Moutere Catchment
Ecological and Water Quality Survey

Trevor James, 2018

Key Messages:

- The Moutere catchment is close the sea and lowland, so is very important for native fish.
- High stream temperatures common due to lack of shading. Likely to be adversely affecting fish and invertebrate life.
- Low dissolved oxygen in several smaller low gradient tributaries due to lack of shading.
- High levels of long green filamentous algae in some parts.
- A few remnants with great tree cover. This could be built on.
- Some narrow riparian strips are limiting potential planting and confining the meander of the river.
- Long sections of rock rip-rap, while stabilizing banks, can adversely affect fish life and limit tree plantings.
- Planting needs to include trees that will grow high and shade the river, especially if planting away from banks.
- Need to replace the crack willows with other bank stabilizing trees that don't go wild and block the channel. This could be an exotic-native mix.
- Need to work with forestry because lots of sediment in river is of pine forest origin, though river banks contributing in some parts of the river.

Summary

A survey of the main stem and tributaries of the Moutere catchment was undertaken over the summer in 2016-17 with the purpose of assessing water quality and stream habitat and the potential for stream restoration. The whole length of the catchment was walked from Jubilee Bridge, near the mouth, to several tributaries including those at Rosedale Rd and Kelling Rd. These surveys occurred on two occasions and repeated spot visits on two subsequent occasions. Comparisons were made with data from Councils long-term monitoring site on the Moutere River at Ching Rd (Riverside) from 2012-2018.

The main findings were:

- Stream temperature increased significantly in areas that were not shaded by overhead tree cover. Water temperatures were over 24^{o}C for much of the lower catchment, high enough to cause significant adverse effects to stream invertebrates and fish. Where there was rock rip-rap there was limited shading and therefore increases in temperature.
- Filamentous green algae cover was 30-40% in the Old House Rd area and even higher at times in parts of the main ditch downstream (recorded at over 80% coverage on several occasions). This is above the criteria set by the National Policy Statement for Freshwater Management and requires Council to undertake investigations to manage this. This coverage was low (<5%) in the upper catchment.
- Macro-invertebrate condition was generally worse where there were higher water temperatures. At the SOE site in the lower catchment the macro-invertebrate community index (MCI) was on average amongst the lowest recorded in the river water quality monitoring programme.
- In terms of stream habitat: Apart from the main stem of the Moutere River downstream of Wilson Road, stream habitat generally had a reasonably natural meander pattern. Overall there was a reasonable variety of cobble-gravel substrate, but waterways were deficient in overhead tree cover, deeper pools and natural depth variety and in-stream cover (such as undercut banks and woody debris) which absent for about 50-60% of the waterway length. With relatively little effort planting riparian trees the complete package of quality stream habitat will be attained for many reaches.
- Anecdotal evidence shows significant stream bed degradation (0.5-1m) and severe bank erosion has occurred in parts of the catchment upstream of Old House Road. This is particularly apparent after flood events in February 2018 (rainfall 110mm on 11 Feb and 120mm on 20 Feb). This may be due in part to crack willow removal, as well as the recent high rainfall events. However, there is no survey history of this stream to prove this. In the lower section of the river, the bed level appears to be stable as the old rip rap has probably been there in excess of 20 years and has not been undercut.
- About 10% of the riparian zones in the upper catchment (down to Old House Rd) have been planted in native trees but these may not provide much shade. While rock-lined banks were found to be relatively short and limited in effect, if some of these got much longer and were not incorporated with plantings, they will start to cause significant adverse effects.

It is recommended that a catchment management strategy and plan be developed for the Moutere catchment as the first step in improving the ecological health of the catchment. Such planning ensures we get the maximum environmental benefit for funding available and the anticipated outcomes are achieved. Specific requirements of such a plan include:

- it takes an integrated approach to riparian and wetland management
- it identifies opportunities for stream habitat restoration in the catchment and the relative benefits of each
- it identifies the costs and limitations of various options for aquatic ecological restoration
- it looks at ecologically-friendly options for stream bank protection and ways to mitigate the effects of floods. Alongside this, it looks at where riparian tree planting can and can't be carried out to achieve shading and 'feeding' of the stream and the proportion of the stream this would make up.
- the local community should be highly involved in the development and implementation of the plan.

- It identifies the best options where Council's catchment enhancement fund could be used to leverage further funds to implement measures recommended in the plan.

Introduction

Improvement of the ecological health of waterways of the Moutere catchment is considered a high priority relative to other catchments because of its potential to improve fish and invertebrate diversity and abundance. In many parts of the catchment the amount of effort and cost expected to reach that potential is considered relatively low compared to the potential gains. However, it is a relatively large catchment and a long-term sustained effort would be required. These gains in fish diversity and abundance are partly a function of the catchment's proximity to the coast and low elevation. These are the greatest natural determinants of fish diversity. This priority is further strengthened by public support for this improvement.

