Healthy Rivers PLAN FOR CHANGE | Wai Ora HE RAUTAKI WHAKAPAIPAI

Draft for discussion purposes

Report No. HR/TLG/2015-2016/2.7

Refined classification of land characteristics to assist economic modelling

This report was commissioned by the Technical Leaders Group for the Healthy Rivers Wai Ora Project

The Technical Leaders Group approves the release of this report to Project Partners and the Collaborative Stakeholder Group for the Healthy Rivers Wai Ora Project.

Signed by: 

Date: 1 December 2015

NIWA
Taihoro Nukurangi

Refined classification of land characteristics to assist economic modelling

Healthy Rivers Wai Ora Project

June 2015

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NIWA CLIENT REPORT No: HAM2015-073
Report date: June 2015
NIWA Project: EVW15216

Quality Assurance Statement		
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Executive summary

This report summarises one component of a suite of technical studies that were commissioned through the Healthy Rivers/Wai Ora Technical Leaders Group (TLG) to address various aspects of river protection.

This report focuses on spatial characterisation of key drivers of contaminant loss such as land use, slope, rainfall, and soil drainage, and the distribution of combinations of these drivers. The results fed directly into *E. coli* modelling, and will also be useful in providing a context for identifying and interpreting the distribution and control of other contaminants. While not attempted in this study, these spatial data may also be helpful when defining the location of different farm classes in future modelling exercises. Key findings in relation to pasture land are as follows:

Dairying land use

- Dairying generally occurs on flat and rolling land (approximately 84% of total dairying area), which reduces the likelihood of sediment transport and sediment-bound P transport.
- 59% of the dairying occurs in low rainfall areas, with another 25% occurring in medium rainfall areas.
- There is little dairying in areas where steeper slope and rainfall classes coincide.
- Approximately 30% of dairying occurs on poor to moderate draining soils, with the remaining 70% occurring on well-drained soils.
- Where dairying occurs on poor to moderately drained soil, slopes tend to be flat and rainfall relatively low. These areas will likely have subsoil drainage which accelerates nutrient and microbial losses.

Sheep and beef land use

- Approximately 78% of Sheep and Beef farming occurs on flat and rolling country, while approximately 17% is on moderately steep areas and 5% is on steep areas. The steep areas are likely to give disproportionately high sediment loss.
- Approximately 55% of the Sheep and Beef farming occurs on land receiving relatively low rainfall, and 45% occurs on flat and rolling country with low rainfall.
- Moderately steep or steep areas with medium or high rainfall occur predominantly in western and southern parts of the Waipa River catchment, with some smaller areas to the northeast of Lake Ohakuri.
- Overall, 83% of Sheep and Beef farming occurs on well-drained soils.
- The greatest risks to water quality related to sheep and beef farming are likely to arise from
  - moderately steep or steep hill country in the higher rainfall class
  - intensive sheep and beef operations on low or moderate slopes.

1 Introduction

The Waikato Regional Council (WRC) and Waikato and Waipa River iwi are partners in "Healthy Rivers: Plan for Change/Wai Ora: He Rautaki Whakapaipai". This partnership has initiated a series of technical projects that provide information to underpin changes to the regional plan. These changes to the regional plan are focused on restoring and protecting the health of the Waikato and Waipa Rivers. The plan aims to reduce inputs of sediment, bacteria and nutrients (nitrogen and phosphorus, N and P) entering water bodies in the Waikato and Waipa River catchments.

The work presented in this report is one component of a suite of technical studies that have been commissioned through the Healthy Rivers/Wai Ora Technical Leaders Group (TLG). These studies will provide information across a range of subjects, including:

- the current state of the streams, rivers and lakes
- historical and current estimates of the magnitude and sources of contaminant loads
- catchment modelling to determine how contaminants accumulate and move through the catchment, and
- economic scenario modelling to determine the cost of meeting water quality goals and targets.

The work described in this report involved a geospatial analysis of key climate, land use, soil drainage and slope information to provide a refined classification of land characteristics within the Waikato/Waipa River catchment considered in the Healthy Rivers project. The refined classification of physical and geomorphological characteristics within the Waikato River catchment accounts for diversity in soil type, drainage, slope and climate.

The focus of the work was on land areas in dairy and sheep and beef operations. The refined classification provided information across a series of sub-catchments within the Waikato River catchment downstream of Lake Taupo which may be used to meet a number of Healthy Rivers/Wai Ora objectives, including:

- Improving understanding of the spatial configuration of factors that may affect sources of contaminants.
- Quantification of areas of a number of combined classes of land use, slope, and rainfall within each sub-catchment and across the Healthy Rivers/Wai Ora study area.
- Developing a common set of data and make available for use in the water quality components of the modelling, which seeks to relate the cost of water quality improvement to farm financial performance.

This report documents key data sources used in the geospatial analysis, provides maps of the base data sources and re-classified maps, and provides maps and summaries of combined classes.

2 Methodology

Five key data sets were input to a Geographic Information Systems (GIS) geospatial database (ArcGIS 10.2.1, ESRI). The datasets are identified in Table 2-1 and described in the text that follows.

Table 2-1: Data sets used for this geospatial analysis.

Data set	Dataset	Dataset name	Source	Figure
1	Land use	CLUES model land use data	Waikato Regional Council "Waikato Lite" land use layer.	Figure 2-1
2	DTM 5m	2012_WRAPS_DTM	Waikato Regional Council	Figure 2-2
3	Drainage	2012_WRAPS_DTM	NIWA	Figure 2-3
4	Rainfall	Nz_ann_rain	NIWA climate database	Figure 2-4
5	Subcatchment boundaries	HEALTHY_RIV_CATCHMENT.shp	Waikato Regional Council	Figure 2-5

1. **Land use.** CLUES model land use data was supplied by Waikato Regional Council (WRC). The land use is aligned to 2012 (Land Cover Database 4 (LCDB4)) land cover extents and incorporates AgriBase™ stocking information as an indicator of pastoral enterprise. The methodology was described in detail by WRC[1].

2. **5 m Digital Terrain Model (DTM).** The DTM is part of the dataset 'Aerial Photography - WRAPS 2012 – GIS layer'. The DTM was supplied in ESRI ASCII grid format, tiled to NZTopo50 sheets. This DTM was originally used to orthorectify the aerial photography. Horizontal accuracy (as stated for orthophoto generation) is ±3.0 m. These data have been described fully by Waikato Regional Council (WRC).[2]

3. **Drainage.** Drainage is an attribute in the Fundamental Soil Layer. The FSL is available under Creative Commons License from Landcare Research Limited.

4. **Rainfall**. These data were derived from the NIWA climate database. Mean annual rainfall data for the period 1981 - 2010 was used.

5. **Sub-catchment boundaries**. The Healthy Rivers/Wai Ora study area comprises 74 sub-catchments. These boundaries were prepared for the Healthy Rivers Project, and are primarily based around the location of key water quality monitoring sites.

2.1 Key steps

2.1.1 Resampling of data and slope calculation

The DTM was resampled to 20 m grid size. Land use data was based on a 100 m grid. For analysis, a grid size of 20 m was selected. The rainfall grid was resampled to 20 m using linear resampling. Each

[1] WRC document '1-3293946-WAIKATO_LITE_CLUES_LU_LCDB4_2012_METHODOLOGY.docx'.
[2] EWDOCS_n2310412_v2_METADATA_1346_00@EW_GOVT_NZ_Aerial_Photography_-_WRAPS_2012-_GIS_Layer.pdf

sub-catchment was assigned a numeric ID from 1 to 74, and converted to 20 m grid for overlay. Drainage polygon data was also converted to 20 m cell size grid. Slope was calculated using tools available in ArcGIS.

2.1.2 Classification or and aggregation of data

To simplify the data and to limit the number of combinations of classes to a manageable amount, various layers were aggregated into classes as described below.

Slope data were aggregated and classified into four classes using the criteria described in Table 2-2. The results of the aggregation are shown in Figure 2-6.

Table 2-2: Criteria used to classify slope data.

Class ID	Fields used to classify slope data		
	slope_code	slope_class	slope_name
1	7	< 7	flat
2	15	7 - 15	rolling
3	25	15 - 25	moderately steep
4	90	> 25	steep

Rainfall data were aggregated into three classes according to the mean annual rainfall value, using the criteria listed in Table 2-3. The results of the aggregation are shown in Figure 3-1.

Table 2-3: Criteria used to classify rainfall data.

Class ID	Fields used to classify rainfall data		
	Rain_code	Rain_class	Rain_name
1	1	< 1400	low rainfall
2	2	1400 - 1800	medium rainfall
3	3	> 1800	high rainfall

Soil drainage data were classified into two classes – soils with “poor to moderate drainage” and “well drained” soils, using the criteria listed in Table 2-4. The results of the aggregation are shown in Figure 3-2.

Table 2-4: Criteria used to classify drainage data.

	Fields used to classify drainage data		
Class ID	Drainage_code	Drainage_class	Drainage_name
1	1	1,2,3	poor-moderate drainage
2	2	4,5 & other	well drained

Land use classes used in the CLUES model were re-classified and remapped to better align with the classes used in the Farm Cost Model (FCM). The FCM is used by other agencies undertaking the economics assessments. The reclassified CLUES model land use types are listed with the associated FCM class in Table 2-5. The results of the aggregation are shown in Figure 3-3.

Table 2-5: Criteria used to classify land use data.

