Te Awarua-o-Porirua Collaborative Modelling Project – Work Brief 11 RM

Assessment of rural economics and mitigation costs FINAL REPORT

December 2018

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Executive Summary

The Porirua Whaitua Committee will recommend objectives and limits for water quality and quantity and could make recommendations for regulation, investment, education programmes and integrated planning with other agencies (*e.g.* TA's and infrastructure providers). The Committee is relying on a number of information sources to help them make these value judgments, including their own experience and expertise, the results from scenario modelling of potential changes in land use and land management practice, and the input of subject matter experts.

This paper is part of the scenario modelling set of inputs, and focuses on the rural sector of the catchment. It is based on a range of information sources, including data from GWRC, Beef and Lamb NZ, Statistics NZ, and from other part of the modelling process. In addition interviews and workshop were undertaken with stakeholders from the rural community, which were used to help develop and refine some of the assumptions and estimates of modelled interventions in the rural environment.

The Porirua Whaitua rural land use is dominated by sheep, beef and deer, which comprises 42% of the rural area. Native vegetation and scrub, together with urban area are each approximately half the area in pastoral activities. Forestry is a reasonably significant land use at 13%, but lifestyle represents only 2% of the catchment (although some lifestyle land may be classified as pastoral land). Horticulture is not a major feature with only 13ha, all of it occurring on smaller blocks.

The model of sheep and beef operations in the catchment are based on data provided by Beef and Lamb NZ for Class 3 (NI Hard Hill country) and adapted based on feedback from rural stakeholders. The resulting model has revenue of $481/ha, expenses of $395/ha, and an operating profit of $87/ha. A horticulture budget was used to represent all horticultural operations, which has a revenue of $8000/ha and expenses of $5,300/ha, with an operating profit of $2,700/ha. Forestry was represented from specific yield modelling for the catchment, and results in an estimated $590/ha/annum operating profit. None of the lifestyle block owners spoken to undertook any rural commercial operations of any scale, apart from some small horticulture operations, so these lifestyle land uses are recommended to be treated as consumption only. A summary of the budgets for these land uses is provided in Table 1.

Table 1: Summary of rural land use operating budgets

Land use	Area applicable	Revenue	Expenses	Operating profit
Sheep and beef	Sheep, Beef and deer not lifestyle	$481	$395	$87
Horticulture	Horticulture	$8,000	$5,300	$2,700
Forestry	Forestry blocks >10ha (70% of forestry)	$2,178	$1,589	$590

The mitigation costs were based on national scale figures adapted using feedback from rural stakeholders and GWRC land managers. These costings for fencing, planting, space planting and retirement of erosion prone land are summarised below in Table 2.

Table 2: Summary of mitigation costs

Mitigation	Basis	Cost	Metric	Area applied to
Stream fencing	Fencing one side to exclude sheep and larger animals, flat slope	$20	$/linear m	Sheep and beef, lifestyle not currently fenced
Planting 5m strip	Cost of planting one side of a stream	$25	$/linear m	Sheep and beef, lifestyle not currently fenced
Land retired with 5m buffer strip	From value of retired land	$5.35	$/linear m	Sheep and beef, lifestyle not currently fenced
Planting 10m buffer	Cost of planting one side of a stream	$50	$/linear m	Sheep and beef, lifestyle not currently fenced
Land retired with 5m buffer strip	From value of retired land	$10.70	$/linear m	Sheep and beef, lifestyle not currently fenced
Annual maintenance	All fenced areas	$2.50	$/linear m	Sheep and beef, lifestyle not currently fenced
Pole planting	Cost of planting poplars 15 stems/ha (average for all of 6e land)	$7.50	$/ha	6e sheep and beef, lifestyle
Retirement ($/ha capital costs)	20th percentile of QV per ha values	$10,700	$/ha	6e, 7e, 8e sheep and beef, lifestyle
Fencing of retired areas	Cost of excluding sheep and large animals on steep land, 50% of perimeter/ha from affected GIS polygons	$2,100/ha for 6e, $1400/ha for 7e, 8	$/ha	6e, 7e, 8e sheep and beef, lifestyle

1 Background

The Porirua Whaitua Committee will recommend objectives and limits for water quality and quantity and could make recommendations for regulation, investment, education programmes and integrated planning with other agencies (eg, TA's and infrastructure providers). The Committee includes local community members, Ngati Toa representatives, and a councillor from each of Wellington and Porirua City Councils and Greater Wellington Regional Council. Their recommendations will reflect the environmental, mana whenua, economic and social values of the Whaitua.

