WATER QUALITY GAINS FROM RIPARIAN ENHANCEMENT - WAIOKURA

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Abstract
The Resource Management Act 1991 is the key statute for managing New Zealand's freshwater resources. In its Regional Policy Statement, the Taranaki Regional Council has identified the intensification of agriculture contributing to diffuse source pollution of waterways as an issue. Policy has been developed to address this issue and a riparian management strategy implemented in 1993 to achieve the expected outcomes. Delivery of the non-regulatory programme includes the provision of information, advice and advocacy, but has a particular focus on individual property planning and ongoing, one-on-one contact with landholders to implement riparian management. The customization of Geographic Information System (GIS) technology and the introduction of the Dairying and Clean Streams Accord (DCSA) have accelerated plan preparation to the extent that 95% of dairy farms now have a riparian management plan in place. The early development of Council's native plant tender scheme has made riparian planting affordable with 1.9 million native plants supplied. The implementation of riparian management in the Waiokura Catchment was adopted as the main vehicle for achieving the objectives of "Best Practice Dairy Catchments Project". Trend analysis of concentration time series data (2001-2008) showed that significant improvements occurring since 2001 may be attributed to changes in farming practices and riparian management. In particular, yields of filterable reactive phosphorous (P), total P and suspended solids (SS) declined by 25-40%. Median annual *Escherichia coli* concentration declined by 116 per 100 ml per year. These marked improvements in water quality are attributed to (a) improved riparian management, and (b) a major switch from pond discharge of farm dairy effluent (FDE) to the Waiokura Stream to land irrigation. Loads of sediment and P declined during 2001-08 even though water yields increased in the same period.

Introduction

Dairying makes a significant contribution to New Zealand's economic and social wellbeing with Taranaki the second largest dairying province in the country where 478,323 cows are milked (Livestock Improvement Corporation, 2010). The majority of dairy farming in Taranaki is located on the ringplain, where over 291,000 hectares of rich volcanic soil flank Mount Taranaki. The ringplain is dissected by over 300, steep-gradient streams, with their source in the Egmont National Park (Taranaki Regional Council, 2000). The impact of pastoral agriculture on New Zealand waterways is well documented (Wilcock 1986; Smith et al. 1993; Parkyn & Wilcock 2004; Parliamentary Commissioner for the Environment 2004).

The Resource Management Act 1991 (RMA) is the key statute for managing New Zealand's freshwater resources. The purpose of the RMA is "…*to promote the sustainable management*

of natural and physical resources" [section 5]. Under section 30 of the RMA, the Taranaki Regional Council is responsible for, *inter alia*, the control of water and land (for the purposes of soil conservation, the management of water quality and quantity, natural hazards avoidance and mitigation and hazardous substances management), and the control of discharges of contaminants into the environment.To give effect to regional council statutory responsibilities, the RMA contains a hierarchy of policy instruments, including regional policy statements and regional plans. These instruments are developed by regional councils in close consultation with their 'local' communities. The *Regional Policy Statement for Taranaki* identifies the effects on water quality arising from diffuse source discharges to water bodies, *inter alia*, as a regionally significant resource management issue and includes objectives, policies and methods to address that issue (Taranaki Regional Council, 1994, 2010).

In 1993, following extensive consultation with the Taranaki community, Council adopted a riparian management implementation strategy to address the issue of runoff from intensive dairy farming. The preferred strategy to deal with diffuse pollution from dairy farming was to promote riparian management through a combination of education and advocacy at a region wide level, with service delivery in the form of technical advice through the preparation of site-specific, riparian management plans (Taranaki Regional Council, 1993).

The first riparian management plans designed by Council were comprehensive reports containing extensive technical information, and detailed recommendations with costings, supported with colour aerial photography and graphics. Council produced between 50 to 100 riparian plans per year of this type from those that requested them. In 2003, the DCSA was signed between Fonterra, Ministry for the Environment, Ministry for Agriculture and Forestry and Regional Councils. The Accord outlines a set of national environmental targets and deadlines to help reduce the impacts of dairying on the quality of New Zealand streams, rivers, lakes, groundwater and wetlands. To give effect to the "National Accord", each region is required to produce a "Regional Action Plan" (RAP) in recognition of regional and geographical differences (Taranaki Regional Council et. al, 2004). A Council prepared riparian management plan and the implementation of riparian planting were incorporated into Taranaki's RAP. These requirements were additional to the national targets under the "Accord" which only required fencing to exclude stock from streams.

