Selecting catchments for streamside management assistance

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Executive summary

The careful management of riparian (streamside) areas can help keep most kinds of stream environments in a reasonably natural condition, even if the stream runs through rural or urban land. Streams without protected vegetated streamside areas can become degraded and their aquatic habitat can be compromised.

There are thousands of kilometres of streams in the Wellington region that would benefit from streamside management. Greater Wellington cannot financially support the rehabilitation of all of them. Our assessments showed that the best community returns accrue when there is full streamside retirement and restoration on streams with high ecological value.

Greater Wellington adopted five criteria in its Riparian Management Strategy to identify the streams that would benefit most from assistance. This report describes the process of applying those criteria using Geographic Information System (GIS) modelling to select the high value catchments.

The modelling process identified 12 catchments that collectively meet all five criteria in the strategy. A ground truthing exercise confirmed the GIS data for land cover and land uses. The accuracy of the GIS data for the other attributes was not assessed.

The 12 catchments eligible for financial assistance for streamside management are:

- Waitohu Stream and Otaki River (flow to the Kapiti Coast)
- Ration Creek (flows to the Pauatahanui Inlet)
- Mangaroa River (Hutt River tributary)
- Karori Stream and Wainuiomata River (flow to Cook Strait)
- Glendu Creek and Kaiwhata River (flow to Wairarapa east coast)
- Owhanga Stream (flows to Lake Wairarapa from the Tararua Range)
- Waiohine River (Ruamahanga River tributary)
- Upper Ruamahanga River (source in the Tararua Range)
- Waihora Stream (lower Ruamahanga River tributary).

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1. Introduction

Greater Wellington Regional Council adopted its Riparian Management Strategy in July 2002.[1] The Strategy includes criteria for selecting the streams that will be given assistance for riparian management and describes what that assistance will be.

Greater Wellington will provide financial support to landowners with land where streamside conditions are threatening what would otherwise be healthy aquatic ecosystems. This decision was made because rehabilitating these streamside areas with appropriate native species will not only achieve significant benefit to the stream's water quality and aquatic habitat, it will strengthen biodiversity in the stream catchment and surrounding area.

2. Prioritising streams to target for financial assistance

The criteria given in the Strategy to identify streams that will be eligible for financial assistance are:

- The stream already has a reasonable amount of high quality aquatic habitat that can be extended and improved by riparian management.
- Riparian management will be effective at rehabilitating any degraded aquatic habitat in the stream catchment.
- The stream will be able to be a functioning ecosystem for the aquatic life that would naturally live there (for example, there are no major barriers to fish passage).
- The stream could provide ecological links and corridors once it is rehabilitated because of the relatively short distance to the sea or Lake Wairarapa.
- The selected stream catchments are representative of the range of stream types in the region.

There is no criterion for addressing cultural values. According to views expressed by iwi during preparation of the Strategy, providing spiritual or cultural value to Maori with streamside rehabilitation is a matter to be taken into account on a stream by stream basis. Notwithstanding this, all Iwi consulted saw the restoration of stream habitats and their ecology as important for food gathering and other cultural purposes.

2.1 Applying the criteria

The criteria were applied in two stages using Geographic Information System (GIS) modelling. Stage 1 short-listed a selection of streams with high quality habitat where riparian management should be effective at rehabilitating degraded areas. Stage 2 applied scores for the ecological diversity that could exist in the short-listed catchments. These exercises are described in sections

[1] Greater Wellington Regional Council (2002). *Greater Wellington's riparian management strategy.*

2.2 and 2.3 below. For the third and final stage of the process, described in section 3, the River Ecosystems Group reviewed the short-listed catchments and checked the GIS desktop results against actual stream and catchment conditions, with the aim of reducing the number of qualifying catchments to a manageable number. The process is shown in Figure 1 below.

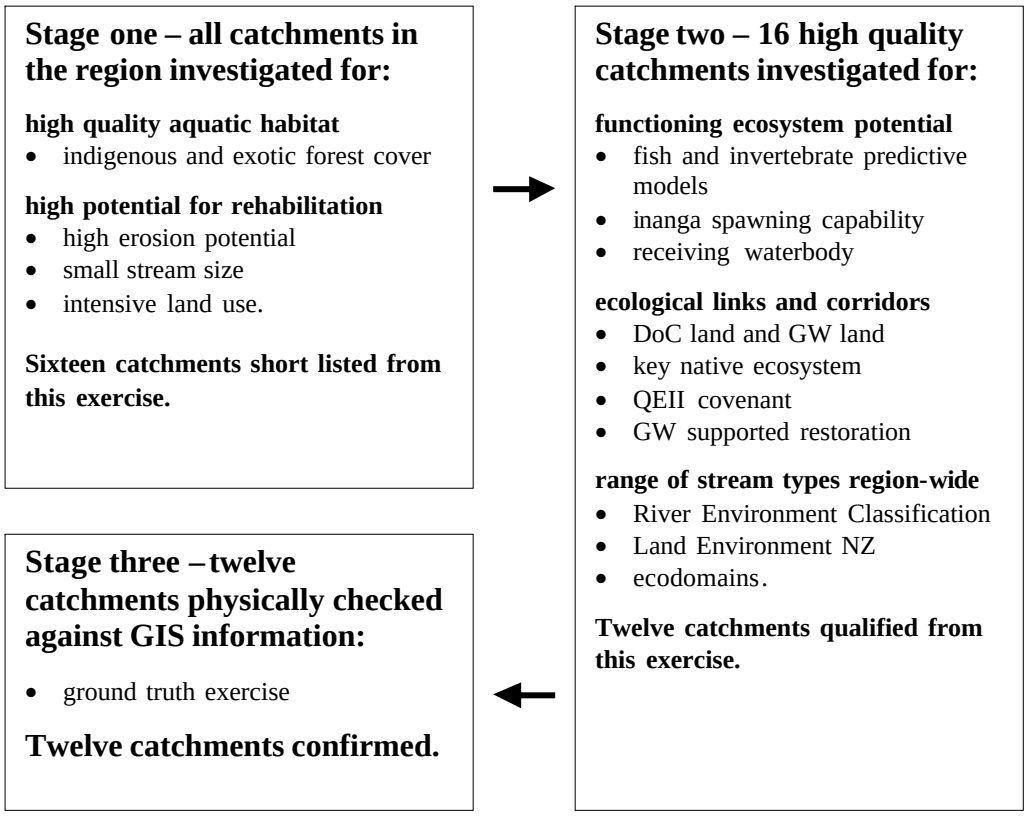

Figure 1 Applying the criteria to identify high priority catchments

2.2 Identifying where poor streamside conditions could threaten healthy aquatic ecosystems

2.2.1 Streams with high quality aquatic habitat

Protecting streams that are in their natural condition is a more efficient and effective way of safe-guarding the life-supporting capacity of the ecosystems than rehabilitating degraded streams. But no streams in the Wellington region are in their natural condition from source to sea. The first criteria - to prioritise streams with "a reasonable amount of high quality aquatic habitat that can be extended and improved by riparian management" - recognises that streams with high quality habitat are likely to be degraded in parts.

The proportion of indigenous vegetation in each catchment was used as a first cut surrogate-measure of the quality of stream habitat because of the very limited data on actual stream habitat. This measure highlighted the scarce indigenous vegetation cover in the Wairarapa valley (see Figure 2 below).

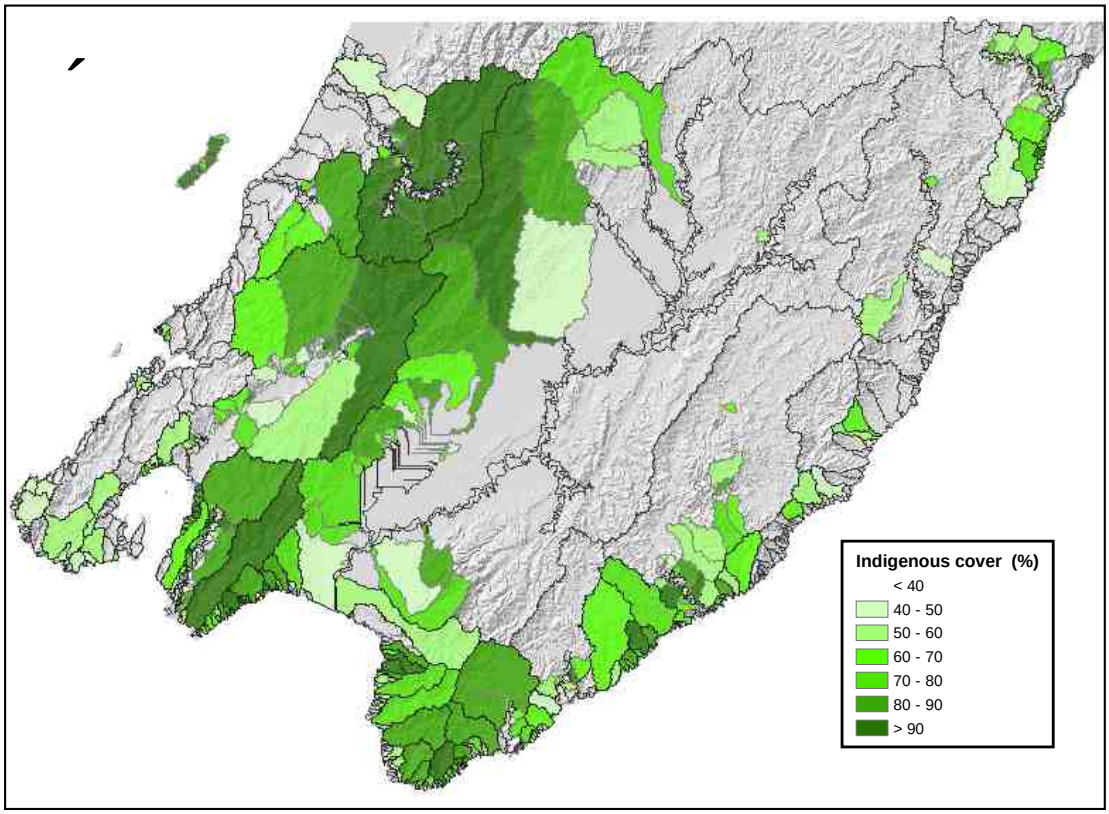

Figure 2. Catchments where land cover is more than 40 percent indigenous vegetation

The selected catchments need to cover the range of stream types in the region but without good coverage of Wairarapa streams, some stream types may have been excluded from the programme. Better regional coverage was investigated by identifying catchments where the amount of indigenous vegetation and exotic forestry combined came to more than 40 percent.

