SCALABLE COST-EFFECTIVE SOLUTIONS TO RESTORE STREAM ECOSYSTEMS

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ABSTRACT

This paper aims to explore how with the right will and working together, diverse groups with an interest in our land drainage channels can collaborate to significantly enhance our waterways. Alternative approaches to land drainage management can create more environmentally sensitive and sustainable channel systems with the 'whole of life' aim of benefiting all parties, with support from local communities.

Historically waterways have been managed largely to ensure performance of their land drainage function, without consideration of the full range of values that they can offer. Healthy waterways where *New Zealanders can swim, fish and gather kai* is part of the national identity, but too often our waterways have been significantly modified and are severely degraded, with freshwater ecosystems impacted by poor water quality.

This paper will outline two areas in lowland Canterbury that, since late 2017, have been the subject of trials to test methods of waterway restoration. They are both spring-fed gravel bed waterways, with a range of native and introduced fish and invertebrate species, including native shortfin and longfin eel, inanga (one of the whitebait species) and introduced brown trout. The sites lie between Springston and the Waikirikiri/Selwyn River, which drains to Te Waihora/Lake Ellesmere, New Zealand's fifth largest lake and an important wetland system with special significance as a tribal taonga (treasure) to Ngai Tahu.

Due to subsequent human activity, water quality has been impacted by excessive suspended sediment, nutrients and contaminants. High nutrients and a lack of shading allows aquatic weeds to flourish, blocking the flow and contributing to flooding, trapping sediment and causing fluctuations in dissolved oxygen. Land use intensification has also resulted in contamination of groundwater.

The trial site at Powells Road drain is being led by 'Living Water', a 10 year partnership between the Department of Conservation and Fonterra. On the Silverstream catchment, the work is led by 'Fish and Game' supported by the 'Water & Wildlife Habitat Trust' and others, with similar objectives.

This paper sets out the work completed to date (i.e. channel shaping, instream features and planting; to create habitat diversity and shading), both to maintain the land drainage function of the watercourse and enhance its ecological function, together with how the sites will be monitored, the early successes and lessons learnt. The importance of collaboration is emphasised, as is selling the vision to encourage and enable the wider community to embrace the change and give the Selwyn District Council a mandate for improved management. Initial setup costs are discussed within the context of the long-term potential benefits, as well as future plans.

A GIS database of watercourse suitability is under consideration, to help identify other trial areas across Canterbury and New Zealand. While these are likely to focus on rural

farmland, there is little reason why many of the lessons learned cannot be applied within more urbanised areas, where opportunities present.

In summary, this paper will provide examples of sustainable whole of life waterway restoration solutions, demonstrating that tangible benefits of stream restoration can be delivered cost effectively.

KEYWORDS

Restoring waterways, ecosystems, sustainable, whole of life, innovation, collaboration

PRESENTER PROFILE

Mike Cope has over 30 years' experience in river/canal control and flood protection, in the UK, New Zealand and on international assignment. His projects include developing a major flood strategy on the River Thames, river rehabilitation in the Caribbean and flood risk management projects in China, Thailand and New Zealand.

1 INTRODUCTION

Healthy waterways where *New Zealanders can swim, fish and gather kai* is part of the national identity, but too often our waterways have been significantly modified and are severely degraded, with freshwater ecosystems impacted by poor water quality. Historically waterways have been managed largely to ensure performance of their land drainage function, without sufficient consideration of the full range of values that they can offer.

This paper describes a collective response by those with a willingness to tackle the impacts that have been occurring and make a difference in terms of the value of our waterways to future generations. This can be done by working with natural processes, finding sustainable solutions that minimise the levels of human intervention required and looking to work in partnerships, share information and learn together to find affordable and implementable measures that will succeed.

We will outline two sites in lowland Canterbury that, since late 2017, have been the subject of trials to test methods of waterway restoration, emerging from a vision for healthier waterways. They are both spring-fed gravel bed watercourses, with a history of trout spawning, leading to a hope for improved fisheries, aquatic ecology and amenity value. However, water quality has been impacted by suspended sediment, nutrients and faecal coliforms, impacting the waterway ecology and making it difficult to meet the water quality needs at locations such as Coes Ford on the Selwyn River downstream of the Silverstream catchment, a historic swimmable location for Selwyn and Christchurch residents. Land use change in the catchment has also led to modification of the waterways, a significant loss of wetland and freshwater ecosystems and pollution of groundwater.

The sites lie between Springston and the Waikirikiri/Selwyn River, which drains to Te Waihora/Lake Ellesmere, New Zealand’s fifth largest lake and an important wetland system with special significance as a tribal taonga (treasure) to Ngai Tahu. The waterways were in fact originally dug to drain swamp in the mid 1800’s for agricultural purposes, or else they are naturally occurring streams which have been straightened and channelised to serve land drainage needs.

This paper aims to explore how with the right will and working together, diverse groups with an interest in our land drainage channels can collaborate to significantly enhance the health of our waterways while minimizing maintenance needs. Alternative approaches to land drainage management can create more environmentally sensitive and sustainable channel systems with the 'whole of life' aim of benefiting all parties, with support from local communities. The process of such a paradigm change in mindset needs to start with questioning the status quo, and this paper explores where to go from there, based on the recent experiences at these sites. Obtaining buy in from the landowners, farmers and local communities is an essential component, with early consultation and engagement of key parties being key to any success.

