e.g. 5e1 differentiated from 6e1.

One of the authors (DLH) gradually did this for Auckland's class 6 LUC units between 1994 and 2010, as and where he encountered them in the course of preparing farm-scale maps for private landowners, local landcare groups, or Auckland Regional Council. The new class 5 units were described in typed notes supplied to landowners with each map, but have never been published as a collated document. Currently two summaries exist: Land Use Capability Field Keys for North Auckland and South Auckland supplied (Hicks 2011b); and Northland - North Auckland - South Auckland Soil Series on Land Use Capability Units (Hicks 2011a).

2.2 Land use capability sub-class

2.2.1 Existing sub-classes

Limitations to use are indicated by assigning a sub-class label. Sub-class labels indicate four general limitations – climate, soil, wetness, erosion – retained through successive revisions of the Land Use Capability Handbook. People who use maps for land management advice – soil conservators, farm advisory officers, agricultural consultants – frequently discover that the four sub-classes have their limitations when explaining maps to landowners.

2.2.2 Reasons to change existing sub-classes

In particular, the erosion sub-class “e” has been greatly over-used; undoubtedly because sub-classes were defined at a time when the organisations which carried out LUC mapping (catchment boards, Ministry of Works for NWASCA) were firmly focussed on erosion control. The reality is that for many LUC units within classes 1 to 5, other soil properties e.g. drainage, structure, texture are a primary limitation to crop or pasture growth; a fact which is often pointed out by growers on sighting a land use capability map.

Where the soil sub-class “s” appears on a map, it does not indicate what soil property poses the limitation. A grower can find this out but not from looking at the map, only by referring to attached documentation (descriptions of land use capability units).

The wetness sub-class “w” indicates more than one limitation. On some parts of a map, it indicates plant growth is limited by seasonal wetness of the soil. On other parts, it indicates that any intensive land use is limited by surface flooding from streams. It is also used to indicate swampy ground, where the limitation is a permanently high water table which may – or may not – be possible to alter through artificial drainage.

The climate sub-class “c”, on arable LUC classes, may indicate merely that there are no significant limitations to any productive use, apart from the constraints imposed by local temperature and rainfall. Or it may indicate that land has been dropped into a less productive class because of some specific constraint e.g. repeated summer drought, winter frost. On non-arable LUC classes, it shows a climate limitation severe enough to minimise or preclude productive use, for instance exposure to coastal gales, or prolonged sub-zero temperatures at high altitude in the mountains.

People who use LUC maps for land management advice experience difficulties when explaining sub-classes and unit numbers (see Section 2.3). By 2013, Auckland Council’s advisory staff concluded that when talking to farmers, it would be helpful if existing LUC sub-classes and unit numbers could be adjusted so that missing detail becomes visible on a farm-scale map face (see Section 3).

2.2.3 New sub-class definitions

New sub-classes (Table 2) were defined and assigned by one of the authors (DLH) who has mapped existing NZLRI sub-class-unit combinations in the Auckland region at farm scale since 1994. The author is also familiar with the properties of Auckland soils through field-viewing, sampling for soil quality monitoring, and summarising DSIR’s previously unpublished information (Hicks, Shepherd and Parfitt 1995, Hicks, Rijkse and Thompson 2004, Martindale, Hicks and Singleton 2016). He has also been involved with surveys of erosion’s extent in the region (Hicks 2000, Thompson and Hicks 2009).

Table 2. NZLRI and FARM LUC limitation sub-classes

NZLRI	FARM LUC	Description
<i>Climate and slope</i>		
c	c	Climate constrains crop, grass or tree growth, any other limitations are negligible
c	s	Slope shape or contour precludes cultivation, slope elevation constrains crop, grass or tree growth, any other limitations are negligible
<i>Soil</i>		
s	r	surface stones or rock outcrops
s	p	poor subsoil structure or subsoil pan
s	n	nutrient deficiency
s	a	salinity
s	y	toxicity
<i>Drainage and wetness</i>		
w	x	excessively free-draining
w	w	imperfectly draining or impeded drainage
w	f	flooding (occasional, regular or frequent)
w	o	over-drainage and/or oxidation of peat
<i>Deposition and erosion</i>		
e	e	alluvial or colluvial sediment deposits
e	t	sheetwash or windblow (exposed topsoil)
e	d	blow-outs and dunes (sand)
e	o	scree (stony slope deposits)
e	b	streambank collapses
e	g	gullies (including under-runners)
e	u	slumps or earthflows
e	l	landslides or debris avalanches
e	k	rockfalls

For climate

Consideration was given to introducing new sub-classes that would indicate specific limitations such as exposure to coastal gales, excessive rainfall, tendency to summer drought, or frequent winter frosts. As indicated by successive revisions of the LUC Handbook, any published information about a region's climate was considered by the original NZLRI mappers when defining LUC units. Their doing so, enabled comments about likely climate limitations to be inserted into the descriptions of LUC units which they wrote for extended legends and regional bulletins. The mapper takes these into account when selecting a LUC unit; however on past and current maps, meteorological data are not recorded as part of inventory. Computer models e.g. LENZ (Leathwick et al 2003) may attach climate estimates e.g. growing degree-days to map polygons, but that is done post facto, not as part of LUC mapping procedure. As site specific climatic data is not usually available when mapping farms, no specific climate limitation sub-classes have been introduced. The undifferentiated climate sub-class "c" has been retained, but only for areas of land where climate is not outweighed by other limitations:

- c – climate constrains crop, grass or tree growth; any other limitations are negligible

For slope

For situations where NZLRI formerly applied the "c" sub-class by default – because there are no significant wetness, soil or erosion limitations – but where slope properties actually limit land use rather than climate, a completely different sub-class "s" has been introduced. Examples are ridges in hill country (easily cultivable but narrow irregular shape precludes cultivation), stable slopes (too much contour to cultivate), and high-altitude slopes (wind exposure, high rainfall, frost frequency or snow cover are due to local elevation, in a climate that does not restrict plant growth at lower altitude):

- s – slope shape or contour preclude cultivation for crops; slope elevation constrains grass or tree growth; any other limitations are negligible

Shape or contour or elevation are grouped for the time being as a single sub-class (though could perhaps be differentiated).

For soil

The existing soil sub-class "s" is replaced by five new sub-classes to indicate the nature of soil limitations:

- r – surface stones or rock outcrops

Applied where rock outcrops or surface stones impede cultivation for crops, or reduce the area available for growth of perennial plants. Not applied where sub-surface stones or rock outcrops limit availability of soil moisture, or affect root penetration (see x and p).

- p – poor structure

Applied where blocky, prismatic or massive structure impedes cultivation for crops or root penetration by perennial plants; also where structure combined with seasonal wetness renders soil susceptible to compaction by machinery or animal treading. Includes presence of uncemented or cemented pans in subsoil. All three are instances where poor structure directly

affects farm management. Not applied where powdery (loose) structure renders soil liable to sheetwash or windblow (see t and d) – here it is the consequential erosion which affects farm management.

- n – nutrient deficiency

Applied where one or more nutrients essential for plant growth and stock health are deficient and technically difficult to rectify. Not applied to soils where deficiency may be rectified by fertilisation, liming or trace element application at a rate that is currently economic for farmers.

