Erosion & Sediment Control App Improvement Project

Final Report

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Agrilink NZ

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Vegetable Research & Innovation Board

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Disclaimer

Contents

Project Overview

Work on an Erosion & Sediment Control (E&SC) calculator started back in 2015 with the launch of the Ministry for Primary Industries (MPI) Sustainable Farming Fund (SFF) project 'Don't Muddy the Water" (DMTW).

The intention in designing this calculator was to enable growers to estimate the erosion rates on their paddocks with and without the application of mitigation measures. The calculator was originally in the form of an Excel spreadsheet, but was converted into a mobile app for use by growers in the field.

The DMTW app went through two prototype versions, hosted on the Agrilink website with password protection and used in a number of projects (http://agrilink.co.nz/dmtw-app/).

Following the conclusion of the DMTW project, it was decided that there were a number of improvements that could be made to the app, including a better User Interface (UI), offline caching, more precise location data, and the incorporation of a Sediment Delivery Ratio (SDR) factor in the results.

VR&I provided funding for a project to improve the prototype DMTW app and to enable a public release. An article for the NZGrower magazine was prepared to promote the release of the app to growers (in press). Through an MPI media release about the project there were several follow-up media articles (see Article section).

The project resulted in a web application that incorporated all suggested improvements and was released on the Vegetable Research & Innovation Board website (https://www.vri.org.nz/esc/) on the 23rd March 2020.

This report was prepared to document the history and methodology of the project, as well as to display the project results and potential uses of the completed application.

Research

The calculations used in the DMTW app are based primarily on the Universal Soil Loss Equation (USLE), with mitigation measures accounted for separately using Load Reduction Factors (LRFs). USLE, and its successor, the Revised Universal Soil Loss Equation (RUSLE), have been used for multiple decades across multiple applications. The app utilised a Landcare Research literature review on USLE and erosion control practices (Basher et al., 2016) to model the USLE in the calculator.

This project used a literature review on predicting the Sediment Deposition Ratio (SDR) (Ouyang et al., 1997) to determine an appropriate SDR to use. More information on USLE and SDRs, as well as how they are used in the app is available in the supporting evidence document that is linked with the app and included at the end of this report.

Location and consequently rainfall intensity is another major contributor to the erosion estimate. This project replaced the original 18 weather station locations with data from 600 stations. The app then uses the grower's paddock co-ordinates to triangulate a localised R-factor based on the nearest three stations.

The research for the Load Reduction Factors came mostly from the DMTW project, particularly the effectiveness of Sediment Retention Ponds (SRPs). Research on buffer strips was informed by Landcare Research as part of DMTW. The equation used to model the impacts of buffer strips on sediment loss was obtained from Xuyang et al. (2010). FAR are currently conducting buffer strip trials. In the future this work could be incorporated into the app.

All research papers, equations and assumptions used to model the erosion and sediment loss rate was documented with a link in the new version of the DMTW app to ensure transparency and reduce the possibility of the app being seen as a 'black box.' As much as possible, the app has been designed to be easily edited so future research can be incorporated into the modelling.

Project timeline and methods

The project began on the 21st October 2019, and research into improving the R-factor and SDR factor began immediately. A web developer was sourced on the 3rd December 2019 from the freelancing platform Upwork (https://www.upwork.com/), which had been used to build the previous prototype version of the app.

The selected contractor (based in Jakarta) had worked on similar projects previously and provided us with examples of his previous work. Overall, the contractor proved reliable and communicative,

although as is the case with many web-based freelancers, the project was delivered later than originally planned. The final version of the app was incorporated onto the VR&I website on the 23rd March 2020.

An article was prepared for the NZGrower magazine to publicise the release of the DMTW app and explain its use to growers and other potential users (in press).

Results

The final version of the DMTW web-app is available on the VR&I website at https://www.vri.org.nz/environmental-resources/.

