# Don’t Muddy the Water

## Final Summary Report

June 2019

**Prepared by:**

**Andrew Barber[1], Henry Stenning[1], and Murray Hicks[2]**

**1. Agrilink New Zealand and 2. NIWA**

**Prepared for:**

**MPI SFF Project 407925**

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# Contents

# 1 Executive Summary

Don't Muddy the Water, was a 4 year long Sustainable Farming Fund (SFF) project focussed on Erosion & Sediment (E&S) control on cultivated horticultural land. The full analysis and results are contained within their own final reports available from HortNZ.

Agrilink and NIWA conducted a trial to determine the efficiency of Sediment Retention Ponds (SRP) on cultivated horticultural land. Weirs and autosamplers measured flow rates and collected suspended sediment samples from three different sized SRPs on a cultivated vegetable production site on Pukekohe Hill in Auckland.

The main outcomes of the SRP efficiency trial were:

- The existing minimum size of SRPs at 0.5% (50m$^3$/ha) detailed in *Erosion & Sediment Control Guidelines for Vegetable Production* (Barber, 2014) were supported by the data gathered from this trial.
- Undersized SRPs (<0.5%) detain almost all (>99%) bedload erosion, which itself comprises around 95-98% of total erosion. The size of an SRP is therefore dictated by suspended sediment reduction efficiency, which increases as the ponds become larger.
- The 0.5% SRP had an average total sediment reduction efficiency of 88%. The average suspended sediment concentration in the discharge water was 410 g/m$^3$.
- Phosphorus is predominantly lost from cultivated horticultural land in the form of particulate phosphorus in overland flow, that is detained attached to sediment by sediment retention ponds.
- The DMTW app has been developed to help in the risk assessment process when preparing an E&S Control Plan. The app calculates unmitigated and mitigated erosion and sediment loss rates using the Revised Universal Soil Loss Equation (RUSLE), as well as the trial results.
- Four example E&S Control Plans have been developed. These plans incorporate the E&S Control Guidelines, actions plans, and link to the NZ GAP assurance programme.

Landcare Research conducted a series of trials focused on the effectiveness of vegetated buffer strips (Levin), erosion rates on flat land (Gisborne) and the effectiveness of wheel track dyking and wheel track ripping (Pukekohe).

The main outcomes from these trials were:

- No sediment was found to have been transported beyond the vegetated buffer strips, although there was little erosion overall due to a lack of higher intensity rainfall events.
- Two replicate plots of wheel track ripping produced very different erosion rates due to variations in in-field topography. This also occurred for the dyked wheel track replicate

plots. The overall range in erosion rates for all 6 plots was 5.5 – 30.9 t/ha, showing the large amount of natural variation.
- Erosion rates were found to be very low on the flat land (≤1°) in Gisborne, despite two high intensity rainfall events.

Overall, the project has generated an enormous amount of runoff and erosion rate data for cultivated horticultural land and has markedly increased our understanding of soil movement and capture in these systems. The project has progressed the development of E&S Control Plans, their implementation and assurance through NZ GAP. This project has improved E&S control good management practices within the cultivated vegetable industry.

# 2 Methods

## 2.1 SRP trial methodology

The SRP trial was located at Calcutta Road in Pukekohe, on the Pukekohe Hill (~5° average slope). One catchment paddock sized at 1.88 hectares fed into an SRP (Pond 1) which was initially sized at 1.3% of the catchment area (242m$^3$) but was reduced to 0.5% of the catchment area (94m$^3$) in early 2017. The second catchment paddock, sized at 2.13 hectares, fed into an SRP (Pond 2) sized at approximately 0.3% of its catchment area (58m$^3$).

Both SRPs had automatic water samplers located at their inlets (between the forebays and ponds) and at their outlets. The volume of water entering and exiting the ponds was measured using weirs and water level gauges, these triggered the automatic samplers when a set volume of water had passed through the weirs.

Once the water samples were collected, they were analysed for suspended sediment concentration by vacuum filtration, followed by drying and weighing.

A one-year extension was granted to the project in June 2018. During this period a floating decant was installed onto the Pond 1 outlet to measure the performance of this device.

**Figure 1.** Pond 1 inlet samples showing a gradient of sediment runoff during a rainfall event

## 2.2 Flat land erosion rates and mitigation methodology

In Levin, 3-5m grass buffer strip plots were established to determine their effectiveness on a range of slopes and row lengths. Deposition was measured by trapping eroded soil using silt fences at the bottom of the fields. The magnitude of deposition was measured using arrays of erosion pins to characterise changes in surface elevation.