	Fields used to reclassify Land use		
Class ID	**CLUES**	**FARM_COSTS_MODEL**	**FCM_codes**
1	DAIRY	Dairy	1
2	SBHIGH	Sheep and Beef - Hill and High	2
3	SBHILL	Sheep and Beef - Hill and High	2
4	SBINTEN	Sheep and Beef - Intensive	3
5	PLANT_FOR	Forestry	4
6	MAIZE	Maize	5
7	ONIONS	Horticulture	6
8	POTATOES	Horticulture	6
9	NAT_FOR	Native Forest & Scrub	7
10	SCRUB	Native Forest & Scrub	7
11	DEER	Other Animal	8
12	OTHER_ANIM	Other Animal	8
13	URBAN	Urban	9
14	APPLES	Miscellaneous	10
15	GRAPES	Miscellaneous	10
16	KIWIFRUIT	Miscellaneous	10
17	OTHER	Miscellaneous	10
18	TUSSOCK	Miscellaneous	10
19	UNGR_PAST	Miscellaneous	10

2.1.3 Overlay analysis

The grids described previously were combined using the “Combine tool”, provided in the Spatial Analyst toolbox in ArcGIS to create a series of unique layers derived from input layers of classified land use, slope, drainage and rainfall.

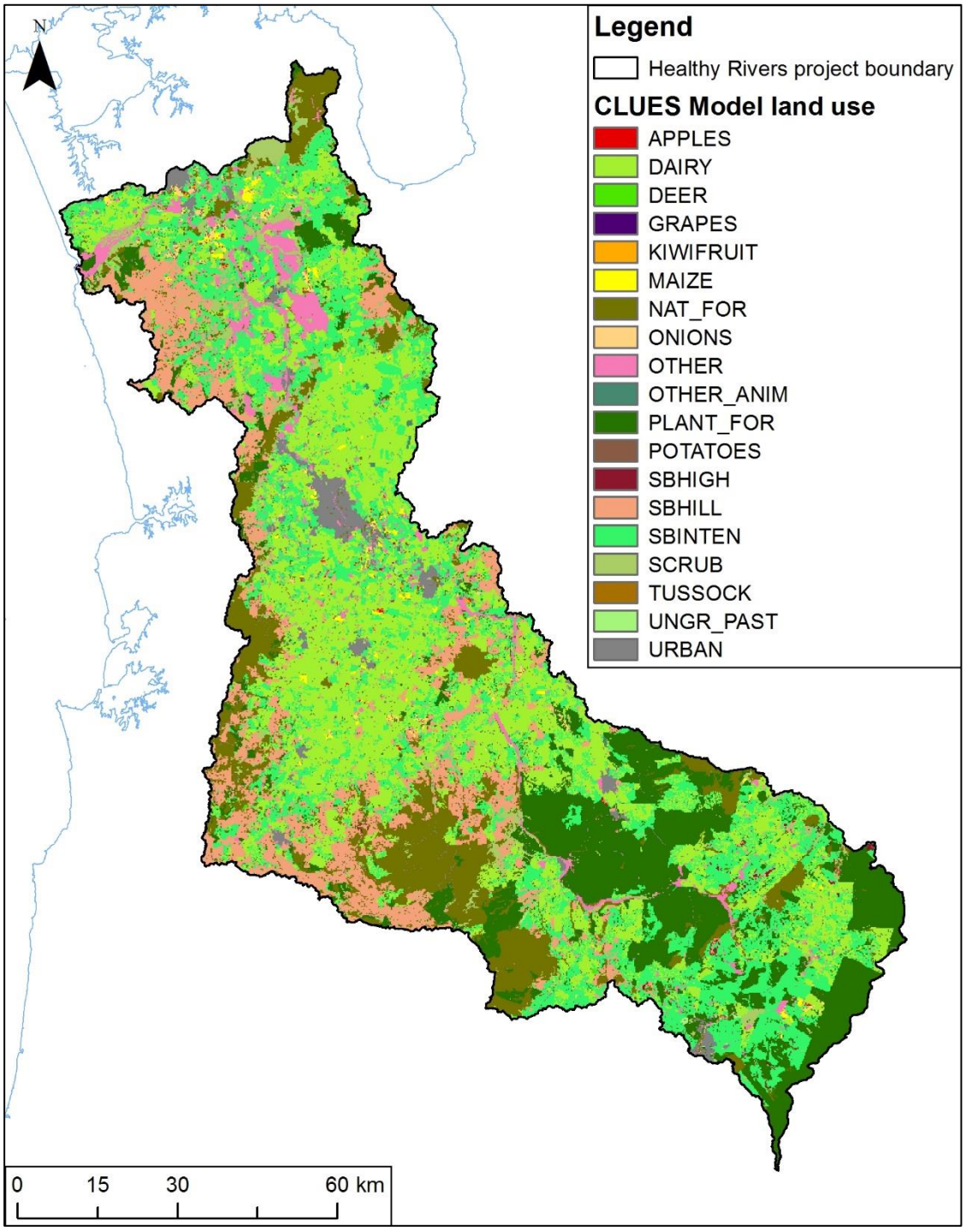

Figure 2-1: CLUES Model Land use classification.

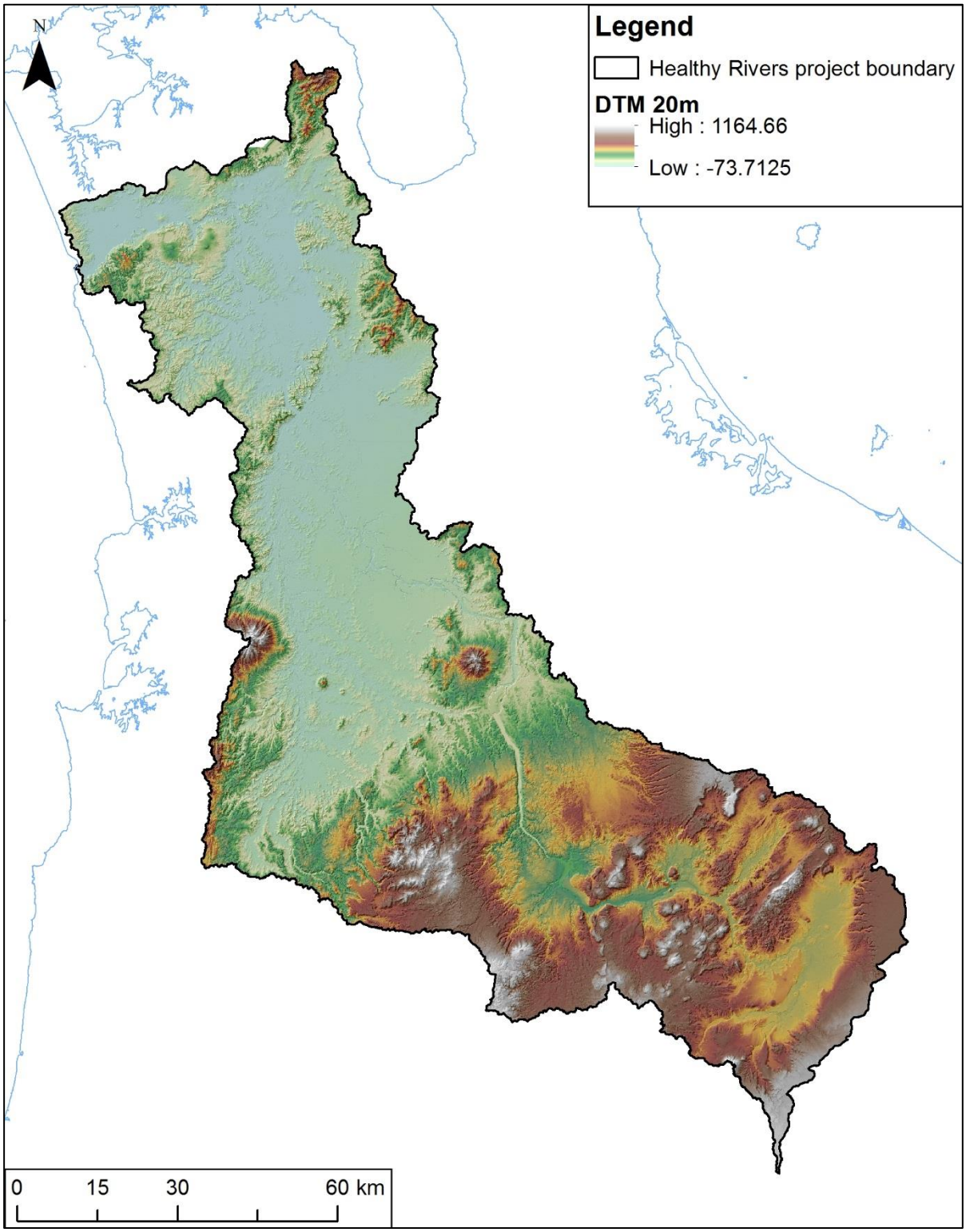

Figure 2-2: Five metre resolution DTM of the Waikato region. Elevations in m above sea level.