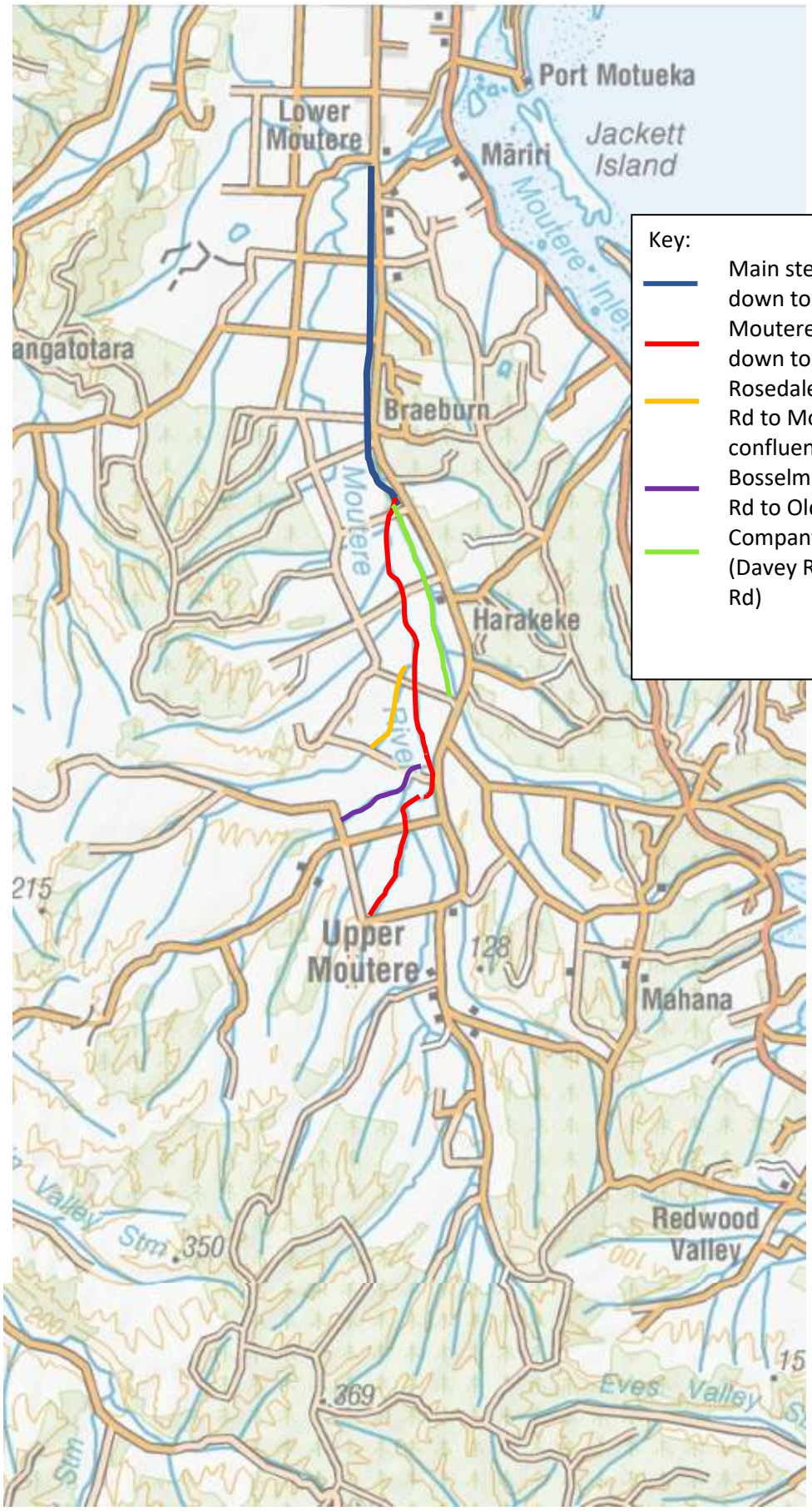
The amount of effort (and therefore cost) needed to improve the existing stream habitat (such as meander pattern, bed substrate, bank shape, water depth and width) is only moderate compared to the high potential gains. There are already a number of areas with good habitat and improvement can come with "joining the dots". Along with providing better fish abundance and diversity, there is huge potential for riparian zones to increase native land animals such as birds and lizards and linking corridors to ensure optimal potential for movement of these animals through the catchment.

The catchment is about 14,680 Ha with the majority in pasture (62%), exotic forest (24%) and horticulture (12%). The main stem from about Wilson Road downstream was dug as a very straight ditch in the 1850's and 60's when the swampland was drained. Summer low flows can be very low for a catchment of this size, with 20-40 l/sec typical in the lower main stem. In the drought of summer 2015 flows got down to 10L/sec at Chings Road (McCallum 2015). Rainfall in the catchment is one of the lowest in the district (Mahana, located in the SE part of the catchment, is the driest place in the district).