- a – salinity

Applied where saline water (usually tidal) floods the surface or flows into subsoil, often enough to depress plant growth and deteriorate soil structure. Not applied where a formerly saline soil (acid sulphate soil) has been reclaimed by stop-banks, pumping or drainage.

- y – toxicity

Applied where an element or compound has accumulated to a level that interferes with plant growth or animal metabolism. Includes soil contaminated by pesticide, herbicide or metal residues. Not applied where toxicity has been rectified by remedial treatment.

For wetness

The existing wetness sub-class “w” is replaced by four new sub-classes:

- x – excessively free-draining

Applied where subsoil texture is coarse (sandy or stony) enough for plant-available water to be depleted by excessively fast natural drainage, either seasonal or year-round.

- w – imperfectly draining or impeded drainage

Applied where subsoil texture is fine (silty or clayey) enough for imperfect or impeded natural drainage to cause saturation, either prolonged or seasonal, to an extent that restricts cultivation for crops, or depresses growth of perennial plants, or renders soil susceptible to compaction (when combined with poor structure). Not applied where saturation is caused by surface inundation or proximity to water table (see f).

- f – occasional, regular or frequent flooding

Applied where surface inundation prevents cultivation for crops, or grazing of pasture, or root penetration by trees. Includes semi-drained or un-drained stream floodways and swamps. Includes low-lying sites where proximity to water table causes standing surface water in a soil that would otherwise be free-draining or slow-draining. Excludes floodplains (where inundation is infrequent or precluded by stopbanks) and drained swamps (where surface water is infrequent due to artificial drainage). “Infrequent” denotes less than annual flooding. “Occasional” denotes flooding at least once a year. “Regular” denotes flooding several times a year after heavy rain. “Frequent” denotes flooding whenever streams rise.

- o – over-drainage and/or oxidation of peat

Applied where over-drainage may cause oxidation, leading to management problems such as shrinkage, powdery structure, and carbon loss.

For deposition associated with erosion

Four sub-classes are applied where bare or revegetating deposits, interspersed with erosion scars, indicate that sedimentation is frequent enough to damage crops, pasture or trees. Includes land not presently farmed or forested.

- e – alluvial or colluvial sediment deposits
- t – sheetwash or windblow (exposed topsoil)
- d – blow-outs and dunes (sand)
- o – scree (stony slope deposits)

For erosion

Five sub-classes are applied where bare or revegetating scars indicate that erosion is frequent enough to damage crops, pasture or trees. Includes land not presently farmed or forested.

- b – streambank collapses

Applied to channels on floodplains or in valley bottoms. Where bank failure is induced by floodwater scouring a bank, or draw-down of water table as floodwater drops. Excludes slope failures from other causes (see u, l and k).

- g – gullies

Applied to small channels on hillslopes, including dis-continuous or sub-surface channels (variously known as tunnel gullies, soil pipes, under-runners or tomos).

- l – landslides or debris avalanches

Applied to shallow mass movements (slope failures) where soil debris falls rapidly downslope.

- u – slumps or earthflows

Applied to deep-seated mass movements (slope failures) where soil debris moves slowly downslope, breaks up and starts to flow.

- k – rockfalls

Applied to slope failures on bluffs or cliffs, where rock debris collapses or breaks away from the face.

2.3 Land use capability unit

2.3.1 Existing units

LUC units are the third element of land use capability classification. A unit number (1, 2 etc.) is a label for land with the same geology, soil and slope (considered to have similar productive potential and management needs). A mapper matches pre-defined NZLRI unit descriptions to the inventory he/she has recorded, or compiles their own if there are no appropriately defined existing units (see section 4.4 of the LUC Handbook). These numbers initially appeared in “extended legends”; multiple-page map keys prepared for the original NZLRI Worksheets (printed maps) between 1973 and 1979. General descriptions of productive potential and management needs, including comments about specific limitations and ease or otherwise of rectifying them, were attached to unit numbers in the keys. For several regions (not all), the unit descriptions were re-compiled into regional bulletins published between 1979 and 1999.

At regional scale (1:50,000) three sets of NZLRI LUC unit numbers apply to different parts of Auckland:

- 66 unit numbers to North Auckland, from first and second editions of the Northland Land Use Capability Classification (Anonymous 1974, Harmsworth et al 1996)
- 48 unit numbers to South Auckland, from first and second editions of the South Auckland – Waikato Land Use Capability Classification (Walsh 1977, Jessen et al 1984)
- 21 unit numbers to Great Barrier Island, from first edition of the Coromandel – Great Barrier Land Use Capability Classification (Trustrum 1974)

Page (1985) correlates the 1st Edition Northland Extended Legend (Anonymous 1974), the 1st Edition Waikato and 1st Edition Coromandel – Great Barrier legends. Jessen (1992) correlates new 2nd Edition units for South Auckland – Waikato while Harmsworth (1996) provides a correlation table between the 1st Edition units and 2nd Edition units for Northland. The correlations are combined in LCR’s geospatial layer version of NZLRI as LCORR, 103 unit numbers of which apply to Auckland’s region.

2.3.2 Reasons to change existing units

There is no correspondence amongst the unit numbers of these classifications and correlations. By way of example, flat to undulating alluvial terraces mantled by volcanic ash are:

- 2s2 in North Auckland
- 2s4 in South Auckland
- undifferentiated on Great Barrier Island
- 2s13 in the North Island correlation.

The number differences have been an ongoing source of confusion for Auckland Council staff and for private planning consultants who access the NZLRI layer on council’s or Landcare Research’s GIS. When viewing the layer LUC labels can be displayed, and any differences in NZLRI inventory for the same label can be ascertained, by clicking on individual polygons. They should either display information with the legend number turned on (01 = Northland, 02 = Waikato, 03 = Coromandel-Great Barrier) or “LCORR” (= North Island correlated unit). However

when printing maps from the layer, few planners or GIS analysts seem to do this, so are not aware that (taking just the previous example) 2s2 in North and South Auckland are not the same unit; or that 2s2 and 2s4 need to be merged as 2s13 if printing a region-wide map. This confusion continues despite that it is all outlined in LCR's land resource information system spatial data layers data dictionary, (Newsome, Wilde, Willoughby 2008).

Landowners find LUC unit numbers difficult to comprehend. They can be explained by rural advisors – council staff or other – as a label denoting areas of land with similar physical properties and as having no numerical significance; but because they convey no information about physical properties, it remains difficult for a farmer to grasp exactly what “the 1 in 6e1” denotes. Past practice – dating back to the days of farm-scale maps prepared by catchment boards (including Auckland Regional Authority 1963-1989) – was to include brief written descriptions of each unit in an attached document called a farm conservation plan.

Very few farm-scale maps or plans were prepared by Auckland Regional Council 1989-2010. Between 2011-2015 the new Auckland Council re-commenced farm plans, preparing about four dozen either to assist landowners undertaking riparian retirement, or converting from stream discharge to land application of dairy effluent. These plans started with “old format” LUC unit numbers on each map, then morphed into “new format” FARM LUC sub-classes plus descriptive keys on the map face.