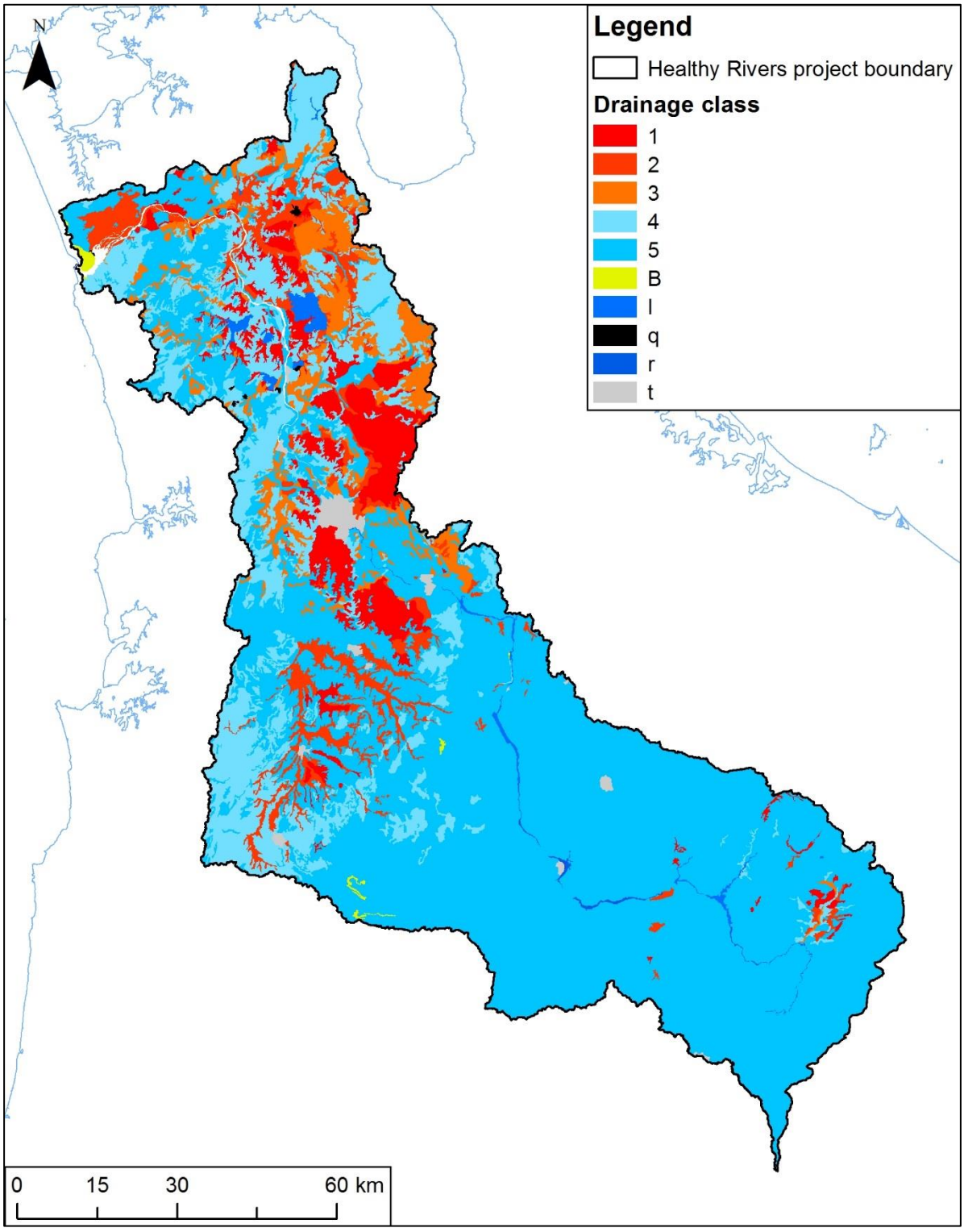

Figure 2-3: Drainage class. The drainage classes are as described in the Fundamental Soil Layer, lower numbers having poor drainage.

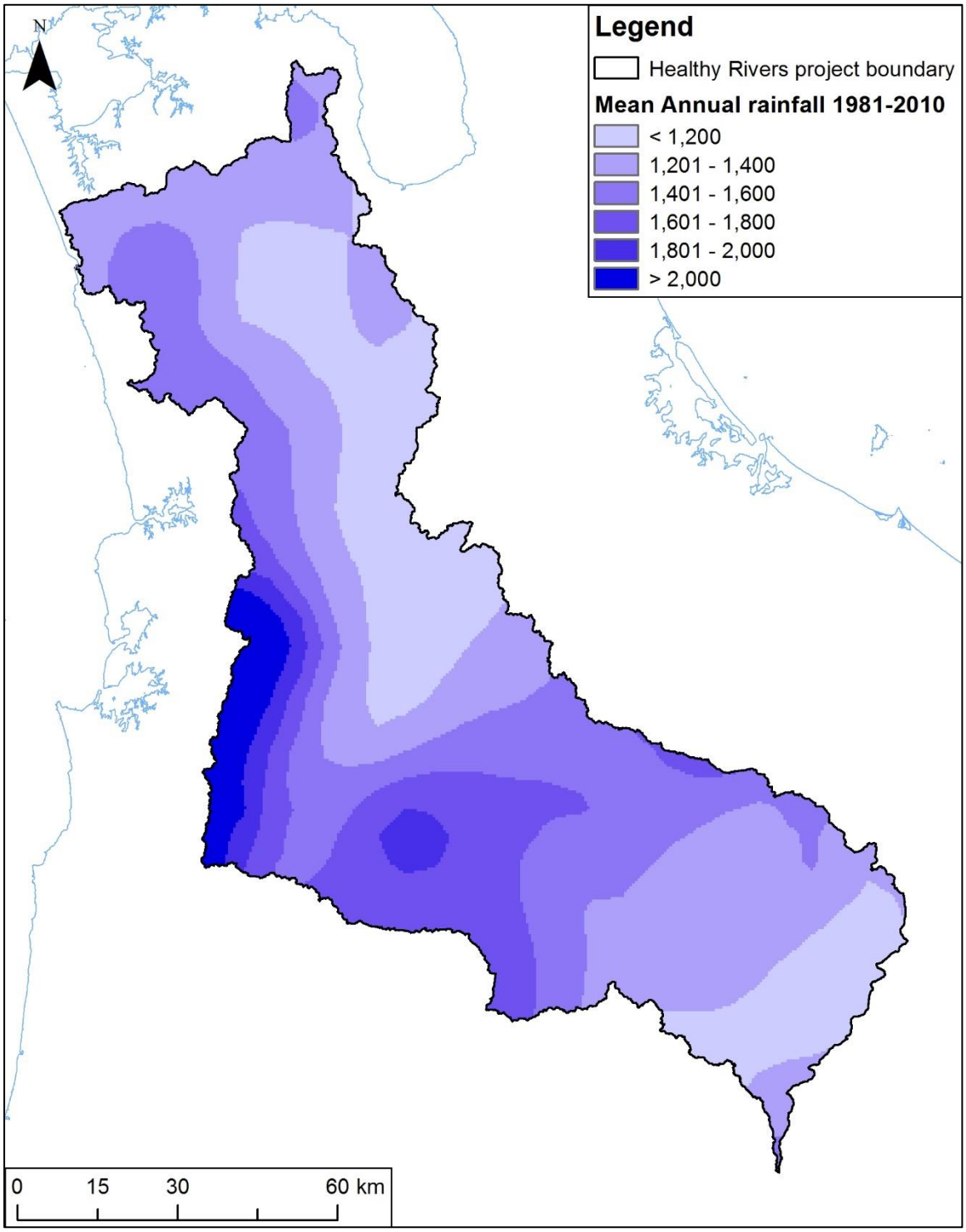

Figure 2-4: Mean annual rainfall.