This decision was made because studies show that streams surrounded by exotic forestry can support good aquatic life. The catchments with more than 40 percent indigenous vegetation and exotic forestry combined were then deemed to meet the criterion of having a "reasonable amount of high quality aquatic habitat". They are shown in Figure 3, below.

Streams larger than fourth order[2] were excluded because they are generally too wide to benefit from riparian management, and can have flood control issues.

[2] Stream order is determined by whether a stream has tributaries or not. First order streams have no tributaries. Second order streams have only first order tributaries. Third order streams have at least one second order tributary, and so on.

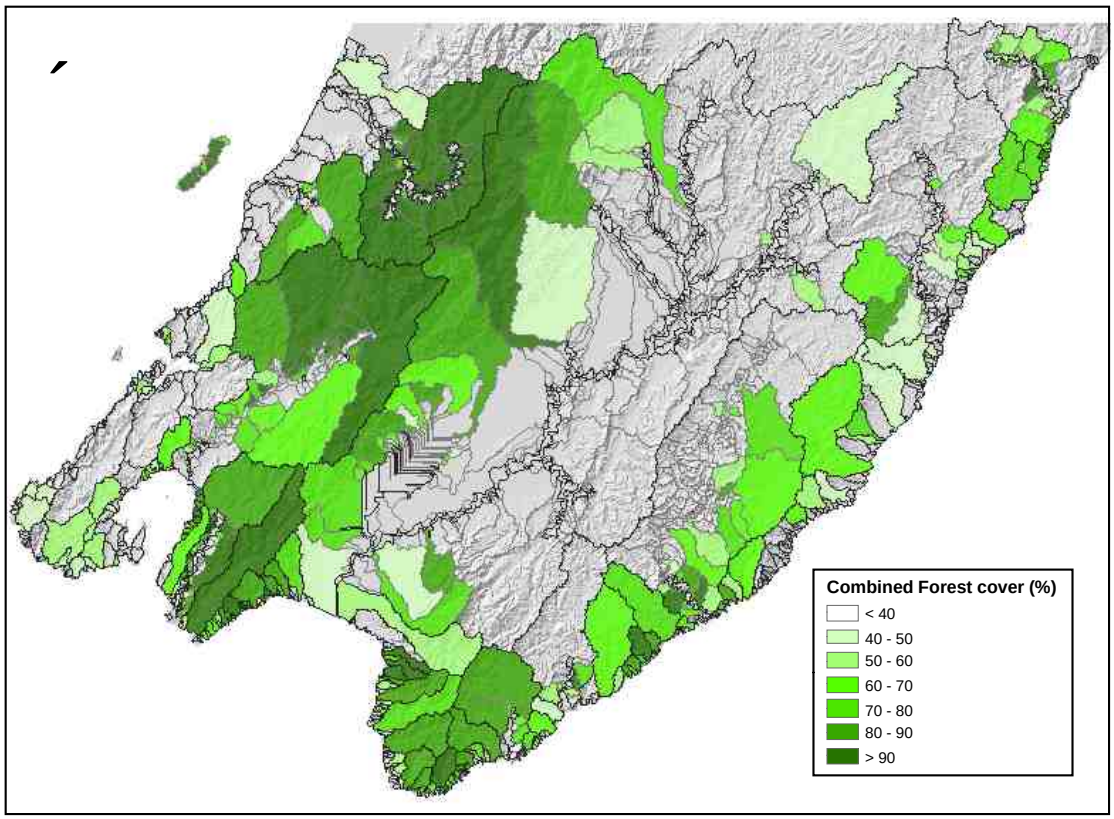

Figure 3 Catchments with indigenous vegetation and plantation forestry

2.2.2 Streams where riparian management will be effective

Riparian management can rehabilitate degraded instream environments by improving stream bank stability, restricting stock access, providing stream shade, removing high nutrient loads, filtering pollutants, and adding wood and plant matter to the stream. Riparian management is especially effective in achieving these benefits on small streams with open channels that are affected by overland runoff, sedimentation and bank damage from stock.

To identify these small streams, we used GIS modelling to score all streams according to their size, the erosion vulnerability of soils in the catchment, and whether the surrounding land uses would contribute to overland runoff, streamside damage or cause other adverse effects on water quality. Deer and cattle, which can cause serious damage to stream banks because of their size and liking for waterways, were given a higher weighting than sheep. The scores were assigned as follows.

1. the land use is deer farming, or beef or dairy farms with stocking rates greater than 2.7 units per hectare: score = 20
2. the land use is beef or dairy farms with stocking rates less than 2.7 units per hectare: score = 15
3. all other farm types: score = 10
4. soil types are loess, peat, wind blown sand: score = 20
5. the Land Use Classification is 6, 7, or 8: score = 15
6. all other soil types: score = 10

The results produced scores ranging from 100 to 400 for all stream sections, with all streams of fourth order or less scoring at least 100. There are 7,765 km of streams scoring 100, while only 70 km of stream sections scored 400. These most highly vulnerable streams (small streams with high stocking rates on erosion prone land) are listed in Appendix 1.

Figure 4 shows the distribution of at-risk streams scoring over 200.

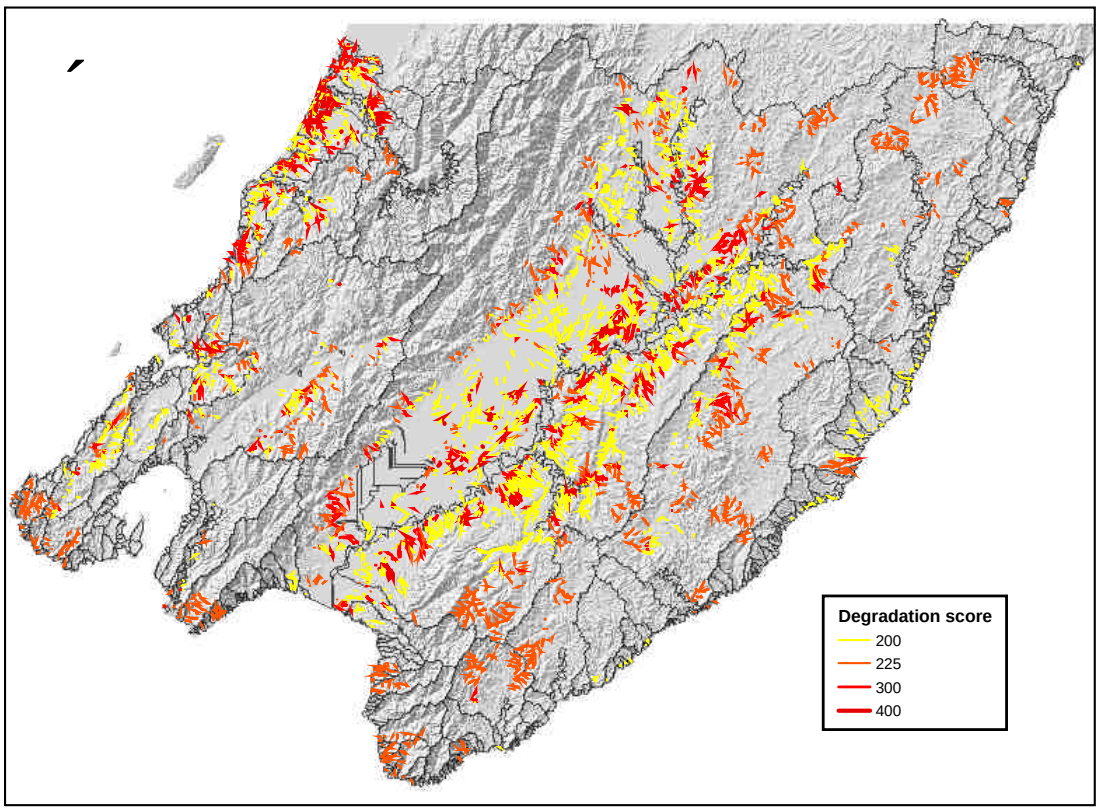

Figure 4 At-risk streams based on stream size, soil type, and surrounding land use

Combining Figures 3 and 4 shows the 'quality' of catchments the at-risk streams flow through (see Figure 5). Not surprisingly, the most at-risk streams are flowing through catchments with less than 40 percent combined forest cover (indigenous vegetation and exotic forestry).

Figure 6 shows the high quality catchments and the sections of streams likely to be most at-risk of having degraded aquatic habitat. These catchments satisfy two of the criteria required before financial assistance would be made available:

- The stream already has a reasonable amount of high quality aquatic habitat that can be extended and improved by riparian management.
- Riparian management will be effective at rehabilitating any degraded aquatic habitat in the stream catchment.