2 EXAMPLES OF INCORPORATING STREAM RESTORATION WITHIN ONGOING MAINTENANCE WORKS

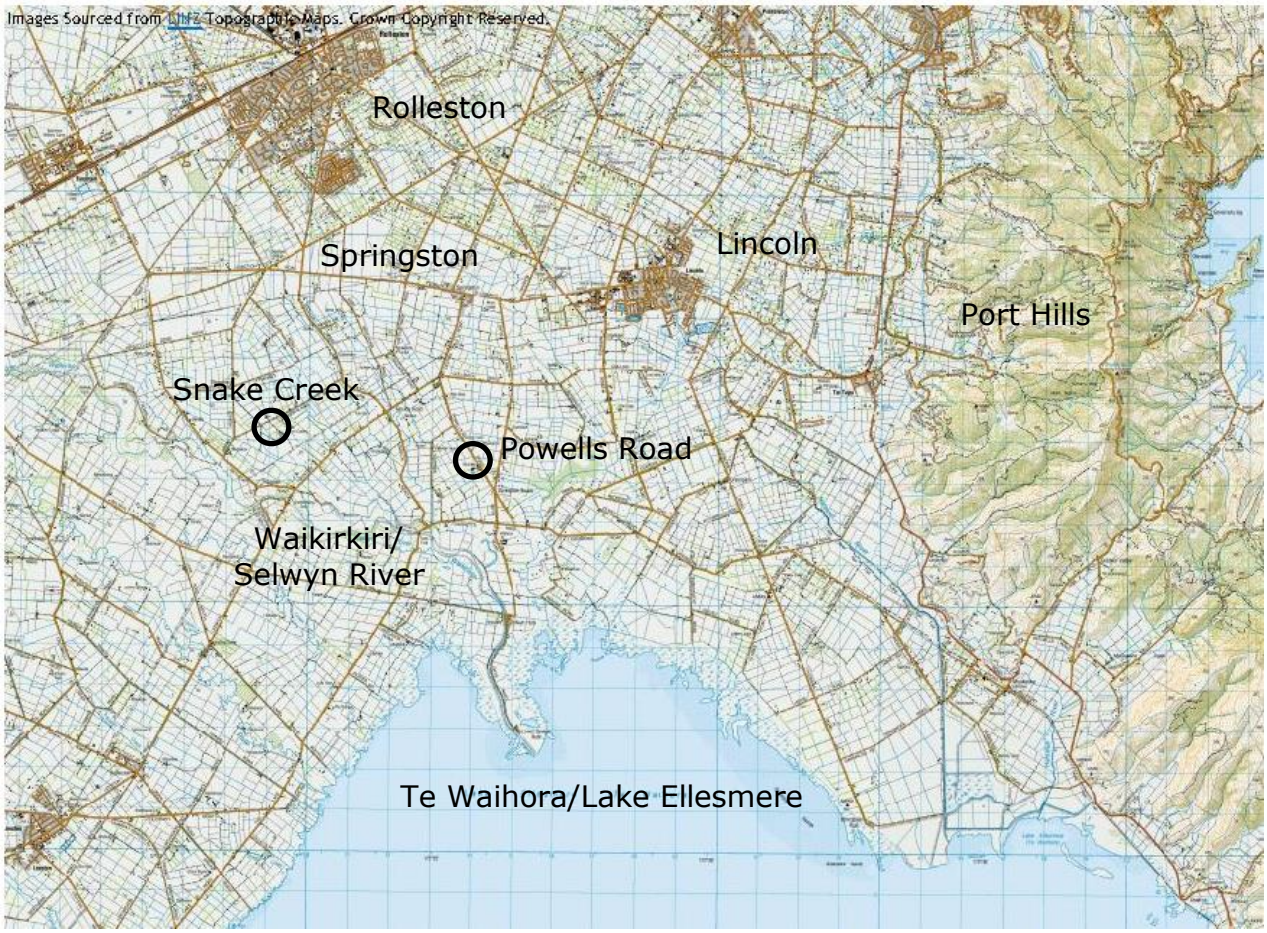
2.1 THE NATURE OF THE SELECTED SITES

2.1.1 THE SITE LOCATIONS AND BACKGROUND

The trial waterway sites explored in this paper are spring-fed tributaries of the Selwyn River and the Ararira/LII River, both significant waterways feeding to Te Waihora/Lake Ellesmere. They are located as shown in Figure 1, and are referred to as:

- Snake Creek, Silverstream; and the adjacent
- Powells Road Drain, part of the Ararira/LII catchment.

Figure 1: Location of Trial Sites in the Waikirikiri/Selwyn River Catchment



The headwaters of the Waikirikiri/Selwyn River lie in the Rockwood Range of the Southern Alps. From here the river flows across the Canterbury Plains, forming the largest tributary of Te Waihora/Lake Ellesmere. The Selwyn River catchment includes a number of streams and waterways originating as springs in the low plains, including Snake Creek and Silverstream.

The Ararira/LII River originates as springs in the Lincoln/Springston area. The Powells Road waterway is a small tributary waterway (originally a hand-dug drain) of the Ararira/LII River.

A once extensive swamp surrounding Te Waihora was drained to make way for farming, particularly dairy, and waterways were heavily modified. The health of these waterways significantly impacts the health of the Selwyn River and Ararira/LII River and in turn Te Waihora/Lake Ellesmere below.

On the Selwyn River degradation in water quality is clearly evident at the swimming hole at Coes Ford which is now often unsafe for swimming, and in the trout fishery degrading severely from what was once some of the best trout fishing in the world. From supporting a run of an estimated 14,000 brown trout in 1962, more recent estimates are around 500. The contributing factors towards this include climate change, water takes and land intensification, as well as loss of habitat in spawning waterways such as Silverstream.

Photograph 1: View of Snake Creek Bank Erosion Prior to the Works

The trial sites were selected to test the design and implementation of tools to improve habitat for instream biodiversity. They were chosen due to their gravel substrate with a

permanent spring-fed base and lack of habitat diversity resulting from traditional maintenance methods. The waterways also used to be important spawning areas for trout.

At Snake Creek the aim is to restore approximately 3km (presently completed is 2.4km) of the farm drain in the upper catchment, which then flows to the Silverstream River and then on into the Selwyn River just upstream of Coes Ford. The works are seen as a precursor to broader restoration works across the catchment and are being led by Fish and Game in conjunction with landowners and multiple funding partners.