In the reaches of the Moutere catchment with poor stream habitat there are typically three to five species of native fish (inanga, smelt, long fin and short fin eel, and common and giant bully). However, in those sections with good stream habitat there are typically five to seven species of native fish present (those in the poor habitat streams as well as: banded kokopu, torrentfish, koaro and redfin bully (the latter species are very rare in the catchment). The catchment used to support reasonable numbers of giant kokopu, but recent surveys have not found any individuals despite a thorough attempt to find them targeting deeper, slow-moving reaches which they prefer (see map of sampling sites in Appendix 3).

Water quality at the State of the Environment monitoring site at Chings Road (Riverside) is relatively good with low levels of disease-causing organisms (median E.coli 100cfu/100ml in base flows and 1000-8000 cfu/100ml during flood flows), relatively low levels of filamentous green algae cover and water temperature for most of the year (although this is a problem during summer), dissolved oxygen above levels required by most aquatic species (this is a problem at some small weedy tributaries), and moderately clear water (median black disk 3.1m at base flows).

Most of the valley floor in the Moutere was covered in wetlands prior to 1800, but now there are less than 5% of the wetlands remaining. Where wetlands remain in the catchment higher flows are maintained in drier periods and better stream habitat occurs. Man-made ponds are very prevalent in the headwaters of this catchment. Eels (particularly shortfin) are common in such ponds. Mass eel death is not uncommon when ponds are dredged. However, eels can easily be recovered by hand after slowly draining the ponds.



Left: Map of the Moutere catchment and the waterways walked in summer 2016-17

Limitations for improvement of the aquatic ecology:

1. The narrow corridor of land available in some parts of the catchment for the waterway to move and to provide riparian restoration. It is well known that rivers need “room to move” and with some particularly high rainfall events in the last year, the river banks are getting severely eroded. With little land to work with, options for bank protection are limited.
2. Bank instability. The river is down-cutting in many areas by 0.5-1m. This increases bank instability and the need for more bank protection work. For much of the river there is call by some river engineers for more rock lining (up to 50% of the stream in some sections). Most rock lining is built with 2h:1v batters (2 horizontal to 1 vertical). This means that it takes up a lot of room and often this means that the meander pattern needs to be straightened and there is no room for any trees, an if there are they are so far from the water that they are not useful to improve the stream ecology. The removal of crack willow (particularly from 2005-2010) has also increased the instability of the stream banks as well as increased quick-flow runoff following removal of pine forest on the north-east side of the catchment and forest harvesting on the south and south-west sides. While crack willow is very good at holding stream banks together and providing reasonable habitat, particularly for eel, it is not the desired tree species because of the way it dominates the waterway and large branches and logs fall in and block the waterway.
3. The very straight form and incised nature of the main stem channel limits the potential for habitat restoration within the wetted area, particularly the diversity of hydraulics (fast and slow flowing zones), as well as water depth and width diversity. These aspects of habitat are very important and without many options to restore habitat, this part of the catchment may remain in poor ecological health. However, the majority of the catchment’s tributaries have good natural meander, diversity of hydraulics and water depth/width.
4. The limited number of wetlands in the catchment also limit the flood mitigation potential and water supply to streams in dry periods. Wetlands act like giant sponges soaking up runoff from the land and then releasing it for long periods in the future. Wetlands also feed streams with dissolved organic carbon which is the fuel for biofilms of bacteria and fungi in the stream, which then in turn fuel a complex food web right up to invertebrates, fish and birds.

Results:

Stream temperature and dissolved oxygen.
There was a strong correlation between the amount of shading of the water (mostly by trees) and water temperature. Where there was limited shading of the stream, water temperatures were highest. The maximum water temperature was found at Wilson Road (25.7^{o}C) with similar temperatures all the way to the estuary. Inanga appeared to be absent when stream temperatures got over 25^{o}C. Note that 24^{o}C was the maximum recorded in continuous sampling over a week in Feb 2014 at the State of the Environment site at Chings Road. This is the zone where significant adverse effects to stream invertebrates occur. Where there was rock rip-rap, there was limited shading (see photo below).

Dissolved oxygen levels were satisfactory in the majority of streams surveyed in the catchment, but were very low in summer in some of the unshaded, weed-choked tributaries and those subject to unauthorised discharges of organic waste.