Screenshots of the web-application are shown in Figures 1 - 4 below:

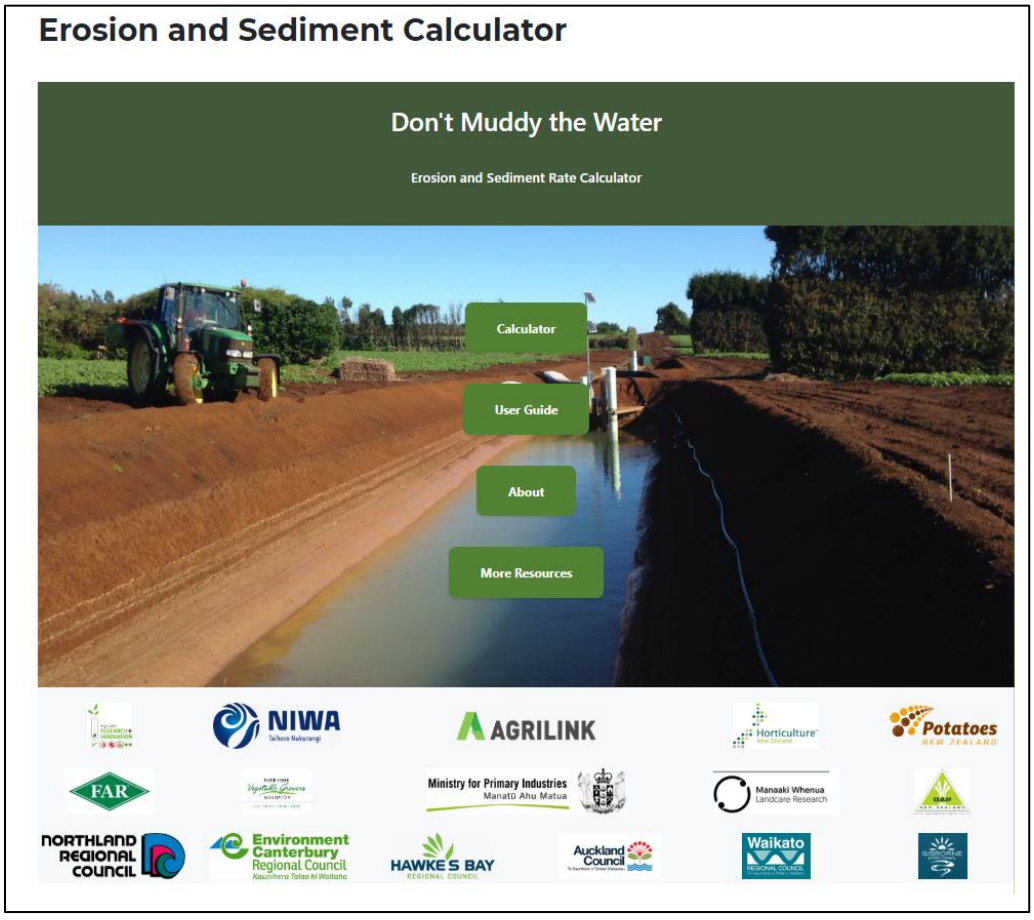


Figure 1. App Home page

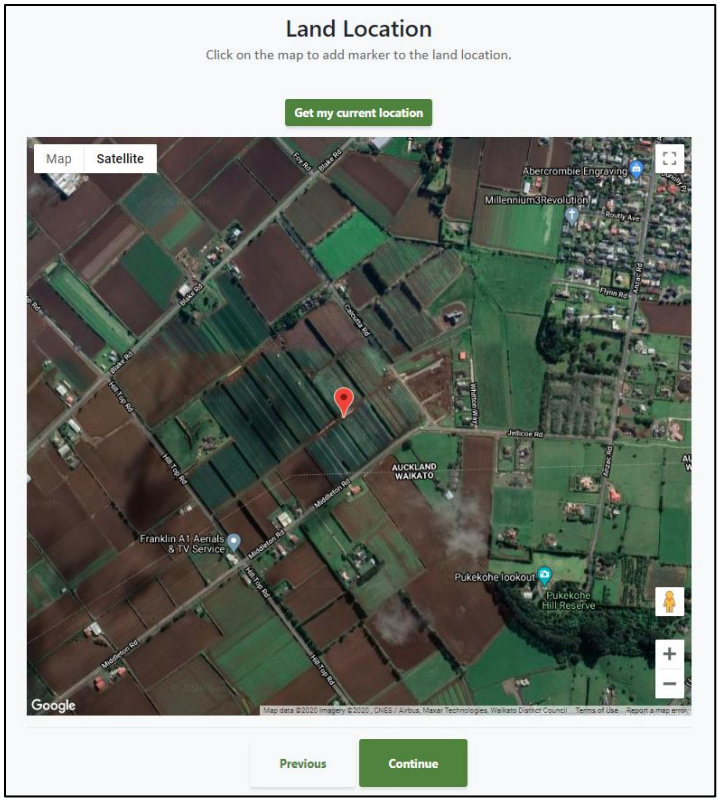