The Powells Road site is a spring-fed roadside drain within the Ararira/LII catchment managed by Selwyn District Council and the LII Drainage Committee. This catchment lies adjacent to the Silverstream catchment but drains separately into Te Waihora/Lake Ellesmere. The works are being led by 'Living Water', a 10 year partnership between the Department of Conservation (DOC) and Fonterra.

Living Water (DOC/Fonterra) gained approval for the waterway enhancement trial from Selwyn District Council and the LII Drainage Committee in November 2017. This allowed for the design and implementation of trial approaches and tools to improve habitat to increase instream biodiversity and reduce drain maintenance.

Photograph 2: View of Powells Road Drain during Early Works

2.1.2 KEY ISSUES AT THE SITES

The Snake Creek is a spring-fed stream, though it is classified as a 'drain' by the Selwyn District Council and every year the aquatic weeds are cleaned out mechanically to retain its land drainage function as part of productive agricultural land (predominantly dairy farming over recent years). Powells Road Drain has been maintained in a similar manner, to drain groundwater, maintain its road drainage function as well as to service the adjacent farmland. These maintenance practices, while standard across most of the country and effective for the stated purpose, have been very destructive for aquatic life, tending to result in an over-widened channel with abundant macrophytes and steep banks which then encourages silt deposition and bank erosion. The inevitable result is that landowners or the Council end up stuck in a costly cycle of drain clearing and then bank stabilisation efforts, both of which can also result in a low diversity of habitat and little appropriate vegetation or tree growth to provide shading. The drain clearing works then continuously disrupt the lifecycle of aquatic species, involving the physical removal of animals (e.g. eels, trout and koura) as an inevitable part of the process, though obviously not the intention.

Due to the drain maintenance and agricultural land use, with a lack of shading and limited protection of the watercourses from surface runoff, the water quality within the catchment becomes a problem. This has become increasingly evident downstream. For example, at Coes Ford on the Selwyn River which was formerly a very popular swimming hole for the local population and wider visitors from around Christchurch. Now the water quality at the ford is poor and anybody swimming there would be at risk of getting sick, potentially severely so, giving rise to much media publicity and frustration from the local community. The Regional Council (Environment Canterbury) has undertaken analyses that indicate the Snake Creek and Silverstream catchment to be a key source of the poor water quality.

These streams are also important trout spawning waterways and are home to many native species, such as the At Risk longfin eel. However, the fisheries have been steadily declining. In the 1980s a spawning survey done by the then New Zealand Acclimatisation Society showed 357 trout spawning redds in the lowland drain Snake Creek (already a rapidly reducing number). However, a survey last year suggested that this had reduced to only 57. North Canterbury Fish and Game wants to change these figures and try to restore the historic fishery levels, starting with a restoration project that aims to turn Snake Creek into a living stream. This should also improve conditions for native species and create a more sustainable waterway system.

Both sites being discussed here face similar issues, though one being more constrained by infrastructure (i.e. primarily a road drain), and the other by farming processes and needs (i.e. primarily an agricultural drainage channel). These various issues to be addressed can be summarised as:

- Habitat diversity significantly reducing, both aquatic and terrestrial;
- The gravels in the bed of the waterways becoming silt laden;
- Poor water quality, reducing ecological diversity and impacting downstream rivers;
- Large amounts of suspended sediment, nutrients (especially nitrogen and phosphorus) and contaminants (such as faecal coliforms);
- High levels of maintenance being required, within very constrained sites;

- The unshaded and over-widened waterways encouraging aquatic weeds to flourish which slows the flow and causes flooding, traps sediment and causes massive fluctuations in dissolved oxygen;

- Land use intensification resulting in contamination of groundwater;

- Resulting reductions in the stream life, including fisheries; and

- Poor aesthetics, with drain maintenance being driven only by functional land drainage requirements, creating unstable channels.

2.2 THE PARTNERSHIP APPROACH

2.2.1 GENERAL APPROACH

Having selected the sites within the broader aims outlined above (objectives are set out in more detail below), partnerships were forged in order to meet the challenges of raising the required funds, delivering the projects and establishing interest from key parties for wider application of the approach in the future. In order to prepare for broader future waterway rehabilitation opportunities, it was clear that there was a need to promote the potential positive outcomes, change certain mindsets and to some extent overcome the concerns of those who doubted the viability of such a change in approach.

We consider that these projects are excellent examples in exploring how diverse motivated groups (e.g. agencies, charities and other interested parties, with strong community input) can collaborate to significantly enhance our waterways, creating environmentally sensitive and sustainable channel systems with the 'whole of life' aim of benefiting all parties. They will leave a legacy for future generations to enjoy, and hopefully can form a template to inspire others to rehabilitate their watercourses, building on and improving the type of works implemented to date.

2.2.2 SNAKE CREEK

The Snake Creek site was selected by Fish and Game, working with Water & Wildlife Habitat Trust (a charitable trust with a focus on education and habitat protection), other interested parties and a local dairy farmer, to restore an initial 1.1km of the farm drain that runs through a section of the Silverstream catchment, plus works to two springheads. These works, now extended to 2.4km from a planned 3km, are part of a wider project to restore the entire Silverstream catchment, and additional improvements are already under way on McGraths Stream and Silverstream. Restoration works include bank planting to create shade, habitat and to filter runoff, and the use of rocks, wood and gravel to form pools, riffles and other instream features to produce diversity in the stream slopes, widths and velocities.

The interest and contributions from the landowners here have been critical to the project success, such as by assisting in putting up the fencing, helping with site preparation and accepting new ways of managing their drains that puts new features and materials into them rather than aiming to "clean them out". They have a real desire to improve the stream, help the fishery and leave a lasting legacy for future generations.