2.3.3 Assignment of new FARM LUC sub-classes and suffixes to LUC unit numbers

Appendix 1 is a correlation table which lists:

- inventory (landform, geology, soil, slope, other distinguishing characteristics) used when differentiating areas on Auckland's farm-scale maps,
- corresponding NZLRI LUC unit numbers (including sub-divided and new units mapped at farm scale 1994-2012),
- equivalent FARM LUC class, sub-class and suffix (mapped at farm scale 2013-2015, or converted on 2011-2012 maps).

How FARM LUC class, sub-class and suffix are assigned when mapping at farm scale, is best seen by reference to the correlation table in Appendix 1. Some examples are given below, by way of illustration.

Unique FARM LUC

A unique FARM LUC (class and sub-class combination) is used instead of existing LUC unit numbers, where a single limitation dominates land management. Here other limitations may be present, but are unlikely to influence management decisions. Examples are land where the only limitation is local climate (1c, 2c), or where the dominant limitation is soil structure (3p, 4p). Other examples are common at the lower end of the land use capability spectrum, where a single limitation often restricts land use options; for instance saline sub-classes (5a, 6a and 7a), flood-prone sub-classes (5f, 6f, 7f), or sub-classes with shallow stony soil or rock outcrop (7r, 8k).

Compound FARM LUC

A compound FARM LUC (class with two sub-classes) is used instead of existing LUC unit numbers, where a second limitation does not over-ride the first, though necessitates an additional adjustment to land management. Examples are undulating to rolling arable land, where risk of sheetwash adds to a climate limitation (3c+t, 4c+t) or to a soil limitation (3p+t, 4p+t). Other examples are unstable hill country, where shallow mass movement or deep-seated mass movement accompany gully erosion (6g+l, 6g+u); or steep land where a severe climate limitation compounds the effect of shallow soil or rock outcrop (7r+c, 8k+c).

Adding extra limitation labels, in decreasing order of importance, was considered though has been rejected for the time being. The possibility could be re-visited when FARM LUC is adapted by other land use capability mappers at a future date. The authors' (DLH and VV) view is that Occam's razor should be applied: seek no explanation beyond that which is necessary i.e. just indicate the limitations which necessitate changing land use or altering land management.

Unique or compound FARM LUC plus character suffix

The correlation table contains many instances of LUC units which are assigned the same FARM LUC. Taking North Auckland LUC units as an example, 6e1, 6e3, 6e7, 6e9 and 6e16 all appear as 6g+l on farm-scale maps. The rationale – from a farmer's viewpoint – is that irrespective of differences in geology and soil type (denoted by LUC unit numbers) on the hills, it is gully and landslide erosion which pose the greatest limitations to sustained grazing where North Auckland's hill country is erodible. Apart from short-term damage to fences and sediment entry into watercourses, gullies and landslides depress pasture growth long-term, creating opportunity for weed infestation and scrub reversion on the scars. The same farm management adjustments – maintaining dense pasture sward, preventive soil conservation plantings on unstable ground, and re-grassing any bare scars – are needed. So 6g+l is all that need appear on a farm-scale LUC map to which soil conservation advice is attached.

For other advisory purposes, it may be necessary to draw a distinction between different kinds of 6g+l. For instance Okaka soil on mudstone hill country has somewhat higher pasture yield than Warkworth soil on sandstone, so may not need as much fertiliser. However the Okaka soil is more susceptible to pugging when wet, so may not carry as many livestock through winter and spring. At the scale of an individual farm map, it will be rare for both soils to appear on the same property. But in instances where they do, suffixed characters enable them to be differentiated (5g> or 6g+l> for Okaka, 5g< or 6g+l< for Warkworth) when providing farm management advice. Other suffixes are used to differentiate Arapohue and related soils on limestone hill country (5g^ or 6g+l^), Marua and related soils on greywacke (5g*, 6g+l*), or Parau and related soils on old basalt (5g#, 6g+l#). Seventeen FARM LUC character suffixes suffice for the Auckland region (Table 3).

Table 3. FARM LUC suffix descriptions for Auckland

Suffix	Description
	<i>Gley, Recent or Raw soils from:</i>
~	estuarine alluvium
@	stream alluvium
(peaty alluvium or peat
)	sandy alluvium
%	windblown sand
	<i>Brown, Melanic or Ultic soils from:</i>
+	old alluvium
&	windblown sand
>	mudstone
<	sandstone
^	limestone
*	greywacke
	<i>Brown, Allophanic or Granular soils from:</i>
!	stony tephra or basalt
\$	young volcanic ash
=	old volcanic ash
#	basalt, dolerite or andesite
	<i>Perch-gley Ultic or Oxidic Granular soils from:</i>
'	any geology
	<i>Podzols or Oxidic soils from:</i>
"	any geology

2.3.4 Advantage of using FARM LUC instead of NZLRI unit number

It may seem that for advisory purposes, nothing is gained by using suffixed FARM LUC. A mapper may as well label the different areas as 5e9 or 6e9 etc. The counter is that 5g* or 6g+l* applies to Marua soil on hill country anywhere in the region. It replaces 5e9 or 6e9 in North Auckland, 5e14 or 6e14 in South Auckland, and 5e7 or 6e7 on Great Barrier Island.

It may also seem that a single corresponding North Island correlation (LCORR) unit number will suffice. In practice this rarely works because the LUC unit numbers grouped by a single FARM LUC often have multiple LCORRs (Table 4).

Table 4. Advantage of FARM LUC suffixes: first example

NZLRI LUC (plus farm-scale subdivisions)			LCORR	FARM LUC
North Auckland	South Auckland	Great Barrier Island		
<i>Soils weathered from mudstone</i>				
5e7	-	-	6e70	5g>
6e7	-	-	6e70	6g+l>
<i>Soils weathered from sandstone</i>				
5e1	5e3	-	6e18, 6e12*	5g<
6e1	6e3	-	6e18, 6e12*	6g+l<
<i>Soils weathered from limestone</i>				
5e3	-	-	6e17	5g^
6e3	-	-	6e17	6g+l^
<i>Soils weathered from greywacke</i>				
5e9	5e14	5e7	6e73, 6e83, 6e73+	5g*
6e9	6e14	6e7	6e73, 6e83, 6e73+	6g+l*
<i>Soils weathered from old basalt, dolerite or andesite</i>				
5e2	-	5e3,8,11	6e16, 6e4	5g#
6e2	-	6e3,8,11	6e73t, 6e81	6g+l#

The problem of multiple LCORR becomes acute for class 1 to 4 units. For farm-scale maps of the Auckland region 1994-2010, it was necessary to subdivide a number of NZLRI units and introduce several completely new ones, to cover combinations of inventory which do not appear in the regional-scale NZLRI unit descriptions. In this situation neither the existing LUC unit number nor the LCORR is useable region-wide. A simple example is recent stream alluvium on floodplains and low flat terraces (Table 5).