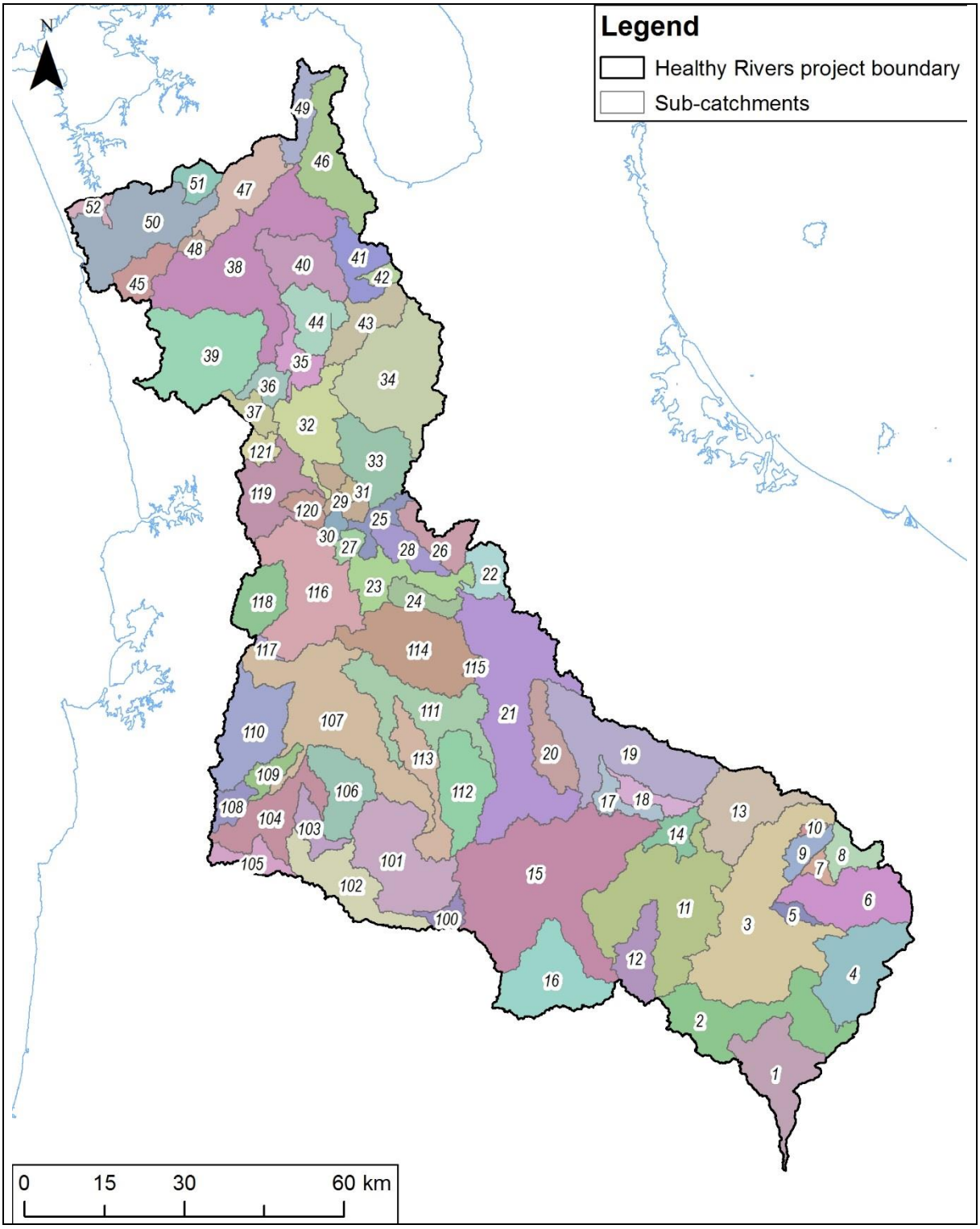

Figure 2-5: Sub-catchment boundaries. Refer to Table 2-6 for selected sub-catchment details.

Table 2-6: Healthy River sub-catchment details. List of sub-catchments and water quality monitoring sites ordered in downstream direction. These sites and sub-catchments were used for water quality modelling. Refer to Figure 2-5 to locate the sub-catchments. Shaded rows indicates sites where a flow record exists.

Map ID	Sub-catchment	Area (ha)	Water quality monitoring station	
			Location code	NZREACH
1	Pueto	20029	EW-0802-001	3042044
2	Waikato at Ohaaki	29009	EW-1131-105	3039804
3	Waikato at Ohakuri	53139	EW-1131-107	3035123
4	Torepatutahi	21721	EW-1057-006	3038300
5	Mangakara	2235	EW-0380-002	3037027
6	Waiotapu at Homestead	20478	EW-1186-004	3037105
7	Kawaunui	2134	EW-0240-005	3034452
8	Waiotapu at Campbell	6079	EW-1186-002	3034280
9	Otamakokore	4573	EW-0683-004	3031549
10	Whirinaki	1080	EW-1323-001	3031392
11	Waikato at Whakamaru	44665	EW-1131-147	3035301
12	Waipapa	10049	EW-1202-007	3035556
13	Tahunaatara	20816	EW-0934-001	3032435
14	Mangaharakeke	5415	EW-0359-001	3032678
15	Waikato at Waipapa	69392	EW-1131-143	3030247
16	Mangakino	22186	EW-0388-001	3036710
17	Mangamingi	5175	EW-0407-001	3027230
18	Whakauru	5302	EW-1287-007	3027821
19	Pokaiwhenua	32701	EW-0786-002	3023849
20	Little Waipa	10649	EW-0335-001	3023862
21	Waikato at Karapiro	53969	EW-1131-081	3020656
22	Karapiro	6741	EW-0230-005	3020352
23	Waikato at Narrows	12987	EW-1131-101	3018977
24	Mangawhero	5347	EW-0488-001	3020102
25	Waikato at Bridge St Br (Hamilton Traffic Br)	5072	NAT-HM03	3017901
26	Mangaonua	8096	EW-0421-010	3017726
27	Mangakotukutuku	2708	EW-0398-001	3018237
28	Mangaone	6760	EW-0417-007	3018213
29	Waikato at Horotiu Br	5405	EW-1131-069	3015830
30	Waitawhiriwhiri	2223	EW-1236-002	3017487
31	Kirikiriroa	1233	EW-0253-004	3016924
32	Waikato at Huntly-Tainui Br	17322	EW-1131-077	3013160
33	Komakorau	16399	EW-0258-004	3014466
34	Mangawara	35884	EW-0481-007	3013137
35	Waikato at Rangiriri	6853	NAT-HM04	3010604

Map ID	Sub-catchment	Area (ha)	Water quality monitoring station	
36	Awaroa (Rotowaro) at Harris/Te Ohaki Br*	4730	EW-1097_1	3012631
37	Awaroa (Rotowaro) at Sansons Br	4561	EW-0039-011	3013581
38	Waikato at Mercer Br	45168	EW-1131-091	3006806
39	Whangape	31767	EW-1302-001	3010847
40	Whangamarino at Island Block Rd	14365	EW-1293-007	3007681
41	Whangamarino at Jefferies Rd Br	9701	EW-1293-009	3008369
42	Waerenga	1959	EW-1098-001	3009556
43	Matahuru	10637	EW-0516-005	3010952
44	Waikare*	10418	EW-326_10	3010071
45	Opuatia	7067	EW-0665-005	3008985
46	Mangatangi	19452	EW-0453-006	3006132
47	Waikato at Tuakau Br	15178	EW-1131-133	3007421
48	Ohaeroa	2033	EW-0612-009	3007733
49	Mangatawhiri	6808	EW-0459-006	3005110
50	Waikato at Port Waikato	28148	Terminal Reach	3009006
51	Whakapipi	4648	EW-1282-008	3006346
52	Awaroa (Waiuku)	2506	EW-0041-009	3007434
100	Waipa at Mangaokewa Rd	3221	EW-1191-005	3036214
101	Waipa at Otewa	28665	NAT-HM01	3029370
102	Mangaokewa	17419	EW-0414-012	3031564
103	Mangarapa*	5443	444_4	3028468
104	Mangapu	16170	EW-0443-003	3027166
105	Mangarama*	5528	EW-1391_1	3031371
106	Waipa at Otorohanga	13889	EW-1191-012	3027129
107	Waipa at Pirongia-Ngutunui Rd Br	43607	EW-1191-010	3022669
108	Waitomo at Tumutumu Rd	4318	EW-1253-007	3028966
109	Waitomo at SH31 Otorohanga	4393	EW-1253-005	3026779
110	Moakurarua*	20630	EW-553_5	3023962
111	Puniu at Bartons Corner Rd Br	22785	EW-0818-002	3023180
112	Puniu at Wharepapa*	16853	EW-818_40	3025988
113	Mangatutu	12269	EW-0476-007	3024473
114	Mangapiko	28069	EW-0438-003	3022010
115	Mangaohoi	431	EW-0411-009	3023476
116	Waipa at SH23 Br Whatawhata	31506	NAT-HM02	3017829
117	Mangauika	978	EW-0477-010	3023179
118	Kaniwhaniwha	10259	EW-0222-016	3019566
119	Waipa at Wainaro Rd Br*	15484	Waipa Waikato confluence	3015066
120	Ohote	4041	EW-0624-005	3017348
121	Firewood*	3372	124_8	3015451