**Figure 2.** The vegetated buffer trial in Levin.

In Auckland/Waikato, six plots were established at two sites (Onewhero and Pukekawa) on different soil types to compare erosion rates from wheel tracks that had been ripped or dyked with untreated wheel tracks. As in Levin, deposition was measured by trapping eroded soil using silt fences and erosion pins.

The ripping and dyking treatments have very different effects on surface soil conditions in the wheel tracks. Ripping involves dragging a bulbed tine to a depth of about 0.5 m down the wheel track. This leaves a deep crack in the soil and breaks up the compaction of the wheel track to a considerable depth. Dyking involves dragging a rotating paddle across the wheel-track surface. This breaks up the surface compaction of the wheel track but has little effect below c. 0.1–0.2 m. The soil surface is left with a series of shallow depressions, which act to detain ponded water within these depressions.

At Gisborne, plots were established on near flat land (<1°) at two sites on different soils. Five sediment traps were placed in wheel tracks at each site. These were constructed from 200 mm diameter plastic pipe open at one end and with silt cloth on the other end to trap sediment (Figure 5). Erosion pins were placed in the wheel tracks to measure the magnitude of erosion and deposition within the wheel tracks.

# 3 Results

## 3.1 SRP trial results

The key research outcomes from the SRP trial was the measurement of total erosion and suspended sediment reduction efficiencies. The results found that bedload accounted for 95% (Pond 1) to 97% (Pond 2) of total erosion. This was completely detained in the forebays and both ponds. The fact that all of the bedload sediment was trapped in the forebays (until they were filled up) indicates the effectiveness of even small ponds (<0.5%) at detaining more than 95% of erosion from a paddock. Suspended sediment reduction was found to be correlated to SRP size, being dependent upon detention time – and therefore the size of the pond. Many variables, including runoff and rainfall volumes, also played a large role in pond performance for a given event.

Pond 1 in the first period of the trial (1.3% pond size) had the best performance with an average suspended sediment reduction efficiency of >93% (average SSC = 240 g/m$^3$, median SSC = 80 g/m$^3$). When Pond 1 was decreased in volume to match the Guideline figure of 0.5% the average suspended sediment reduction efficiency was 87% (average SSC = 410 g/m$^3$). Pond 2 (at 0.3%), had an average suspended sediment reduction efficiency of 73% of (average SSC = 980 g/m$^3$).