The Committee is relying on a number of information sources to help them make these value judgments, including their own experience and expertise, the results from scenario modelling of potential changes in land use and land management practice, and the input of subject matter experts. This paper is part of the scenario modelling set of inputs, which aims to ground the Committees choices for water quality objectives and limits with an assessment of what water quality changes might be possible with different levels of effort. It contributes to the economic modelling stream of the scenario modelling, which provides a financial indicator for the outcomes in the catchment under each scenario.

The scenario modelling helps the Committee explore possible outcomes within a set of broad assumptions about how contaminant loads might change in response to different practices and where changes in practices go across the landscape. While the scenario modelling is limited to those we can make those assumptions about, there are many other changes possible. This means the modelled scenarios are not the only option, the preferred option or an optimal option. Rather, they are a representation of some changes in practice to help show the Committee what water quality changes might be possible with different levels of effort.

This report focuses on the rural sector of the catchment. It is based on a range of information sources, including data from GWRC, Beef and Lamb NZ, Statistics NZ, and from other parts of the modelling process. In addition interviews and workshop were undertaken with stakeholders from the rural community, which were used to help develop and refine some of the assumptions and estimates of modelled interventions in the rural environment.

The report describes the characteristics of the catchment, models of rural land use, and the cost of mitigations being assessed for the rural sector.

2 Characteristics and economics of rural land uses in the catchment

The Porirua Whaitua land use is shown in Figure 1 and Table 3 below. It is dominated by pastoral sheep, beef and deer, which comprises 42% of the rural area. Native vegetation and scrub, together with urban area are each approximately half the area in pastoral activities. Forestry is a reasonably significant land use at 13%, but lifestyle represents only 2% of the catchment (although some lifestyle land may be classified as pastoral land). Horticulture is not a major feature with only 13ha all of it occurring on smaller blocks.

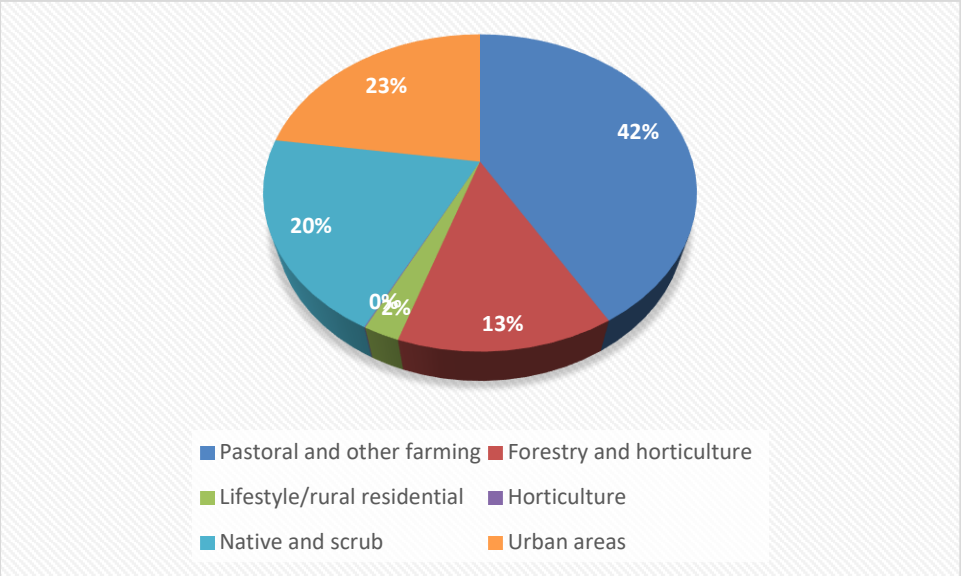

Figure 1: Proportion of Porirua Whaitua by land use

Table 3: Land use in Porirua Whaitua

Land use	Area (ha)	Proportion (%)
Pastoral and other farming	8,424	42%
Forestry	2,723	13%
Lifestyle/rural residential	457	2%
Horticulture	13	0%
Native and scrub	4,028	20%
Urban areas	4,594	23%
Total	**20,227**	**100%**

The sheep and beef land is primarily in sheep, although one property interviewed ran only beef, and another had a small proportion of beef cattle for grazing management and farm system purposes. Other landholders saw beef cattle as too difficult to manage on the steep country. The sheep and beef blocks are in larger units, ranging from 55ha up to ~800 ha for the largest farm in the catchment. It appears that almost all the flatter country has been subdivided for lifestyle blocks and other small holdings, and the nature of these larger sheep and beef properties appears to be primarily rolling to steep, with only very limited areas of flat country. Some of this country appears to be potentially worked with a tractor, but the sowing of winter feed crops or pasture renewal through cultivation and sowing does not appear to be common practice.