The Canterbury Waterway Rehabilitation Experiment (CAREX) team at the University of Canterbury have been a valuable partner in sharing ideas and concepts for the stream rehaibilitaion. CAREX have been developing low cost practical strategies for some of the planting (trialed in other sections of the Silverstream catchment), and they have also restored the springs and immediate upstream channel, working with local landowners and Living Water.

A novel approach within an adjacent reach of the Silverstream catchment is the use of crowdfunding, which is being used successfully to help cover the costs of reshaping the banks of the stream and for planting of 875m of the banks.

There has also been significant support from schools, such as nearly 70 Leeston School students being put to work helping to restore the stream. In fact the schoolchildren also initially visited the site to come up with the restoration plan they put into practice, involving providing shading to suppress water weeds, appropriate planting of the reshaped banks (see Photograph 3) above the normal water line and improving diversity and narrowing the channel locally by adding rock and wood features.

Photograph 3: Reshaping the over-steepened banks

At other times there have been volunteer days held, so that the local community can get involved in the physical works.

Groups providing funding and support to the project include:

- Rata Foundation (offering community support in Canterbury, Nelson, Marlborough and the Chatham Islands)
- North Canterbury Fish & Game
- Living Water – DoC/Fonterra
- Environment Canterbury
- Ministry for the Environment's Freshwater Improvement Fund
- Selwyn District Council

- Charity Organisations
- Fulton Hogan
- Landowners

2.2.3 POWELLS ROAD DRAIN

Living Water gained approval for the enhancement of a 500m trial section of waterway from Selwyn District Council and the LII Drainage Committee in November 2017. This allowed for the design and implementation of tools to improve habitat, to increase instream biodiversity and reduce drain maintenance. The envisaged works were to be similar to Snake Creek above.

The Powells Road trial section was largely completed in late 2018 with riparian planting of trees and shrubs on the true right bank planned for autumn 2019.

Support for the project was provided by:

- North Canterbury Fish & Game
- Te Taumutu Runanga
- Selwyn District Council
- Local landowners

2.3 THE COLLECTIVE VISION AT THE SITES

2.3.1 THE OVERALL AIM

The ultimate aim of these projects might be summarised as to produce healthy waterways requiring limited maintenance looking over the medium to long term. It has to be accepted that to make fundamental changes to the watercourse form and function requires short term efforts that are likely to need initial additional inputs over the norm.

We have noted how the Selwyn River, its tributaries and surrounding waterways were once one of the most famous brown trout fisheries in the world. As a result, the area was very popular with Selwyn residents and Christchurch people, being a very good place to teach children the sport of fishing and as a result appreciate the value of waterways and the life cycles that they can support.

The decline in waterway ecological value has been a steady process over decades, which has resulted through limited historic farming practices, limitations in waterway management and maintenance and other human intervention. The actions required to reverse this process, and start to restore sections of the Selwyn River catchment closer to their potential value, dovetail nicely with the wider objectives relating to the water environment in the area.

Projects such as those at Snake Creek and Powells Road are therefore aiming to restore some of the most important trout spawning watercourse channels in this area, to thus improve angling opportunities in the wider river catchment. This ties in nicely with other ecological, social and water quality objectives, together with the sustainability goal of more self-cleaning, low maintenance watercourses.

The Snake Creek works currently being implemented are intended to form part of a wider project to restore the entire Silverstream catchment. Some work has also been done

near the confluence of Silverstream with the Waikirikiri/Selwyn River, and working with partners, it is hoped to create a connected network of improved stream reaches from the springs through to the Selwyn (Waikariri) River. Using the partnerships forged, with the landowners, Living Water, Selwyn District Council, Environment Canterbury, the CAREX team and others, it is hoped to turn this vision into a realistic aim within the next few years, and it is intended to continue working through the Silverstream catchment as opportunities arise. Indeed it will become increasingly possible to create those opportunities, as more people see the improvements that are possible and understand the implications, both in terms of stream ecology and also sustainable and affordable drainage management.

It could be said that these projects will maximise the environmental function of the drains, whilst looking to make their drainage function more efficient within a sustainable approach that is affordable for broader application. Finally it is hoped that these works may showcase an alternative way to manage drains and streams, as and where appropriate to the local circumstances.

2.3.2 KEY OBJECTIVES

The above aims can be realised by targeting the following key objectives in carrying out the waterway improvement works:

- Create a more aesthetically pleasing amenity;
- Enhance the fisheries, with clean gravels suitable for spawning;
- Improving aquatic habitat diversity;
- Improving terrestrial habitat diversity;
- Improving water quality to assist with achieving an improved aquatic ecology and "swimmable" rivers objectives;
- Reducing sediment and contaminant loads;
- Reduce macrophyte growth; and
- Maintaining or reducing medium to long term maintenance needs.

Any works to achieve the above objectives need to be completed within tightly constrained sites, working within road and farm land/boundary constraints, while maintaining a land drainage level of service and supporting the local farming community.

2.4 PLANNING AND IMPLEMENTING THE WORKS

2.4.1 PLANNING THE WORK FEATURES

In order to restore an ecologically diverse and healthy watercourse, and to reverse the decline in waterway value that has resulted through limited land management practices, a range of measures were put forward to contribute towards achieving the above objectives. The stream restoration features were intended to be mutually beneficial in terms of the value they provide to achieving water quality, biodiversity, fisheries and amenity use improvements within the area, as well assisting in waterway management and maintenance.

It was also recognised that transforming a waterway that has been managed like a 'drain' back into a thriving, living stream requires a change in mindset by all those involved in

the ‘drain’ management. This means everybody at all levels of influence, from the funding authorities through management and design processes to the digger driver desilting the watercourse.