Table 5. Advantage of FARM LUC suffixes: second example

NZLRI LUC (plus farm-scale subdivisions)			LCORR	FARM LUC
North Auckland	South Auckland	Great Barrier Island		
<i>On floodplains (infrequently flooded)</i>				
2w1	2w1	2w1	2w4, 2w3, 2w5*	2w+e@
3w1	3w1	3w1	3w6, 3w1+, 3w7	3w+e@
4w1	4w1	4w1	4w2, 4w6	4w+e@
<i>On low flat terraces (rarely flooded)</i>				
2w1b	2w4	2w1b	2w4, 2w3, 2w5*	2w@
3w1b	3w3	3w1b	3w6, 3w1+, 3w7	3w@
4w1b	4w3	4w1b	4w2, 4w6	4w@

A more complex example is weathered alluvium, partly ash-mantled, on high dissected terraces (Table 6).

Table 6. Advantage of FARM LUC suffixes: third example

NZLRI LUC (plus farm-scale subdivisions)			LCORR	FARM LUC
North Auckland	South Auckland	Great Barrier Island		
<i>Soil weathered from alluvium</i>				
2s	2e5	2s	2e9	2p+
3s3	3s5	3s	3e11	3p+
3e2	3e7	3e	3e4	3p+t+
4e	4e7	4e	4e11	4p+t+
<i>Soil weathered from volcanic ash</i>				
2s2	2s4	2s	2s13	1c \$
2e2	2e4	2e	2s13, 2e7	2c \$
3e2b	3e5	3e	3e4, 3e12	3c+t \$
4eb	4e5	4e	4e11	4c+t\$

Tables 4, 5 and 6 demonstrate how a distinct FARM LUC sub-class (single, compound or suffixed) now exists for each instance where LCORR is undifferentiated or overlaps.

2.3.5 Depiction of FARM LUC at various map scales

FARM LUC has been designed to help rural advisors (soil conservators, land management officers, land and water advisors) provide landowners with understandable and focussed advice at farm-scale (1:5,000 - 1:10,000). There are also circumstances in which a depiction of FARM LUC at regional scale (1:50,000 - 1:250,000) may be helpful, for instance as a guide to where class 1 land may be re-mapped at farm scale within areas formerly mapped as class 2 at

regional scale. Other examples are as a guide to where class 5 land is likely to be re-mapped within class 6; indicating locations where a particular FARM LUC limitation (sub-class) may be expected on a specific group of soils (character suffix); and as a frame for displaying the spatial pattern of other data which may be attached to FARM LUC now or in future (Hicks and Curran-Cournane 2017).

To enable such depictions, a copy of the 1:50,000 NZLRI layer has been created in Auckland Council's GIS. After examining inventory recorded by the original mappers when they determined each polygon's NZLRI LUC, this report's correlation table (Appendix 1) has been used to add an equivalent FARM LUC label, alongside the polygon's original NZLRI LUC label. The NZLRI-FARM LUC conversion layer is stored in Auckland Council's GIS. When using such a map, several caveats should always be attached to any screen display or printed copy:

- it depicts the main FARM LUC class/sub-class/suffix which would be recorded if a 1:50,000 NZLRI polygon were to be remapped at farm-scale,
- other FARM LUC classes/sub-classes/suffixes are present inside each polygon's boundary but the conversion layer does not indicate their location or extent inside the polygon's boundary,
- to find out for a particular property, it is necessary to field-map FARM LUC at a scale appropriate for the current or intended land use.

Appropriate scales range from 1:5,000 or greater for intensively used properties such as market gardens, orchards and vineyards, through 1:5,000 - 1:10,000 for dairy and drystock fattening farms or special-purpose timber woodlots, to 1:10,000 - 1:25,000 for extensive hill country farms and forest plantations. If FARM LUC is mapped at 1:25,000 - 1:50,000 or smaller scale, the depiction is unlikely to be good enough for property-specific advice.

3. Results and application

After field mapping on orthophotos (aerial photos rectified to fit the NZTM map grid), good copies of maps were hand-drawn. Inventory and capability were entered into spreadsheets. Computer-plotted layouts were prepared by scanning the maps to GIS and converting spreadsheets to attribute tables. Map layout conventions were developed between 2011 and 2015 by one of the authors (VV) running successive draft layouts past the owners of about four dozen farms for their comments and suggestions.

Appendix 2 is a specimen of the final map layout settled on by 2015. This particular example has been selected because it depicts several arable and non-arable LUC classes, plus a range of sub-classes for each. The map face may appear quite complex at first sight, but has been carefully designed to convey a great deal of information simply by cross-reference with three separate map keys. Farmers expressed a strong liking for this format.

3.1 Land use capability class

FARM LUC class is depicted on the map face solely by colour (using standard colours specified in the Land Use Capability Handbook). Each colour is a transparent wash, so that underlying photo detail remains visible to the farmer. The LUC class corresponding to each colour appears in a map key, which specifies features of the class (arable or non-arable; negligible, slight, moderate, severe or extreme limitations).

3.2 Land use capability sub-class

FARM LUC sub-class is depicted on the map face by a letter (high-lighted with white border). Limitations indicated by each sub-class appear in a second map key.

3.3 Soil name

Inventory (geology, soil, slope etc.) for each area on the map is recorded in a GIS attribute table. It is technically possible to print all inventory, but the result is a cluttered map, often with inventory overlapping the boundaries of small areas (polygons). Farmer “feed-back” indicated early on, that they found such a map difficult to use, and preferred to receive inventory in accompanying documents. There is just one item of inventory which they really wish to see on a map : soil names. Each area’s soil is identified from exposures, spade-holes and augering. Soil names are depicted by a two-letter label (using the same labels as appear on DSIR’s regional-scale soil maps), in places suffixed by a third letter to indicate texture variation.

3.4 Accompanying documents

Each map is accompanied by three tables:

- Inventory and corresponding capability (Table A in Appendix 2),
- Principal limitations: current land use; uses of which the land is capable; any management recommendations to help sustain existing or proposed use (Table B),
- Pasture yields and stock carrying capacities for each FARM LUC, estimated by the method described in Hicks and Curran-Cournane (2017) (Table C).

These tables are the basic documents supplied for farm visits/discussions. If the advisor subsequently prepares a conservation plan at the landowner's request, text describing each FARM LUC class and sub-class is added. However, farmer "feed-back" has generally been that the tables are easier to read and use, than ten-plus pages of text.

3.5 Map overlays

Where farm visits/discussions result in a request for specific advice e.g. areas which need riparian fencing and planting; areas suitable/unsuitable for dairy effluent application, such areas are indicated on map overlays by the council's advisor. Advice may be supplied verbally, or as additional tables, or as part of a farm conservation plan.

4. Summary and conclusion

In Auckland three of the limitations with using and interpreting existing land use capability (LUC) maps are firstly, class 1 (the best arable land) and class 5 (the best non-arable land) appear limited in extent on 1:50,000 maps. Farm-scale 1:5,000 – 1:10,000 maps show class 1 and class 5 land to be more extensive. Secondly, different LUC units are mapped on similar soils north, south and east of the city which can confuse planners as well as the public. Thirdly, there is a perception on the part of landowners that LUC map labels – the existing sub-classes and unit numbers in particular – are difficult to comprehend, when rural advisors advocate changes to land use or management.

In response to these issues, the contents of this report outline a better map format developed when preparing farm-scale LUC maps for supply to landowners between 2011 and 2015. Key elements in the new map format are:

- retention of existing classes (1 to 8),
- twenty new sub-classes to indicate the nature of limitations,
- sub-classes (singly, combined, or suffixed) replace unit numbers,
- the same classification appears on farm-scale maps anywhere in the region.