Pre-empting the introduction of the DCSA in May 2003, Council introduced a geographic information system (GIS) and developed state-of art, customized ArcView software to speed up plan preparation. This reduced preparation time by two thirds. As a result, over 95% of dairy farmers now have a Council-prepared, riparian management plan (Taranaki Regional Council, 2010). A key component of Council's riparian management strategy is for planholders to have access to riparian planting material at cost to make it more affordable for landowners. In 1996, Council developed a native plant scheme which operates through a bulk-tendering and contract system to acquire plants at wholesale rates and then passes these savings back to planholders. To date, over 1.9 million plants have been supplied to landholders through the scheme on a cost recovery basis.

The Waiokura catchment study

Concern about increasing degradation of soil and water quality and about the long-term sustainability of dairy farming led to the New Zealand dairy industry initiating in 2001, a study ("Best Practice Catchments for Sustainable Dairying") in which four regionally representative catchments were chosen for long-term monitoring. One of these is the

Waiokura Catchment in Taranaki. The goal of this study was to derive best management practices (BMPs) that would be widely adopted by dairy farmers and result in better environmental performance (e.g., better stream water quality). The main purposes of the programme are to: (1) establish baseline water quality monitoring in each stream; (2) infer the linkages between land use and water quality and use these to derive BMPs that are appropriate for the sensitivities of receiving waters in each of the regions; and (3) track water quality change as BMPs are implemented by farmers (Wilcock et al. 2007). Waiokura Stream is typical of many small streams in dairying catchments in New Zealand (Wilcock et al. 2007). However, it is atypical of ringplain streams in Taranaki because it is spring-fed and does not originate in the Egmont National Park. BMPs had been identified for Waiokura Catchment, with the specific purpose of reducing inputs of faecal matter, sediment and P to Waiokura Stream. BMPs were: permanent fencing to exclude livestock from waterways, with riparian plants to intercept and filter particulate contaminants in overland flow; reduction of effluent pond discharges through adoption of deferred irrigation of dairy shed effluent (DSE) to land; and reduction of soil P levels to their economic optimum values (Betteridge et al. 2005; Wilcock et al. 2007).

Council had already prepared plans for the majority of landowners in the Waiokura catchment by 2003. Ostensibly, the implementation of these plans was considered first priority to align the project's objectives of implementing BMPs to improve water quality. Project funding through the Sustainable Farming Fund (SFF) was used over 3 years to increase the implementation rate of riparian planting in the catchment. The SFF enabled a 50% subsidy on the cost of plants and 50 cents towards the planting cost. Farmers funded all of their own fencing under Council's riparian programme and their "Accord" obligations.

A more thorough description of the improved water quality outcomes from changes in farming practices and riparian management is covered by Wilcock et al. (2009).

Intensification of dairy farming

Since 1959, dairy cow numbers in Taranaki have steadily increased from 258,000 (Burgess, 1958) to a peak of 501,004 in 2001-02 (Livestock Improvement Corporation, 2010), nearly a doubling in 40 years.

Table 1: Taranaki cow numbers

Year	Dairy cow numbers
1959-60	258,375
1985-86	382,383
1995-96	427,884
1990-00	482,000
2001-02	501,004
2005-06	481,272
2009-10	478,323

Intensification has resulted in an average increase of stocking rate from 1.45 cows per hectare in 1979-1982 to 2.8 in 1998-2001; however, actual stocking rates range from 0.9 cows per hectare to a maximum of 5 per hectare with the most intensive dairying occurring on the South Taranaki ring plain (Taranaki Regional Council, 1998). The intensification of dairying has increased the loadings of dung, urine and nutrients on pasture, increasing the potential for nutrients, organic matter and bacteria to enter both surface water and groundwater.

Much of the vegetation along river and stream margins has been removed during the course of land development in Taranaki and existing riparian vegetation is now found predominantly in the mid to upper reaches of mountain fed catchments (Taranaki Regional Council, 1995). GIS data from Council's coverage of riparian management plans indicate that 4557 kilometres of suitable existing vegetation were present when plans were prepared and 4636 kilometres of planting was required (Taranaki Regional Council, 2010). In the lower reaches, cows typically graze pasture to the water's edge resulting in the breakdown of the banks. Grazed stream banks provide no physical barrier to runoff, allowing contaminants to enter waterways more freely when it rains. Where cattle cross streams without bridges or culverts, they are 50 times more likely to defecate directly in streams than on adjacent races (Davies-Colley, et al. 2002). When high *E.coli* levels deriving from dung are found in water, they are indicative of the potential for harmful pathogens like *Giardia, Cryptosporidia, Salmonellae, Fosciola, Leptospira* and *Campylobacter* to be present, also (Ministry for the Environment, 2001).

