REALISING THE VALUE OF REMNANT FARM WETLANDS AS ATTENUATION ASSETS

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Abstract

Attenuation is the loss or temporary accumulation of contaminants along the transport pathway from where they are generated to where they have impacts on the water quality of a stream, lake or estuary. Wetlands are one of the tools farmers can use to intercept and attenuate diffuse losses of sediments, nutrients, and faecal contaminants. With the co-operation of farmers within the Waituna catchment and Environment Southland, we undertook an assessment of potential sites for implementation of constructed wetlands to reduce nutrient and sediment flux to the Waituna lagoon. We found re-integration of wetlands into the highly modified Waituna mole and tile drainage system was challenging, often requiring significant excavation of potential wetland areas to maintain drain function in surrounding areas. However, an extensive range of potentially viable wetland sites were able to be identified, particularly located in natural swales and gullies in the upper catchment. Such wetlands were estimated to be able to intercept 60-90% of the surface and subsurface run-off from the catchment. Wetlands occupying 2-3% of the contributing subcatchments were predicted to be able to reduce annual nitrate-N losses by ~30-40%. Suspended solids and particulate P loads would also be substantially reduced. However, a major constraint identified was that many of the most feasible areas identified for wetland construction were former wetlands that had been recently drained – many in the last 5 years or less. Farmers were understandably less than keen to convert such areas back into wetlands. Given the frequent need for extensive excavation, the cost of constructing (or re-constructing) wetlands is relatively high at around $100-200 K/ha (lowest for larger-scale systems), with implementation costs of around $2K-5K per ha of farmed catchment. Farmers often spend substantial sums of money and hard work attempting to drain persistent small remnant areas of wetland on their farms, frequently with marginal financial returns. With the transition towards farming under environmental limits, the potential value of maintaining and enhancing such remnant wetland areas on farms need to be reassessed. In many cases these relatively small natural wetlands can provide important attenuation assets, markedly reducing export of contaminants from the catchment.

Introduction

Waituna Lagoon is the focal point of the Ramsar-designated Awarua wetland complex on the Southern Coast of the South Island of New Zealand. It is considered to be one of the best remaining examples of a natural coastal lagoon in New Zealand and is highly valued by Ngai Tahu, fisherman, hunters, naturalists and local landowners. Increasing agricultural development and intensification in the Waituna catchment has been implicated in the declining water quality and environmental health of the lagoon (Environment Southland

2012). A range of management actions to reduce sediment and nutrient inputs to the lagoon are now being considered to address these problems.

Building on a previous preliminary study done in association with Environment Southland and DairyNZ, we set out to identify specific locations and types of constructed wetlands that could be implemented in the Waituna catchment to intercept nutrients and sediments (Tanner et al. 2013). An iterative series of site assessments was undertaken to determine in more detail the most appropriate sites for implementation of wetlands in the upper catchment (an area identified to have high nitrate losses), including identification of a sites suitable for a demonstration trial.

Methods

The following criteria were developed at the beginning of the assessment process to guide site investigations:

- Tile drain flows are the dominant flow path, expected to contribute 60-90% of run-off (Hughes et al. 2013).
- Tile drains commonly follow natural drainage channels, wetlands sited in these locations are also likely to intercept a high proportion of surface run-off during large events.
- Target areas expected to have high nitrate-N export. Use flow and drain nitrate concentration estimates from an earlier report by Tanner et al (2013).
- Wetland should occupy 2-3 % of catchment area, ideally utilising natural landscape features and lower value land to maximise cost:benefit (Tanner et al. 2013)
- Sites suitable for a demonstration trial would also need to be generally representative of and applicable across a significant area of the catchment, and be reasonably accessible, to facilitate demonstration of these mitigation options to other farmers. Additionally, the sites chosen needed to involve farmers receptive to trialling the concept of wetland attenuation and agreeable to use of their land for a demonstration trial.

A six step method was used to identify potential wetland sites within the vicinity of Oteramika in the upper Waituna Creek catchment:

1. Initial satellite imagery search (e.g. Figure 1)
2. Check landowner willingness.
3. Desktop GIS analysis (e.g. Figure 2)
4. Site visits, visual assessment (see Figure 3) and farmer knowledge input.
5. Preliminary engineering assessment.
6. Detailed feasibility, design and costing assessment.

Google Earth satellite imagery was used to identify potential locations for wetlands. Prime wetland sites were commonly found along swale or gully systems that intercepted drainage flows, and provided natural boundaries for wetland construction and ground levels below those of the surrounding pastures.

DairyNZ and/or Environment Southland staff spoke with the land owners involved and assessed whether they were prepared to be involved. For sites where general agreement to proceed was provided by the landowner, a desktop GIS analysis was done to gain further detailed information on the topography and contributing catchment areas.