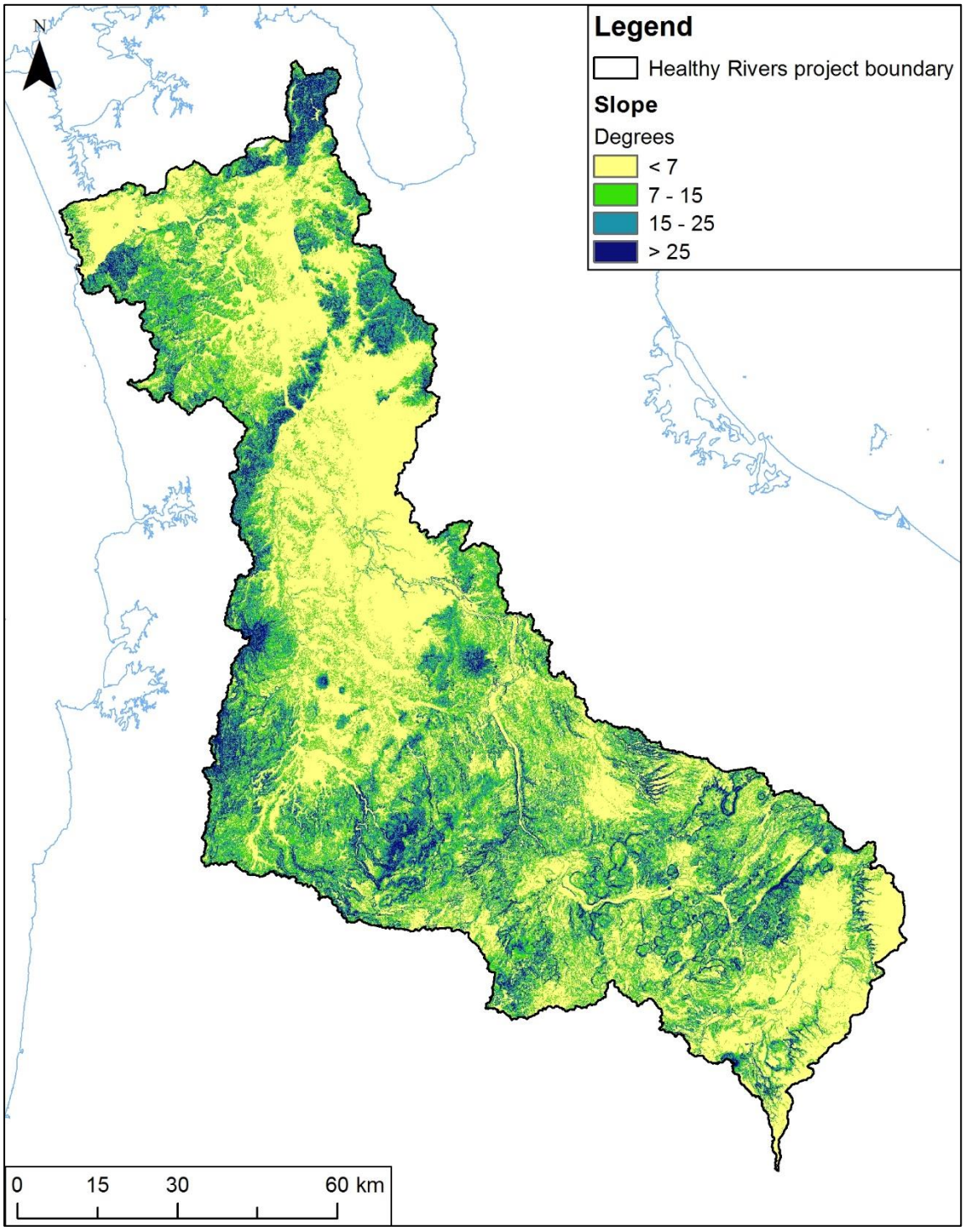

Figure 2-6: Slope in degrees - created using the DTM.

3 Results, discussion and key findings

3.1 Classified and aggregated layers

Classified or aggregated layers are shown in Figure 3-1 to Figure 3-3, while the slopes are classified in Figure 2-6.

Flatter areas occur in the Hamilton Basin (from Te Awamutu to Taupiri and the lower catchment around the Waikato River) and in plateau areas in the upper (southeast) of the catchment.

Relatively high rainfall occurs around the Rangitoto ranges and from Pirongia southward, while relatively low rainfall occurs in the northeast and southeast of the study area.

Poor to moderate drainage occurs primarily in flat intensively-farmed areas in the northern half of the catchment, although some steeper hill country in the northeast of the catchment also has poor drainage.

Dairy and intensive sheep and beef are spread through the catchment, interrupted by areas of native vegetation in steep or reserve areas, pine plantation in the upper catchment, and hill sheep and beef that is more concentrated in the upper and western Waipa River catchment, and hills in the lower catchment.

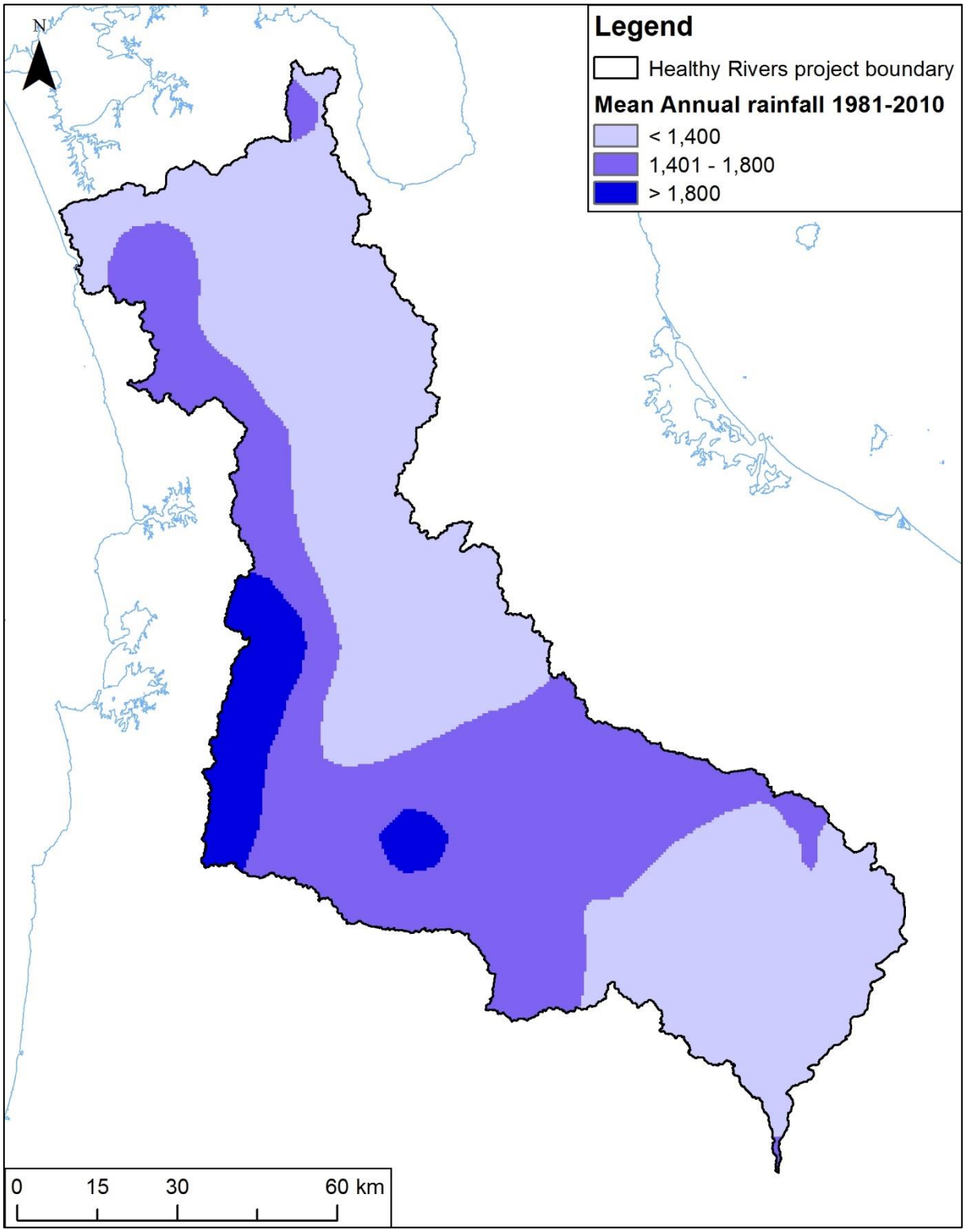

Figure 3-1: Rainfall classes.

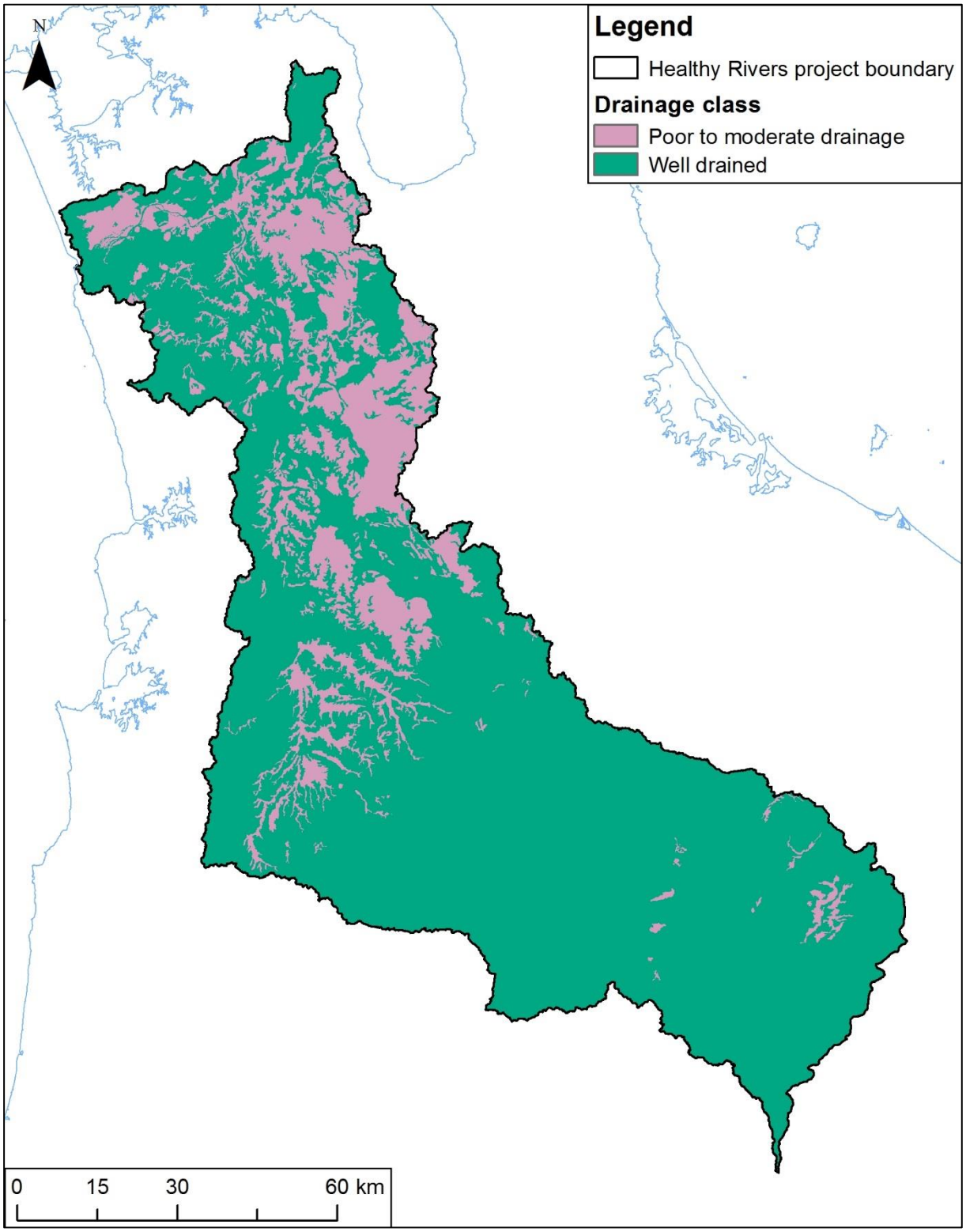

Figure 3-2: Aggregated drainage classes.