Water quality in Taranaki

The Macroinvertebrate Community Index (MCI) is based on scores for individual taxa living in stony bottomed streams according to their particular tolerance to organic pollution. In summary, the higher the MCI, the greater the proportion of organisms present that prefer better water quality and better ecological condition to complete their lifecycle. In general, Taranaki has excellent to moderate quality in most mountain fed streams (Taranaki Regional Council, 2003). However, there is a general trend of reduced water quality from the Egmont National Park boundary to the sea as shown through the distribution of MCI values (Taranaki Regional Council, 1999). To a certain extent, this is a natural result of changing physical habitat downstream. Moreover, it is due to the effects of agricultural land uses on water quality and habitat such as nutrient run-off, loss of riparian vegetation over the last 160 years and increased sedimentation as a result of erosion of the stream margins.

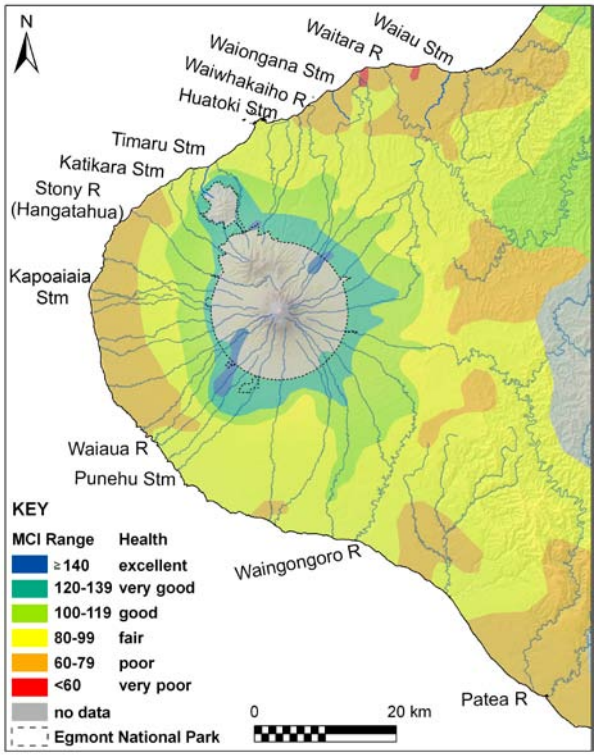


Figure 1 MCI values decrease downstream between the Egmont National Park and the coast

Community collaboration and riparian implementation strategy

The riparian management programme is a very carefully considered programme that has the support of farmers, landowners, industry (including Fonterra and Federated Farmers), environmental groups and the wider community. Shortly after the enactment of the RMA, the Council moved quickly to address the issue of diffuse source contamination of Taranaki waterways. This involved engaging all stakeholders with a significant interest or contribution to make in policy development. Clearly, as major stakeholders, farmers needed to be engaged. However, other affected parties, often with disparate interests, included Federated Farmers, the dairy industry, water users/advocates, Iwi, environmental groups, and the wider community.

In August 1992, Council released a discussion document entitled *Management of Riparian Margins in Taranaki – A Discussion Document*. The discussion document explored the benefits of and options for delivering riparian management. The management options canvassed included:

- Education and advocacy whereby the Council seeks to raise landowner awareness of the benefits of riparian management and to provide landowners with practical advice
- Service delivery whereby the Council provides labour, services and other assistance to undertake riparian management works
- Economic instruments whereby, through rate relief, grants and or penalties, the Council subsidises landowner costs to undertake riparian management
- Regulation involving local government bylaws and or regional rules.

The discussion document was distributed to a large number of affected stakeholders and made available to the public to get their feedback and input. Following public submissions on the discussion document, the Council adopted the report *Management of Riparian Margins in Taranaki – Implementation Strategy* (Taranaki Regional Council, 1993). The Strategy was based on a voluntary approach to riparian management with Council providing education, information, advocacy and service delivery support at the property level to assist landowner efforts. Service delivery focused on the preparation of free, property-specific riparian management plans and ongoing technical advice and assistance.

Riparian management plan development & dairying and clean streams accord
Council prepares site-specific riparian management plans to assist with the planning and implementation of fencing and planting. All plans are prepared from information recorded in the field, therefore, are an accurate account of a farm's stream bank fencing and vegetation status. The plans are prepared in close consultation with the landowner which ensures they are tailored to the needs of the property, therefore, more likely to be implemented. The plans are supplied at no cost and no obligation to the landowners.