Auckland's new farm-scale classification (FARM LUC) remains interchangeable with the combinations of sub-class and unit in New Zealand Land Resource Inventory (NZLRI), a regional-scale land use capability map series which appears as a layer in Auckland Council's Geographic Information System, and which is referred to by the council's planners as an aid for planning activities.

When preparing the farm-scale maps, land inventory recording and land use capability classification remain consistent with standard procedures as described in third edition of the Land Use Capability Handbook (Lynn et al 2009).

Conclusions about development and use of the new farm-scale classification are that:

- A unique FARM LUC (class and sub-class combination) is a practical alternative to existing LUC unit numbers, where a single limitation dominates land management. Here other limitations may be present, but are unlikely to influence management decisions.
- A compound FARM LUC (class with two sub-classes) can be substituted for existing LUC unit numbers, where a second limitation does not over-ride the first, though necessitates an additional adjustment to land management.
- For other advisory purposes, it may be necessary to draw a distinction within the same FARM LUC, particularly where it contains different soils (which could be denoted by using various LUC unit numbers in different parts of Auckland). Suffixed characters can be used to subdivide FARM LUC sub-classes in situations where a LUC unit needs to be depicted at farm-scale, including instances where such units have different numbers, are undifferentiated, or overlap in the several existing regional-scale NZLRI LUC classifications.

Satisfactory farm-scale map layout conventions have been developed by running successive draft layouts past the owners of farms for their comments and suggestions. Key features of map layout are:

- FARM LUC class is depicted on the map face solely by colour (using standard colours specified in the Land Use Capability Handbook). Each colour appears in a map key, which specifies features of the class.
- FARM LUC sub-class is depicted on the map face by a letter (high-lighted with white border). Limitations indicated by each sub-class appear in a second map key.
- Inventory (geology, soil, slope etc.) for each area on the map is recorded in a GIS attribute table. Just one item of inventory which farmers really wish to see appears on the map face: soil names are depicted by a two-letter label (using the same labels as appear on DSIR's regional-scale soil maps).

FARM LUC enables a map format which farmers say they find easier to understand, and more informative as an aid for farm management, than the existing NZLRI class – sub-class – unit combinations.

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7. Appendices

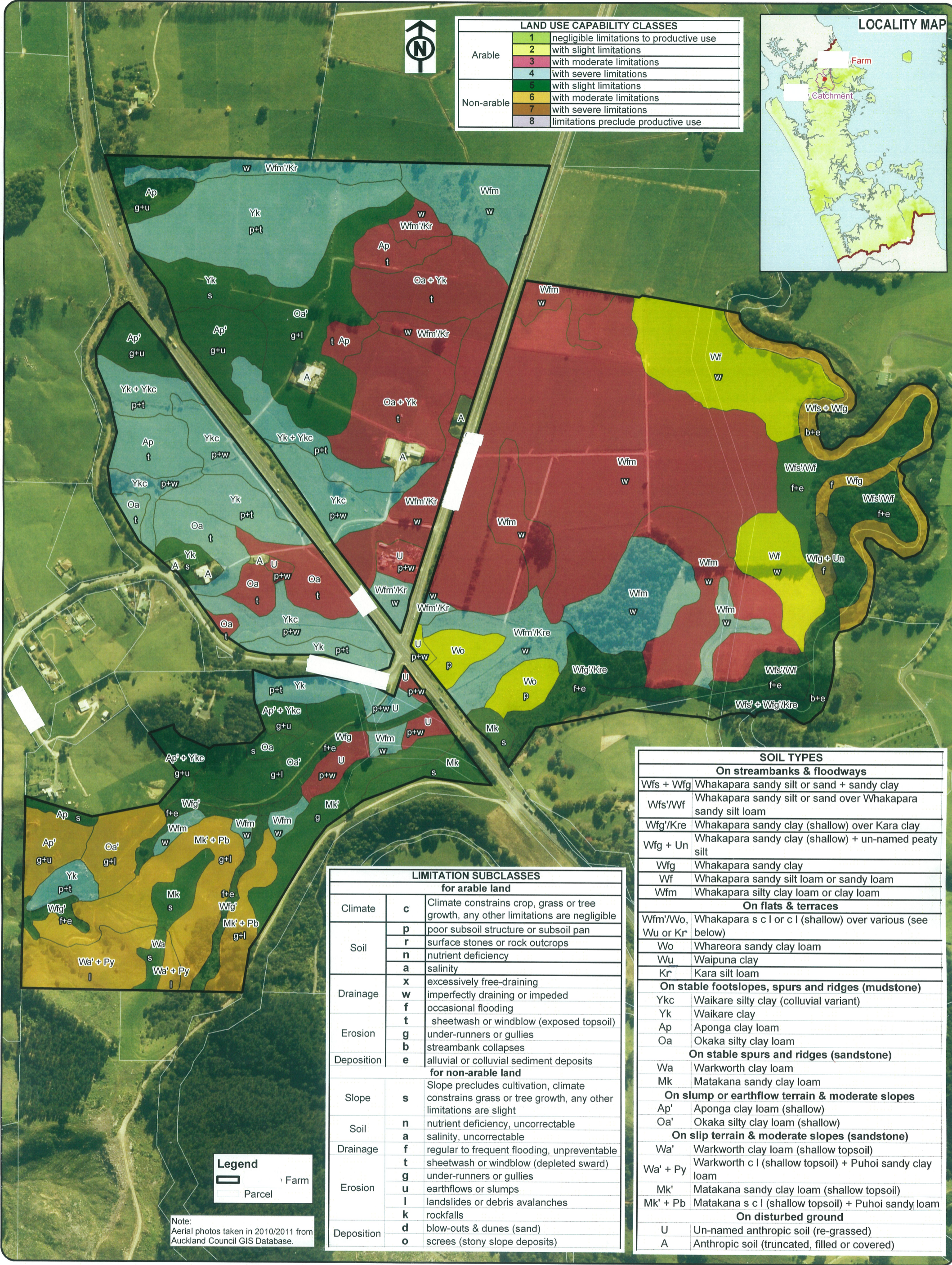
Appendix 1: FARM LUC-NZLRI LUC correlation table