Figure 2. Land location page with map function on mobile

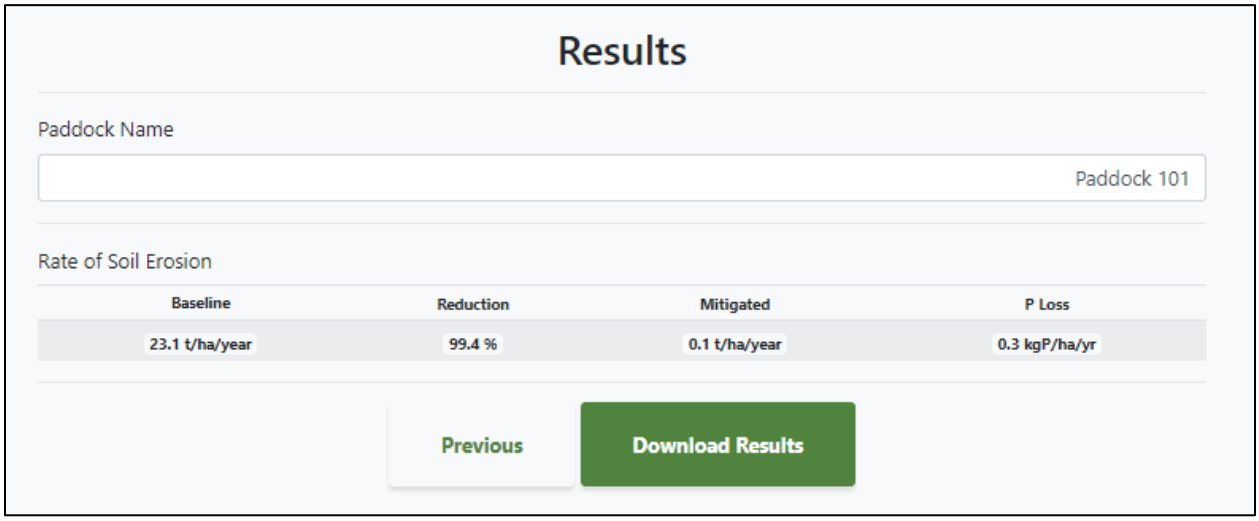
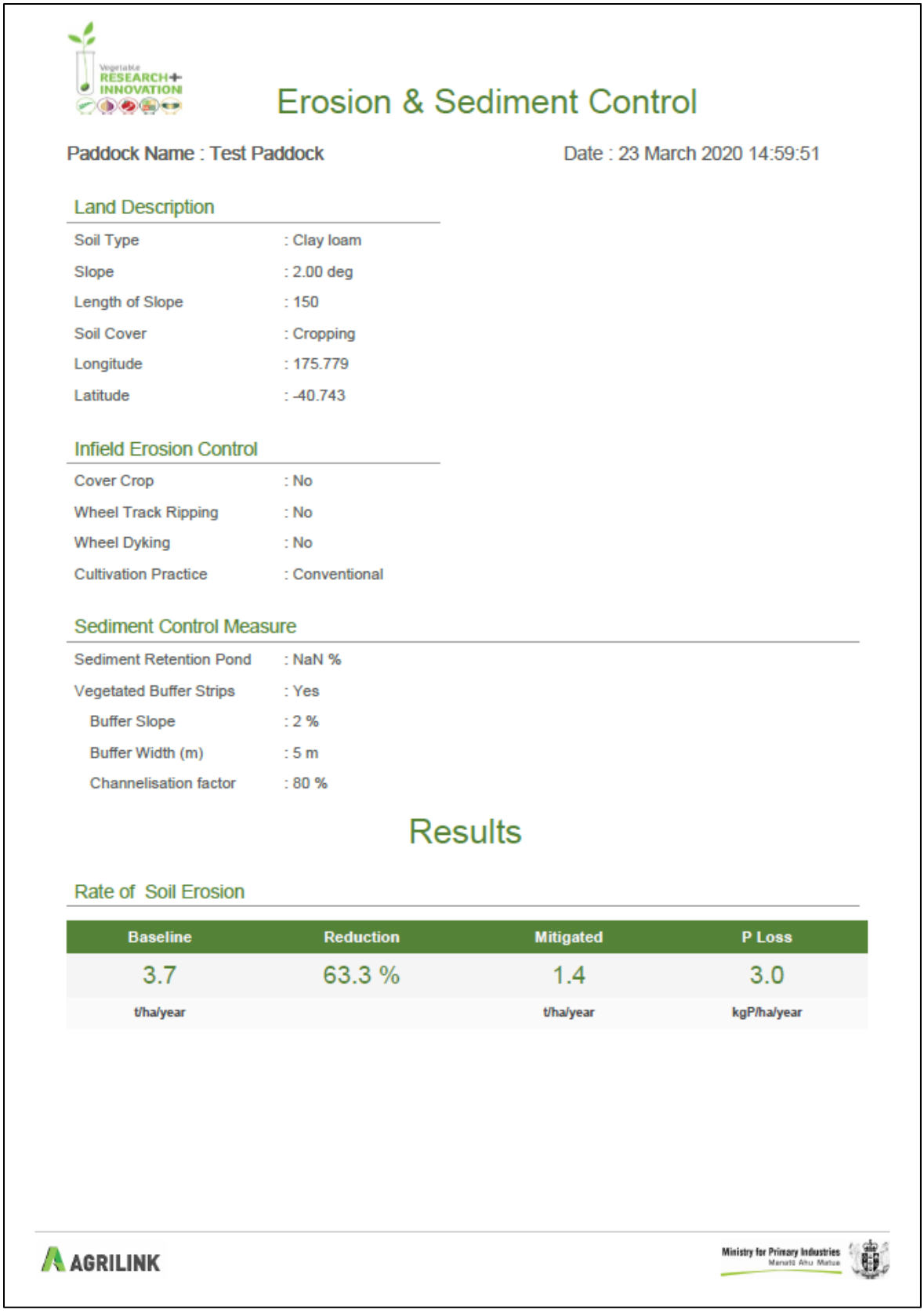