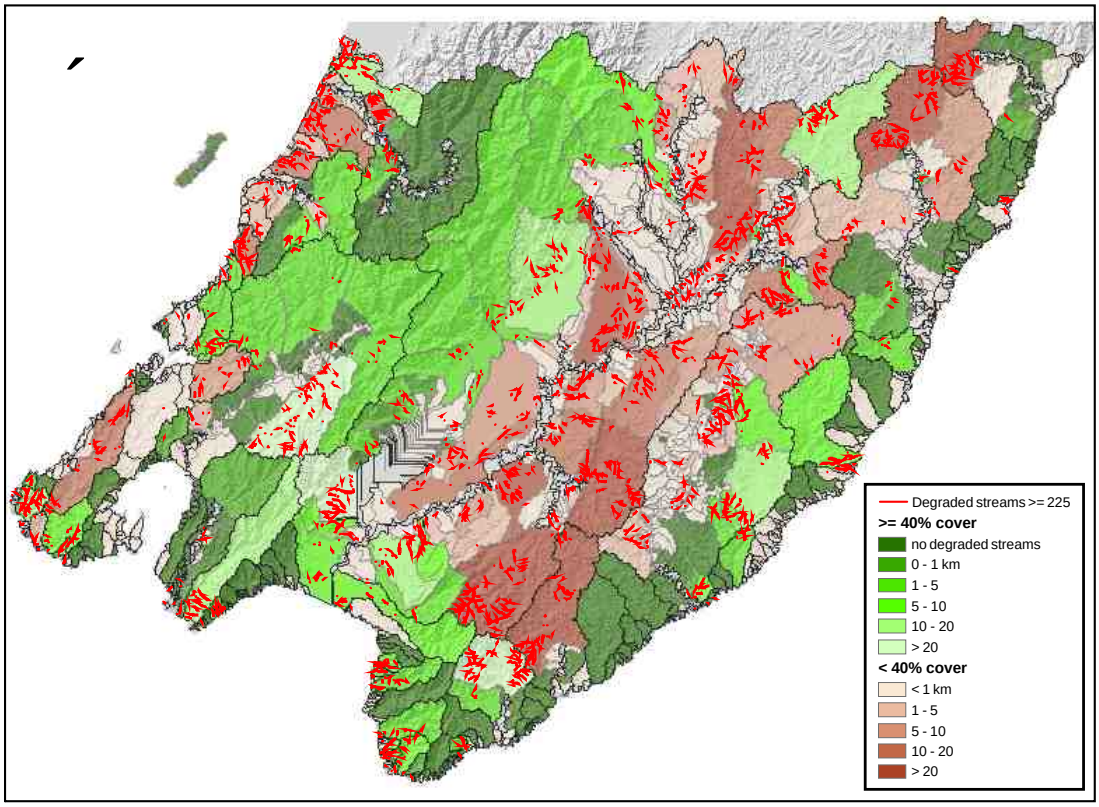

Figure 5 Overall picture of the most at-risk streams and the amount of catchment cover

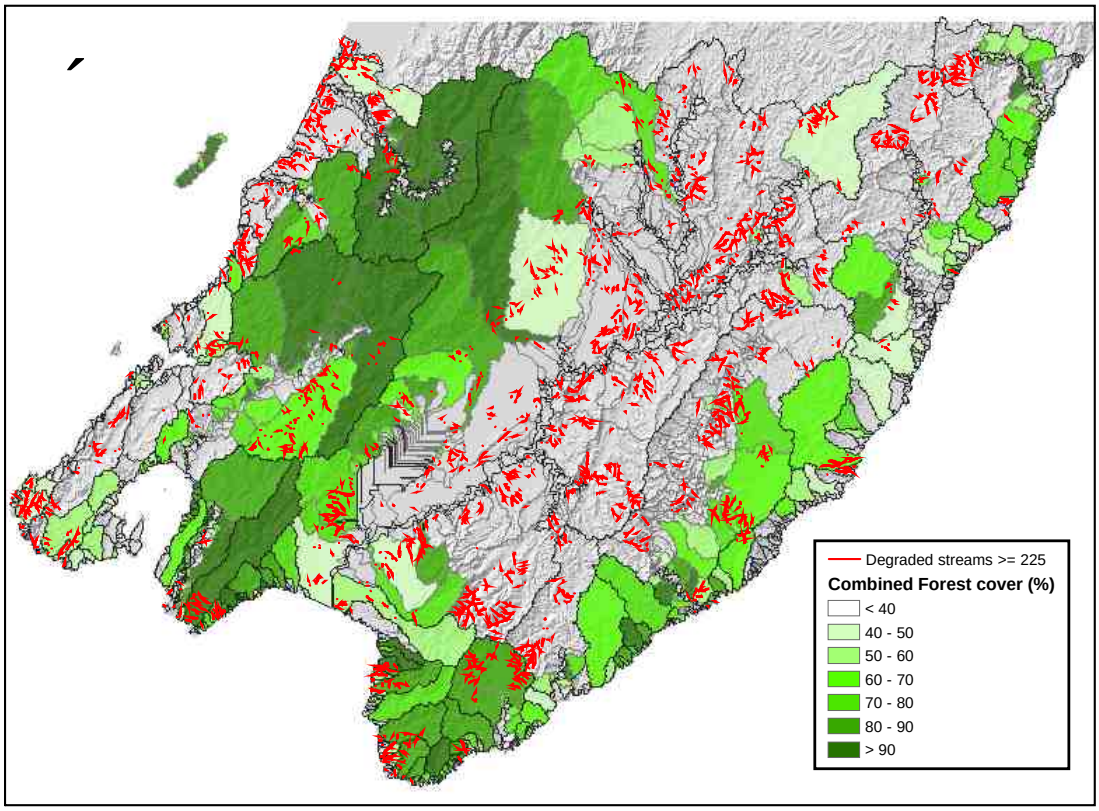

Figure 6 Most at-risk streams in the highest quality catchments

Sixteen catchments were short-listed for the Stage 2 assessment by inspecting Figure 6 and identifying catchments

- with the most indigenous vegetation and exotic forestry, and
- with some, but not too many, degraded stream sections in them, and
- that appeared to have a range of River Environment Classes and LENZ classes in them (see Figures 10 and 11).

The assessment would be extended to other catchments in Figure 6 if all the Stage 2 criteria couldn't be met from the short-list.

2.3 Promoting biodiversity

Stage 2 assessed the extent to which 16 short-listed catchments could promote biodiversity and so meet the remaining three criteria in the Strategy. The 16 catchments were –

- Waitohu Stream and Otaki River (Tararua Range to Kapiti Coast)
- Ration Creek (to the Pauatahanui Inlet between Pauatahanui Stream and Horokiri Stream)
- Mangaroa River (Hutt River tributary from Blue mountains)
- Karori Stream, Wainuiomata River, Mangatoetoe Stream (hill country to Cook Strait)
- Glendu Creek, Kaiwhata River, Whakataki River (hill country to Wairarapa east coast)
- Owhanga Stream (Tararua Range to Lake Wairarapa)
- Waiohine River (Tararua Range Ruamahanga River)
- Upper Ruamahanga River (source in the Tararua Range)
- Waihora Stream (lower Ruamahanga River tributary from Te Maunga)
- Mangatopitopi Stream and Stoney Creek (Tauweru River tributaries)

2.3.1 Stream can be a functioning ecosystem

Functioning stream ecosystems need a range of aquatic habitats to support a diverse population of species. Fish are a high profile component of a functioning stream ecosystem. There have been 31 freshwater fish species recorded in the Wellington region since 1921, of which 23 are native.[3] One, the grayling, is now extinct. Five species (the shortjaw kokopu, giant kokopu, brown mudfish, and long finned eel) require conservation action.[4]

[3] Strickland, R, and A Quarterman (2001). *Review of freshwater fish in the Wellington Region*. Cawthron Institute and Wellington Regional Council.

[4] Department of Conservation (2002). NZ threat classification system lists. Department of Conservation, Wellington.

Habitat requirements for native fish vary between species and even within species according to their stage in the life-cycle. For example, inanga like low altitude (< 200 metres) open rivers, streams, lakes, and swamps near the coast, koaro prefer rocky, tumbling well-forested streams, giant bullies like slow flowing coastal habitats, and bluegill bullies inhabit similar habitat as torrentfish – swift broken water in open rivers and streams.

Up to 36 aquatic invertebrate species are commonly found in the Wellington region. They are an essential part of any freshwater ecosystem and some, like mayflies, cannot tolerate high temperatures often associated with unshaded streams.

Fish and invertebrate species presence and diversity were estimated using the predictive GIS based models "point-click-fish" and "point-click-critter".

Point-click-fish compares information from the River Environment Classification (REC - see Appendix 3) with habitat preferences of 18 native fish species and their recorded whereabouts as reported on the NZ freshwater fish database to predict which species are likely to be present in any stream in the region. Five native fish species (brown mudfish, grey mullet, yelloweye mullet, triplefins and black flounder) are not included in the model, but *Paranephrops planifrons* (koura) are. The result is given as a presence-probability for each reach of stream. Point-click-critter compares REC information with invertebrate habitat preferences to predict invertebrate presence.

The spawning habitat requirements of native fish are very specific. Inanga, for example, rely on tidally inundated riparian vegetation in or near the river estuary. Inanga spawning areas have been identified for most streams in the region (see Appendix 2). The banded kokopu, koaro and shortjaw kokopu lay their eggs on stream banks or amongst the coarse gravels on the stream margins when the streams in which they live are in flood.[5] Greater Wellington does not have information about the actual whereabouts of their spawning areas. Restoring the banks and margins of small gravel bed streams with suitable plants should enhance their spawning habitat and so improve the functioning of the ecosystem.

Eighteen of the native fish species recorded in the region need to migrate between fresh water and the sea. Streams that connect upstream habitat to the coast can provide for these migratory needs better than sub-catchments remote from the coast, provided there are no barriers to fish passage. Improving fish passage past major barriers[6] can be investigated as part of the stream rehabilitation process.