They have developed from a comprehensive report with detailed cross-sectional designs, which include plant types, plant numbers and individual costings for each stream section. Schematics were simple black and white diagrams but improved over time when colour aerial photographs annotated with CorelDraw graphics were introduced. Production efficiency was further improved when a customized version of the software "Farmtracker" was introduced to measure stream lengths. Preparation time could take up to 3 days.

Pre-empting the introduction of the DCSA in 2003 and the RAP in 2004, Council started developing and trialing a new riparian plan format in October 2002. Council recognized the synergies that could be gained from its existing riparian programme and the DCSA to significantly increase the planning and implementation of riparian management in Taranaki. In collaboration with Fonterra and Federated Farmers, a requirement for 90% of all dairy farmers to have a Council prepared plan by 2010 was included in the RAP (Taranaki Regional Council et al., 2004). To achieve this target, planning had to be improved significantly and subsequently introduced the GIS version of the plan in 2003 after a successful trial period.

The GIS application was designed to run on both file geo-databases as well as the corporate, enterprise, ArcSDE implementation. Base data in support of the application is derived from

New Zealand's Core Record System, cadastral framework, supported by region-wide digital ortho-rectified photography.

Plans are prepared by a Land Management Officer (LMO) walking the lengths of all streams and recording existing vegetation and fencing, recommendations for each planting category, and annotating coded line-work onto a colour aerial photograph while in the field. This typically takes half a day. The line-work is redrawn by the LMO in the office using the GIS software ArcView which takes a further half day. Line-work is "attributed" according to the number of rows by planting type and plant spacing. Following this process, a riparian plan is produced which consists of an A3, double-sided, laminated sheet. The front of the plan includes a colour, ortho-rectified A3 aerial map (0.75m pixel resolution) showing the GIS layers of existing and recommended works along with their respective distances. The reverse side consists of a series of planning and budgeting tables. The tables outline a schedule for the timing of works, calculation of costs for different implementation operations and stages, and a list of plant species suitable to the farm's climatic location which are available through the Council's riparian plant scheme. Automation allows a Crystal Report to generate a summary from the GIS linework showing the lengths in metres of existing fencing and vegetation, along with their respective lengths of proposed fencing and planting. The report also shows the number of plants in each planting category required to complete the proposed planting in each section. A summed total of all statistics is provided at the end to enable an estimate of the likely cost for the whole property. The customization of GIS and the automation of manual functions has cut plan preparation from 3 days to 1, allowing up to 350 plans to be prepared annually, far exceeding the demand from those that requested them. Therefore, the 25 priority catchments identified in the Regional Freshwater Plan for Taranaki were targeted first until eventually all catchments in the region were covered by plans. This required pro-active marketing to landowners through correspondence and direct telephone contact to obtain their permission to proceed with a plan. Two thousand three hundred riparian plans have now been prepared in the region and ninety five percent (1615) of all dairy farmers have one.