Beef and Lamb NZ provided data from their farm survey on two relevant classes – Class 5 (NI Intensive Finishing) and Class 3 (NI Hard Hill country). The data sample was drawn from the lower NI, specifically the districts of Horowhenua, Kapiti Coast, Porirua City, Upper Hutt City, Lower Hutt City, Wellington City. More specific data was not able to be provided for confidentiality reasons.

The Beef and Lamb data breakdown of landforms from their sample data is shown in Table 4 below, which suggests that the NI Hard Hill country type property (Class 3) is the most appropriate match. The sheep and beef properties in the Porirua Whaitua are likely to experience higher rainfall (1200 - 1600mm), and the slope descriptions tally well with 17% of the sheep and beef land in the flat to rolling category, and the remainder in strongly rolling to steep and steep land.

Table 4: Rainfall and land types for sheep and beef properties in eastern lower NI (Beef and Lamb NZ)

Beef and lamb class	Rainfall	Flat (ha)	Rolling(ha)	Steep (ha)	Total (ha)
N.I. Hard Hill Country (Class 3)	1,030	17	65	389	472
N.I. Intensive Finishing (Class 5)	1,132	138	30	70	238

Stocking rates from the Beef and Lamb NZ data for the Class 5 property are 7.2 su/ha, with 70% sheep and 30% cattle stock units. This proportion of cattle is higher than has been evident from discussions with landholders in the area, and the overall stocking rate for the Porirua sheep and beef properties appears likely to be lower at 5.2 – 7 su/ha. This reflects the fact that for many of the operations the owners are retired or have other sources of income in addition to farming. The model has therefore been developed to reflect a lower stocking rate but at similar per stock unit production. Expenditure was varied based on feedback from the rural stakeholders group, which has suggests lower revenue, significantly higher expenditure, and significantly lower profit than the average farm figures from Beef and Lamb NZ. The revised budget is shown in Table 5. The key items that have been changed are:

- Wages have been removed as most farms appear to be owner operator only.
- Fertiliser has been decreased to $25/ha, given the apparent lower intensity of operations in the catchment.
- Rates have been increased in line with the higher costs associated with being in an urban dominated district. The figures received ranged from $23/ha on larger blocks to $800+/ha on smaller blocks. $100/ha has been added to the total standing charges
- Weed and pest control has been increased by 50% to reflect the costs of operating on small blocks and a peri-urban environment.
- Crop, grain and seed revenue was removed as this does not occur in the catchment.

The resulting model has revenue of $481/ha, expenses of $395/ha, and an operating profit of $87/ha. While the profitability of the resulting modelled operation is lower than Beef and Lamb typical properties in the lower NI, this is not unreasonable given the predominance of smaller properties, and lower intensity of operations in the catchment.

The horticulture budget is also attached in Table 6 based on blackcurrants as discussed at the meeting with rural stakeholders. This has a revenue of $8000/ha and expenses of $5,300/ha, with an operating profit of $2,700/ha. The resulting operating profit is likely to be significantly lower than a typical blueberry operation, which may result in an underestimate of horticulture returns in the catchment given that blueberries appear to be the dominant crop. However given the smaller size of the horticulture operations in the catchment, and the

presence of a number of other operations, the use of this budget is considered not unreasonable.