Contributing flow networks and catchment areas were calculated in ArcGIS on Lidar elevation data (1 m^2 cell size) provided by Environment Southland. A network of convergent flow areas was delineated using output from the ArcGIS Flow Accumulation tool. The Flow Accumulation Tool generates a raster layer of the number of upslope cells that flow into each cell. By applying a threshold value (500 m^2) to the results of the Flow Accumulation Tool, a virtual stream network was delineated. Although, in reality, an actual stream may not exist in many places, an area of convergent flow will exist during rainfall events and subsurface drainage will typically either be connected to or follow these flow pathways. These inferred surface drainage networks, supplemented with farmer knowledge of farm drainage systems (where available), were then used to estimate catchment areas above the prospective wetland sites and calculate the appropriate wetland areas required. These were then compared with the apparent wetland areas that could be feasibly constructed within the natural landforms. Lidar maps showing elevation contours, supplemented by strategically located cross-sectional profiles, were used to characterise the natural landforms.

Nine general sites were initially identified and visited with Environment Southland and DairyNZ staff in April 2014. Following field assessment of these sites, 6 specific sites (including some new ones identified during site visits) were then short-listed for preliminary investigation by an experienced agricultural engineer. These were sites that could feasibly accommodate a wetland of the required wetland to catchment ratio of 2-3% and where possible involved lower value land. In particular we focussed on smaller sites suitable for a pilot-scale demonstration trial.

The preliminary engineering assessments involved a visual assessment and GPS marking, supplemented by prodding into the soil with a steel rod to provide information on subsurface materials (e.g., presence and depth of peat, sand, gravel, clay, hard-pans etc.). On the basis of this information, 4 wetland sites were prioritised for more detailed field assessment including preliminary engineering feasibility, design and costing

Results and Discussion

An extensive range of potentially viable constructed wetland sites was identified in upper Waituna Creek catchment in the vicinity of Oteramika, suggesting wetlands would have wide applicability for interception and attenuation of nutrient and other pollutant losses.

The upper Waituna catchment is a slightly to moderately undulating landscape dissected by natural swales and gullies feeding the upper tributaries of the Waituna Creek. The common placement of tile drains within or linking into these natural drainage channels provides multiple opportunities to integrate wetlands into the natural landscape. As an estimated 60-90% of run-off (including both subsurface drainage and episodic surface flows) is expected to be transported through these areas (Hughes et al. 2013), they also offer the potential to intercept a substantial proportion of nutrient losses from the catchment. The real challenge is to retrofit constructed wetlands into the current highly modified drainage network in a way that maintains upstream drainage function and is acceptable to farmers.

Over the years the main course and tributaries of the Waituna Creek have been extensively channelized, straightened and deepened. Mole and tile drainage networks have gradually been implemented across the landscape to overcome impeded drainage. Dairy conversions and intensification has more recently led to significant additional investment in drainage within the catchment, reducing areas of poor drainage and gradually whittling away at remnant wetland areas in the landscape. This intensification of drainage will cumulatively have considerably increased the rate of soil drainage, and deepened ground-water tables and channel bed depths across large areas of the landscape. In this landscape, creation of constructed wetlands requires excavation below the level of the drainage system to avoid impacts on the drainage of upslope land. Although this is practically achievable, it significantly increases the cost of wetland construction, particularly in low gradient areas.

A range of potential constructed wetland sites were identified in the upper Waituna catchment. At the upper end of the size range identified was the ~3ha wetland site shown in Figure 1 which would comprise ~2.3% of its estimated 130 ha catchment area. The wetland proposed would require construction of 2 low dams across the existing relatively straight section of channel and adjacent flood-plain, and some re-contouring to occupy the base of valley. A wetland constructed at this site would occupy land that appeared to be of relatively lower agricultural value than the surrounding uplands.

Figure 1: Potential ~3ha constructed wetland site in the upper Waituna Catchment viewed using Google Earth Satellite image. The proposed approximate boundaries of the wetland are shown by the yellow lines