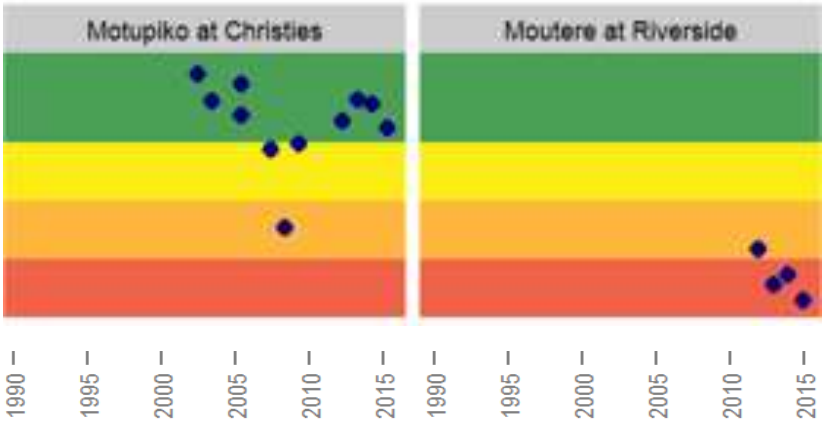
Nuisance biological growths. Filamentous green algae cover was low (<5%) in the upper catchment eg at Kelling and Rosedale Roads and increased downstream to upstream of Old House Rd weir and the lower 200-300m of Rosedale Stream where it was highest at about 30-40% (see photo below). For this latter site, a septic tank at a house at the upstream extent of this occurrence may have been

Photo above: 80% filamentous green algae in lower Rosedale Stm

Photo above: 100% filamentous green algae cover in near Chings Rd (SOE site)

the cause. Sampling at the SOE site at the Moutere River Chings Rd was greater than 80% on a few occasions in mid summer. McCallum (2015) found 70-80% coverage all the way from Chings Rd to Davey Road (including Drummond and Holdaway Roads) after an extended dry period. Very little toxic algae (*Phormidium autumnale*) was found despite the surveys being carried during a long period with stable flows. This suggests a low risk to people and dogs drinking out of the river. However, for people, drinking raw water from waterways with reasonable areas of farmland in the catchment is not recommended.

Macro-invertebrate condition was generally worse where there were higher water temperatures. At the SOE site in the lower catchment the macro-invertebrate community index (MCI) was on average amongst the lowest recorded in the river water quality monitoring programme (orthoclad flies, snails and axehead caddisflies were often abundant). However, most sites on streams draining the Moutere Hill country and poor or fair condition. This may be due to the high level of fine sediment with the stream bed.



Stream habitat: In general, apart from the main stem of the Moutere River downstream of Wilson Road, stream habitat was reasonably good apart from tree cover and in-stream cover which was good for about 40-50% of the waterway length. There was reasonable meander pattern, diversity of bank shape (dead crack willows present in the bank provided some particularly good undercuts), diversity of water depth/width and hydraulics and natural bed substrate (however, generally limited for woody debris). Anecdotal evidence shows significant stream bed degradation (0.5-1m) and severe bank erosion. This may be due in part to crack willow removal, as well as the recent high rainfall events. About 10% of the riparian zones in the upper catchment (down to Old House Rd) have been planted in native trees but these may not provide much shade.

While rock-lined banks were found to be relatively short and limited in effect, if some of these got much longer and were not incorporated with plantings, they will start to cause significant adverse effects. However, subsequent to this survey there have been some particularly large floods and a lot more bank protection and river work has occurred. For some sections of this waterway there is now about 35% of either bank lined with rip-rap and there are suggestions that up to 50% will be rock lined in the near future. There is reasonable evidence elsewhere in New Zealand, and emerging in our region, that at about 30% of such rock rip-rap in a water is the limit at which significant adverse effects occurs.

Unequivocally, there is a need for bank protection as many in the catchment will agree that there has not been such extensive bank erosion. However, there are several options available other than long lengths of rock rip rap. Many locals say that the erosion has got a lot worse since the crack willow were removed on many reaches in the Moutere which has been a factor in leading to the subsequent degradation of the stream bed.

Along with the recent rock rip-rap, some areas the stream have been widened to over double the previous width making shading of the stream bed very difficult to achieve. The stream is now much more shallow and even in depth and is even more vulnerable to over-heating than was found in the 2016-17 survey.

There are several options to avoid such adverse effects on stream habitat that will be discussed by all relevant staff in mid-November 2018 with the help of external advice from recognised experts.

Photo above: A deeper zone caused by the old willow stump. Filamentous green algae about 30% cover. About 2km downstream Kelling Road.

While the water clarity was very high on the days of the survey, the re-suspendable fine sediment (that stirred up from disturbing the cobbly bed) was high (averaged a score of 3-4, Sediment Assessment Method #5, Clapcott et al 2011). Potential sources of this sediment are: winter cropping and grazing, cultivation on steeper hill country and poor pine forest harvesting coupled with poor riparian management are potential reasons for this along with bank erosion. Sediment source tracking carried out in the Moutere catchment showed the Moutere Estuary is receiving a high proportion of sediment directly attributable to pine forest harvesting (Gibbs and Woodward, 2018). See Appendix Two. The large-scale conversion of pine forest to pasture and rural residential in this catchment in 2007-08 to beat climate change regulations may have been the origin of the sediment in Gardner Valley and Upper Moutere despite the source being identified as mainly from 'bank erosion'. Downstream of these catchments the main sources of fine sediment were from recently-harvested pine forest, with only a small pasture contribution. Almost 90% of the sediment at the Moutere River mouth was identified as being from pine forest origin.