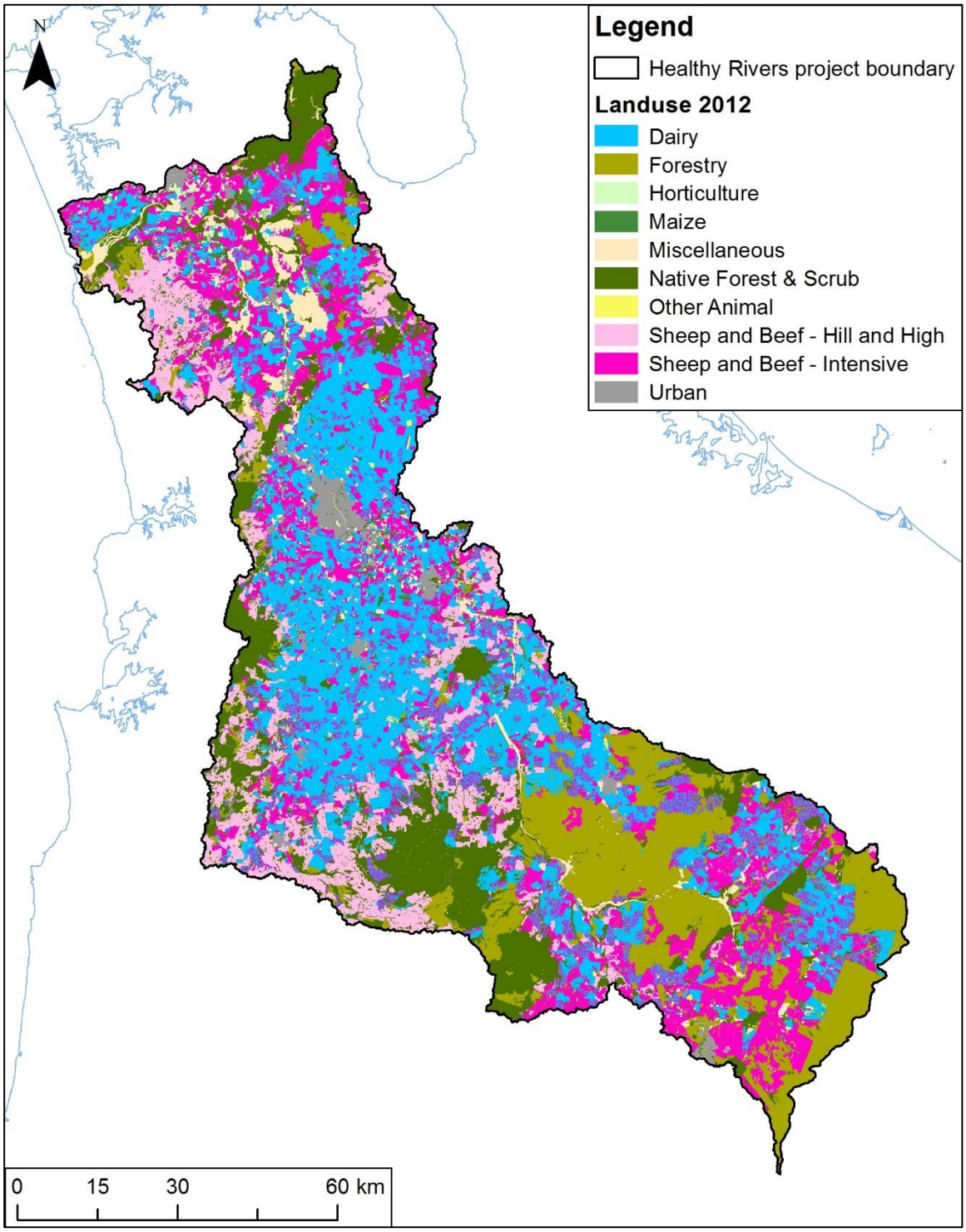

Figure 3-3: Aggregated land use using classes derived from the Farm Costs Model.

3.2 Overlay analysis

This section presents results for pastoral land uses, which are of key interest. The results of the overlay analyses are shown visually as Figure 3-4 to Figure 3-7. Information derived from analysis of the overlay data set is listed in Table 3-1 and Table 3-2.

3.2.1 Dairy areas

Analysis of geospatial data where dairy farming occurs provide the information summarised in Table 3-1, which gives the proportion of dairying in each combined class. The distribution of classes across the catchment is shown in Figure 3-4 and Figure 3-5 (one figure for each of poor-moderate drainage and well-drained soils). Key features of these data include:

- Dairying generally occurs on flat and rolling land (approximately 84% of total dairying area), which reduces the likelihood of sediment transport and sediment-bound P transport.
- 59% of the dairying occurs in low rainfall areas, with another 25% occurring in medium rainfall areas.
- Little dairying occurs in areas where steeper slope and higher rainfall classes coincide.
- Approximately 30% of dairying occurs on poor to moderate draining soils, with the remaining 70% occurring on well-drained soils.
- Where dairying occurs on poor to moderately drained soil, slopes tend to be flat and rainfall relatively low. These areas will likely have subsoil drainage which accelerates nutrient and *E. coli* transport, but will tend to have higher likelihood of denitrifying conditions for N attenuation.

Table 3-1: Summary of soil-rainfall-drainage classes in dairy areas in the study area. Areas with high proportions of either drainage class are highlighted.

land_use	drainage_name	rain_name	slope_name	Area(m²)	proportion
Dairy	poor-moderate drainage	low rainfall	flat	692290490	22.68
Dairy	poor-moderate drainage	low rainfall	rolling	36370546	1.19
Dairy	poor-moderate drainage	low rainfall	moderately steep	13179017	0.43
Dairy	poor-moderate drainage	low rainfall	steep	1871443	0.06
Dairy	poor-moderate drainage	high rainfall	flat	11832381	0.39
Dairy	poor-moderate drainage	high rainfall	rolling	2141699	0.07
Dairy	poor-moderate drainage	high rainfall	moderately steep	522790	0.02
Dairy	poor-moderate drainage	high rainfall	steep	53781	0
Dairy	poor-moderate drainage	medium rainfall	flat	116334412	3.81
Dairy	poor-moderate drainage	medium rainfall	rolling	11835141	0.39
Dairy	poor-moderate drainage	medium rainfall	moderately steep	2313777	0.08
Dairy	poor-moderate drainage	medium rainfall	steep	224943	0.01
Dairy	well drained	low rainfall	flat	798341781	26.15
Dairy	well drained	low rainfall	rolling	275058078	9.01
Dairy	well drained	low rainfall	moderately steep	91591025	3
Dairy	well drained	low rainfall	steep	19181951	0.63
Dairy	well drained	high rainfall	flat	42817753	1.4
Dairy	well drained	high rainfall	rolling	40084642	1.31
Dairy	well drained	high rainfall	moderately steep	17235446	0.56
Dairy	well drained	high rainfall	steep	3179154	0.1
Dairy	well drained	medium rainfall	flat	474181365	15.53
Dairy	well drained	medium rainfall	rolling	275849302	9.04
Dairy	well drained	medium rainfall	moderately steep	103760258	3.4
Dairy	well drained	medium rainfall	steep	22330852	0.73