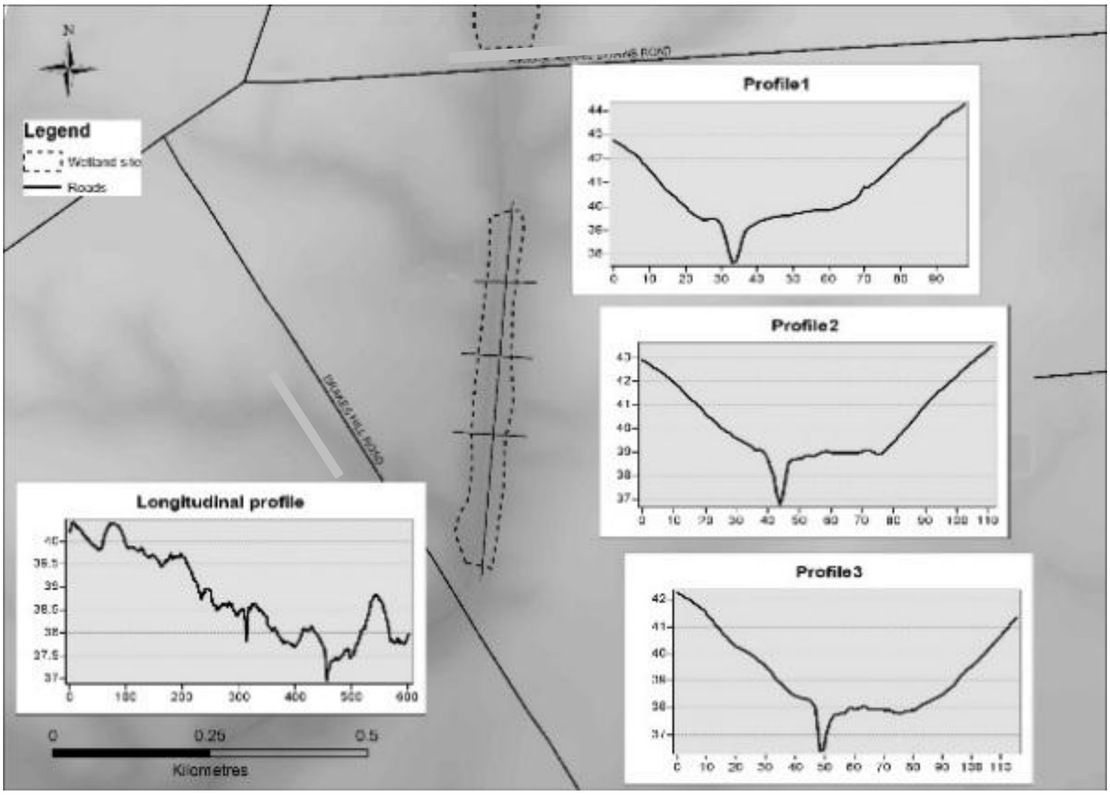


Figure 2: Lidar surface elevation image of potential ~3ha wetland site in the upper Waituna Catchment. Longitudinal and transverse cross sections are shown as an indication of the natural form of the valley

Figure 3: Example ~3 ha potential wetland site in the upper Waituna Catchment viewed from downstream end.

A common issue we encountered during our investigations was that farmers had recently spent substantial amounts of money draining the very areas where wetland construction was most feasible (see examples; Figs 4 and 5). In many cases these had been the last and most difficult low-lying areas to drain and farmers understandably were reticent to see these hard-won areas converted back into wetland, and forego the expected payback on their investment. So, although it would still be practically feasible to build wetlands in these areas, there would likely be significant antipathy from farmers, creating a significant hurdle to future application of constructed wetlands in such areas across the catchment. We estimate that this may affect around half of all potential wetland sites we investigated in the areas of the upper Waituna Catchment where our investigations were focussed. This emphasises the need for early intervention before farmers have invested large sums of money into wetland drainage, as well as the need to foster greater awareness of the potential value of natural wetlands for contaminant attenuation of intercepted run-off. The cost of constructing or re-constructing such wetland areas is significant. Estimates derived during the present study suggest the capital cost of constructing wetlands as proposed in the present study would be around $100-200 K/ha (lower for larger-scale systems), meaning the initial implementation costs per ha of farmed catchment would be around $2-5K. However, ongoing operational costs would be low.