Table 5: Revised sheep and beef operating budget

Stocking rate (su/ha)	6
Revenue ($/ha)	
Wool	$68.48
Sheep	$257.96
Cattle	$132.03
Dairy grazing	$0.00
Deer	$0.00
Other	$22.89
Gross farm revenue	**$481.37**
Expenditure ($.ha)	
Wages and rations	
Animal health	$19.54
weed and pest	$14.69
Shearing	$26.80
Fertiliser and lime	$25.00
Seeds	$1.46
Vehicles, fuel and electricity	$17.81
Feed and grazing	$13.86
Cultivation and Sowing	$0.00
Cash Crop sundry	$0.00
Repairs and maintenance	$69.61
Other working expenses	$24.80
ACC and insurance	$15.73
Other standing charges	$148.47
Total cash expenditure ($/ha)	**$377.77**
Depreciation	$17.01
Total expenditure excl interest ($/ha)	**$394.79**
Farm operating profit before interest, wages of management and other capital costs($/ha)	**$86.58**

Table 6: Horticulture operating budget

Revenue ($/ha)	
Horticulture	$8,000.00
Gross farm revenue	**$8,000.00**
Expenditure ($/ha)	
Wages and rations	$955.00
weed and pest	$1,371.00
Fertiliser	$175.00
Vehicles, fuel and electricity	$980.00
Repairs and maintenance	$120.00
ACC and insurance	$215.00
Other standing charges	$485.00
Total cash expenditure ($/ha)	**$4,301.00**
Depreciation	$1,000.00
Total expenditure excl interest ($/ha)	**$5,301.00**
Farm operating profit before interest, wages of management and other capital costs($/ha)	**$2,699.00**

The lifestyle block holdings all reported sheep or cattle only systems on any productive land, plus some other stock such as chickens, horses, ducks and bees. None of the lifestyle farms interviewed sold any stock commercially, and all were either eaten on the block or gifted to family and friends. One block grazed horses for agistment and alpacas on a small scale, and there were other farm enterprises such roses and herbs, hazelnuts, blueberries and a saddlery. All lifestyle blocks had off farm income associated with them.

There is a significant area of plantation forestry in the catchment (2723ha), mostly on steeper ground (>95%). The economics of forestry on steeper country is that larger blocks are required to are necessary to enable higher fixed harvesting costs (such as roading and machinery) to be spread over the larger volume. Following feedback from the community group about the difficulty of economically harvesting some forestry blocks, the report uses a threshold of 10ha as a minimum size for economic harvest (MOF, NZFRI, 1996). It is estimated that 70% of the forestry land is in blocks larger than 10ha.

Returns for forestry have been estimated on the same basis as Ruamahanga analysis (A. Daigneault, pers.comm), which utilises a Landcare/Scion model for yields (Kirschbaum & Watt, 2011), the weighted average of the last five years' MPI historic log prices[1], and Motu Forest Profit Expectations dataset for costs[2]. These were generated as a NPV of returns, then converted into annual equivalent figures at an 8% discount rate result. The results are shown in Table 7 below.

[1] http://www.mpi.govt.nz/news-and-resources/open-data-and-forecasting/forestry/wood-product-markets/historic-indicative-new-zealand-radiata-pine-log-prices/

[2] https://motu.nz/our-work/environment-and-resources/lurnz/forest-profit-expectations-dataset-1990-2013/

Table 7: Forestry revenue, expenses and operating profit ($/ha/annum)(Diagneault, pers.comm)

Item	$/ha/annum
Revenue	$2178
Expenses	$1589
Operating profit	$590

3 Impact of mitigations

3.1 Scenarios

There are three major scenarios being considered in the Porirua catchment. These are Business As Usual, which continues the current approach to land management, Improved Management, and Water Sensitive Urban Development (WSUD). Each of these has different combinations of mitigation measures (Table 8), but because the management of Transmission Gully and forestry areas are the same across all three scenarios, the key impacts for rural stakeholders in the catchment from mitigation requirements are riparian fencing and planting, pole planting on erodible land, and retirement.

Table 8: Scenarios for modelling of changes in water quality outcomes under different land management practices

Requirement	Scenarios		
	Business as usual	**Improved**	**WSUD**
Erosion prone land stabilisation	None	Retirement of class 8 and 7e pastoral land and space planting on class 6e pastoral land (LUC)	Retirement of class 8, 7e and 6e pastoral land (LUC)
Transmission Gully offset	Retirement of specified areas	Retirement of specified areas	Retirement of specified areas
Forestry sediment management	Proposed National Environmental Standard for Plantation Forestry	Proposed National Environmental Standard for Plantation Forestry	Proposed National Environmental Standard for Plantation Forestry
Riparian management	Current planting - no additional	Stock exclusion and 5m riparian planting on all streams	Stock exclusion and 10m riparian planting on all streams

3.2 Fencing and planting

Stream planting options from national studies were presented at the stakeholders workshop. However review at the workshop and by Jamie Peryer (Land Management Advisor, Kapiti/Porirua) highlighted that nationally based assumptions around the costs of establishing native vegetation on buffers were too low for the Porirua whaitua. Current planting costs in the GWRC area are estimated at $50/m for a 5 m buffer and $125/m for a 10 m buffer for both sides of the stream planted with natives. These costs are reasonably high, but reflect strong grazing pressure from pest populations, herbicide application, and site visits for establishment and maintenance. They are higher but not unreasonably so when compared with the nationally based assumptions when allowing for both sides of the stream and maintenance.