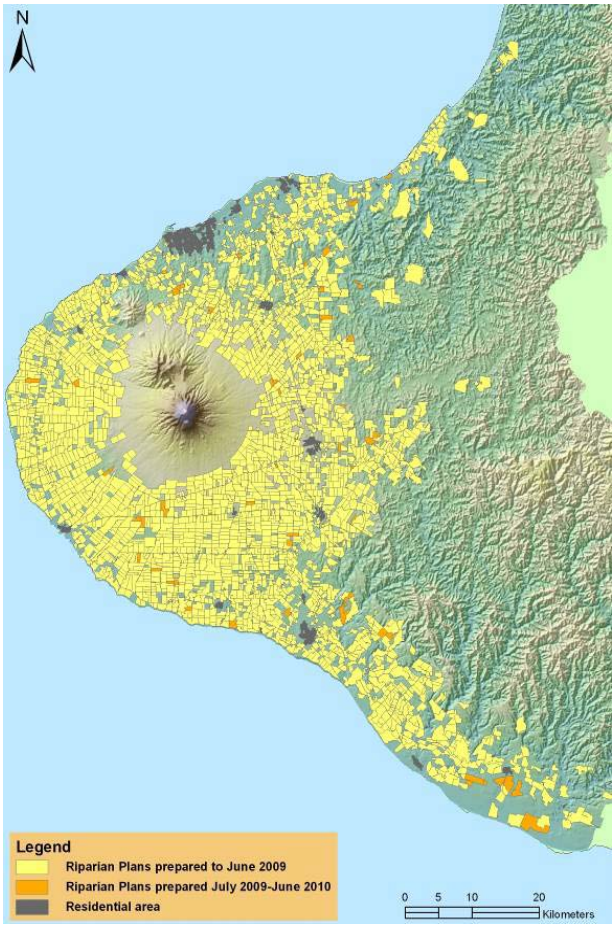


Figure 2: 2300 riparian plans prepared as at 30 June 2010

Native plant scheme

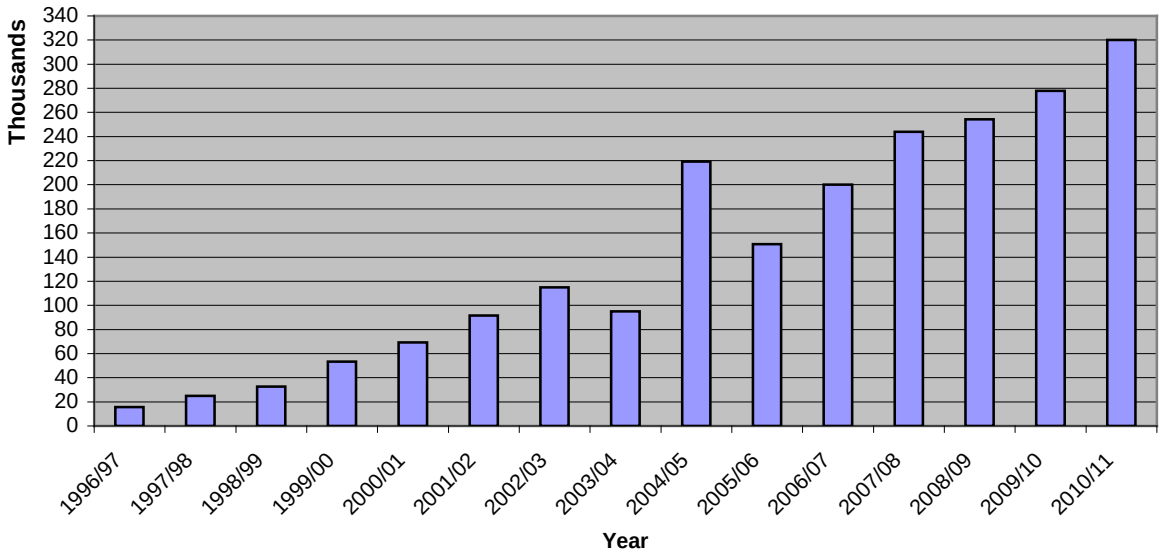
Council recognizes the cost burden on farmers to implement riparian planting and has addressed this in its Implementation Strategy by proposing the development of a native plant scheme. The RAP for Taranaki also requires 90% of all waterways fenced and planted by 2015 to be consistent with Council's riparian programme objectives (Taranaki Regional Council, 2004). The scheme operates through a tendering system for Council to secure plants at wholesale rates which are then grown on contract by nurseries a year before the planting season. Council then recovers the cost from the landowner, they are not subsidised. Native

plants are generally recommended because they thrive in Taranaki's moist climate and have the potential to enhance the region's biodiversity by creating corridors of habitat from the mountain to the sea.

A computer programme was written by Council in Visual Basic to process the tender information entered into a database. It allows instantaneous comparisons across all tenderers for preferred grades, quality and price by species. The database information is then used against set criteria in the tender specifications to award contracts, for example eco-sourced plants and ability to meet contract numbers get preference. There is often more than one contracted supplier for each species required as production of large numbers is often beyond the capacity of individual nurseries.

An invitation to tender was first advertised in 1996 to supply 15,000 plants consisting of 20 different native species. Contracts were awarded to 6 nurseries. In 2010, 300,000 plants consisting of 35 species were contracted to 14 suppliers through the tendering system. Since 1996, the demand for native plants through Council's plant scheme has increased steadily and has supplied 1.9 million plants to landholders.

Figure 3: Increase in riparian plant numbers



Once the plants have been grown to specification, nurseries deliver them during the last week of May to any of 4 dispatch sites around Taranaki which is included in the contract price. Farmers collect their plant orders the following week and are then subsequently invoiced. Seasonal staff are employed at each dispatch site to assist with unloading and loading.

Advantages accrued to farmers are the provision of good quality plants at wholesale rates to implement planting and to meet both Council's riparian objectives and the RAP targets. Without Council's native plant scheme, regional plant demand could not be met by local nurseries without them making significant investment in resources and increased risk taking.

Monitoring of plans

Emphasis is on building relationships with farmers through "one on one" contact to help them implement the plan's recommended planting and fencing proposals. Planholders are visited annually to record implemented works, to provide further onsite advice and information and to take a plant order for the following winter. The recorded information is used to update the GIS layers, which are then used to produce a monitoring map for reporting at the individual property level. The map is produced using a customized version of "Mapbook". The monitoring map shows spatially and quantitatively, implemented works by (metres and percentages) vegetation type and fencing type. Overall implementation progress can be compared to what existed at the time of plan preparation. Monitored information can also be collated to report at the catchment level as well as regionally for Council's annual reporting requirements. Up until the 30th June 2010, 1383 kilometres of fencing and 769 kilometres of planting has been implemented (Taranaki Regional Council, 2010).