Table 1 shows scores for the functioning ecosystem potential of each stream catchment using five criteria which are –

[5] McDowall, R. (2000). *Hidden Treasures Exposed: discovering our freshwater fish fauna*. Cawthron Institute, New Zealand.

[6] Major barriers are identified in *Structures in rivers of the Greater Wellington region*. Greater Wellington (2003).

- the percentage of indigenous and exotic forest (as a measure of high quality aquatic habitat),
- the stream's connection to the sea (for its capability of meeting the needs of migratory species),
- the stream's inanga spawning capability,
- the number of fish species likely to be present,
- the number of invertebrate species likely to be present.

The predicted length of stream that could be compromising each stream's habitat is given to indicate the probable amount of work required for the stream. The actual length of stream that may need rehabilitating can only be worked out by physically inspecting the streams. In addition, for the streams to be functioning ecosystems, a whole catchment approach is required, not just rehabilitation of the most degraded areas.

Table 1 Functioning ecosystem potential

Catchment (hectares)	Length of most at-risk stream (km)	Percentage indigenous and exotic forest	Connection to sea, lake or river	Inanga spawning capability	Likely fish species present[7]	Likely invertebrate species present[8]
Glendhu Creek (676 ha)	6.4	58.9	Pahaoa River to Pacific Ocean	Good on Pahaoa: gravel soils but some good area on right bank	10	25
Kaiwhata River (10,210 ha)	9.6	69.4	Pacific Ocean	Not surveyed	17	31
Karori Stream (3,072 ha)	7.8	55.8	Cook Strait	No: gravel soils subject to grazing and vehicle use	15	30
Mangaroa River (10,310 ha)	30.2	63.5	Hutt River	No: too far up the catchment	18	34
Mangatoetoe Stream	5.4	88.8	Cook Strait	Not surveyed	7	28

[7] The number in this column represents the number of species (out of a possible 18) with a greater than 50% chance of occurring for more than 200 metres of stream length. The fish species by stream is in Appendix 2.

[8] The number in this column represents the number of macro-invertebrate species (out of a possible 36) with a greater than 50% chance of occurring for more than 200 metres of stream length. The macroinvertebrate species by stream is in Appendix 2.

Catchment (hectares)	Length of most at-risk stream (km)	Percentage indigenous and exotic forest	Connection to sea, lake or river	Inanga spawning capability	Likely fish species present[7]	Likely invertebrate species present[8]
(1,457 ha)						
Mangatopi-topi Stream (295 ha)	2.3	51.7	Ruamahanga River	No: too far up the catchment	7	19
Otaki River (34,788 ha)	27.1	88.4 %	Tasman Sea	Very good: in lower tributaries	17	33
Owhanga Stream (1,407 ha)	3	67.2	Lake Wairarapa	No: drains to the lake, not the sea	17	32
Ration Creek (677 ha)	5	58.0	Pauatahanui Inlet	Not surveyed	13	22
Stoney Creek (1,343 ha)	5.8	56.0	Ruamahanga River	No: too far up the catchment	8	21
Upper Ruamahanga (11,520 ha)	8.3	73.3	Ruamahanga River	No: too far up the catchment	14	36
Waihora Stream (2,238 ha)	7.8	85.1	Ruamahanga River (lower)	Low: some suitable areas in Lake Onoke	13	30
Wainuiomata River (13,378 ha)	2.1	43.0	Cook Strait	Very good: but mouth sometimes closed by bar	17	33
Waiohine River (20,346 ha)	2.9	92.8	Ruamahanga River	No: too far up the catchment	14	33
Waitohu Stream (4,580 ha)	12.7	47.7	Tasman Sea	Low: too sandy	16	30
Whakataki River (213 ha)	2.9	73.0	Pacific Ocean	Very good	7	9

2.3.2 Streamside planting could provide ecological links and corridors

To provide ecological links and corridors with planted riparian margins we identified which catchments had significant areas of indigenous vegetation and significant habitats of indigenous fauna. These areas are mostly in the Department of Conservation estate, or are part of land that Greater Wellington owns or manages as water collection areas or forest parks. Other areas that could be extended by ecological links and corridors are areas of public and private land protected by covenants or land where restoration projects are already taking place.

Some of the region's Key Native Ecosystems could also be extended by appropriate streamside planting. Key Native Ecosystems (KNE) are areas of native bush, dune vegetation, and wetlands that Greater Wellington has identified as being vital to the long-term viability of the region's unique plant and animal life. KNE are eligible for funding (up to 100%) for protection and enhancement measures like fencing, and plant and animal pest control if they are on private land. Greater Wellington also funds ecosystem rehabilitation and restoration work, primarily streamside planting, carried out by Care Groups throughout the region.

The amount of land in the short-listed catchments owned or managed by Greater Wellington or DOC, or identified as a KNE, a covenanted area, or a Care Group restoration project area is shown in Table 2.

2.3.3 Selecting a representative range of stream types

Three environment classification methods were used to provide confidence that the selected streams would be representative of the range of stream types in the region. These classification methods were eco-domains, the River Environment Classification (REC) and the Land Environment New Zealand (LENZ).

Ecodomains combine geology, geomorphology, meteorology, biology, and human resources with sensitive and extensive personal knowledge of the ecological processes of the Wellington region. The basis for the classification is similar to LENZ. The eco-domains (developed by Isobel Gabites) represented among the short-listed catchment are shown in Figure 7 below.

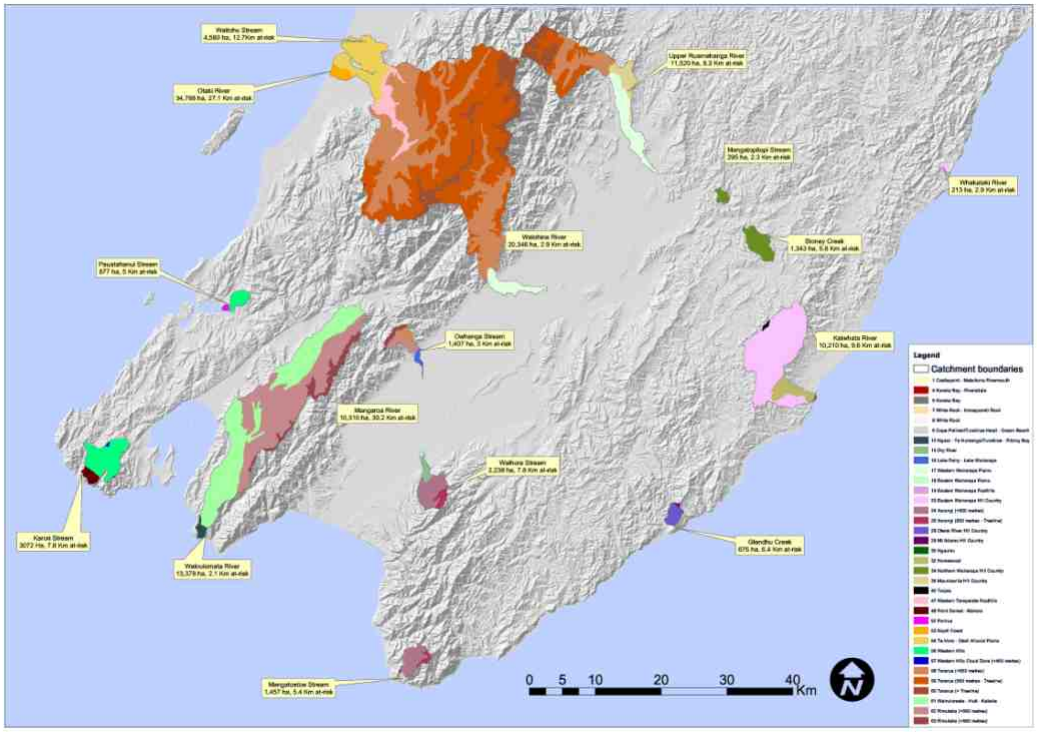

Figure 7 Variety of ecodomains (out of a possible 63) in 16 short-listed catchments

The REC, developed by the National Institute of Water and Atmospheric Research (NIWA), classes rivers according to their natural characteristics (catchment climate, geology, source of flow, elevation, size, and morphology). The river environments in the Wellington region are shown in Appendix 3. Eleven of the 29 river environment classes - totalling 20.3 km of stream length (less than 0.2 % of the region's streams) - were not represented in the short-listed catchments.

The LENZ classes, developed by Landcare Research, sort land environments according to climatic influences, landforms and soil properties. The variables used to define this classification place a heavy reliance on the environmental relationship of New Zealand tree species. The assumption behind this is that these variables would also directly affect the distribution of other flora species and accordingly their fauna, including insects, birds and reptiles. The land environments in the Wellington region are shown in Appendix 4.

The variety of stream types as determined by the REC, the LENZ, and the ecodomains is given in Table 2 below.

Table 2 Potential to provide ecological links and corridors, and representation of stream types

Catchment (hectares)	KNE (ha, %)	Covenant, GW or DoC (ha, %)	GW supported restoration or GW land[9]	LENZ types[10]	REC types[11]	Eco domains[12]
Glendhu Creek (676 ha)	140.98, 20.84%	0.00, 0.0%		3	4	3
Kaiwhata River (10,210 ha)	45.00, 0.44%	1102.84, 10.8%		4	6	3
Karori Stream (3,072 ha)	481.54, 15.67%	124.21, 4.0%	1 care group GW land (13.7 ha)	7	3	4
Mangaroa River (10,310 ha)	495.26, 4.80%	2,083.78, 20.2%	GW land (1949.8 ha)	7	6	3
Mangatoetoe Stream (1,457 ha)	0.00, 0.0%	644.84, 44.26%		4	3	4
Mangatopi-topi Stream (295 ha)	39.99, 13.54%	0.00, 0.0%		3	1	2
Otaki River (34,788 ha)	2.17, 0.01%	27757.87, 79.79%	1 care group GW land (148 ha)	9	8	6
Owhanga Stream (1,407 ha)	0.00, 0.0%	915.54, 65.07%	GW land (8.5 ha)	6	4	4
Ration Creek (677 ha)	7.97, 1.18%	15.54, 2.3%		6	3	2
Stoney Creek (1,343 ha)	0.00, 0.0%	0.00, 0.0%		2	2	1
Upper Ruamahanga (11,520 ha)	47.21, 0.41%	7357.83, 63.87%	GW land (5.4 ha)	8	8	5

[9] Values given for Greater Wellington land are exclusive of overlaps with DoC land or covenanted land.