This analysis therefore suggests an estimate in the order of $50/m for planting and maintenance of both sides with a 5m planted strip ($25/m one side), and $100/m for a 10m planted strip ($50/m one side), with costs spread 60%, 20% and 20% for years 1, 2 and 3 to allow for follow up release spraying and maintenance. The predominance of sheep in the catchment indicates that the higher costs for permanent fencing are likely to be appropriate, and because there is a slope limitation of 15 degrees on the reaches of streams requiring fencing, the fencing costs for exclusion of sheep on flat land ($20/m) are considered appropriate. Annual maintenance costs of $2.50/m are appropriate for fencing and planting subsequent to year 3.

Streams requiring fencing are defined as REC[3] orders 2 and above, and order 1 in catchments with an average slope <15 degrees. Jacobs used LINZ regional imagery for 2012/13 to assess the coverage of streams by woody vegetation as an indicator of the extent of fencing and planting in the catchment. The results of their analysis for two predominantly rural catchments is provided in Table 9. This shows that 47% of stream length is not planted in the case study catchments, and for streams running through pastoral land cover approximately 70% is not planted. Using these figures to represent both planting and fencing may overestimate the extent of fencing required, because there will be streams that have been fenced, and areas that have been fenced and planted but for which the planting is too young to show up in aerial photos as woody vegetation.

Table 9: Proportion of streams requiring fencing

Planting status	Proportion of stream length
Pastoral land cover not planted	47%
Pastoral land cover planted	16%
Non pastoral cover	36%
Total	**100%**

3.3 Space planting

Space planting is indicated on the 6e hill country with the Improved scenario. The estimated cost of 60 poles per ha, at a cost of $30 per pole was questioned by stakeholders who argued that pole planting was not feasible on the hill country due to dry summers challenging their establishment. This was tested with Jamie Peryer (Land Management Advisor, Kapiti/Porirua), who advised that poplar and willow poles will struggle to grow, particularly on faces with north or west aspects and with a particularly dry summer. He notes that planting is limited to the

[3] Using NIWAs River Environment Classification (REC) system.

toes of slopes and gullies to limit landslide erosion, rather than over the whole of 6e land types. These toe slopes and gullies would generally be suitable for pole planting because they are in a more sheltered situation. Using this approach reflects better the both the feedback from stakeholders and current planting programmes being undertaken by GWRC. Based on this GWRC feedback an average of 15 stems per ha is allowed for space planting on 6e at $7.50/ha, with the likelihood that this planting will be concentrated on parts of the that 6e land rather than across the whole area.

3.4 Land retirement

Land retirement is a component of the Improved and WSUD scenarios. The majority of the land requiring retirement will be on the larger properties, with smaller properties typically (but not exclusively) located on flatter land. Feedback was received from stakeholders on values of their properties, and this information was compared with the rating valuation database (pastoral land use categories, excluding properties <5ha and some high value properties outside the catchment such as the recently subdivided Pikarere farm). The valuations in figures from individuals in the stakeholder group ranged from ~$6000/ha to $130,000/ha+ over 4ha plus properties, but $900,000+ for smaller blocks, while the valuation database figures range from $500,000/ha+ down to $5,000/ha. The valuation database was cleaned and truncated at a minimum property size of 5ha, and with a maximum per ha valuation of $200,000 per ha (to exclude outlier very small or very high value properties). The spread of per ha value by parcel size is shown in Figure 2 and shows that there is a large range of per ha values, and that these are dependent on parcel size in what is likely to be a power law relationship – i.e. the smaller the parcel the exponentially larger the per ha valuation is likely to be.

In terms of assigning a value to retired land, it is not likely that the very desirable small properties on flat land will be required to retire much land, and that retirement is most likely to occur on the less desirable parts of larger properties. Furthermore only the pastoral values associated with a property are likely to be lost with retirement – while the stakeholder group has indicated that open pasture is the most sought after feature of property in the catchment, there are still values associated with land that may be retained after retirement planting.