Figure 3. App Results page



Erosion & Sediment Control

Paddock Name : Test Paddock

Date : 23 March 2020 14:59:51

Land Description

Soil Type	: Clay loam
Slope	: 2.00 deg
Length of Slope	: 150
Soil Cover	: Cropping
Longitude	: 175.779
Latitude	: -40.743

Infield Erosion Control

Cover Crop	: No
Wheel Track Ripping	: No
Wheel Dyking	: No
Cultivation Practice	: Conventional

Sediment Control Measure

Sediment Retention Pond	: NaN %
Vegetated Buffer Strips	: Yes
Buffer Slope	: 2 %
Buffer Width (m)	: 5 m
Channelisation factor	: 80 %

Results

Rate of Soil Erosion

Baseline	Reduction	Mitigated	P Loss
3.7	63.3 %	1.4	3.0
t/ha/year		t/ha/year	kgP/ha/year

AGRILINK

Ministry for Primary Industries

Figure 4. Download of App results (PDF format)

Potential uses

Individual paddock assessment – Erosion and Sediment Control Plans

The app can be used to plan appropriate mitigation measures. For example a 5m buffer strip that reduces a flat-land (1 deg.) grower's estimated sediment loss from 1.1 t/ha/year to 0.3 t/ha/yr may be sufficient, whereas it may only reduce sediment loss on steeper land (5 deg.) from 23.1 t/ha/yr to 6.8 t/ha/yr. This result might indicate the need for a different mitigation measure such as a sediment retention pond, resulting in sediment loss being reduced from 23.1 to 0.1 t/ha/year.

Another benefit to using the DMTW app is being able to prioritise which paddocks get which mitigation measure and in which order. Being able to prioritise the paddocks with the highest erosion risk is positive both for the environment and for the grower who can stage the E&S control works. Staging mitigation measures based on modelled data is useful to the grower both financially and environmentally and helps ease the financial and labour burden of increasing environmental regulations.

The example below shows the erosion and sediment loss estimates on a case study property. This includes unmitigated, current, and future enhanced practice erosion and sediment loss rates.

Table A1. Erosion and sediment loss estimates for Farm X

Paddock name	Unmitigated sediment loss (t/ha/yr)	Level of sediment loss with current practice (t/ha/yr)				Level of sediment loss with enhanced practice (t/ha/yr)	
		Total sediment loss (t/ha/yr)	Suspended sediment reduction (%) *	Risk assessment	Priority ranking	Total sediment loss (t/ha/yr)	Suspended sediment reduction (%)
A	34	0.3	73%	High	3	0.2	88%
B	29	0.2	73%	High	4	0.2	88%
C	24	0.2	73%	High	2	0.1	88%
D	3	0.0	<73%	High	5	0.0	93%
Alternative buffer strip in Paddock D							
D						*0.0*	*73%*
E	12	9.7	0%	High	1	0.1	88%
F	4	0.0	73%	High	6	0.0	88%
Total	**11**	**1.8**	**60%**	**High**	-	**0.1**	**90%**

*Note- this is assuming that the current sediment traps are approximately 0.25%. Some are less than this, so the effectiveness of reducing suspended sediment may be lower than is shown.