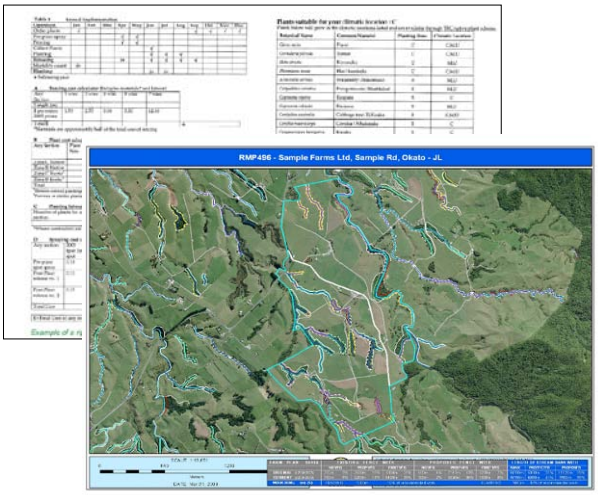


Figure 4: An example of a riparian plan monitoring map prepared using GIS technology

Monitoring of the Waiokura Catchment

After the introduction of the Best Practice Dairy Catchments project in 2001, 44 riparian management plans were prepared in the Waiokura Catchment by 2003. Sustainable Farming Fund (SFF) of $40,000 was used over 3 years to increase the uptake of riparian planting. Council's monitoring shows that 17.5 kilometres of planting has taken place up until the end of June 2010. Farmers also funded the entire cost of implementing 20.4 kilometres of fencing to protect their plantings and retire streambanks.

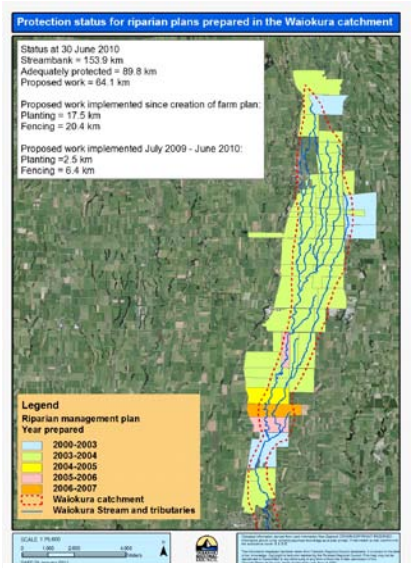


Figure 5 Riparian monitoring in the Waiokura Catchment.

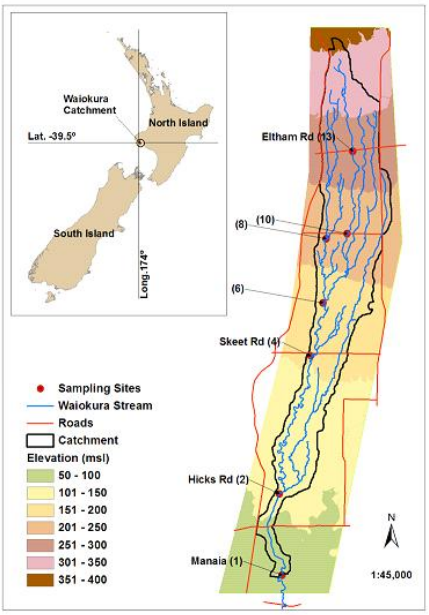


Figure 6: Map of the Waiokura Catchment with water quality monitoring sites.

Water quality in Waiokura Stream has been monitored since 2001 as part of an ongoing multi-catchment study following changes in water quality as BMPs are adopted by dairy farmers (Wilcock et al. 2007). The principal sampling site was the catchment outlet (Manaia), where a water level recording station gave a continuous record of stream flow. Intensive water quality monitoring was conducted fortnightly at three sites including the recorder site for 16 months from May 2001 to Oct 2002, and thereafter monthly from the recorder site only (Fig. 6). Details of the water quality monitoring methods are given elsewhere (Wilcock et al.2007;2009).