[10] This exercise used 11 Land Environment Classes identified in the region, based on climate, landform and soil.

[11] This exercise used 18 River Environment Classes based on climate, source of flow, and geology.

[12] This exercise used 35 Ecodomains based on geology, geomorphology, meteorology, biology and local knowledge.

Catchment (hectares)	KNE (ha, %)	Covenant, GW or DoC (ha, %)	GW supported restoration or GW land[9]	LENZ types[10]	REC types[11]	Eco domains[12]
Waihora Stream (2,238 ha)	0.00, 0.0%	1654.32, 73.9%		8	5	4
Wainuiomata River (13,378 ha)	945.61, 7.07%	6326.49, 47.29%	GW land (4161.8 ha)	7	5	4
Waiohine River (20,346 ha)	72.79, 0.36%	18488.67, 90.87%	GW land (15.7 ha)	9	4	4
Waitohu Stream (4,580 ha)	12.89, 0.28%	1661.34, 36.27%	2 care groups GW land (6.8 ha)	7	7	4
Whakataki River (213 ha)	0.00, 0.0%	0.00, 0.0%		3	2	2

3. Making the cut

3.1 What the GIS exercise revealed

Stage 3 of this exercise checked the aggregated scores for promoting biodiversity determined in Stage 2, applied local knowledge of the streams by the River Ecosystem Group, and checked the GIS desktop exercise against actual stream conditions.

The overall score for the range of stream types in the catchment is the sum of the number of River Environment Classes, Land Environment Classes and eco-domains. The total possible score is 29 + 11 + 63 = 103.

The overall score for the capability to be a functioning ecosystem is the sum of the number of fish and invertebrates likely to be present, and a score between 0 and 3 for inanga spawning capability. The total possible score is 18 + 36 + 3 = 57.

Table 3 Short-listed catchment comparison for the final cut

Catchment (hectares)	Amount of KNE, and covenanted areas in the catchment (percentage)	Access to the sea	Stream type variety (out of 103)	Functioning ecosystem potential[13] (out of 57)
Glendhu Creek (676 ha)	21	Pahaoa River estuary to Pacific Ocean	10	38
Kaiwhata River (10,210 ha)	11	Open coast (Pacific Ocean)	13	49
Karori Stream (3,072 ha)	20	Open coast (Cook Strait)	14	45
Mangaroa River (10,310 ha)	25	Hutt River	16	52
Mangatoetoe Stream (1,457 ha)	44	Open coast (Cook Strait)	11	36
Mangatopitopi Stream (295 ha)	14	Ruamahanga River	6	26
Otaki River (34,788 ha)	80	Open coast estuarine (Tasman Sea)	23	53
Owhanga Stream (1,407 ha)	65	Lake Wairarapa	14	50
Ration Creek (677 ha)	3	Pauatahanui Inlet	11	37
Stoney Creek (1,343 ha)	0	Ruamahanga River	5	29
Upper Ruamahanga (11,520 ha)	64	Ruamahanga River	21	50
Waihora Stream (2,238 ha)	74	Ruamahanga River (lower)	17	44
Wainuiomata River (13,378 ha)	54	Open coast (Cook Strait)	16	52
Waiohine River (20,346 ha)	91	Ruamahanga River	17	47
Waitohu Stream (4,580 ha)	37	Open coast (Tasman Sea)	18	46
Whakataki River (213 ha)	0	Open coast estuarine (Pacific Ocean)	7	19

For this assessment, we decided that streams with the greatest diversity of fish and the greatest diversity of aquatic invertebrates, regardless of the species, had the greatest potential to support a functioning ecosystem.

[13] Streams where the inanga spawning capability is not known were given a score of 1

The lowest scoring streams are: Glendu Creek, Mangatoetoe Stream, Mangatopitopi Stream, Ration Creek, Stoney Creek, and Whakataki River. For the selected catchments to collectively represent the range of stream types in the region, and have the potential to provide for a range of functioning ecosystems, the group decided that they should cover a variety of receiving environments (larger river tributary, lake, protected harbour, estuary, and open coast). Despite their low score, Glendu Creek and Ration Creek were retained so that there would be representation from streams that connect to a protected harbour (the Pauatahanui Inlet) and streams that connect to a Pacific Ocean estuary.

The selected stream catchments (shown in Figure 8, below) that collectively meet the criteria given in the Strategy are –

- Waitohu Stream and Otaki River (flow to the Kapiti Coast)
- Ration Creek (flows to the Pauatahanui Inlet)
- Mangaroa River (Hutt River tributary)
- Karori Stream and Wainuiomata River (hill country to Cook Strait)
- Glendu Creek and Kaiwhata River (hill country to Wairarapa east coast)
- Owhanga Stream (flows to Lake Wairarapa from the Tararua Range)
- Waiohine River (Ruamahanga River tributary)
- Upper Ruamahanga River (source in the Tararua Range)
- Waihora Stream (lower Ruamahanga River tributary).

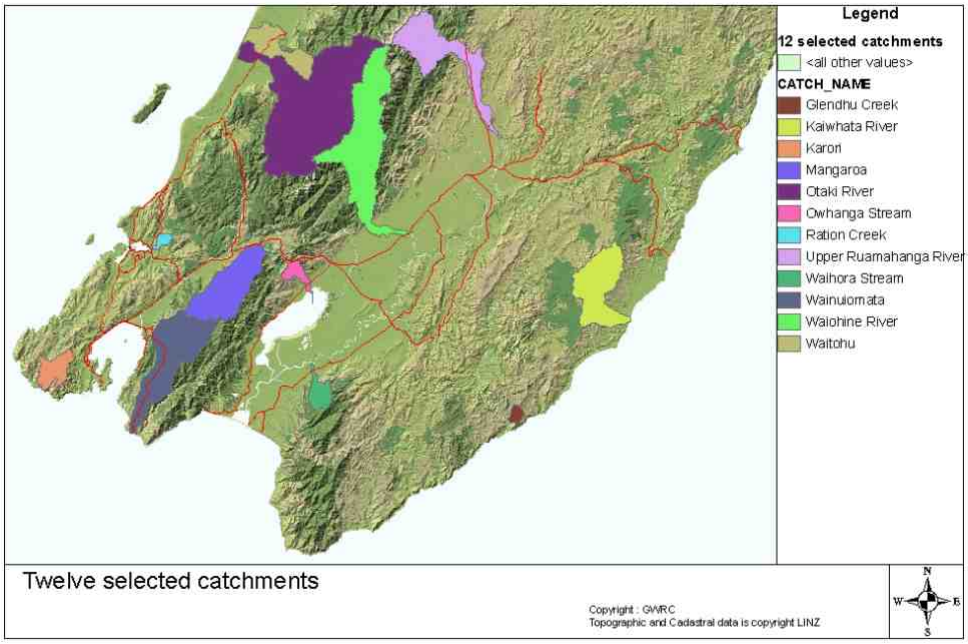

Figure 8 High value catchments selected for financial assistance

3.2 Confirmation of final selection

In June 2004, three Greater Wellington staff flew over 11 of the selected catchments to verify whether or not they had the kinds of land cover and land uses attributed to them in the GIS exercise. For one catchment, the Waitohu, this exercise was done by car. Staff could find no difference between what was observed and what was mapped by the GIS.

With the GIS exercise confirmed, the River Ecosystems Group decided that the 12 catchments selected for meeting the criteria in the strategy would be eligible for funding for streamside management assistance.

The group's one concern about the selection process was that three small catchments (Ration creek, Owhanga stream and Glendu creek) have only one or two landowners. If those landowners choose not to work with Greater Wellington and the stream sections on their properties are not planted and managed, those stream types will effectively be excluded from the programme. To address this, the group will review the requests for assistance in 2005-06 and determine whether more catchments should be added to the programme.

Appendix 1 Most at-risk streams in Greater Wellington

Greater Wellington's Riparian Management Strategy requires that if any streamside management is financially supported by the Council, we must be satisfied that it will be effective at rehabilitating degraded aquatic habitat in the stream catchment. The streams with the **highest risk** of having degraded aquatic habitat that can be rehabilitated by riparian management were identified by –

- the stream size,
- the vulnerability of the soils to erosion, and
- whether the surrounding land uses would contribute to overland runoff, streamside damage and other effects on water quality (see section 2.2 of this report).

The maximum score is 400 (high stocking rate on erosion prone land). There are about 70 km of streams in this group. Streams with significant areas scoring 400 are –

1. tributaries of upper Otaki River (Kapiti Coast).
2. tributaries of lower Otaki River (Kapiti Coast).
3. tributaries of lower Mangaone Stream (Kapiti Coast).
4. mid Kakariki Stream (Kapiti Coast).
5. upper Kakaho Stream (Porirua City).
6. mid Horokiri Stream (Porirua City).
7. tributary of Ration Creek (Porirua City).
8. tributaries of the lower Ruamahanga River: Kelly's Stream, Te Maire stream, unnamed streams near Pirinoa, Waihora and Tiroroa (South Wairarapa District).
9. tributaries of Lake Wairarapa: Mangatete stream, small streams near Kaiwaiwai, and Otukura stream near Morrisons bush (South Wairarapa District).
10. tributaries of Parkvale stream near Carterton (Carterton District).
11. tributaries of the Kopuaranga River near James Road, and beside Kakaamu Road (Masterton District).
12. sections of the Waipoua stream and a tributary of the Waipoua stream north of Te Mara stream (Masterton District).