Figure 5. Example of the DMTW App outputs being used in an E&S Control Plan

NZGAP EMS and catchment level analysis

The DMTW app supports the development of E&S Control Plans, as shown above, which in turn support growers' overall Environmental Management System – a module of NZGAP.

With the updated download feature, growers can date-stamp the results reports (PDF file) for a given paddock. This can be used as evidence in an FEP of the efficacy of the selected mitigation measures.

Once the number of paddocks builds, aggregated data (potentially collected through NZGAP – EMS) can be used to tell an industry story on environmental improvement. Levin provides a very good example of this, where the app has been used to calculate erosion rates across 1,090 ha, comprising of 22 operations and 263 paddocks.

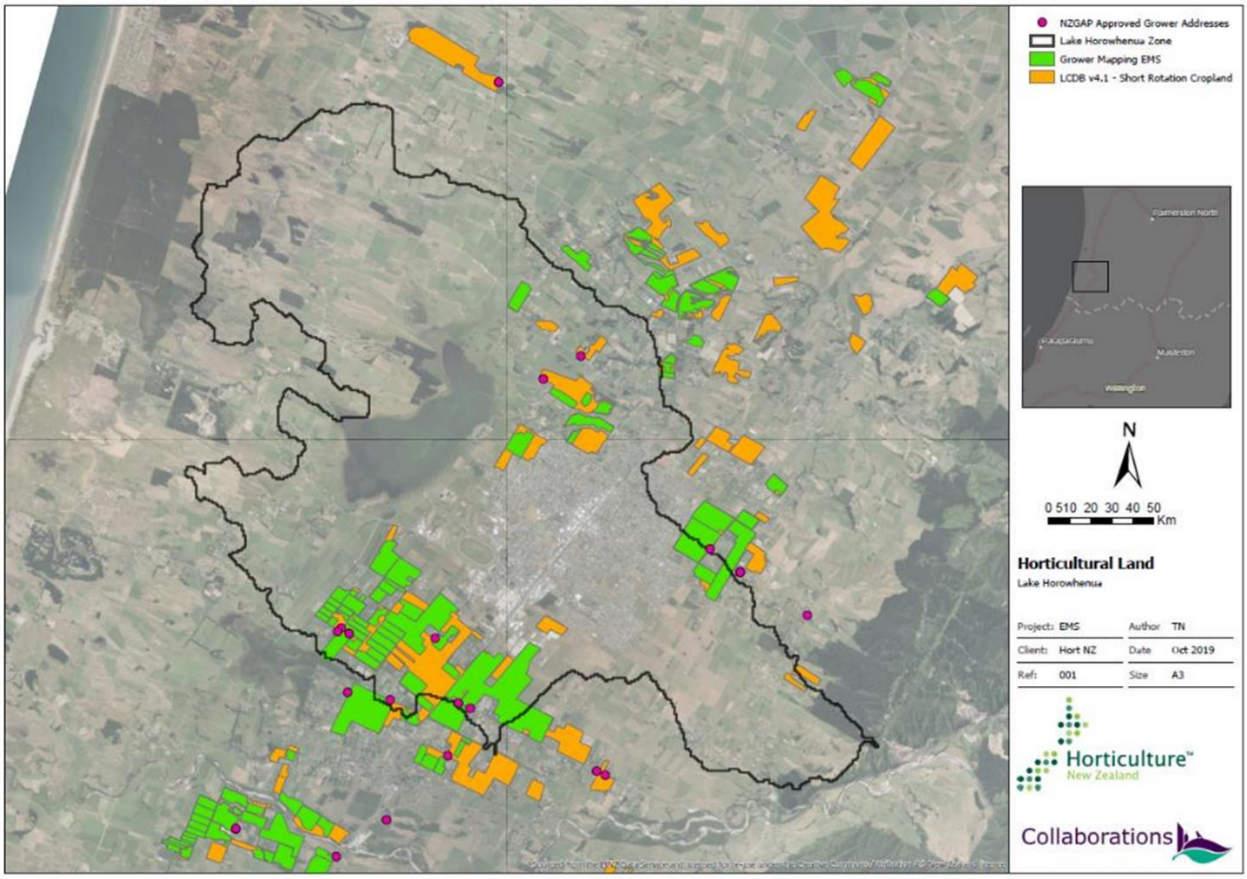


Figure 5. Vegetable cropping land in Levin with a complete or partial EMS in green and the balance of the vegetable cropping land in orange