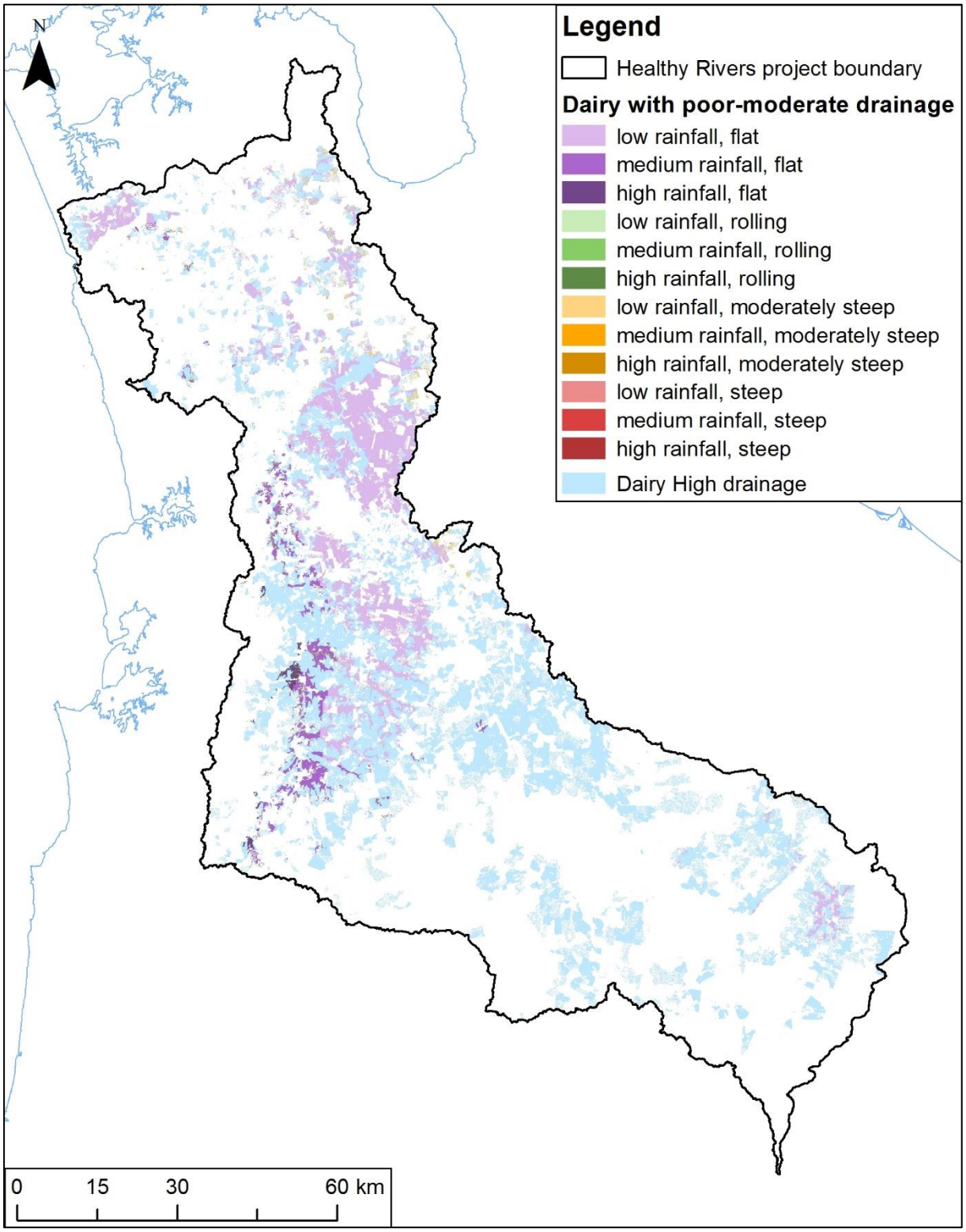

Figure 3-4: Dairy with poor to moderate drainage differentiated by rainfall and slope.

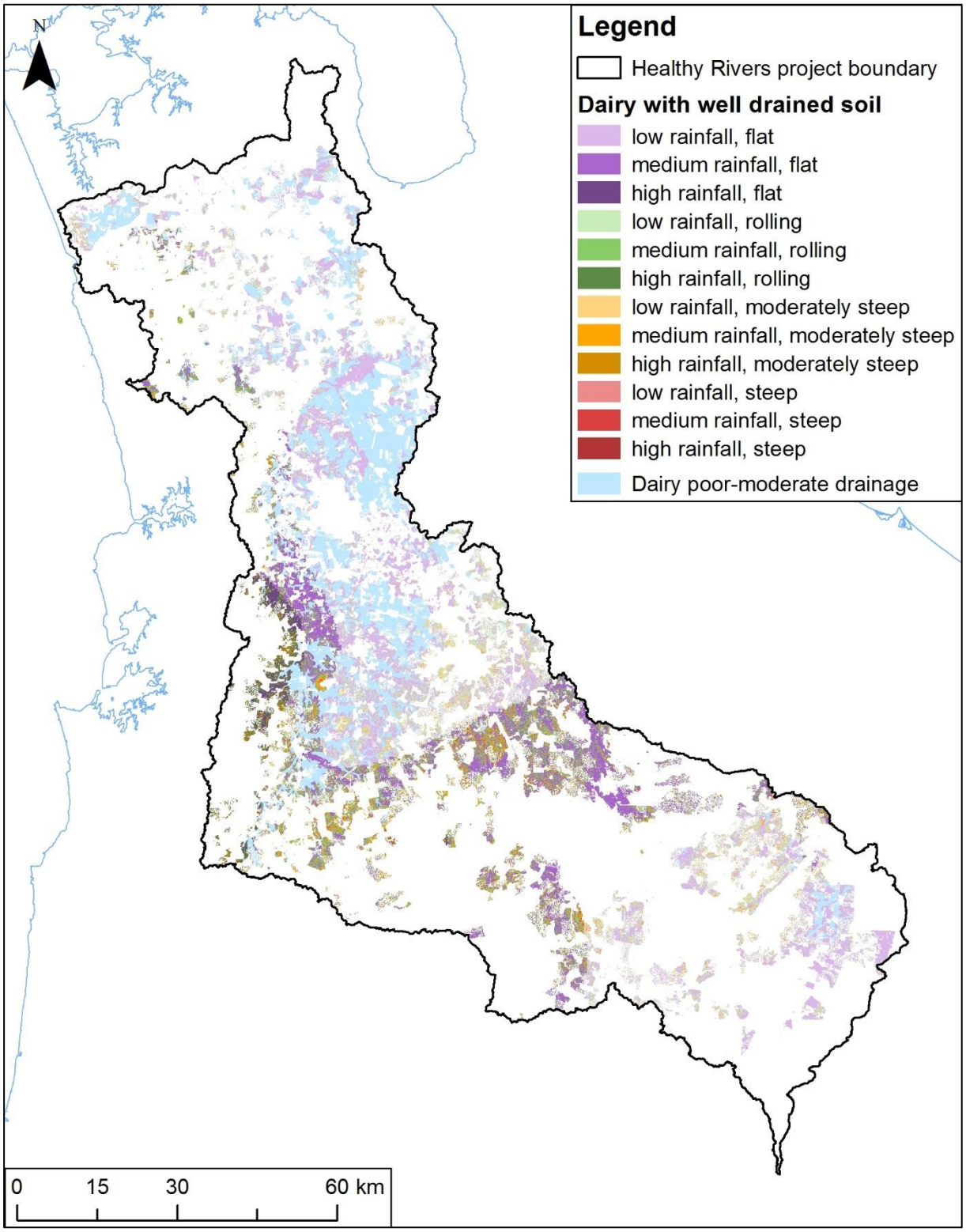

Figure 3-5: Dairy on well-drained soil differentiated by rainfall and slope.

3.2.2 Sheep and Beef farms

Analysis of geospatial data where sheep and beef farming occurs provides the information summarised in Table 3-2, which gives the proportion of sheep and beef in each class. The distribution of classes across the catchment is given in Figure 3-6 and Figure 3-7 (one figure for each of poor-moderate drainage and well-drained soils).

- Approximately 78% of Sheep and Beef farming occurs on flat and rolling country, while approximately 17% is on moderately steep areas and 5% is on steep areas. The steep areas are likely to give disproportionately high sediment loss.
- Approximately 55% of the Sheep and Beef farming occurs on land receiving relatively low rainfall, and 45% occurs on flat and rolling country with low rainfall.
- Moderately steep or steep areas with medium or high rainfall occur predominantly in western and southern parts of the Waipa catchment, with smaller areas also occurring to the northeast of Lake Ohakuri.
- Overall, 83% of Sheep and Beef farming occurs on well-drained soils.

The greatest risks to water quality are probably related to sediment and *E.coli* loss from moderately steep or steep hill country in the higher rainfall class, as well as from areas used for intensive sheep and beef farming on low or moderate slopes.

Table 3-2: Summary of soil-rainfall-drainage classes in sheep-beef areas in the study area. Areas with high proportions are highlighted.