Of these streams, the Otaki River, Ration Creek and Waihora Stream are in catchments with a reasonable amount of high quality habitat (see section 2.3).

Appendix 2 Functioning ecosystem indicators

A2.1 Likely fish species present in the short-listed catchments

Table 4 Length of stream (km) with at least 50% probability of the fish species living in the stream

Catchment	Total length	Shortfin eel	Longfin eel	Torrent-fish	Giant kokopu	Koaro	Dwarf Galaxias	Banded kokopu	Inanga	Shortjaw kokopu	Lamprey	Non-mig bullies
Glendhu	9.79	6.04	5.45	1.99	2.23	0.03	5.65	3.46	2.77	0.77		
Kaiwhata	152.48	91.72	57.09	2.64	22.94	95.97	63.10	45.20	47.24	21.99	7.67	57.32
Karori	45.43	6.69	37.29		43.99	38.22	1.25	13.60	5.32	27.08	1.84	4.21
Mangaroa	157.77	65.80	91.67	1.81	31.91	38.92	42.95	11.91	26.37	6.24	8.37	104.81
Mangatoetoe	19.51		1.97	1.44	3.89	18.79		19.38		18.96		
Mangatopitopi	4.18	3.76	4.18					1.70		4.18		4.18
Otaki	523.12	93.59	322.99	160.09	16.17	381.38	42.26	124.58	27.24	264.70	23.61	0.43
Owhanga	24.23	8.56	12.31	7.77	0.59	9.45	3.81	2.21	0.64	9.81	1.41	1.41
Ration	11.19	8.32	5.53	2.37	10.40	0.50	1.84	1.33	9.65		9.86	10.69
Stony	18.78	18.29	18.49		8.03			1.29		18.78		18.78
Upper Ruamahanga	168.12	28.99	52.75	120.91	3.86	9.79	27.73			0.94	11.22	97.81
Waihora	37.19	5.01	19.92		2.51	16.33	6.02	28.68		22.59		2.34
Wainuiomata	189.28	39.29	109.64	0.17	31.55	47.62	117.63	56.79	8.86	10.96	13.18	10.90
Waiohine	286.86	21.80	50.60	98.99	1.32	56.75	27.06	17.76		58.85		40.66

Catchment	Total length	Shortfin eel	Longfin eel	Torrent-fish	Giant kokopu	Koaro	Dwarf Galaxias	Banded kokopu	Inanga	Shortjaw kokopu	Lamprey	Non-mig bullies
Waitohu	73.47	33.33	69.77	13.16	13.16	21.18		27.54	27.85	18.02	10.72	
Whakataki	3.64	3.64	3.64		0.87			3.64	3.64			

Table 4 continued

Catchment	Common bully	Giant bully	Bluegill Bully	Redfin bully	Koura	Smelt	Brown Trout
Glendhu				0.98	9.79		
Kaiwhata	10.70	2.98	6.47	124.60	147.83	2.11	
Karori	2.49			16.14	25.41	5.96	10.55
Mangaroa	22.62	15.44	12.09	42.55	7.98	7.21	94.98
Mangatoetoe				14.12			
Mangatopitopi					4.18		1.43
Otaki	19.46	24.81	192.38	189.88	65.73		157.94
Owhanga	7.84	0.97		10.63	0.97	4.07	4.05
Ration	2.37			11.19			4.66
Stony					18.78		10.75
Upper Ruamahanga		1.08	2.56		10.88	8.18	146.09
Waihora	8.72		2.63	7.85	37.19	3.72	
Wainuiomata	60.81	29.27	3.75	43.01	51.55	0.37	68.84

Catchment	Common bully	Giant bully	Bluegill Bully	Redfin bully	Koura	Smelt	Brown Trout
Waiohine	22.59	2.96		5.31	9.18		256.14
Waitohu	9.81	13.63	57.80	9.87	29.93	9.44	16.25
Whakataki	1.04			1.86			

A2.2 Inanga spawning potential

Riparian areas beside the Otaki River, Mangaone Stream, Ngarara Stream, Porirua Stream, Pauatahanui Stream, Kakaho Stream, Duck Creek, Makara Stream, and Wainuiomata River could all be improved to provide high value inanga spawning habitat.[14] Of the Wairarapa rivers, the Whakataki River, Pahaoa River, Motuwaireka Stream, Whareama River, Oterei Stream, and Whangaimoana Stream all have good areas for inanga spawning, or have areas that are suitable for enhancement.[15] Lake Onoke provides the only area suitable for inanga spawning for the Ruamahanga River – there is nothing suitable beside the Ruamahanga River or Lake Pounui Stream. Access to the lake and the Ruamahanga River is via the cut in the bar at Lake Ferry. Greater Wellington has no information about whether inanga and the juveniles of other migratory fish species can negotiate this cut through the bar and get upstream although some must because people go whitebaiting at Lake Ferry.

[14] Taylor MJ, and GR Kelly (2001). *Inanga Spawning habitats in the Wellington Region, and their potential for restoration. Part 1: Kapiti, Porirua, Wellington, and Hutt City*. NIWA and Wellington Regional Council.
[15] Taylor MJ, and GR Kelly (2002). *Inanga Spawning habitats in the greater Wellington Region. Part 2: Wairarapa*. NIWA and Greater Wellington Regional Council.

A2.3 Likely invertebrate species present in the short-listed catchments

Table 5 Length of stream (km) with at least 50% probability of the macroinvertebrate species living in the stream

Catchment	Total stream length	Amphipoda (other)	Aoteapsyche (caddis)	Aphrophila (diptera)	Archichauliodes (other)	Austroclima (mayflies)	Austroperla (stoneflies)
Glendhu Creek	9.79	0.00	5.82	1.02	6.48	2.01	0.03
Kaiwhata River	152.48	4.19	74.65	27.50	131.42	9.65	12.98
Karori Stream	45.43	0.88	22.91	23.35	38.46	0.30	15.52
Mangaroa River	157.77	50.59	61.86	51.91	129.22	23.05	78.17
Mangatoetoe Stream	19.51	0.00	15.93	7.24	16.00	2.17	8.67
Mangatopitopi Stream	4.18	4.18	2.38	0.84	4.18	2.60	0.00
Otaki River	523.12	124.46	125.05	330.61	95.87	23.71	257.21
Owhanga Stream	24.23	2.48	19.97	6.37	18.71	2.86	13.73
Ration Creek	11.19	9.65	1.04	1.83	2.86	0.00	3.83
Stony Creek	18.78	0.45	0.49	0.00	11.51	2.19	0.74
Upper Ruamahanga River	168.12	13.16	47.17	98.52	100.06	16.24	60.30
Waihora Stream	37.19	3.69	5.22	9.36	30.59	0.54	25.81
Wainuiomata River	189.28	56.60	59.59	87.01	147.04	23.29	102.56
Waiohine River	286.86	24.23	50.91	225.80	97.83	36.61	95.78
Waitohu Stream	73.47	18.89	27.57	28.55	17.26	1.86	16.91
Whakataki River	3.64	2.77	0.00	0.00	0.00	0.00	0.92

Table 5 continued

Catchment	Austrosimulium (diptera)	Beraeoptera (caddis)	Coloburiscus (mayflies)	Costachorema (caddis)	Deleatidium (mayflies)	Diamesinae1	Elmidae (beetles)
Glendhu	3.60	0.00	8.71	0.00	9.79	5.96	9.17
Kaiwhata	105.07	5.55	99.21	0.00	152.48	47.20	134.27
Karori	33.76	0.00	30.30	0.00	45.43	12.95	30.01
Mangaroa	52.57	29.38	56.91	7.38	151.14	62.34	85.80
Mangatoetoe	3.91	1.80	16.29	0.00	19.51	14.42	15.45
Mangatopitopi	4.18	0.00	0.00	0.00	4.18	0.00	4.18
Otaki	117.67	61.40	249.53	101.64	501.54	69.72	457.10
Owhanga	7.10	0.97	13.29	5.68	24.23	10.08	22.80
Pauatahanui	11.19	0.00	4.07	0.00	7.98	0.00	3.90
Stony	14.98	0.00	13.34	0.00	18.78	0.49	0.00
Upper Ruamahanga	30.97	40.49	89.51	20.00	168.03	35.98	156.01
Waihora	11.09	1.21	37.19	0.00	37.19	0.75	26.23
Wainuiomata	89.46	3.10	146.73	0.00	188.11	22.56	186.30
Waiohine	51.04	32.13	105.95	65.33	286.86	14.90	276.79
Waitohu	31.66	17.97	53.91	0.00	57.05	6.16	44.25
Whakataki	2.83	0.00	0.00	0.00	3.64	0.00	3.64