Fish passage barriers. There is only one known significant fish passage barrier (about 500m downstream of Old House Rd – see photo to the right) and several less significant fish passage barriers on public land. However, very little investigation of in-stream structures has been undertaken on private land in this catchment.

Other water quality parameters such as water clarity and *E.coli* were found to be generally good at the SOE site in the lower catchment. The low *E.coli* concurs with the limited stock access witnessed in this study.

Unauthorised water takes. Only one unauthorised water take was found in this study but no follow-up undertaken. The photo to the right shows how it is typical to dig a hole in the waterway to install the intake structure (this was compliant). Several of the screens on these intakes have velocities at the screen that are too high and therefore are likely to suck up fish. The TRMP rules require low velocities at the intake to avoid this. McCallum 2015 noted that in the drought to 3 March 2015 (34mm over the 3 months prior), flows were 12-14 L/sec at Holdaway Road. This is substantially higher compared to a similar drought in 1998-99 when the river ran dry. This is most likely due to all consented water takes now having a cease-take minimum flow when the river reaches 20 L/sec.

Litter. Generally very little litter was found in the Moutere catchment. The main litter found was plastic twine (see photo to the left taken upstream Davey Road on Motuere ditch), most likely from hop orchards and baleage wrap.

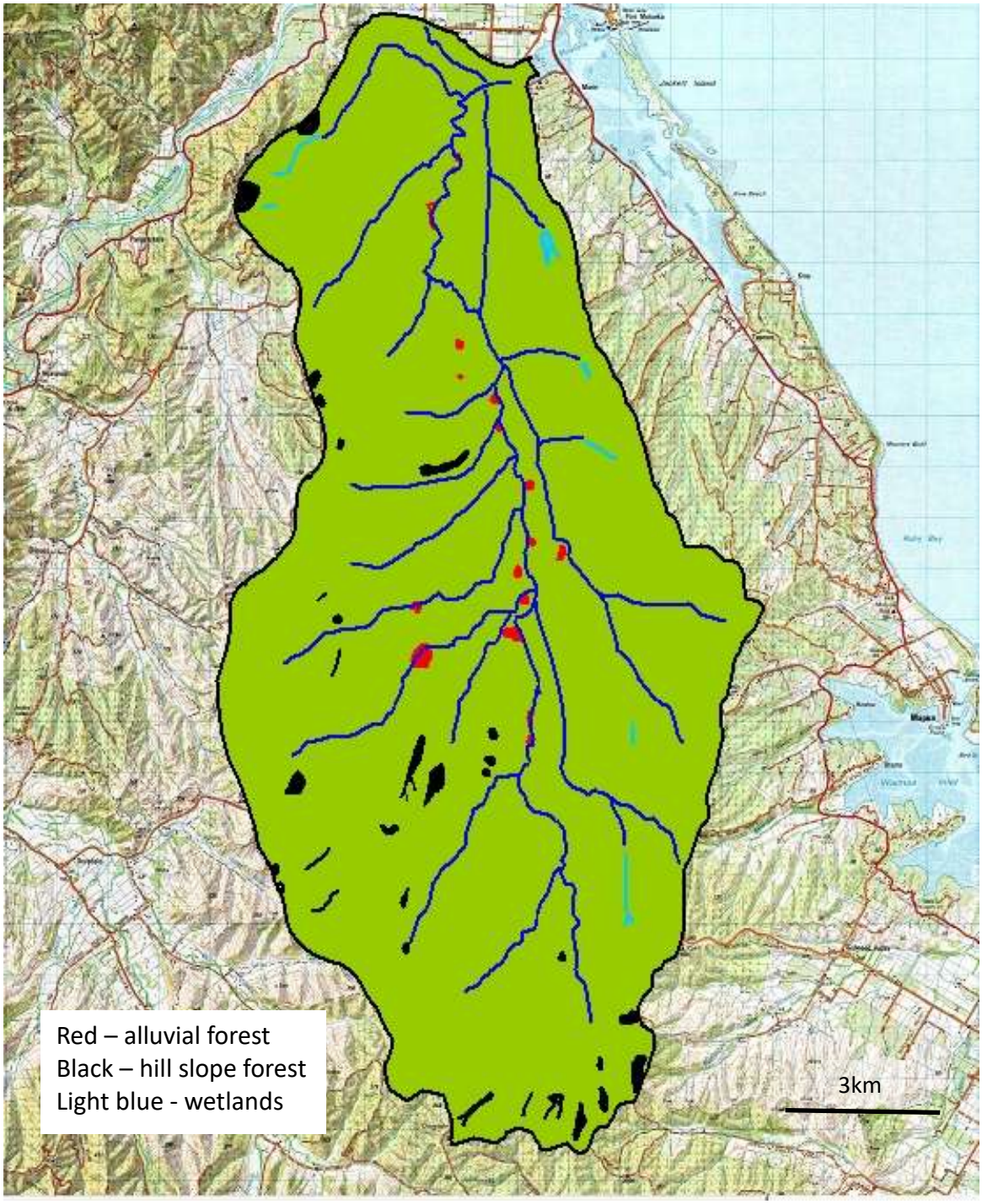
Recommendations:

1. A coordinated catchment management plan should be developed to restore the streams of the Moutere catchment to improve aquatic ecosystems. The plan should take an integrated approach to riparian and wetland management and identifies the costs and benefits of various opportunities for ecological restoration to come up with a prioritised action plan. The plan should investigate ecologically-friendly options for stream bank protection and ways to mitigate the effects of floods. The local community should be highly involved in the development and implementation of the plan. Council's catchment enhancement fund could be used to leverage further funds to implement measures recommended in the plan. Existing bush remnants located adjacent or near riparian areas and wetlands could be expanded and linked by future restoration activity. The map below shows how many of the ecologically-significant alluvial forest is located near the stream in the middle reaches of the catchment. By linking these areas as a priority for riparian restoration, we can not only achieve better corridors for freshwater fish, but also for birds and other animals. The map also shows how few larger wetlands are left within the catchment.

2. A plan to manage stream bank erosion using methods more sympathetic to aquatic ecology should be developed. At present rock rip-rap is being placed along large lengths of the stream without much regard to stream ecology, despite good evidence from around New Zealand showing that this degrades the ecological health of waterways. Soft engineering approaches (using trees, sometimes in combination with some rock) are likely to produce a good compromise. This strategy should be developed with landowners adjacent to the waterways and the wider community.

3. Undertake an on-the-ground audit of water takes should be undertaken in the catchment at peak demand times to ensure that there are no unauthorized takes.

4. Undertake sediment source tracking closer to the source of erosion to determine what activities within a particular land use are causing the greatest export of fine sediment.


Red – alluvial forest
Black – hill slope forest
Light blue - wetlands
3km

References:

Clapcott, JE, Young RG, Harding JS, Matthaei CD, Quinn JM, Death RG. 2011. Sediment Assessment Methods: Protocols and guidleines for assessing the effects of depositied fine sediment one in-stream values. Cawthron Institute.

Gibbs and Woodward, 2018. Waimea and Moutere Sediment Sources by Land Use. Report prepared for Tasman District Council, February, 2018. NIWA Client Report No. 2018026HN.

McCallum, J. 2015. Moutere River Inspection, March 2015.

Ministry for the Environment, 2014. National Policy Statement for Freshwater Management, amended to 2017.

Appendix One: Photos

Below: The landscape following forest harvesting operations SW of Upper Moutere in autumn 2017 (near Cut Hill west of the Moutere Highway). Root-raking (particularly perpendicular to the contour) is well known to make the stream banks and riparian zone very vulnerable to erosion and is the reason the TRMP rule (28.1.6.1(d)(viii)(d) was proposed. The follow-up with the forestry company (Nelson Forests Ltd) was limited.

Below: Erosion potential and fine sediment discharges from winter cropping seen from Neudorf Road (August 2016). The stream is in the channel indicated by the red arrow. It is important to fence off areas where runoff funnels into the stream. Black arrows indicate direction of flow of runoff. This stream is now fenced.

Below: Potential fine sediment discharges from cultivation and side-casting from road building as seen from upper Rosedale Road (September, 2016). The lower part of this slope would ideally have been left in rank grass to trap any eroded soil washed off during higher rainfall events.

Left: **Unnamed creek at Central Road**, between Davey and Wills Roads, view upstream. This stream had **low dissolved oxygen** in summer (below national standards). This is an example of a small tributary that would benefit greatly with shading from riparian trees and wetlands in the headwaters. While this stream almost dries up in many years, there are enough residual pools to support life until the flows return.

Below: Note the deep pool adjacent to the steep bank. The geology of this material is more resistant to erosion than in other parts of the catchment where the banks consist more of silty material. Some planting at the top of the bank would be advantageous for shading/feeding the stream as well as bank stability. **'Rosedale Stream' ~300m downstream Old House Road**.

Photos below: **'Greenhough Creek' near Braeburn, lower Moutere.**

Left: While this creek has been dug straight to drain the original swampland, there is surprisingly good hydraulic and bank shape diversity (see bottom photo). The wetland circled in red the upper part of the catchment provides good stream flow all year round. Reasonable fish diversity where there is tree cover.