Non-parametric statistics were used for central tendency (median) and dispersion (interquartile range, IQR) for selected water quality variables. Annual stream loads at the catchment outlet were calculated from the product of discharge-weighted mean monthly concentration and true mean flow (Fergusson 1987). Yields (load divided by catchment area, kg ha^{-1} yr^{-1}) were calculated for 12-month periods with estimated uncertainties of ±25% for TN, NO_X-N, FRP and TP, and ±60% for SS (Fergusson 1987). Yields were not calculated for *E. coli* because storm loads, known to carry more than 90% of annual loads (Davies-Colley et al. 2008), were not specifically monitored. Trend analysis was carried out with the Seasonal Kendall test (Hirsch & Slack 1984) for turbidity (NTU), and SS, NH_4-N, NO_X-N, TN, FRP, TP and *E. coli* concentrations, for monthly time intervals during May 2001-Jul 2008 and Jun 2004-Jun 2008 (to detect changes following the 2004 fencing survey and changes in DSE discharges to the stream). Water quality summary statistics were compared with data pooled from the principal monitoring stations of 4 other monitored dairy catchment streams in (Wilcock et al. 2007) for SS (N = 505), NH_4-N (552), NO_X-N (553), TN (537), FRP (532), TP (499), and *E. coli* (460).

Results and Discussion

Trend analyses for water quality variables for 2001-2008 show significant decreases in concentrations of SS, turbidity, *E. coli*, FRP and TP (Table2). The trends for concentrations of N forms increased but were not statistically significant. Recent analysis shows that these trends are ongoing, most notably for *E. coli* (Fig. 7). Loads and yield trends (loads expressed per km of catchment area) show similar patterns to the concentration trends with major reductions in sediment (SS), *E. coli* and P forms. It is likely that riparian protection has contributed to the observed reductions in SS and P loads in Waiokura Stream. Effective livestock exclusion increased between 2001 (40%) and 2004 (52%) and there has been a focus on riparian fencing and planting vegetation in the stream reaches near Skeet Rd, where 60-90% of SS and 80-100% of FRP entered the stream. Particulate P comprises 70% of total P inputs to Waiokura Stream (Wilcock et al. 2007).

Sediment and associated particulate P inputs to Waiokura Stream in winter and spring have been shown to derive mostly from stream banks; from trampling by livestock, channel straightening and sediment removal (for improved drainage), and removal of riparian trees that stabilise stream banks (McDowell & Wilcock 2007). Approximately half the sediment and P loads enter Waiokura Stream in winter and spring, so that fencing may reduce stream banks destabilisation caused by livestock. Topsoil was identified by McDowell & Wilcock (2007) as the dominant source of sediment to Waiokura Stream in summer and to a lesser extent autumn. Livestock exclusion with suitable fencing, and riparian tree planting to stabilise banks were recommended for minimising sediment and particulate P losses, with simple in-stream structures for stabilising banks where planting was not a desired option (McDowell & Wilcock, 2007).

Recent research on grass filter strips indicates that where they are located at the down-slope margins of intensively grazed fields, they achieve 20-70% reductions in SS and TP concentrations (McKergow et al. 2008). Thus, a relatively small increase in riparian management in an area where stream loadings occur may have considerable benefits of improved water quality. Fewer pond discharges of farm dairy effluent and greater use of land irrigation are also a major cause of the improved water quality in Waiokura Stream. The combined trend analysis results and causes ascribed to the trends are summarised in Table 3.

Table 2: Seasonal Kendall trend analysis results for Waiokura Stream water quality variables during May 2001-Jul 2008. Sen slope units are g m^{-3} yr^{-1}, except for *Escherichia coli* (MPN/100 ml yr^{-1}). (SS, suspended solids; NH_4-N, ammoniacal nitrogen; NO_X-N, nitrate+nitrite nitrogen; TN, total nitrogen; FRP, filterable reactive phosphorus; TP, total phosphorus; NS not statistically significant)

	2001-08	
Variable	Sen slope	*P* value
SS	-1.46	0.001
Turbidity	-0.81	0.001
E. coli	-116	0.011
NH_4-N	0.0001	0.922 (NS)
NO_X-N	0.015	0.487 (NS)
TN	0.010	0.538 (NS)
FRP	-0.002	0.002
TP	-0.0060	0.001

Table 3: Trends in stream quality variables during 2001-08 for Waiokura Stream, and likely reasons for change. Trends show the overall changes in median concentration (upper number) and yield (lower number) and arrows indicate an increasing (↑) or decreasing (↓) trend. (SS, suspended solids; TP, total phosphorus; FRP, filterable reactive phosphorus; NO_X-N, nitrate+nitrite nitrogen; TN, total nitrogen; DSE, dairy shed effluent; MCI, Macroinvertebrate community index.)