APPENDIX 1	CORRELATIONS BETWEEN NZLRI LAND USE CAPABILITY AND AUCKLAND FARM-SCALE LAND USE CAPABILITY, OCTOBER 2016																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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APPENDIX 1	CORRELATIONS BETWEEN NZLRI LAND USE CAPABILITY AND AUCKLAND FARM-SCALE LAND USE CAPABILITY, OCTOBER 2016														PAGE 3 of 4
Landform descriptions etc. derive from NORTHLAND - NORTH AUCKLAND - SOUTH AUCKLAND SOIL SERIES ON LAND USE CAPABILITY UNITS (Compiled by D Hicks 2007, updated 2011 & 2013)															
Landform & geology	NZSC soil order & group	Local series name (North Auckland)	Local series name (South Auckland)	Local series name (Great Barrier)	Other distinguishing characteristics	NZLRI LUC units (adapted for farm-scale use 1994-2010)			FARMLUC (developed for farm-scale use 2011-2016)						
		? denotes NZSC order &/or group doesn't make sense * denotes series name omitted from NZLRI unit descriptions	? denotes NZSC order &/or group doesn't make sense * denotes series name omitted from NZLRI unit descriptions	? denotes NZSC order &/or group doesn't make sense * denotes series name omitted from NZLRI unit descriptions		North Auckland	South Auckland	Great Barrier	North Island correlation (don't use as obsolete) pt / pts = part/s of NZLRI unit/s *, + = subdivision of NZLRI units	Class	Subclass	Suffix			
FOOTSLOPES, SPURS AND RIDGES															
any sedimentary rock type	perch-gley ultic or melanic	Waikare (UE?), Pokapu* (UE?), Otaika (UE?) Mahurangi (UE?), Oturu (UE?) Dairy Flat & related soils (EP)	Brookby (Mahurangi) variant (UY?), Mangatawhiri (UY?)	No equivalent soil present	undulating, with deep topsoil undulating, with shallow topsoil rolling, with deep topsoil rolling, with shallow topsoil	3w (pt 3s3) 4w3 3e12 (pt 3e2) 4e12.	- - -	 4w3 	pt 3e11 pt 3e12 4e36.	3 4 3 4	p+w p+w p+w p+w	' ' ' '			
	albic ultic	Otangaeroa* (UE), Puketitoti (UE), Pukewaenga (UE) Hukerenui (UE)	Brookby (Hukerenui) variant (UY?), Maramarua (UY?)	No equivalent soil present	undulating, with deep topsoil undulating, with shallow topsoil rolling, with deep topsoil rolling, with shallow topsoil	3s (pt 3s3) 4s4 3e12 (pt 3e2) 4e12.	- - - -	 4s3 	pt 3e11 pt 3e12 4e36. 6e91.	3 4 3 4 5	p p p+t p+t p	" " " " "			
	densipan ultic	Wharekohe (UD), Omaiko* (UD), Hurewai (UD)	No equivalent soil mapped	No equivalent soil present	cemented pan	5s10 (ex 6s5)	-								
any volcanic rock type	perch-gley or oxidic granular	Rangioru (NP), Awarua (NX), Cornwallis (NX), Hihi (GO?), Aranga (NX)	No equivalent soil present	Manganui* (NO?)	undulating, with deep topsoil undulating, with shallow topsoil rolling, with deep topsoil rolling, with shallow topsoil	3s (pt 4s3) 4s3 3e (pt 4e3) pt 4e3.	- - -	 4s8 pt 4e3	Incl. in 4s8 4s8 Incl. in 4e37 No unit defined, pt 6e77	3 4 3 4	p p p+t p	" " " "			
	perch-gley or densipan ultic	Tinopai (ZO?), Pukenamu (UP), Parahaki (UD)	No equivalent soil present	Omaiko (??)	iron pan	5s8 (pt. 4s3)	-	pt 6e9		5	p	"			
claystone, mudstone, shale (includes complex with other rocks)	orthic brown or yellow ultic	Te Tio* (UY), Omu (UP?), Aponga (UE?), Mata (UY), Okaka (UE?), Puwera (UE?) Whirinaki (BO?), Omanaia (BO?), Autea (UY), Kapowairua (UY), Wairiki (UY) Whakara* (BO?)	No equivalent soil present	No equivalent soil present	colluvial footslopes regolithic footslopes spurs & ridges	3e6, 3e8 (ex 3e3) 4e6, 4e8 5s6 (pts 4e6 & 4e8)	- - -	 	3e11. 4e9, 4e36 No unit defined	3 4 5	e t s	> > >			
shattered shale & sandstone (includes complex with other rocks)	acid brown or yellow ultic	Purua (UY), Tanoa (UY) Waiotira variant (BA?), Puketurua (UY)	No equivalent soil present	No equivalent soil present	colluvial footslopes regolithic footslopes spurs & ridges	Incl. in 3e6, 3e8 Incl. in 4e6, 4e8 Incl. in 5s6	- - -	 	3e11. 4e9, 4e36 No unit defined	3 4 5	e t s	> > >			
banded or massive sandstone (includes complex with other rocks)	acid brown or yellow ultic	Whangaripo (UY), Omahuta (UY), Warkworth (UY), Awanui (UY) Waiotira (BA?), Riponui (UY)	Brookby (UY) - Warkworth and Whangaripo variants	No equivalent soil present	colluvial footslopes regolithic footslopes spurs & ridges	3e3, 3e3b 4e5, 4e5b 5s5 (pts 4e5 & 4e5b)	3e4. 4e3. 5s3	 4e3. 	3e11. 4e9, 4e36 No unit defined	3 4 5	e t s	< < <			
limestone (includes complex with other rocks)	orthic or rendzic melanic	Arapohue (ER), Motatau (ER), Rockvale (UY?) Konoti (ER), Maungaturoto (EO)	No equivalent soil present	No equivalent soil present	colluvial footslopes regolithic footslopes spurs & ridges (shallow or stony)	3s5, 3e4 4e1, 4e4 5c1, 5s4	- - -	 4e22. 5c4	3e11. 4e22. 5c4	3 4 5	e t s	^ ^ ^			
quartzite (usually as complex with other rocks)	yellow ultic	No yellow ultic soils mapped. Omaiko? (according to NZLRI)	No equivalent soil present	No equivalent soil present	colluvial footslopes regolithic footslopes spurs & ridges	Incl in 3e6 Incl in 4e6 Incl in 5s6	- - -	 	No unit defined No unit defined No unit defined	3 4 5	e t s	< < <			
greywacke	orthic brown or yellow ultic	Marua (BO), Rangiora (UE?)	Marua (BO), Rangiora (UE?), Opaheke (RO?)	Marua (BO), Rangiora (UE?)	colluvial footslopes regolithic footslopes spurs & ridges plateaux	3e7 (pt 4e7) 4e7. 5s7 (pt 4e7) 5c2b, 6c1b	3e9 (pt. 3e4) 4e9 (pt. 4e3) 5s9 -	 4e9 (pt. 4e3) pt 6e7	Incl. in 3e11 Incl. in 4e9 No unit defined 4s8, 6e73, pt 6e73+	3 4 5 5, 6	e t s c	* * * *			
dolerite or andesite	orthic or oxidic granular	Takitu (BX?), Awapuku (NO), Waimatenui, Manganui (NO) Hunoke (NO), Bream (NO), Parau (NO), Waitakere (NO) Katui (NO), Waipoua (NO), Whatoro (NX), Tutamoe (NO or NP)	No equivalent soil present	Awapuku (NO) Parau (NO), Waitakere (NO)	colluvial footslopes regolithic footslopes spurs & ridges plateaux	3e8 (pt 4e3) 4e3. 5s2 (pt 4e3) 5c2, 6c1	- - - -	pt 4e3 5s (pt 4e3) 6e2, 6e3, 6e8	Incl. in 4e6, pt 4e37 4e6, pt 4e37 No unit defined 4s8, 6e73, pts 6e16+, 6e4, 6e73+	3 4 5 5, 6	e t s c	# # # #			
dacite or rhyolite	ortic brown or yellow ultic	Maungarei (UY), Kumurau* (BO?), Piroa (UY)	No equivalent soil present	Un-named soils* (??)	colluvial footslopes regolithic footslopes spurs & ridges plateaux	3e11 (pt 4e11) 4e11. 5s11 (pt 4e11) 5c2c, 6c1c	- - - -	 pt 4e3 5s (pt 4e3) 6e2, 6e3, 6e8	No unit defined No unit defined No unit defined No unit defined	3 4 5 5, 6	e t s c				