Left: 1.2km upstream of Moutere Highway looking upstream (E1601055 N5439376) as shown by the red arrow in the top photo.

Note: Riparian planting was carried out on the true left bank upstream of here but there was a poor survival rate due to inadequate releasing.

Left: Close-up showing hydraulic diversity (fast and slow flowing zones, backwaters, deep pools and runs.

Below: **Powely Creek upstream Starnes Road** (view upstream). Note the **erosion and sediment discharge** caused by deer. Note the brown staining of the water showing that this is **fed by a wetland**. With a wetland in the hinterland and a reasonable amount of natural meander , this creek has a “head start” for restoration. The lowest reaches (600m) have good riparian tree cover and habitat.

Left: **Powely Creek about 1.8km upstream of Starnes Road**. While this section has been straightened in the past (and a bit more meander would be good) the small meanders in this small creek still provide reasonable hydraulic diversity. It is mainly riparian tree planting that would be required.

Left and below: **Blue Creek at Fickling Bush**, upstream of Drummond Road. Very good habitat provided in this 170m long remnant of native bush. Inanga, banded kokopu and koura were abundant with longfin eel rare.

Below left: Blue Creek upstream of Fickling Bush (looking downstream). If this riparian zone could be 'connected' with Fickling Bush and the 2km section of Blue Creek between Edwards and Chings Roads, there could be a large improvement to this part of the catchment. B**elow right: Blue Creek downstream of Holdaway Road** (looking downstream).

Left: the section of **Blue Creek** in very original condition (natural meander and mature forest dominated by native trees). This section would benefit from increased flows in summer as the dissolved oxygen levels get low. Historically a lot more flow would have passed through this channel. There are some temporary (consented) dams not far upstream and downstream of Chings Road that should be assessed for fish passage.

Left: **Moutere Rv looking downstream to Wilson Road** (E1599733 N5439178). Note >90% cover of filamentous green algae.

Below: **Moutere River at 400m upstream Wilson Road** looking downstream (E1599752 N5438457). Rock rip-rap on the left bank is relatively short and does not appear to have an adverse effect on water depth or hydraulics. However, this relatively unshaded section of the waterway led to a significant increase in water temperatures. Planting trees near the top of the rip-rap bank in this situation would have a large beneficial effect for stream shading.

Below: **Moutere River at Wills Road** viewed downstream (E1599985 N5437635). This habitat is reasonably typical of sections in the mid reaches of this river showing the limited shading.

Left: **Company Ditch No1 at 220m downstream Davey Road** (E1600728 N5436205) and ~400m downstream of the photo below. A real opportunity exists to plant trees at the top of the bank along this part of the stream. Cattle are grazed in this area occasionally.

Below: Looking downstream from the Moutere Highway (Mission Bridge).

Left: **Company Ditch No1 approximately 300m upstream of Wilson Road**. Shows the removal of shrubby willow. Replanting in mixed natives and shrubby willow would achieve good shading through this section.

Below: **Company Ditch No1** approximately 300m downstream Wills Road.

Photos below: **Moutere River between Old House Road and Davey Road**. This section has good hydraulic diversity including: riffles (shallow 'babbling' sections), runs (flowing sections where stones don't puncture the water surface), pools, and a backwater (a blind sub-channels). While there are some good copses of riparian shrubby willows in the section more riparian tree planting, including some natives, would help this shade and 'feed' this section of the waterway.

Left: Moutere River 1km downstream Old House Road (E1600176 N5435630). Note the backwater seen to the left of the photo) and the riffle (more turbulent water) in the centre of the photo.

Left: 1.06km downstream Old House Road. This shows a pool about 1m deep adjacent to a shrubby willow.

Left: 1.3km downstream Old House Road. Shows good bank shape variety with a steep bank on the outside of the bend and a beach on the inside of the bend.

Photo below: Small rock groynes like this create good variety of water depth. **Moutere River 250m downstream Kelling Road**. Note the almost vertical bank of original Moutere glacial outwash gravel/clay that is relatively common in this section of the waterway.

Below: **Moutere River downstream Kelling Road**. Unfortunately the trees (mostly smaller trees such as tarata (Pittosporum) estimated to be 10-12m) planted to the left of the photo will be limited in the amount they can shade the stream. Trees planted strategically at the top of steeper banks such as on the right above the rock rip rap would be effective at shading and feeding the stream. Small amounts of rock rip rap such as this are curved and are not adversely effecting the in-stream morphology.

Below: This section of rip-rap retains a lot of the original meander. However, planting of the downstream (furthest away) section of battered rock 91h:1v) would be beneficial. **Moutere River ~600m upstream Old House Road** (E1600012 N5434364).

Below: More typical unshaded sections of the Moutere River but with good meander and water depth variety. **Moutere River ~360m upstream Old House Road**.