Land_use	drainage_name	rain_name	slope_name	Area	proportion
Sheep Beef	poor-moderate drainage	low rainfall	flat	326863544	8.9
Sheep Beef	poor-moderate drainage	low rainfall	rolling	82231735	2.24
Sheep Beef	poor-moderate drainage	low rainfall	moderately steep	60708041	1.65
Sheep Beef	poor-moderate drainage	low rainfall	steep	12289040	0.33
Sheep Beef	poor-moderate drainage	high rainfall	flat	6381747	0.17
Sheep Beef	poor-moderate drainage	high rainfall	rolling	1341906	0.04
Sheep Beef	poor-moderate drainage	high rainfall	moderately steep	491460	0.01
Sheep Beef	poor-moderate drainage	high rainfall	steep	179908	0
Sheep Beef	poor-moderate drainage	medium rainfall	flat	78431938	2.13
Sheep Beef	poor-moderate drainage	medium rainfall	rolling	22206285	0.6
Sheep Beef	poor-moderate drainage	medium rainfall	moderately steep	7116069	0.19
Sheep Beef	poor-moderate drainage	medium rainfall	steep	1466340	0.04
Sheep Beef	well drained	low rainfall	flat	829209451	22.57
Sheep Beef	well drained	low rainfall	rolling	440455361	11.99
Sheep Beef	well drained	low rainfall	moderately steep	221847448	6.04
Sheep Beef	well drained	low rainfall	steep	59532913	1.62
Sheep Beef	well drained	high rainfall	flat	46067647	1.25
Sheep Beef	well drained	high rainfall	rolling	88470399	2.41
Sheep Beef	well drained	high rainfall	moderately steep	69134558	1.88
Sheep Beef	well drained	high rainfall	steep	24983226	0.68
Sheep Beef	well drained	medium rainfall	flat	478788182	13.03
Sheep Beef	well drained	medium rainfall	rolling	475578357	12.94
Sheep Beef	well drained	medium rainfall	moderately steep	269477311	7.33
Sheep Beef	well drained	medium rainfall	steep	71293557	1.94

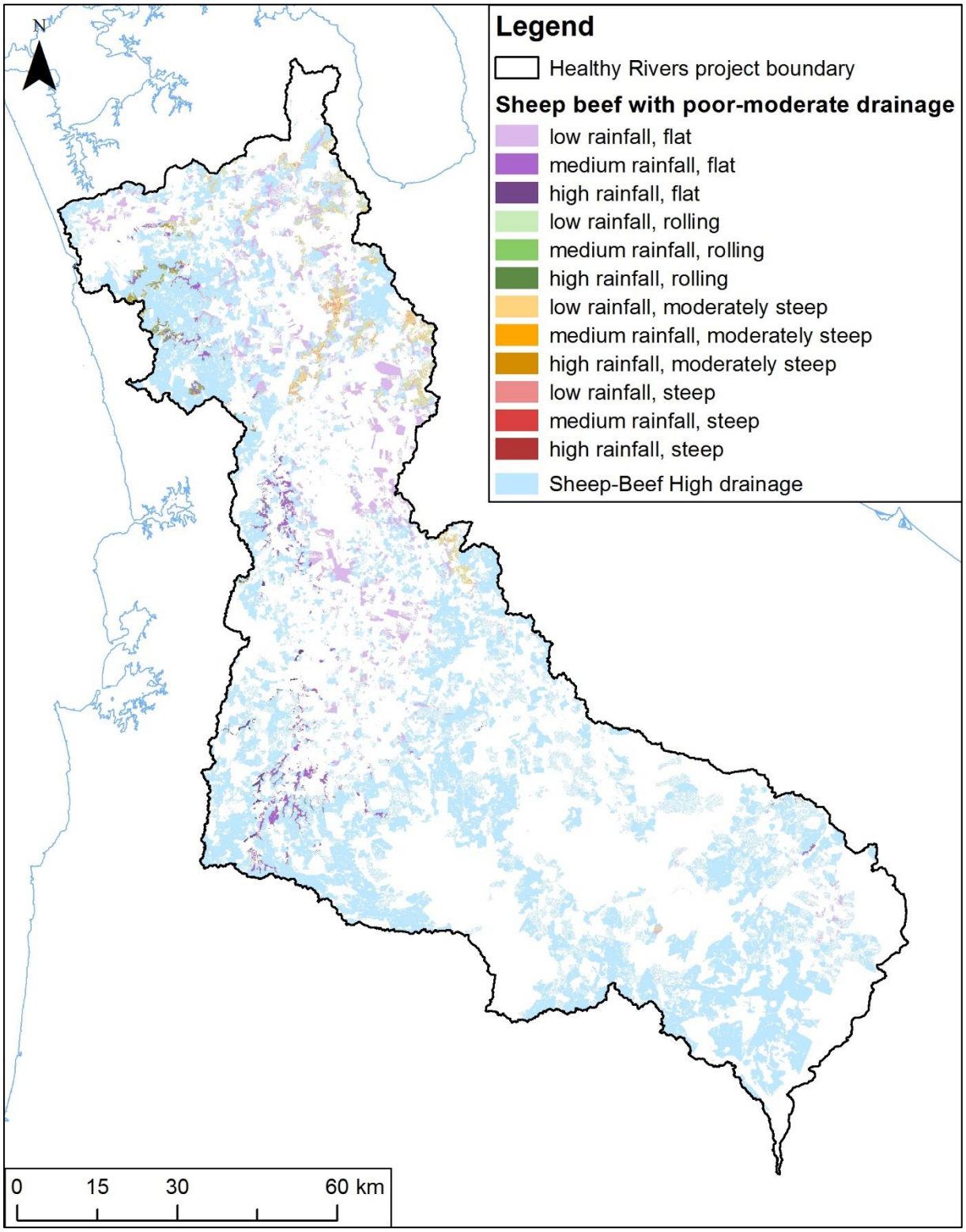

Figure 3-6: Sheep and beef on poor to moderately drained soil differentiated by rainfall and slope.

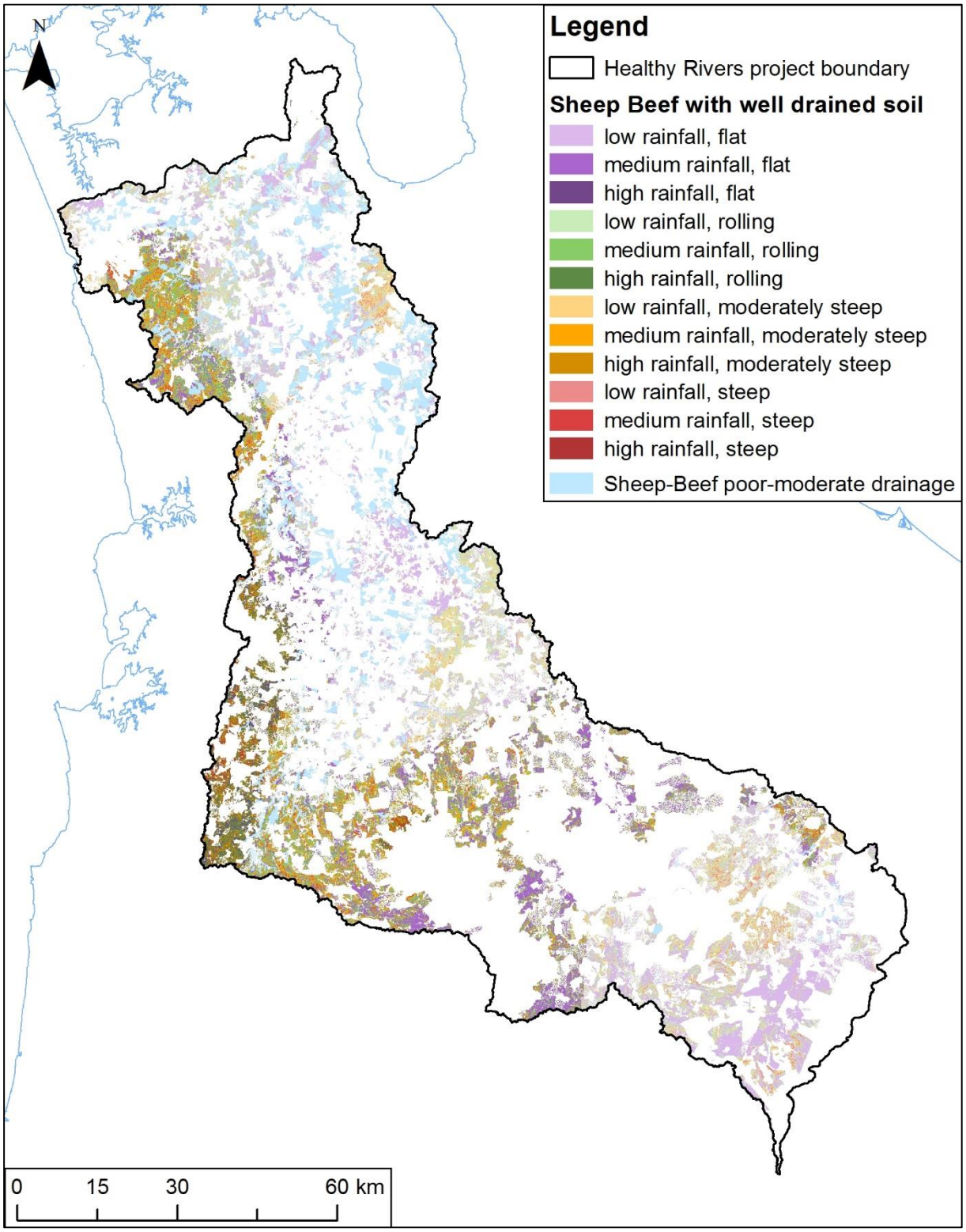

Figure 3-7: Sheep and beef on well-drained soil differentiated by rainfall and slope.

4 Limitations and uncertainties

The land use data that was supplied is based on analysis with grids of 100 m cell size, which is relatively coarse given the fine spatial variation of actual land use. Other data (such as the DTM) was

available at 5 m resolution. Overall, 20 m grid size was selected for the analysis as a reasonable compromise, which is regarded as adequate to meet the objectives of the Healthy River project.

The input data provided does not fully inform us regarding farm types, feeding regimes and management strategies across the sub-catchments – this information is not available to us in spatial format but if it were to be it would allow a greater granularity in our overlay analysis.

The land use data used in this assessment was derived from Agribase, which in turn is derived from voluntary farmer surveys. Despite quality assurance checks, uncertainties within the Agribase data will be carried into subsequent analysis that uses these data. One example of the uncertainty related to land use is associated with the rapid changes in land use in the upper catchment – the change in land use is happening at a rate that cannot always be reflected in the periodic summary of land use data available through Agribase.