Appendix 2: Extract of a farm-scale map example

Map:	Farm soils and land use capability [example]
Table A:	Example farm: relationship between soils and land use capability
Table B:	Example farm: recommended management of soils
Table C:	Example farm: annual pasture growth estimates



REV	AMENDMENTS	BY	APV	DATE
DRAFT	DRAFT	H.M	D.H	01/12/2014
FILE: E:\Projects\Sustainable Catchments Program\Farm_Soil_Map				

FARM

SOILS AND LAND USE CAPABILITY

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Scale: 1:5,000 (Original A3)

0 40 80 120 Meters



TABLE B EXAMPLE FARM : RECOMMENDED MANAGEMENT OF SOILS

Soil label	Local soil name	Land use capability	Differentiating factor	Present use	Sustainable uses	Principal limitation to use	Soil conservation suggested	Ecological remnants present
On streambanks and floodways								
Wfs' + Wfg'/Kre	Whakapara s si or s + s c (shallow) over Kara clay	5 b+e	Stable streambank	Ungrazed rank pasture in parts	Semi-improved pasture	Occasional bank scour and sediment deposits	Utilise as sediment trap and nutrient filter?	Totara and kahikatea groves
Wfs + Wfg	Whakapara sandy silt or sand + sandy clay	6 b+e	Unstable streambank	Ungrazed rank pasture in parts	Semi-improved pasture	Regular bank scour and sediment deposits	Utilise as sediment trap and nutrient filter?	Totara groves
Wf	Whakapara sandy silt loam or sandy loam	2w	Highest floodway, free-draining subsoil	Improved pasture	Grain and fodder crops; improved pasture	Infrequent flooding; high water table during rain	-	-
Wfm	Whakapara silty clay loam or clay loam	3w	Highest floodway, imperfectly draining subsoil	Improved pasture	Occasional grain and fodder crops; improved pasture	Infrequent flooding; high water table after rain	Maintain open and subsoil drains?	-
Wfm	Whakapara silty clay loam or clay loam	4w	Highest floodway, impeded subsoil drainage	Improved pasture	Occasional fodder crops; improved pasture	Infrequent flooding; high water table through winter and spring	Improve open and subsoil drains?	Fenced kahikatea grove
Wfs'/Wf	Whakapara sa si or s (shallow) over Whakapara s si l or s l	5 f+e	Higher floodway, semi-drained	Semi-improved pasture on margins	Semi-improved pasture	High water table year-round; occasional sediment deposits	Utilise as sediment trap and nutrient filter?	Rush and sedge; fenced totara and kahikatea groves
Wfg'/Kre	Whakapara s c (shallow) over Kara clay	5 f+e	Higher floodway, semi-drained	Semi-improved pasture on margins	Semi-improved pasture	High water table year-round; occasional sediment deposits	Utilise as sediment trap and nutrient filter?	Rush and sedge; fenced kahikatea groves
Wfg + Un	Whakapara sandy clay + un-named peaty silt	6f	Cut-off floodway	Ungrazed rank pasture on margins	Semi-improved pasture	Water table close to or at surface; regular to frequent sediment deposits	Utilise as sediment trap and nutrient filter?	Rush, sedge, raupo, flax, fenced kahikatea groves
Wfg + Un	Whakapara sandy clay + un-named peaty silt	7f	Cut-off floodway	Ungrazed rank pasture on margins	Semi-improved pasture	Water table close to or at surface; regular to frequent sediment deposits	Utilise as sediment trap and nutrient filter?	Rush, sedge, raupo, flax, fenced kahikatea groves
On flats and terraces								
Wfm'/Kre or Kr	Whakapara si c l or cl (shallow) over Kara clay or silt loam	3w	Shallow flood deposit, imperfectly draining subsoil	Improved pasture	Occasional grain and fodder crops; improved pasture	High water table after rain	Maintain open and subsoil drains?	-
Wfm'/Kre or Kr	Whakapara si c l or cl (shallow) over Kara clay or silt loam	4w	Shallow flood deposit, impeded subsoil drainage	Improved pasture	Occasional fodder crops; improved pasture	High water table through winter and spring; pugging	Improve open and subsoil drains?	Scattered rushes
Wo	Whareora sandy clay loam	2p	Old alluvial terrace, sandy clay subsoil	Improved pasture	Horticulture; grain and fodder crops; improved pasture	-	-	-
Wu	Waipuna clay	3p	Old alluvial terrace, clay subsoil	Improved pasture	Occasional grain and fodder crops; improved pasture	Poor structure	Subsoil drains?	-
Kre	Kara clay	4 p+w	Old alluvial terrace, heavy clay subsoil	Improved pasture	Occasional fodder crops; improved pasture	Poor structure; pugging	Subsoil and open drains?	Scattered rushes
Kr	Kara silt loam	4p	Old alluvial terrace, uncemented pan in subsoil	Improved pasture	Occasional fodder crops; improved pasture	Poor structure; pugging; low nutrient retention	Open drains?; fertilise and lime at higher rate?	Scattered rushes
On stable footslopes, spurs and ridges (mudstone)								
Ykc	Waikare silty clay (colluvial variant)	4 p+w	Colluvium (slopewash deposit)	Improved pasture	Occasional fodder crops; improved pasture	Poor structure; pugging	Maintain open drains?	Scattered rushes
Yk	Waikare clay	4 p+t, 5s	Clay weathered from mudstone	Improved pasture	Occasional fodder crops; improved pasture	Poor structure; pugging; low nutrient retention	Fertilise and lime at higher rate?	-
Ap	Aponga clay loam	3t	Crushed mudstone	Improved pasture	Occasional fodder crops, improved pasture	Risk of topsoil loss if cultivated; blocky subsoil structure when dry	Minimum till or direct-drill when renewing pasture?	-
Oa	Okaka silty clay loam	3t	Bedded mudstone	Improved pasture	Occasional fodder crops, improved pasture	Risk of topsoil loss if cultivated	Minimum till or direct-drill when renewing pasture?	-
Ap	Aponga clay loam	4t	Crushed mudstone	Improved pasture	Occasional fodder crops, improved pasture	Risk of topsoil loss if cultivated; blocky subsoil structure when dry	Minimum till or direct-drill when renewing pasture?	-
Oa	Okaka silty clay loam	4t	Bedded mudstone	Improved pasture	Occasional fodder crops, improved pasture	Risk of topsoil loss if cultivated	Minimum till or direct-drill when renewing pasture?	-
On stable spurs and ridges (sandstone)								
Yk	Waikare clay	5s	Clay weathered from mudstone	Improved pasture	Occasional fodder crops; improved pasture	Poor structure; pugging; low nutrient retention	Fertilise and lime at higher rate?	-
Wa, Mk	Warkworth clay loam, Matakana sandy clay loam	5s	Sandstone or tuffaceous sandstone	Improved pasture	Occasional fodder crops, improved pasture	Blocky subsoil structure when dry	-	-
On slump or earthflow terrain and moderate slopes (mudstone)								
Ap'	Aponga clay loam (shallow topsoil)	5 g+u	Crushed mudstone, old earthflow and gully scars	Improved pasture	Improved pasture; woodlots	Slight risk of gullies and earthflows	Maintain dense sward?	-
Ap'	Aponga clay loam (shallow topsoil)	6 g+u	Crushed mudstone, inactive earthflows and gullies	Semi-improved pasture	Semi-improved pasture with soil cons. trees; woodlots	Moderate risk of gullies and earthflows	Space-plant poplars on any earthflows?; keep existing line-planted poplars on old gully scars?	Fenced regenerating scrub (two patches) and bush (one patch)
Oa'	Okaka silty clay loam (shallow topsoil)	5 g+l	Bedded mudstone, old soil slip and gully scars	Improved pasture	Improved pasture; woodlots	Slight risk of gullies and soil slips	Maintain dense sward?	-
Oa'	Okaka silty clay loam (shallow topsoil)	6 g+l	Bedded mudstone, inactive soil slips and gullies	Semi-improved pasture	Semi-improved pasture with soil cons. trees; woodlots	Moderate risk of gullies and soil slips	Re-sow grass on any slip scars?; keep existing line-planted poplars on old gully scars?	-
On slip terrain and moderate slopes (sandstone)								
Wa'	Warkworth clay loam (shallow topsoil)	5l	Sandstone, old soil slip scars	Improved pasture	Improved pasture; woodlots	Slight risk of soil slips	Maintain dense sward	-
Wa' + Py	Warkworth c l (shallow topsoil) + Puhoi sandy clay loam	6l	Sandstone, inactive soil slips	Semi-improved pasture	Semi-improved pasture; soil conservation trees; woodlots	Moderate risk of soil slips	Re-sow grass on any slip scars?; line-plant poplars on any gully scars?	Fenced regenerating bush (one patch) + scattered scrub
Mk'	Matakana sandy clay loam (shallow topsoil)	5g	Tuffaceous sandstone, old gully scars	Improved pasture	Improved pasture; woodlots	Slight risk of gullies	Maintain dense sward	-
Mk' + Pb	Matakana s c l (shallow topsoil) + Puhoi sandy loam	6 g+l	Tuffaceous sandstone, inactive gullies and soil slips	Semi-improved pasture	Semi-improved pasture; soil conservation trees; woodlots	Moderate risk of gullies or soil slips	Re-sow grass on any slip scars?; line-plant poplars on any gully scars?	Fenced regenerating bush (one patch) + scattered scrub
On disturbed ground								
U	Un-named anthropic soil (re-grassed)	2 p+w	Road/demolition fill; or excavated building platforms	Semi-improved pasture; or houses, sheds, yards	Improved pasture	Shallow topsoil above compact fill	Allow time for topsoil to build up under pasture	-
U	Un-named anthropic soil (re-grassed)	3 p+w	Road/demolition fill; or excavated building platforms	Semi-improved pasture; or houses, sheds, yards	Improved pasture	Shallow topsoil above compact fill	Allow time for topsoil to build up under pasture	-
U	Un-named anthropic soil (re-grassed)	4 p+w	Road/demolition fill; or excavated building platforms	Semi-improved pasture; or houses, sheds, yards	Improved pasture	Shallow topsoil above compact fill	Allow time for topsoil to build up under pasture	-