Descriptor	Trend (%)	Reason	Comment
SS	40↓ 38↓	Riparian management	Most sediment from stream channel and banks (McDowell & Wilcock 2007)
TP	30↓ 32↓	Riparian management Fewer dairy shed effluent (DSE) discharges Less P fertiliser used	P associated with stream channel sediment (McDowell & Wilcock 2007); DSE accounts for about 70% of farm P runoff loss (Betteridge et al. 2005)
FRP	20↓ 29↓	Fewer DSE discharges Less P fertiliser used	
E. coli[+]	40↓ –	Riparian management Fewer DSE discharges	Reduced inputs of faecal matter Collins et al. (2005; 2007)
NO_X-N	14↑ 25↑	Increased N fertiliser use	Increased production (intensification of land use)
MCI	NSC[++]	——	Too soon to detect changes (Collier et al. 2001)

[+]*Escherichia coli* loads are based on fixed-interval sampling and do not necessarily take storm-flow loads into account (Davies-Colley et al. 2008)
[++]NSC = No significant change

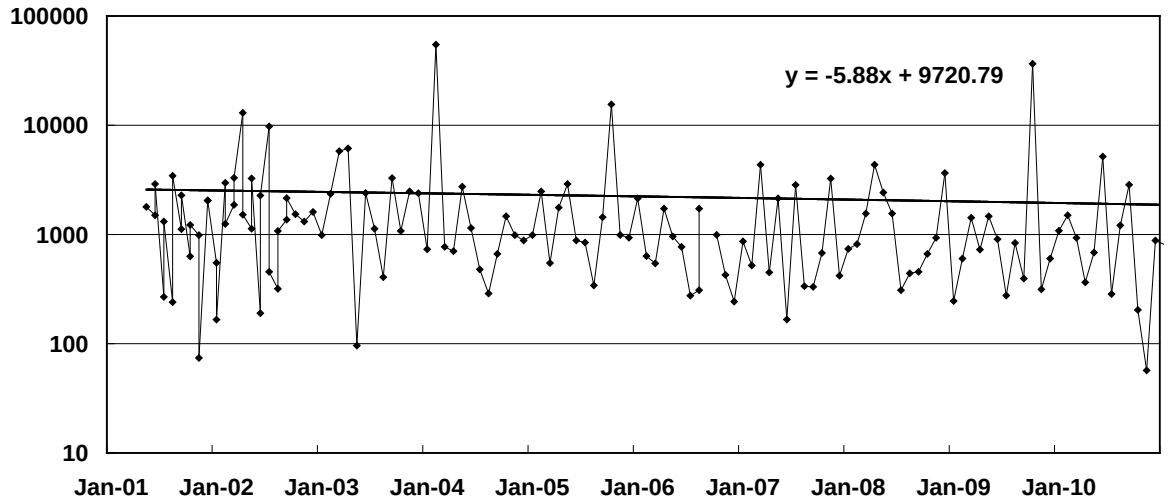


Figure 7: Time-series and trend analysis for *E. coli* (Y-axis) in MPN/100 ml in the Waiokura Stream during May 2001-Jan 2011.

Conclusions

The loss of natural riparian vegetation and the intensification of dairying have impacted on water quality in Taranaki. Taranaki Regional Council has a statutory obligation to protect and enhance water quality and is leading the way in how to address this increasingly important issue through its riparian management programme. It has identified the issue early, consulted widely with the community, and collaborated with stakeholders to develop an agreed strategy to improve water quality through riparian management. A key component of the strategy is its voluntary approach and the provision of a free property planning service which has proved successful in establishing initial relationships with landowners. One-to-one annual monitoring visits on the farm and the provision of ongoing technical advice, encouragement, and native plants at cost through Council's native plant scheme, have kept landowners engaged which has resulted in the implementation of their riparian plans. Significant advances have been made to the planning process through innovation and the adoption of customized GIS technology, to the extent that the majority of dairy farms now have a plan in place.

The introduction of the Dairying and Clean Streams Accord and the Regional Action Pan for Taranaki has provided a fillip to accelerate the objectives of Council's riparian programme. The "Best Practice Catchments for Sustainable Dairying" project and the completion of planning in the Waiokura Catchment, tested whether the implementation of riparian management would improve water quality. The reductions in discharges of farm dairy effluent and improved riparian fencing and planting are the main reasons for the improved water quality in the Waiokura Catchment. Dairying is an intensive form of agriculture that occurs where there is a high degree of connectivity between the land and stream networks. Riparian management is therefore essential for buffering waterways from the adverse effects of this land use and the Waiokura study suggests that significant improvements have been achieved in water quality with less than half of the stream length protected.

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