Accepting that these waterways and their associated floodplain were heavily influenced by the previous draining of the marshes for farmland, such that there is no historical untouched desirable natural state to get back to, their “natural” form (based on the present dominant land use, topography, soils and flow patterns) was taken to be sinuous gravel bed streams that would form riffle-pool sequences. The types of features that were envisaged to try and create this form are summarised below, indicating how these were intended to enhance the waterway functions.

Reshaping of banks

Battering of the often over-steepened channel sides, often just on one bank, was planned to provide a more stable channel shape and provide more planting opportunities (see Photograph 3). As well as assisting with planting of the slopes, such work increases the flow area of the waterway (thus potentially offsetting any possible capacity reduction due to the replanting of the banks and the introduction of Carex secta at the edge of the flowing waters) and together with other measure below (e.g. rock features) should reduce erosion of the banks and thus sediment entering the stream flow.

The bank slopes were adjusted by scraping them with a digger and woody material growing in the banks was generally mechanically removed. The resulting clean slope was first grassed, to limit initial erosion, before being planted up on one or both banks. A dwarf turf rye grass was sown and some spot spraying of weeds carried out. Perennial weeds (e.g. blackberry, ivy, periwinkle) were allowed to regrow and were treated prior to seeding and replanting. To limit soil loss from steep and eroding or battered slopes, an erosion sock/log was tested running along the base of the worked slope.

Addition of flat berm near normal water level

Where space allowed, a small flat berm area just above normal water level was planned as a planting platform for Carex secta or for native emergent plants, creating some early shading of the flowing water areas. This is a major diversion from previous drain management practices. However, it provides increased diversity in the waterway flow and habitat, more planting opportunities and it provides the channel width to maintain flow capacity for high flow events while restricting the width of low flows such that adequate velocities are maintained to keep the gravels clear of silt. It also helps to reduce sediment runoff entering the watercourse.

Aerating gravels and macrophyte control

It was envisaged that some mechanical intervention might be required in forming a cleaner gravel bed to encourage more fish spawning, though this has not been necessary.

After completion of the initial proposed works, cleaning of macrophytes (growth to be monitored at specific transects) was expected to be necessary by hand, possibly for two to three years, to stop them building up and trapping silt. However, once the planting has established and starts to create more shading we should see significant reduction in emergent and submerged macrophytes and therefore in maintenance requirements.

Toe rock (erosion control)

Although the drain has been straightened, the watercourse naturally tries to create some lateral shape along its length (looking to reach a more natural state), alternately pushing the force of the flow more onto one bank and then the other. This also occurs due to the effects of any vegetation or bank slips that protrude into the flowing area. For areas where undercutting of the existing (and/or reprofiled) banks was evident, small piles of rock were planned to be placed local to the vulnerable bank to deflect flow away from these and thus protect against further bank destabilisation. This also provides instream features for diverse stream flow conditions and habitat creation.

Rock tumbling weirs and islands

These were planned where the waterway slope allowed a small elevation drop in the normal flow water surface, as a low cost (e.g. no need to tie into bank or bed) method of breaking up and giving some aeration to the flow to give increased diversity and potentially interesting habitat possibilities in the gaps between the rocks (see Photograph 4). This should help improve invertebrate diversity, as well as mahinga kai, helping to increase a number of species such as tuna (eels). To some extent the rock tumbling weirs try to mimic the shallow flow riffle features (at the flow crossover points between bends) of a riffle-pool sequence within a naturally meandering coarse bed stream, though in these test reaches there is insufficient space to realign the straightened channel and form meander bends. The weirs will tend to focus flow towards the centre of the channel, creating fast flowing water downstream that will form clean gravels, good for spawning and for more sensitive invertebrates. However, near the banks they will provide sheltered low velocity areas for juvenile fish.

Small groups of rocks or rock "islands", embedded into one bank, have also been introduced to provide instream diversity, especially where there is less channel gradient.

Photograph 4: View of Snake Creek Rock Features and Planting

Woody matter

Two types of woody materials were tested, firstly irregularly shaped logs or other woody matter embedded in the bank materials (e.g. into the rocks or hessian bags) to provide additional habitat and secondly small wood weirs made from more regular shaped wood. The wooden weirs, forming an alternative to the rock tumbling weirs, were sloped towards the channel centre and pointed downstream, to keep higher velocities away from the banks and create variable flow conditions around the structure, with more static flow at the side by the banks.

Bank bags for instream features

Gravel filled bags were planned to be used to form local instream features, narrowing the waterway section for higher low flow velocities and sometimes alternating from one side of the watercourse to the other in order to give the appearance of some stream sinuousity within the straight channel. These would be quite localised, similar to the use of rocks noted above but less permanent as the bags are designed to disintegrate over time, leaving the gravels to spread into the channel once any related planting has become established. Rock features were generally used where potential for bank erosion was considered to be highest, to give more permanent erosion protection.

Bank bags for channel narrowing

The use of lines of gravel filled bags, within the channel on both sides (about 800mm apart and slightly sinuous in plan shape), was planned to create narrowed "flume" type sections of channel where gradient allowed (at least 10m apart), creating lengths of increased velocity and good clean gravels to encourage trout to create redds here for egg laying, even during low flow conditions. Gaps behind the bag line were to be filled with gravels such that the structure as a whole would give good protection to any eroding areas at the toe of the bank.

Bank bags (filled with soil for planting Carex Secta)

Within the various gravel bag features, some of the bags (at intervals along the narrowed sections) were filled with soil and punctured in the top centre for planting Carex secta. This provided a stable base for such planting, though their effect on the channel flow will need to be carefully monitored. However, the channel narrowing combined with planting will quickly shade out the adjacent stream flow.