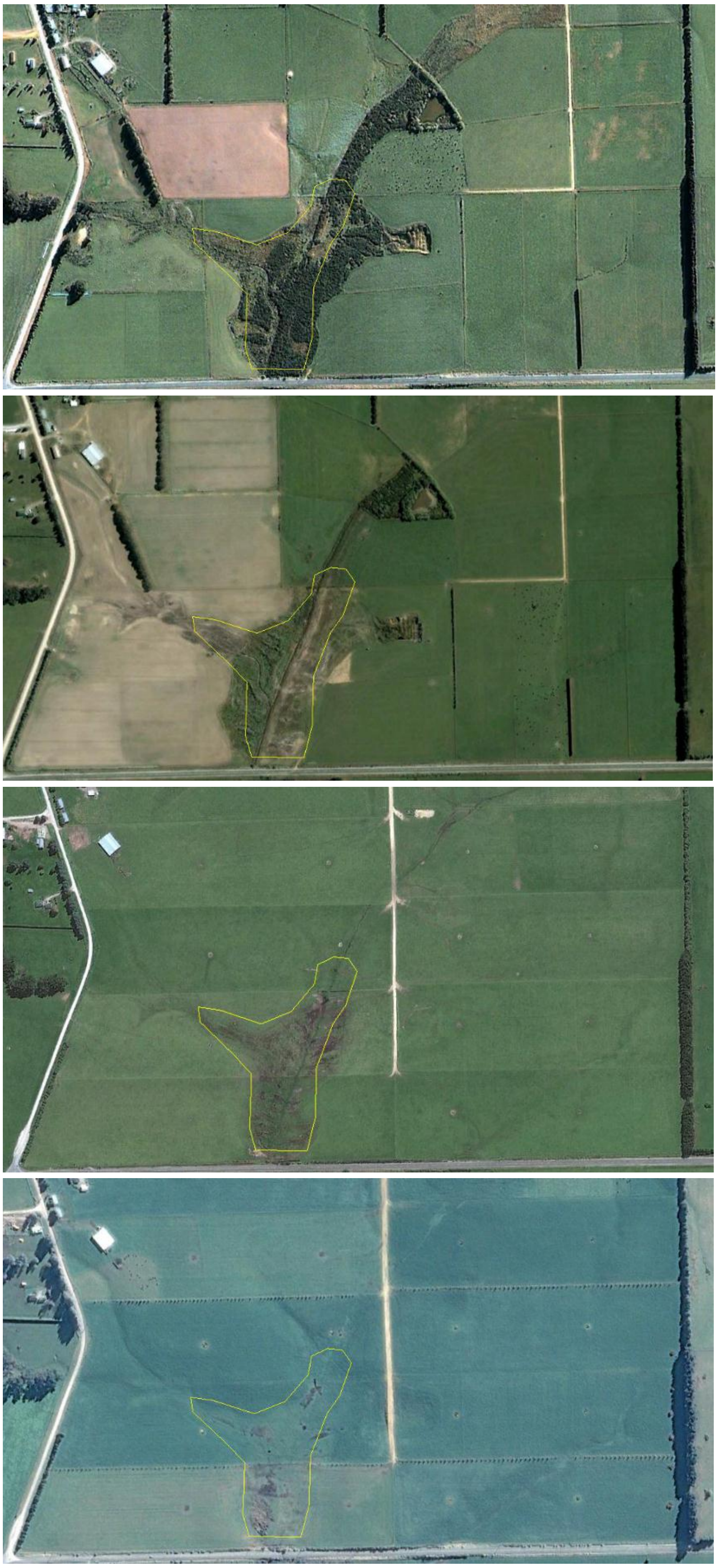
The approach used in the present study provides a practical means to identify potential wetland locations on farms in similar landscapes and soil types elsewhere in Southland where subsurface drainage networks are the dominant pathways for run-off. Google Earth satellite imagery or equivalent high resolution aerial photography provides a ready means to view the main drainage channels and swales across the landscape and initially identify potential locations for interception of flows and wetland construction. Lidar elevation data provides a basis to infer surface drainage networks to supplement farmer knowledge (where this is available) of farm drainage systems and determining where wetlands would most optimally be situated. Farm advisors and/or Regional Council Land Management Officers would potentially be able to assist farmers with generation of suitable maps from Lidar elevation data

2003

2009

2013

Figure 4: First example of recent wetland drainage in the upper Waituna Catchment from historical Google Earth images. Prospective sites investigated for wetland construction during the current project are marked.



2001

2004

2009

2013

Figure 5: Second example of recent wetland drainage from historical Google Earth images. Prospective sites for wetland construction investigated in the present study are marked. Various episodes of drainage works are visible in 2003 (not shown), 2004 and 2009 views.

Conclusions

Wetlands have widespread potential application in the upper Waituna Catchment, with the potential to intercept and treat 60–90% of run-off. Wetlands comprising 2–3% of catchment are predicted to be able to remove 30–40% of nitrate-N in run-off. Suspended solids and particulate phosphorus would also be substantially removed. A major constraint to uptake and implementation of wetlands is recent drainage of many remnant wetland areas as farms intensify. Farmers are understandably not keen to convert such areas back into wetlands.

The cost of constructing wetlands is relatively high. Remnant natural wetlands need to be appreciated as potential attenuation assets for farmers operating under nutrient limits. The first priority should be to retain and enhance the wetland areas that do still remain. Ideally, to promote greater use of wetlands as a mitigation option within the catchment, trials should be carried out to demonstrate their efficacy to farmers and regulators.

Acknowledgements

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