Based on the data collected through the complete and partially complete FEPs it is possible to calculate unmitigated erosion rates and estimated current and projected erosion rates using enhanced mitigation practices.

This method of aggregating erosion rate data in conjunction with mapping, provides a powerful tool in telling an industry story for the Levin area.

At this stage we don't have all of the growers completed FEPs and a system of aggregating the information has not yet been devised. Therefore, where we had the growers current and planned mitigation practices, we entered these. Where is was unknow we assumed no mitigation and known buffer strips were 50% effective. For enhanced practice we assumed 5m wide buffer strips, that were between 80% and 90% effective. We also tested the effect of using a cover crop.

Table 1. Aggregated erosion rates and practice impacts across 1,090 ha of vegetable cropping land in Levin

Levin	Unmitigated	Current practice	Enhanced practice	Pasture*
Average erosion rate (t/ha/yr)	1.4	0.7	0.3	0.1
Total erosion rate (t/ha)	1,480	760	360	90
Reduction compared to unmitigated	-	720	1,120	-

* Replacing cropping with pasture.

Being able to demonstrate to regional councils the impact of FEPs and their associated mitigation practices is an important tool for the industry, and these aggregated erosion rate numbers provide powerful supporting evidence.

Future enhancements

In the future new mitigation tools or improved understanding of how existing measures perform can be added to the DMTW App. The app then becomes both a repository for erosion and sediment control mitigation measures and a dissemination tool for new ideas, research and practices.

Examples of this could include the incorporation of research currently being conducted by FAR into the effectiveness of vegetated buffers. The App could be used to help disseminate their findings. Likewise, new mitigations could be added, such as baffles or drop out pits in drains, or incorporating polyacrylamide (PAM) soil stabilisers applied to land or sediment retention ponds.

References

Barber, A. 2014. *Erosion & Sediment Control Guidelines for Vegetable Production*. Prepared for Horticulture New Zealand. Link.

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Basher, L., Moores, J., and McLean, G. 2016. Scientific basis for erosion and sediment control practices in New Zealand. Prepared for Tasman District Council. Link.

Ouyang, Da., Bartholic, J. 1997. Predicting Sediment Delivery Ratio in Saginaw Bay Watershed. Institute of Water Research, Michigan State University. Link.

Franklin Sustainability Project. 2002. Soil and Drainage Management Guide. Prepared for Horticulture New Zealand. Link.

Klik, A., Haas, K., Dvorackova, A., and Fuller, C. 2015. Spatial and temporal distribution of rainfall erosivity in New Zealand. Soil Research v.53. Link.

Xuyang, Z., Liu, X., Zhang, M., Dahlgren, R. 2010. A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution. Journal of Environmental Quality. Volume 39:76–84. Link.

Articles

https://www.agriculture.govt.nz/dmsdocument/39500-new-app-helps-decision-making-about-erosion-and-sediment-control-on-cultivated-vegetable-land-article

Agriculture & Investment Services
Ministry for Primary Industries
Manatū Ahu Matua

New app helps decision-making about erosion and sediment control on cultivated vegetable land

Farmers and regional authorities will soon have an app to help them make better decisions about how to control erosion and reduce sediment entering New Zealand waterways, thanks to a four-year project supported by the Ministry for Primary Industries' (MPI's) Sustainable Farming Fund (now superseded by Sustainable Food & Fibre Futures).

Developed through the 'Don't Muddy the Water' project, led by AgriLink and NIWA, the app measures the impact of various practices for reducing sediment and phosphorus loss. The app user is required to enter factors such as soil type, slope and location. Mitigations, such as vegetated buffer strips and sediment retention ponds, can then be added to assess the impact of these practices.

"The project came out of the need to put some numbers behind the performance of typical sediment control measures," says Andrew Barber, Managing Director, AgriLink.

"While the horticultural industry had developed 'Erosion and Sediment Control Guidelines for Vegetable Production', they needed to be better justified with quantified data."