Planting of Carex Secta

Carex secta was planted alongside much of the waterway at a low level on the bank (or on the low berm mentioned above). This is a large and fast growing NZ native sedge that is hardy and evergreen and does very well next to rivers, ponds and wetlands. It forms an attractive foliaged grass that as it gets older, the older foliage dies down and the roots grow upwards to form a trunk like appearance up to 1-2m high. It can be seen in many locations along the River Avon through Christchurch. The large root system helps to hold the stream edge together and avoid erosion and it tends to flatten down as it becomes submerged during high flow events. There is obviously some potential for loss of waterway capacity and increased roughness in the channel, which is being offset by the sloping of the banks. The Carex secta will assist in providing some quick shading of sections of the watercourse until a tree canopy can be established (see Photograph 5).

Photograph 5: View of Early Shading from Carex Secta on Powells Drain

Planting of waterway banks/shading

Selective native shrub and tree planting was planned along the waterway banks in most areas, to significantly improve both terrestrial and instream biodiversity. On Snake Creek the planting is limited by the existing centre pivot irrigators, which cross the watercourse here on small concrete crossing points. As the bank planting matures, the water surface will become much better shaded by the grasses and forest trees, cooling the stream water and helping to stop problem water weeds (such as monkey musk and watercress) from appearing. With reduced macrophyte growth, which tends to clog up the waterways in warm weather, this should encourage more native fish and spawning trout at the site, also hopefully meaning no more diggers in these waterways!

Native planting along the waterway banks has the additional benefit of filtering the runoff from the adjacent agricultural land before it enters into the watercourse, helping to improve water quality and limit the amount of sediment, bacteria and other contaminants in the watercourses. The provision of such buffer zones, between the agricultural land and waterway environment, we consider to be a vital component in achieving improved ecological value as well as significant improvements in our surface water quality.

Farm management

For the waterway improvements noted above to reach their full potential, they need to work in parallel with changes to farming methods and practices. From experience to date, as landowners hopefully buy in to the suggested types of works and see benefits, they will take on more bank battering, planting and setting back of fences. While for such benefits to be seen more widely across New Zealand farmland may require changes to legislation, monitoring and enforcement, it is hoped that with good examples of where it

can provide a win-win solution this will be achieved more through collaborative processes. The early engagement of landowners within such processes is obviously a key aspect. The works carried out to date have achieved a lot, with only a small impact on the areas available for farmland, and providing benefits in reduced excavator work to constantly dig out the waterways. While there will be additional efforts required to maintain the riparian corridor, tree establishment will provide additional shading to cattle.

As well as silt traps (effectively widened depressions in the channel bed to encourage sediment deposition) built into the watercourse improvement works, the run-off passing from a cattle track directly into the Snake Creek has had its overland flow directed into a newly dug detention pond, providing some measure of treatment prior to the flow passing through a gravel filter and entering the waterway through a piped connection.

2.4.2 IMPLEMENTING, MONITORING AND MAINTENANCE

The main works over the initial trial site lengths were completed last year, enhancing their ecological function while maintaining the land drainage function of the watercourses. The riparian planting, woody debris, boulders, weirs and gravel filled bags have started to recreate an ecosystem that will support biodiversity and improve stream health.

Much of the planting has been done in one planting season, and it is now about 18 months since the first works were carried out, so the sites are starting to develop nicely and they are largely looking as was envisaged during the design. Maintenance is being carried out by the project teams for at least the first three years, to give the plants the best chance of success and correct any issues that arise. During this period the teams will monitor the water quality, ecology, bank stability and flood flow performance within the watercourses, understanding the successes and lessons learnt from the works to date so as to take those forward and develop improvements for further test sites in the future, hopefully including extending the present works downstream.

Close monitoring of the restoration effectiveness is being carried out in conjunction with the University of Canterbury's CAREX team (for the Carex secta performance), Water & Wildlife Habitat trust and Fish & Game (for the health of the trout fishery).

The three sediment traps created on the Snake Creek have been filling with silt very quickly, highlighting the high level of sediments entering the waterways, even in the headwaters of these spring fed channels. They are needing to be dug out by an excavator about every 6 months (some 50 tonnes of silt per year), this now leading to closer examination of the sources of this material.

The costs of implementing the works (over the initial 3 year development period) vary and depend on what you include, but they are generally in the range $100-200 per metre including all the various works required. There are already new savings being made, such as in the type of bank bags used and the methods of filling them, so it should be safe to say that the initial costs will reduce over time. In addition, with these being early trial sections there was a tendency to pack in a lot of different features, and so as their effectiveness becomes better understood we are sure that schemes will be able to be successful while using fewer features with greater spacing between them.

While the implementation costs of the proposed approach may be higher than simply continuing with traditional methods (depending on the condition of the watercourse and its current maintenance needs), we are confident that the whole of life costs should not be. While difficult to assess until more data is available and meaningful comparisons are carried out, they should hopefully show significant savings over the long term, but in any case should definitely represent a much more sustainable approach!

2.4.3 SUCCESSES AND LESSONS LEARNT

The aim to produce healthy waterways requiring limited maintenance is felt to be on track, with the planting developing, cleaner sections of gravel bed appearing and early evidence of spawning fish returning. A drain with a poor ecosystem is rapidly becoming an excellent example of a restored waterway offering increased biodiversity and improved recreational opportunities, while at the same time retaining its function for adjacent land users. The sites have been observed in a range of flow conditions, and to date the flows appear to be passing through satisfactorily without causing any issues with the various features.