These factors suggests that a value that is skewed towards the lower end of the range shown in Figure 2 is likely to be most appropriate to represent the losses to landholders. An approach which adopts the 20th percentile value of the truncated (as above) land values land is suggested as an appropriate value to represent the cost of land no longer available for pastoral activities. The 20th percentile valuation for the truncated valuation database is $10,700/ha, which is higher than the per ha value of some of the larger properties, but is substantially less than the losses that might be experienced for a smaller lifestyle block.

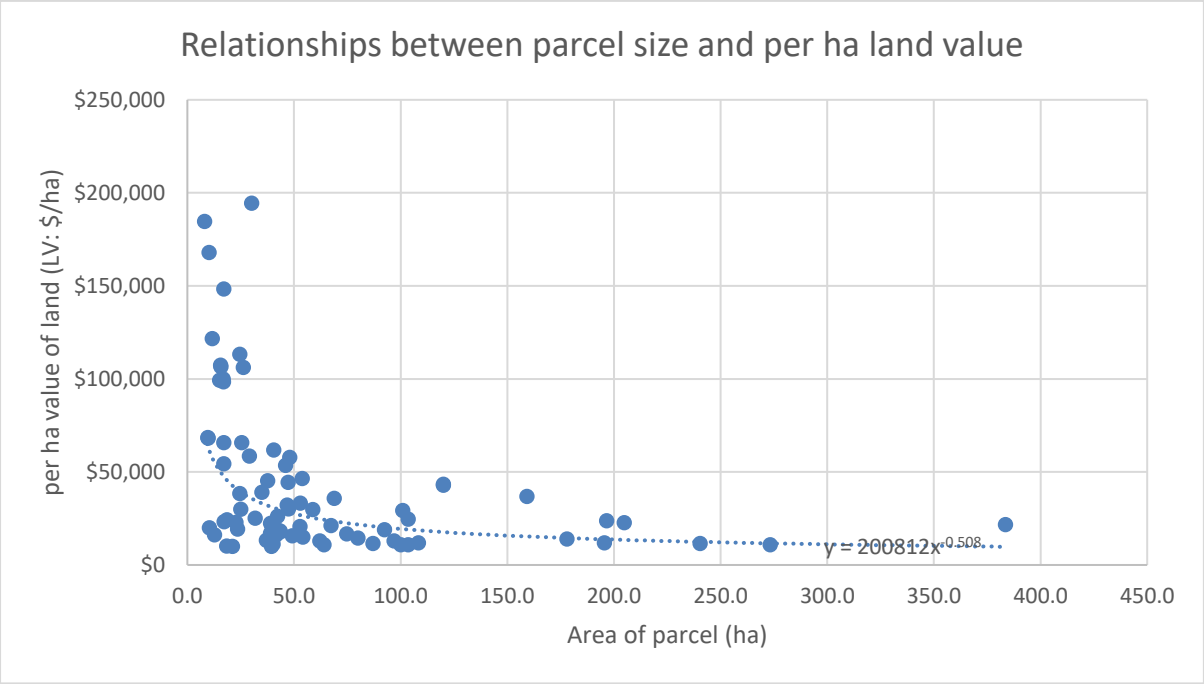

Figure 2: per ha value of land by parcel size for Porirua catchment (Source: GWRC valuation database)

In addition to the costs associated with loss of land value there will be a requirement for additional fencing. These are difficult to quantify because the areas that are fenced may be larger than the areas that require retiring because of practical limitations on where fences can be installed. Furthermore some of the block boundaries may be paddock or property boundaries that are already fenced. We have therefore used a crude measure which is the ratio of perimeter of GIS polygons to area, adjusted by 50% to take into account joint boundaries and other natural features. This allows for 60m of fencing/ha for class 6e, and 40m of fencing per ha for class 7e and 8[4]. Allowing for exclusion of sheep, beef and cattle, and the steepness of terrain involved, $35/m of fencing is allowed. This results in an additional cost of $$2100/ha for LUC class 6e land, and $1400/ha for class 7e and 8.