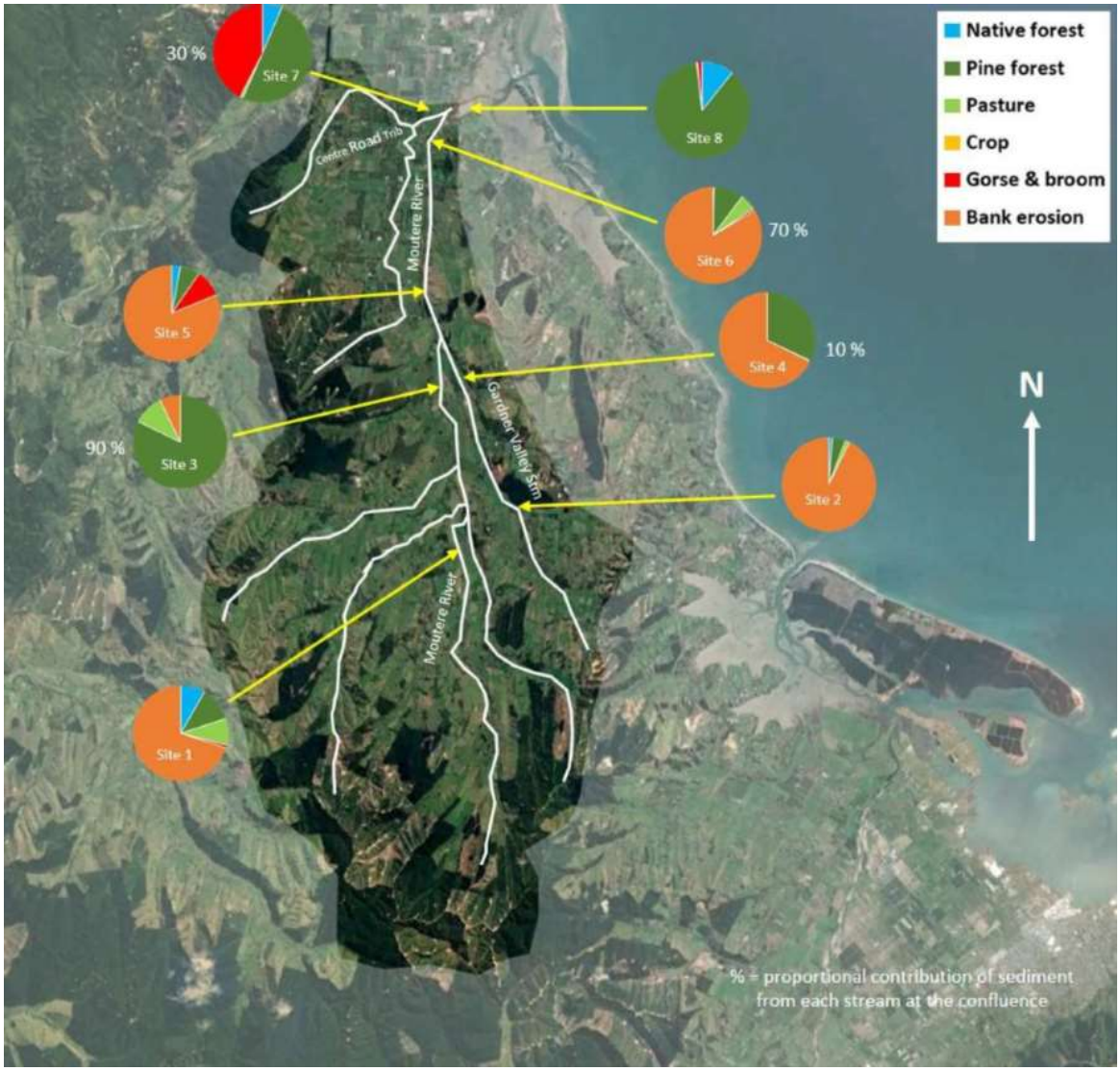
Left: This shows the proximity of the waterway to hop orchards and the limitation for the river to move and be protected by soft engineering approaches. **'Bosselmann Stream' looking downstream from Old House Road** (E1600123 N5434800).

Below: **'Bosselmann Stream' at Rosedale Road** showing willows and poplars providing good shade. A mix of natives and exotics would be much better for our native freshwater fauna.

Left: **Moutere River at Chings Road**, view upstream. Reasonable shading is provided in this section.

Below: **Moutere River at Edwards Road**, view downstream. Reasonable shading is provided in this section.

Appendix 2: Land use soil contributions to fine sediment the Moutere River system at each river confluence (from Gibbs and Woodward, 2018). Data is presented in pie-chart format where the pie chart includes all land use sources modelled. River channels are marked in white and the yellow arrow tips indicate the relative position of the sample. Values are not absolute and are best estimates from the data modelled.



Appendix 3: Fish survey sites on the lower Moutere catchment targetting giant kokopu in 2012