The project ran trials of different good management practices to test how best to keep soil in the paddock and out of waterways. This included measures such as cover crops, sediment retention ponds, vegetated buffer strips and wheel track dyking/ripping.

The project found that 96 percent of large soil particles would be stopped by almost any sized pond. However, a minimum pond size of 50m³/ha was required to capture more than 80 percent of light suspended soil. These findings, along with work on vegetated buffer strips, were added to the app.

"Demonstrating the key control measures and collecting the data that can be used in our tool to calculate their effectiveness, has enabled a more cohesive approach nationally to soil management," says Barber.

"It allows farmers to do a paddock risk assessment and subsequently prioritise their actions as part of their future Farm Environment Plans. The app also allows them to provide robust evidence to support consents or prove to regional authorities that their control measures are effective."

AgriLink has been hosting workshops around the country to inform farmers about their findings.

"Our 'Don't Muddy the Water' app is a tool to help decision-making. I have been asked what next; the answer is implementation, we just need to get on and do it," says Barber. "Ultimately, this is a win-win for farmers and the environment."

Steve Penno, Director Investment Programmes at MPI, says the app is a practical tool that will help farmers take action to reduce their environmental footprint. "This project has provided quality information on how erosion and sediment loss can be effectively mitigated, and the app makes this information available to farmers in a practical and useful way."

The 'Don't Muddy the Water' app will be free and is expected to be publicly available from February 2020.

> "Demonstrating the key control measures and collecting the data that can be used in our tool to calculate their effectiveness, has enabled a more cohesive approach nationally to soil management."

www.mpi.govt.nz/funding-and-programmes

New Zealand Government
January 2020

https://www.nzherald.co.nz/the-country/news/article.cfm?c_id=16&objectid=12300624

THE COUNTRY | Environment

New app helps erosion and sediment control on cultivated vegetable land

15 Jan, 2020 4:00pm

3 minutes to read

A forebay full of sediment following a large storm in April 2017. Photo / Supplied

The Country

Farmers and regional authorities will soon have an app to help them make better decisions about how to control erosion and reduce sediment entering New Zealand waterways, thanks to a four-year project supported by the Ministry for Primary Industries' (MPI's) Sustainable Farming Fund (now superseded by Sustainable Food & Fibre Futures).

Developed through the "Don't Muddy the Water" project, led by Agrilink and NIWA, the app measures the impact of various practices for reducing sediment and phosphorus loss.

https://www.ruralnewsgroup.co.nz/rural-news/rural-management/no-more-muddying-of-the-waters

RURAL NEWS

Thursday, 30 January 2020 09:52

No more muddying of the waters

Written by Staff Reporters

Farmers will soon have an app to help them make better decisions about controlling erosion and reducing sediment entering New Zealand waterways.

Farmers will soon have an app to help them make better decisions about how to control erosion and reduce sediment entering waterways.

This follows a four-year project supported by the Ministry for Primary Industries' (MPI's) Sustainable Farming Fund (now superseded by Sustainable Food & Fibre Futures). Developed via the 'Don't Muddy the Water' project, led by Agrilink and NIWA, the app measures the impact of various practices for reducing sediment and phosphorus loss.

The app user is required to enter factors such as soil type, slope and location. Mitigations, such as vegetated buffer strips and sediment retention ponds, can then be added to assess the impact of these practices.

Factors and Assumptions Used in the Don't Muddy the Water Erosion and Sediment Rate Calculator

Erosion Rate Calculations:

The baseline erosion rate was calculated using a modified version of the Revised Universal Soil Loss Equation (RUSLE). This is an updated version of the Universal Soil Loss Equation (USLE) first developed by W. Wischmeier and D. Smith (1978 – link) and uses the same base equation, shown below:

A = R * K * LS * C * P

Where:

A is the annual soil loss per unit area;

R is the rainfall erosivity factor;

K is the soil erodibility factor;

LS is the slope length and steepness factor;

C is the cover management factor; and

P is the supporting practices factor.

The rainfall erosivity factor R was obtained from Klik et al, 2015[1]. This provided R-factors for 600 weather stations across the entirety of New Zealand. The app then uses the grower's paddock co-ordinates to triangulate a localised R-factor based on the nearest three stations.

The K factors were established using soil texture classes from Dr. Paolo Bazzoffi's USLE calculator.