Therefore in general it is considered that the rehabilitated lengths of channel have functioned well. Some indicators of the project giving successful outcomes, and some lessons learnt, are summarised below:

- Limited soil erosion being evident, due to the bank battering and various methods of bank toe protection put in place, and the process followed in clearing the banks, seeding and planting together with use of erosion socks;

- Planting has generally been successful, and though some Carex secta did not survive the winter flows others have grown very well;

- The rock tumbling weirs have had some movement of the rock, but this was to be expected in the initial high flow periods and they appear to be working well, maintaining function and providing fish passage in low flows but also fully drowning out in higher flows such that they do not cause any reduction in channel capacity – the spacing of these features does however need careful consideration, as in low gradient reaches they can drown out upstream features and cause excess silt to build up;

- The rock tumbling weirs and islands have been observed to be providing valuable flow complexity and habitat diversity, scouring clean the adjacent gravels and performing well across a range of flow conditions;

- The channel sections where the low flow channel width has been narrowed with bank bags have created a good flow through them which has resulted in clean gravels, with a good number of redds observed where trout are spawning;

- In these narrowed sections, where Carex secta and other planting has been most successful, the shading created has also already largely removed the macrophyte problem, acting together with higher velocities;

- No mechanical intervention has been necessary to clean the gravels, with the introduced features doing a good job of this working together with nature; the amount of silt in the system would in any case probably negate any benefits that might be achieved through mechanical work;

- In general where the macrophytes have been reduced there is a noticeable reduction in siltation, suggesting that the macrophytes capture a lot of sediment – however ongoing water way maintenance including hand removal of macrophytes remains a critical part of the overall project in these first years;

- While more work is required to develop and improve the "low-tech, low-cost" solutions, the bank bags, rock and wood features have stayed in place, now look established and are creating additional habitat as the channel bed adapts to them – trials of biodegradable jute bags for planting into have been successful and these

are now being adopted in place of more long-lived synthetic bags, with the jute bags being cheaper and avoiding plastic entering waterways;

- Wooden V-shaped and straight weirs have been less effective in creating diversity, are less natural looking and tend to foul with macrophytes during high flows, also functioning less well in low flow conditions. Root wads are good but also tend to accumulate material, pushing the channel flow to the opposite bank and so, while this is a relatively natural process, their locations should be carefully considered prior to installation;

- The farmers involved have been observed to be replicating similar works on other parts of their land, as well as interest spreading through the community and the approaches being replicated elsewhere; and

- Sediment traps have been very effective in trapping sediments entering the watrway reach, though this has highlighted the high sediment loads, particularly after significant rainfall.

The significant constraints at the sites have been overcome, such as the adjacent roads, power line poles and land use, centre pivot crossing points, sediment loads and flood risk issues, not to mention the perfectly normal concerns in changing to a completely different method of drain maintenance. Trust has had to be built through the process, requiring good communications, an open mind and a respectful approach. But a good level of trust now exists between the parties, with a positive and collaborative approach emerging.

A number of site visits have been carried out to date with Selwyn District Council, the drainage committees and asset managers and other interested parties. These have generated much interest in the projects as they develop, and in finding alternative ways to manage our drains more sustainably. An information board has been added at the Powells Road site to inform the public and to clarify the status of the projects as trial sites under the Living Water initiative.

While getting all parties to buy in to a new process such as this takes time, once a shared vision and common view of the potential benefits of the proposals has been reached then this becomes a key strength in helping to drive the process forwards and help to develop more projects. Once a few groups come together then an initiative like this can just start to snowball and build momentum, with others then keen to join in. Amazing things happen through collaboration, and projects can be much more successful when lots of parties come together. In the case of these projects, it is clear that their success would not have been possible without the level of collaboration achieved, such as with Environment Canterbury, Selwyn District Council and the local landowners but also with many others.

2.5 THE LONG-TERM VISION

Local to the sites the intention is to complete similar works across the whole catchment. There also needs to be more analysis of where the sediment is still coming from, and how to restrict or manage this, which may require further treatment ponds or similar, potentially requiring additional land that the farmers are likely to be reluctant to provide. The impacts of the Silverstream catchment works should hopefully then be evident downstream, such as at the Coes Ford site on the Selwyn River where water quality is regularly monitored. The Environment Canterbury Zone Committee is committed to making Coes Ford swimmable again, and they see projects like these as crucial to achieving that goal.

Thinking in broader terms the vision would be to have this new approach adopted in other catchments across Canterbury and then in other parts of New Zealand. This would aim to get to a point where drain management objectives and costs are much less about "clearing drains" and much more about maintaining plantings and emptying of sediment traps. However, it is accepted that it will be important to remove vegetation that could impede flood flow or that may cause downstream blockage during high flows. But there is no reason a waterway cannot be an attractive diverse habitat for many species of fish, insects and birds, acting as a natural filter to improve water quality, while functioning effectively and cost-efficiently in terms of land drainage and supporting farm productivity. Mostly this requires a paradigm shift from Councils, engineers, landowners and the public, to consider a highly modified water way as a living thing and not just a land drain.

Such a vision is not achievable for any one organisation working in isolation, rather it requires a collaborative approach starting with sharing the vision and developing trust, including with the landowner who can be key to moving forward. The early stages are critical to successful projects, such as for example the 1-2 years spent planning the Snake Creek and Powells Road projects before beginning on site. The design and implementation are then probably the more easy part of the process. Once a vision is shared, then a funding model can be developed which will also need a multi-agency approach. It is hoped that with example trial projects such as those outlined in this paper, demonstrating tangible benefits to all parties, then these early stages can be navigated more easily, to more successful outcomes. It will be key to share best practice and learn together.

A key successful outcome will be a general acceptance among the wider community (farming, drainage authorities, councils, engineers and asset managers, as well as the public) of the proposed change in approach, and much more debate about the management of drains in the community. In the short term this will require education and engagement, to achieve a common vision to drive long term success.

A useful tool for the broader long-term vision would be a GIS system of watercourses across the region, or hopefully nationally, populated with attributes that are relevant to whether a river, stream or other waterway has good conditions and potentials for receiving restoration works. Such a system would help to plan for future waterway restoration projects, prioritise those that will result in most benefit and that are more easily developed and provide an overview of the challenges ahead. This would usefully include a high level assessment of silt loads in the various river systems, as silt loads entering waterways in high rainfall events seems to be underestimated and forms a large ongoing problem. Such a tool could potentially result in more strategic solutions to problems, rather than tackling them locally. It would also potentially assist the farming communities to better understand the issues around their land management and farming practices and plan improvements starting where these can be most effective.