Table 5 continued

Catchment	Eriopterini (diptera)	Helicopsyche (caddis)	Hydraenida (beetles)	Hydrobiosella (caddis)	Hydrobiosis (caddis)	Megaleptoperla (stoneflies)	Neozephlebia (mayflies)
Glendhu	8.02	3.75	0.00	2.31	7.80	0.00	0.00
Kaiwhata	31.85	22.91	0.00	9.62	137.41	0.00	7.06
Karori	2.97	13.99	0.00	11.39	33.16	0.00	0.86
Mangaroa	43.03	30.33	0.00	78.73	139.40	6.97	30.85
Mangatoetoe	6.67	3.63	0.00	10.16	18.26	1.37	0.00
Mangatopitopi	0.00	0.00	0.00	3.55	4.18	0.00	4.18
Otaki	100.41	117.05	56.70	389.50	433.76	35.84	19.12
Owhanga	7.52	9.24	0.00	9.13	12.34	2.24	0.48
Pauatahanui	0.00	0.50	0.00	2.63	10.16	0.00	0.00
Stony	0.00	0.49	0.00	0.78	17.50	0.00	17.69
Upper Ruamahanga	59.41	32.85	14.89	92.85	150.63	48.30	26.68
Waihora	30.41	7.17	0.00	27.93	37.01	0.00	1.00
Wainuiomata	19.10	38.97	0.00	69.54	99.42	0.77	20.44
Waiohine	98.14	37.65	27.30	208.30	261.66	125.90	0.85
Waitohu	22.14	16.50	0.00	27.54	56.49	0.49	11.90
Whakataki	0.00	0.00	0.00	0.00	2.77	0.00	0.00

Table 5 continued

Catchment	Nesameletus (mayflies)	Oligochaeta (other)	Olinga (caddis)	Orthocladiinae (diptera)	Orthopsyche (caddis)	Oxyethira (caddis)	Podonominae (diptera)	Potamopyrgus (other)
Glendhu	0.03	4.20	1.77	5.01	0.00	3.16	1.02	9.79
Kaiwhata	14.85	112.69	107.57	109.75	18.64	18.48	1.47	116.74
Karori	16.57	39.13	29.02	45.30	19.63	4.46	0.00	26.68
Mangaroa	63.59	29.42	108.77	134.29	41.23	14.09	12.98	47.60
Mangatoetoe	11.18	1.65	14.64	17.46	1.83	0.83	0.00	3.65
Mangatopitopi	0.00	1.38	0.00	4.18	1.38	1.97	0.00	4.18
Otaki	322.02	146.41	386.42	382.44	289.70	0.48	15.61	220.50
Owhanga	16.77	7.18	13.62	13.91	3.60	0.46	2.21	13.57
Pauatahanui	0.00	3.69	1.90	5.14	5.64	1.83	0.00	8.82
Stony	0.00	11.53	0.00	0.94	0.00	0.49	0.00	17.09
Upper Ruamahanga	72.02	19.87	105.66	122.24	47.24	2.98	15.86	8.50
Waihora	14.17	23.88	26.44	27.43	32.12	5.78	0.00	5.57
Wainuiomata	39.36	70.50	151.77	173.11	100.91	18.51	0.83	96.93
Waiohine	161.01	20.21	137.11	264.18	161.36	0.00	5.15	79.40
Waitohu	18.01	27.60	33.35	50.06	18.51	0.00	1.10	35.96
Whakataki	0.00	1.04	0.00	0.00	0.00	0.92	0.00	3.64

Table 5 continued

Catchment	Psilochorema (caddis)	Pycnocentria (caddis)	Pycnocentrodes (caddis)	Stenoperla (stoneflies)	Tanypo-dinae (diptera)	Zelandobius (stoneflies)	Zelando-perla (stoneflies)	Zephlebia (mayflies)
Glendhu	1.89	3.42	1.74	0.00	2.24	0.00	0.40	2.33
Kaiwhata	92.29	0.11	33.84	1.90	1.53	0.00	67.56	34.17
Karori	27.97	1.16	9.58	0.97	20.09	0.00	12.26	19.30
Mangaroa	30.98	0.00	5.52	35.06	5.61	4.75	112.04	42.19
Mangatoetoe	13.51	0.00	0.00	2.36	2.64	0.00	12.25	1.01
Mangatopitopi	0.00	0.58	2.06	0.00	4.18	0.00	0.00	0.00
Otaki	113.57	0.03	24.47	112.60	0.75	63.60	277.23	197.69
Owhanga	8.05	0.00	0.00	3.80	5.40	0.00	9.66	12.60
Pauatahanui	0.50	0.00	0.81	0.00	0.00	0.00	1.04	4.93
Stony	7.39	0.49	0.00	0.00	1.85	0.00	0.00	1.58
Upper Ruamahanga	88.54	5.95	3.96	27.36	45.03	20.70	117.40	23.90
Waihora	20.91	0.00	2.34	23.39	0.00	1.03	11.67	1.00
Wainuiomata	69.90	0.00	31.14	50.73	17.76	11.59	108.62	52.62
Waiohine	133.77	0.00	7.74	80.70	15.72	41.26	267.26	114.26
Waitohu	11.01	0.00	0.00	3.67	0.00	0.92	23.01	14.29
Whakataki	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A2.4 Key Native Ecosystems

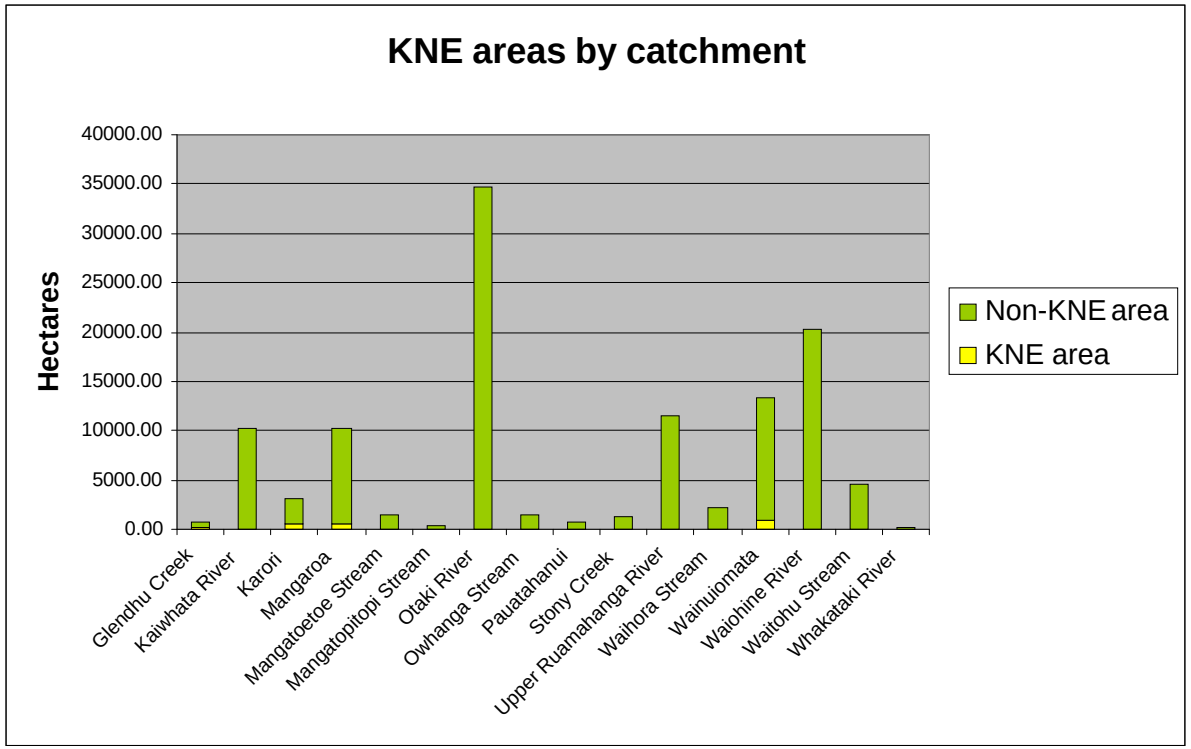

Figure 9 Area of Key Native Ecosystems in each catchment

Appendix 3. The River Environment Classification

The River Environment Classification (REC) system, developed by NIWA, helps identify and characterise the physical diversity in the region's river and stream ecosystems. The REC is a 'controlling factor' approach that classifies and maps New Zealand's river environments. Classification is based on characterising four environmental components of the upstream catchment (climate, topography, geology and land cover) and two of the stream section itself (network position and valley landform). The REC has assigned unique combinations of catchment climate, source of flow and catchment geology to each river reach to identify natural large-scale variation amongst all rivers in the region.

There are 23 classes in the Wellington region, but the five main classes are:

- Cool humid, hill, hard sedimentary (CH/H/HS) reaches.
- Cool humid, low elevation, hard sedimentary (CH/L/HS) reaches.
- Cool humid, low elevation, soft sedimentary (CH/L/SS) reaches.
- Cool dry, low elevation, soft sedimentary (CD/L/SS) reaches.
- Warm dry, low elevation, alluvial (WD/L/Al) reaches.

The REC classifies the region's rivers and streams into 29 classes.