3.5 Estimating land required for space planting and retirement

There are some difficulties in using noted the difficulty of using regional NZLRI classification in the scenario modelling because the regional scale mapping is very coarse and assigns land to classes 6e and 7e which would not be classified in that manner when mapped to farm scale[5]. Comparison of more detailed farm scale mapping with the regional NZLRI mapping suggest that while there not an exact match: Class 6e is reasonably close (underestimated in NZLRI by 18%), and the combination of erodible classes (6e, 7e and 8e) are also close with an overestimation by NZLRI of 15%. Class 7e appears to be reasonably significantly overestimated by NZLRI (farm scale is only 45% of NZLRI), with some of the NZLRI 7e being 6e in farm scale mapping.

[4] The perimeter/area ratio was higher for class 8 but there are only very small areas involved so the figures are considered not robust enough to take into account here, and the ratio for Class 7 land has been used.
[5] Jamie Peryer pers.comm. November 2017

The initial scenario modelling will use the coarser scale LUC mapping, but the actual impacts in terms of area planted and retired are likely to be more limited. The importance of this overestimation issue that may need to be addressed depending on the significance of the mitigations achieved through retirement and pole planting, and the scope of the likely differences in costs and benefits from using more accurate mapping of erodible land is being explored further in the modelling process. From an economics perspective these differences between farm scale and NZLRI are likely to mean that for the initial modelling:

- The Improved scenario will significantly overestimate the costs of retirement on Class 7e land, but slightly underestimate the cost of space planting.
- The costs of the WSUD scenario will be slightly overestimated but within the scope of overall errors for this type of modelling.

Table 10: Differences between farm scale mapping of LUC and NZLRI regional scale mapping (Jamie Peryer, GWRC, pers.comm)

LUC Class	**Ratio farm scale mapping/NZLRI**
6e	119%
7e	45%
8e	123%
Combined 6e, 7e, 8e	85%

The areas of land affected are described in Table 11 and Table 12 below. They show that there is approximately half of pastoral land requiring planting or fencing, and approximately 30% of lifestyle blocks. As noted above the LUC classification used to define these areas is coarse, and it is highly likely that with more detailed classification of slopes that the proportions affected will vary.

Table 11:Area of land by land use and LUC class (ha)

Land use	**Class 2-4**	**Class 6**	**Class 6e**	**Class 7**	**Class 7e**	**Class 8**	**Urban areas**	**Total**
Pastoral and other farming	897	3,334	2,605	25	1,464	84	14	**8,424**
Forestry and horticulture	77	541	1,026	12	1,064	0	4	**2,723**
Lifestyle/rural residential	146	137	97	6	12	36	23	**457**
Native and scrub	130	415	1,526	91	1,712	106	49	**4,028**
Urban areas	81	593	545	5	61	5	3,304	**4,594**
Total	**1,331**	**5,020**	**5,799**	**139**	**4,314**	**231**	**3,393**	**20,227**

Table 12: Proportion of land affected by space planting and retirement requirements

	Improved scenario			Water sensitive	
	Not affected	Space planting	Retire	Not affected	Retire
Pastoral and other farming	51%	31%	18%	51%	49%
Lifestyle/rural residential	68%	21%	11%	68%	32%

4 Summary of mitigation costings

Mitigation	Basis	Cost	Metric
Stream fencing	Fencing one side to exclude sheep and larger animals, flat slope	$20	$/linear m
Planting 5m strip	Cost of planting one side of a stream	$25	$/linear m
Land retired with 5m buffer strip	From value of retired land	$5.35	$/linear m
Planting 10m buffer	Cost of planting one side of a stream	$50	$/linear m
Land retired with 5m buffer strip	From value of retired land	$10.70	$/linear m
Maintenance of fence and buffer	Cost of maintenance one side of stream	$2.50	$/linear m
Pole planting	Cost of planting poplars 15 stems/ha (average for all of 6e land)	$7.50	$/ha
Retirement ($/ha capital costs)	20th percentile of QV per ha values	$10,700	$/ha
Fencing of retired areas	Cost of excluding sheep and large animals on steep land, 50% of perimeter/ha from affected GIS polygons	$2,100/ha for 6e, $1400/ha for 7e, 8	$/ha

Acknowledgements

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5 References

Kirschbaum, M. U., & Watt, M. S. (2011). Use of a process-based model to describe spatial variation in Pinus radiata productivity in New Zealand. *Forest Economy and Management*, 262: 1008-1019.

MOF, NZFRI. (1996). *Establishing a small forest.* Wellington: Ministry of Forestry Small Forest Management 5.