While the waterways best suited to similar restoration works are likely to be mostly rural in nature, there is little reason why many of the lessons learned cannot be applied within more urbanised areas, where opportunities present. Indeed in populated areas they could form an integral part of a water quality improvement strategy and/or landscape enhancement initiative. In such cases, and where space allows, a larger low-lying berm on one side of the channel a little above normal water levels (i.e. forming a 2-stage channel) could be very effective in making sure that the channel flow capacity is not reduced and if anything is enhanced. Where there is sufficient width available the narrowed low flow channel could then follow a sinuous path within the berm area to create a more natural appearance, flow complexity and habitat diversity. The berms could

be planted either with emergent native species or used as a flat base for planting of Carex secta, or they may be grassed to form more of a community area.

3 CONCLUSIONS AND FORWARD LOOK

3.1 CONCLUSIONS

This paper has provided examples of sustainable whole of life waterway restoration solutions, demonstrating that tangible benefits of stream restoration can be delivered cost effectively, even at heavily constrained sites. The two trial sites lie in the headwaters of Selwyn River tributaries that have historically been some of the most important spawning watercourses in the catchment. It is hoped that these works may showcase an alternative way to manage drains and streams, as and where appropriate to the local circumstances, with the overall aim to produce healthy watercourse environments with diverse habitats that require only limited maintenance.

The main works over the initial trial site lengths were completed last year, both to maintain the land drainage function of the watercourse in a more sustainable manner and to enhance its ecological function.

In order to bring back a thriving, living watercourse, and to reverse the decline in waterway ecological value that has resulted through limited land management practices, a range of measures have been tested at the two trial sites. The types of features used are summarised below, indicating how these were intended to enhance the waterway functions.

Reshaping of the channel – to narrow the low flow channel, stabilize the banks, assist with planting and maintain channel flow capacity;

Creation of instream features – using rock, wood and gravel-filled bags (or soil-filled for planting) to give complexity to the flow velocities and diversity of aquatic habitat, flushing sections of the gravels clean to encourage fish to spawn; and

Planting of the banks – to provide shading to the watercourse for control of macrophytes, create more diverse habitats and limit silts and contaminants entering the waterway, also involving planting of Carex secta by the water edge to give early shading.

While the space available was too tight to alter the overall watercourse plan shape, it has been possible to use instream features to create the appearance of a sinuous channel, providing variations in stream velocities and habitat and formation of clean gravel bed areas with minimal risk of any increased erosion. The idea is that if the features are designed in sympathy with natural processes, then once installed nature does the rest. For such improvements to be truly successful and show their long term potential value however also requires local farm management practices to be sympathetic to the waterway environment, especially in terms of water quality.

The initial success of the projects is indicated by the features and planting surviving high flow periods and establishing flow complexity, evidence of emerging habitat diversity, early shading of the waterway reducing macrophyte abundance and clean gravel areas being used for spawning. There has also been excellent farmer participation and further initiatives as well as significant interest in the works from landowners, drainage boards, the local communities and the wider public.

The measures required to realise improvements to in-stream biodiversity and the local fishery stocks (mahinga kai) fit very well with also improving water quality throughout the Selwyn / Waikirikiri catchment, helping to return areas such as Coes Ford to being swimmable locations for Selwyn and Christchurch residents.

It is recognised that for widespread adoption (as and where appropriate) of the types of measures being proposed, effectively to consider a highly modified waterway as a living thing and not just a land drain, requires a paradigm shift in thinking by many of those involved, from Councils, engineers, landowners through to the public. But the right drivers, framework and science appear to be well aligned to make it a real possibility.

3.2 FORWARD LOOK

For the success of projects such as these to continue, obtaining buy in from the landowners, farmers and local communities is an essential component, with early consultation and engagement of key parties being key to any success. Our trial sites benefited from open-minded and enthusiastic local farmers, who were happy to listen to the ideas being put forward and were able to see the long term benefits to their farms as well as to the natural environment.

There is a need for collective action at all levels (national, regional and local, including community involvement) to protect, enhance and sustain New Zealand waterbodies, within a catchment framework and with a clear vision. Such a vision needs to be formed through wide consultation and engagement of the key stakeholders, with the resulting activities taking on board the needs and concerns of the impacted communities and interested parties.

A step by step process is envisaged, whereby best practice and lessons learnt are shared across the wider community, providing collective improvement as knowledge increases. The process of such a paradigm change in mindset needs to start with questioning the status quo, develop through gaining knowledge at the site, become a more integrated approach through understanding of the wider picture and sharing knowledge and lastly create a series of objectives and actions as part of an informed plan that reflects a broad view of the opportunities and risks.

While establishment costs are going to be generally greater than the status quo, works like those carried out in the trial sites discussed clearly have the potential to reduce long term maintenance inputs and costs. This can provide win-win outcomes, for the environment, the responsible authorities or landowners, other interested parties (e.g. fisheries and environmental bodies) and the public at large. Much more work needs to be done to fully quantify this potential, and then time allowed to monitor the sites and assess their longer-term sustainable benefits against any maintenance work needed. However, it is never too early (or too late) to start making steps towards more environmentally sensitive, aesthetic, sustainable and healthy watercourses, whether these are in rural farmland or urban housing.

The suggestion emerging from this paper is therefore that there is a present opportunity, which if we embrace it and think outside the box in terms of our watercourse upgrades, modifications and maintenance works, we can create a more healthy, diverse, sustainable and enjoyable system of waterways for future generations to enjoy.

ACKNOWLEDGEMENTS

Significant thanks go to Robin Smith (Senior Ranger - Living Water Ararira Site Lead), for his engaging and thoughtful leadership of the works to the Living Water Ararira site, his always helpful responses to queries and his assistance in the completion of this paper.