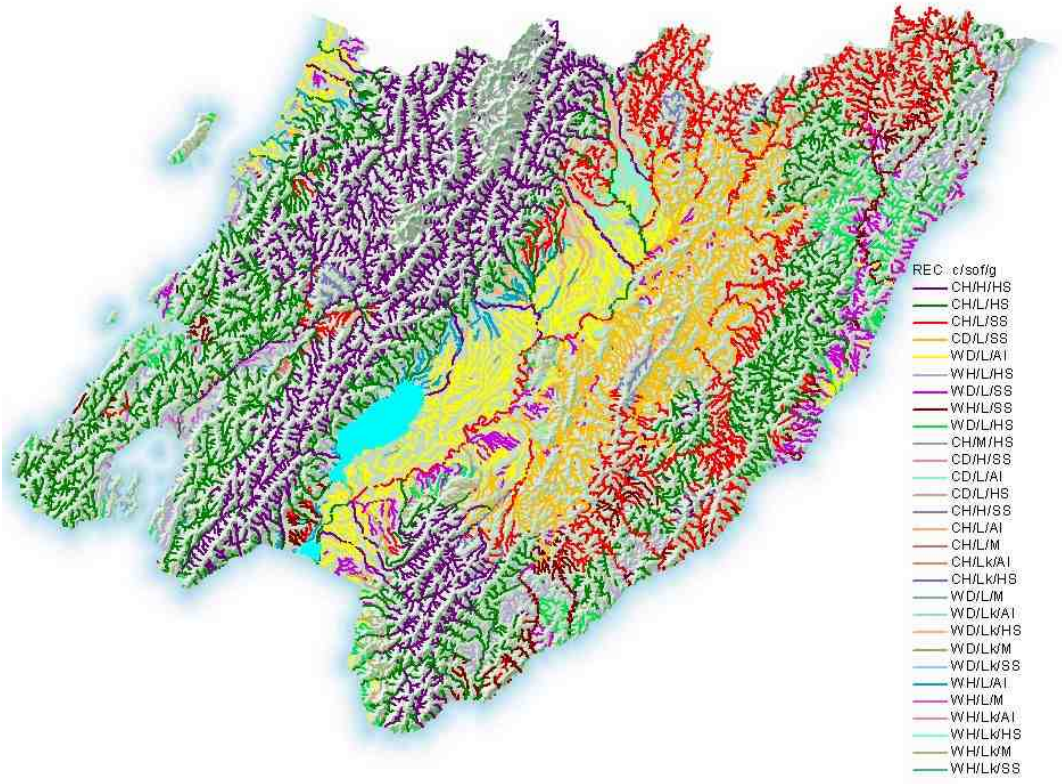

Figure 10 River Environments in the Wellington region

Table 6 Total length of River Environment Classes in the Wellington region

Climate/Source of flow/Geology	Sum LENGTH (m)	Length (Km)
CD/H/SS	18074.1039	18.1
CD/L/Al	95908.4588	95.9
CD/L/HS	208910.6470	208.9
CD/L/SS	1302689.3512	1302.7
CH/H/HS	2373754.8883	2373.8
CH/H/SS	125529.6102	125.5
CH/L/Al	125737.3268	125.7
CH/L/HS	2713559.1675	2713.6
CH/L/M	6300.5801	6.3
CH/L/SS	1718032.8310	1718.0
CH/Lk/Al	13573.2208	13.6
CH/Lk/HS	4580.9545	4.6
CH/M/HS	224049.7464	224.0
WD/L/Al	1111033.0314	1111.0
WD/L/HS	384885.3696	384.9
WD/L/M	55636.0584	55.6
WD/L/SS	506641.0729	506.6
WD/Lk/Al	28308.6710	28.3
WD/Lk/HS	789.4113	0.8
WD/Lk/M	60.0000	0.1
WD/Lk/SS	247.2792	0.2
WH/L/Al	209246.2488	209.2
WH/L/HS	591976.6139	592.0
WH/L/M	31363.4351	31.4
WH/L/SS	474237.7181	474.2
WH/Lk/Al	17140.1428	17.1
WH/Lk/HS	13024.9957	13.0
WH/Lk/M	834.8528	0.8
WH/Lk/SS	3485.8788	3.5
TOTAL		**12,359.6**

Note: the highlighted REC were not represented in the 16 short-listed catchments.

Appendix 4. Land Environments of New Zealand (LENZ)

A4.1 What is LENZ?

Land Environments of New Zealand (LENZ) is a classification of New Zealand's landscapes using a comprehensive set of climate, landform and soil variables chosen for their roles in driving geographic variation in biological patterns. LENZ can identify geographic areas with similar ecosystem characteristics. This makes it easier to assess how common or rare each kind of area is, the biodiversity value of natural ecosystem remnants, and where they should be protected and restored.

A4.2 Climatic influences on the environment

- mean annual temperature (influences actual plant productivity)
- mean minimum winter temperature (relative severity of winter temp)
- mean annual solar radiation (principal determinant of potential productivity)
- minimum winter solar radiation (the lowest solar radiation input through the year)
- October vapour pressure deficit (dryness of the air, a powerful control of evaporation from plants)
- monthly water balance ratio (an indicator of site wetness, as opposed to drought)
- annual soil water deficit (the extent of drought limitation on plants)

A4.2 Landform and soil influences

- Slope (a major driver of drainage, soil rejuvenation processes and micro climate)
- Soil drainage (influences the availability of oxygen in the upper soil layers)
- Acid soluble phosphorus (a key soil nutrient required by plants)
- Calcium (both a plant nutrient and a determinant of soil weathering processes)
- Particle size (affects the rate at which soil formation proceeds and nutrients are released for plant growth)
- Induration (resistance of the soil parent material to weathering)
- Soil age (estimated in two classes, separates recent from older soils)
- Chemical limitations to plant growth (indicates the presence of salinity or ultramafic substrates)

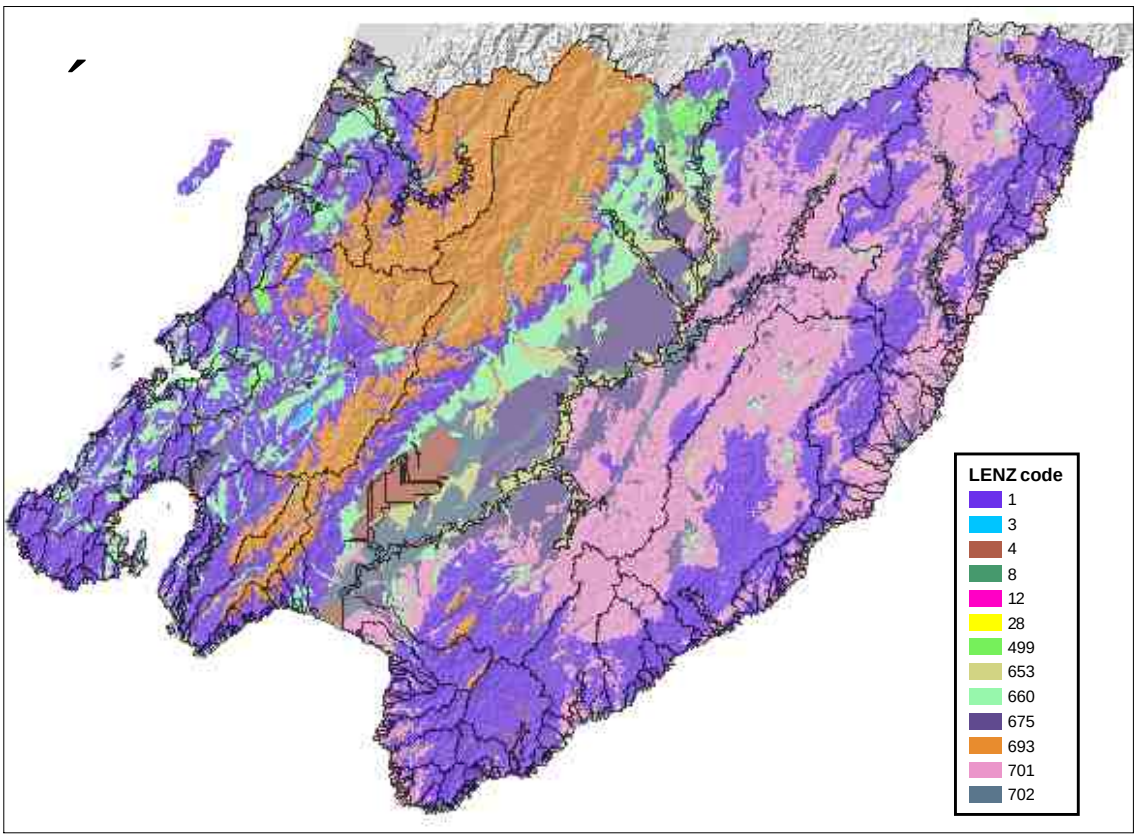

Figure 11 Land Environment New Zealand classes in the Wellington region

1 (F1): mild temperatures, high solar radiation, low to slight annual water deficits. Well-drained low fertility soils from mudstone, sandstone, greywacke or argillite. Strongly rolling to steep hill country.

3 (C1): mild to warm temperatures, high solar radiation, slight annual water deficits. Flat to gently rolling plains. Poorly drained peat of low fertility.

4 (WATER): Lake Wairarapa.

8 (H1): mild temperatures, high solar radiation, slight annual water deficits. Very gently undulating hills to undulating hills. Recent, well drained soils of very low to moderate fertility from granite and alluvium.

499 (F7): mild temperature, high solar radiation, slight annual water deficits. Undulating volcanic plateau. Well-drained soils very low fertility soils from rhyolitic flow tephra.

653 (J4): warm temperatures, high solar radiation, low to moderate annual water deficits. Flat flood plains, coastal sandplains or undulating coastal floodplains. Recent, well-drained soils of low to moderate fertility from sand and mixed alluvium.

660 (C2): mild temperature, high solar radiation, moderate vapour pressure deficits, and low annual water deficits. Gently undulating plains. Imperfectly drained soils of low fertility from loess with some fine alluvium.

675 (C3): warm temperatures, high solar radiation, and low annual water deficits. Flat plains. Well-drained low fertility soils of loess with some alluvium.

693 (P8): cold temperatures, moderate solar radiation, low vapour pressure deficits, low to intermediate monthly water balance ratios, no to slight annual water deficits. Steep mountainous terrain. Imperfectly drained peat or other soils of low natural fertility from greywacke with some argillite.

701 (F4): mild temperatures, high solar radiation, moderate vapour pressure deficits, low annual water deficits. Easy rolling hills. Imperfectly drained soils of low fertility from mudstone, sandstone and argillite.

702 (I2): warm temperatures, high solar radiation, moderate annual water deficits. Flat plains. Poorly drained recent or saline soils of low to moderate fertility from fine or estuarine alluvium.