The LS factor was determined for each row slope and row length using equations from: Basher, L. 2016. *Erosion mitigation and prediction on cropland*. Landcare Research.

The C factor was set based on the selection of ground cover as pasture or cropping. Both factors were obtained from Basher et al, 2016[2]. The C factor for pasture is set to 0.02, whilst for cropping it is set to 0.33. Whilst both, and especially cropping, can have a wide diversity of C factors based on crops selected and operations conducted over the course of a year, inputting the numerous factors required to get a custom C factors would have added a large degree of

[1] Klik, A., et al. 2015. *Spatial and temporal distribution of rainfall erosivity in New Zealand.* Soil Research v.53. DOI: 10.1071/SR14363. Link.

[2] Basher, L., et al. 2016. Scientific basis for erosion and sediment control practices in New Zealand. Link.

complexity to the app. Therefore, these general factors were selected to ensure simplicity and usability of the app without sacrificing too much accuracy.

The P factor represents the influence of conservation cropping practices and surface roughness on soil loss. As this is highly variable, the P factor was set to a default of 1.0 in the app, indicating bare earth without erosion and sediment control measures, which are considered separately as Load Reduction Factors (LRFs).

The Sediment Deposition Ratio (SDR) is used to calculate the proportion of sediment generated that gets to the bottom of the row, which becomes the Sediment Yield (SY) in waterways. An SDR of 1.0 indicates that all sediment that is generated on the paddock over the course of the year ends up at the bottom of the row in drains or sediment control devices. This is clearly not the case in reality, as sediment is often captured along the bottom of wheel tracks and within the topography of a vegetable row – which is not uniform along its entire length.

Unfortunately, calculating SDR is extremely challenging due to the large number of factors influencing sediment deposition. For the app, in consultation with Les Basher (pers. comm.) the SDR was calculated using a simple method collected from a literature review on methods to calculate SDR[3]. This method uses the slope of the main stream channel and two constants to calculate the deposition ratio. The formula is shown here:

$SDR = 0.627 * Slope\ (\%)^{0.403}$

Note that this does not consider other factors such as surface roughness or paddock lengths but was found to be the best solution for our purposes.

Mitigation Measure Factors and Assumptions:

Load reduction factors

The Load Reduction Factors (LRFs) used in the app come from several sources and are applied to the result of the RUSLE and SDR components of the model.

The estimate of efficacy of Cover Crops in reducing erosion assumes they reduce erosion by 60% during 1/3 of the year, resulting in a 20% reduction in erosion over the course of the year.

The estimate of efficacy of Wheel Track Ripping and/or Dyking assumes they reduce erosion by 90% during 1/3 of the year, or by 30% over the course of the year.

The estimate of efficacy of Minimum Cultivation assumes it reduces erosion by 50% during 1/3 of the year or by 17% over the course of the year.

[3] Ouyang, Da., Bartholic, J. 1997. Predicting Sediment Delivery Ratio in Saginaw Bay Watershed. Institute of Water Research, Michigan State University. Link.

The efficacy of Sediment Retention Ponds (SRPs) was determined from the SFF project *Don't Muddy the Water* (2019). Table 1 shows the efficiencies of different sized SRPs (as percentages of their catchment areas) at detaining suspended and total sediment.

Table 1. Sediment reduction efficiencies by trap size

Trap size	Trap efficiency (fraction of sediment reduced)	
	All sediment	Suspended sediment
2.0%	1.0	1.0
1.0%	0.997	0.93
0.5%	0.993	0.88
0.25%	0.991	0.73

The efficacy of Vegetated Buffer Strips comes from an equation in Xuyang et al. (2010). The equation is outlined below for slopes of ≤10% with grass only (a) and for slopes of >10% with grass only (b):

(a) $Y = 21.7 + 2.0 \times X_{slope} + 61.0 \times (1 - e^{-0.35} \times X_{width})$

(b) $Y = 79.7 - 3.8 \times X_{slope} + 61.3 \times (1 - e^{-0.35} \times X_{width})$

Where;

Y = Removal efficacy (%),

X_{slope} = Slope (%), and

X_{width} = Width (metres)

This equation was determined to overestimate the sediment reduction capabilities of vegetated buffer strips in many real-world horticultural applications, so an 'Integrity of buffer' factor is applied to the results of the equation. This is a user-input value which specifies the percentage of the area of the buffer strip that is performing properly, once channelisation and preferential flow is considered. Further research on the effectiveness of buffer strips is necessary.