TABLE C EXAMPLE FARM : ANNUAL PASTURE GROWTH ESTIMATES

Sourced from MAF, DSIR and MWD pasture yield trials for various soils on North Auckland hill country

Adjusted for landform and to average rainfall of 1450mm per annum

Soil label	Local soil name	LUC code	Pasture growth (kg dm/ha/yr)			Comments
			Un-improved	Semi-improved	Improved	
On streambanks and floodways						
Wfs' + Wfg'/Kre	Whakapara s si or s + s c (shallow) over Kara clay	5 b+e	4600	6300	-	Scaled down from Wf & Wfm
Wfs + Wfg	Whakapara sandy silt or sand + sandy clay	6 b+e	<4600	-	-	Scaled down from Wf & Wfm
Wfs'/Wf	Whakapara si s or s (shallow) over Whakapara s si l or s l	5 f+e	4600	6300	-	Scaled down from Wf & Wfm
Wfg'/Kre	Whakapara s c (shallow) over Kara clay	5 f+e	4600	6300	-	Scaled down from Wf & Wfm
Wfg + Un	Whakapara sandy clay (shallow) + un-named peaty silt	6f, 7f	<4600	-	-	Scaled down from Wf & Wfm
Wf	Whakapara sandy silt loam or sandy loam	2w	9100	11500	13900	
Wfm	Whakapara silty clay loam	3w	6800	8600	10400	
Wfm	Whakapara clay loam	4w	<6800	<8600	<10400	No separate trial data
On flats and terraces						
Wfm'/Kre or Kr	Whakapara s c l or c l (shallow) over Kara clay or silt loam	3w	6800	8600	10400	
Wfm'/Kre or Kr	Whakapara s c l or c l (shallow) over Kara clay or silt loam	4w	<6800	<8600	<10400	
Wo	Whareora sandy clay loam	2p	8200	10600	13000	
Wu	Waipuna clay	3p	6000	8300	10500	
Kre	Kara clay	4 p+w	5000	7000	10600	
Kr	Kara silt loam	4p	<5000	<7000	<10600	No separate trial data
On stable footslopes, spurs and ridges (mudstone)						
Ykc	Waikare silty clay (colluvial variant)	4 p+w	4600	6300	8000	No separate trial data
Yk	Waikare clay	4 p+t, 5s	4600	6300	8000	
Ap	Aponga clay loam	3t, 4t, 5s	6200	8500	10900	
Oa	Okaka silty clay loam	3t, 4t, 5s	6200	8500	10900	Probably lower
On stable spurs and ridges (sandstone)						
Wa, Mk	Warkworth clay loam, Matakana sandy clay loam	5s	5300	7700	10100	
On slump or earthflow terrain and moderate slopes (mudstone)						
Ap'	Aponga clay loam (shallow topsoil)	5 g+u	5200	8200	11200	
Ap'	Aponga clay loam (shallow topsoil)	6 g+u	3700	5800	8000	
Oa'	Okaka silty clay loam (shallow topsoil)	5 g+l	3800	6800	9800	
Oa'	Okaka silty clay loam (shallow topsoil)	6 g+l	2600	4700	6800	
On slip terrain and moderate slopes (sandstone)						
Wa'	Warkworth clay loam (shallow topsoil)	5l	3800	6800	9800	
Wa' + Py	Warkworth c l (shallow topsoil) + Puhoi sandy clay loam	6l	3600	6400	-	
Mk'	Matakana sandy clay loam (shallow topsoil)	5g	>3800	>6800	>9800	No separate trial data
Mk' + Pb	Matakana s c l (shallow topsoil) + Puhoi sandy loam	6 l+g	>3600	>6400	-	No separate trial data
On disturbed ground						
U	Un-named anthropic soil (re-grassed)	2,3,4 p+w	?	?	?	No trial data

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