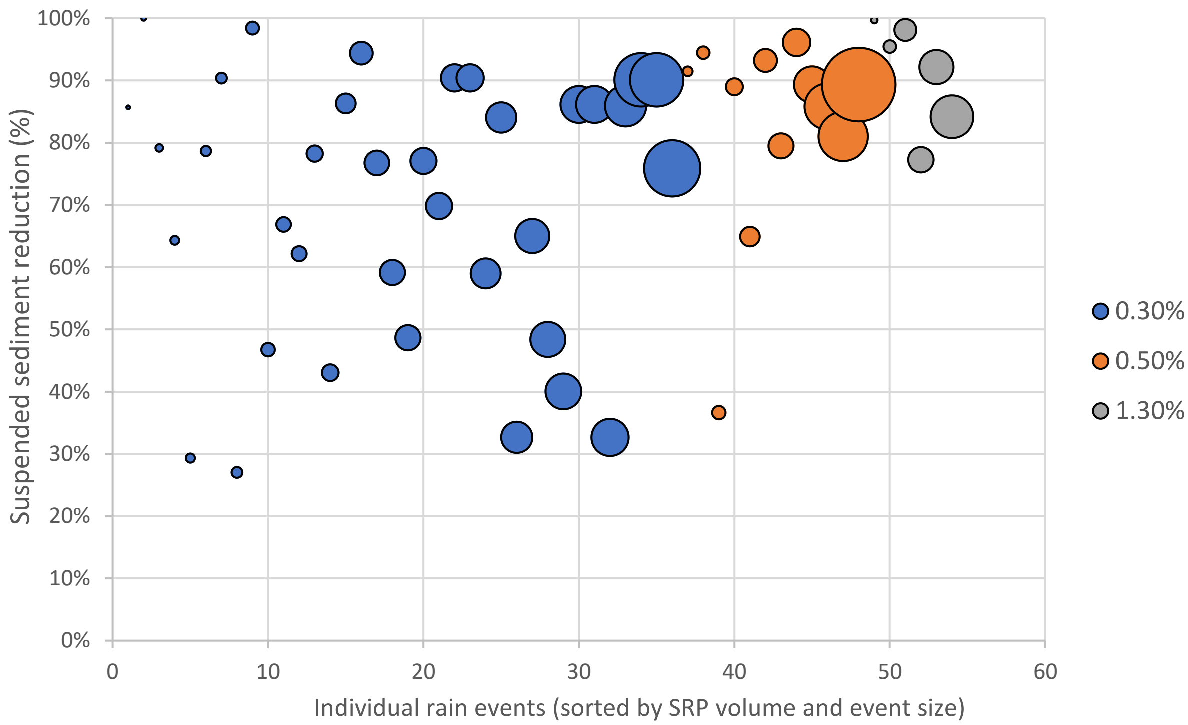



**Figure 3.** Proportion of suspended sediment removed by different sized SRPs. The colour of each bubble refers to the size of the SRP as a percentage of its catchment area, whilst the size of the bubble indicates the relative size of the rainfall event.

The detention time of each pond was the largest contributor to these results, with a 1.0% sized pond taking 400 minutes to drain its live storage at an outflow rate of 3L/s/ha, compared to 100 minutes for a 0.25% sized pond.

It was found that suspended sediment reduction efficiency could be increased further by installation of a floating decant device. Although data was confined to one rainfall event, it was found that Pond 1 with the floating decant attached had a 99% suspended sediment reduction efficiency. The floating decant had a peak outlet flow rate of 1.6L/s/ha, with an average suspended sediment concentration of 22 g/m$^3$. This compared to average suspended sediment concentrations ranging between 39 and 66 g/m$^3$ for the snorkel at the same flow rate.

This trial also determined the phosphorus reduction potential of SRPs. As phosphorus is largely attached to sediment in the form of particulate phosphorus, SRPs were found to reduce phosphorus losses beyond the pond by greater than 98%, with the majority of the reduction being in the particulate phosphorus attached to bedload and suspended sediment.

## 3.2 Flat land erosion rates and mitigation trial results

### Vegetated buffer strip trials

In the vegetated buffer strip trials, no significant changes in surface elevation were recorded at any of the plots. This lack of deposition as measured by the erosion pins was consistent with the small daily and hourly rainfall totals during the course of the trials. No sediment was deposited beyond the grass buffer strips at the downslope end of the plots, suggesting they had been very effective at trapping any sediment that had moved. Most of the visual signs of erosion were associated with compacted wheel tracks within the fields.

**Figure 4.** Grass buffer strip with a channel cut through it delivering dirty water into the drainage system.

Water ponding behind bunds on flat land is a significant issue. Observations around the Levin district shows some buffer strips had channels cut through them to prevent flooding of the paddocks. This then severely compromises their effectiveness (Figure 4). The installation of vegetated buffer strips needs to be done in such a way to minimise channelising.

### Wheel track ripping and dyking trials

There was clear evidence of wheel-track treatment effects at the Onewhero site but not at Pukekawa, where there was no significant change in surface elevation in any of the plots. This erosion rate difference was likely caused by the difference in soil types between the two sites. Over the course of the trial there was low rainfall, with all events having a recurrence interval of <1 year.

At Onewhero, all the plots showed a significant increase in surface elevation at the end of the rows in front of the silt fences, indicative of deposition. The results were complicated due to the two replicate plots of both the dyking and ripping wheel track treatments producing very different results. This is likely due to in-field topographical differences.

The wheel track treated plots overall produced less soil accumulation, although in-field topography has as much of an effect as wheel track treatments. Despite this it is clear that cultivation of the wheel tracks does reduce surface runoff and erosion. The soil erosion rates for all plots ranged from 5.5 to 30.9 t/ha. The two control plots producing erosion rates of 19 and 27 t/ha. The ripped plots had erosion rates of 5.6 and 17.6 t/ha and the dyked plots had erosion rates of 5.5 and 30.9 t/ha. Considering that these trials ran for only 3 months, this is a significant erosion rate.

**Erosion on flat land**

As with the other trial sites, daily rainfall totals were relatively low with the exception of two storms with exceptionally high short-duration rainfall intensities (reaching a rate of 101 mm/hr).

Despite these large storms the sediment traps captured very little sediment, and the erosion pins recorded little change in elevation. Although it was unclear how effective the sediment traps were in trapping sediment, with evidence suggesting that a large proportion of runoff bypassed the traps, rendering the data unreliable for calculating erosion rates.

**Figure 6.** Dirty water bypassing a sediment trap during one of the storms.

# 4 Conclusions

## 4.1 SRP trial

The results from the SRP trial at Pukekohe support the existing *Erosion & Sediment Control Guidelines for Vegetable Production* (Barber, 2014) in setting the minimum size of SRPs at 0.5%, which also aligned with previously modelled results (Barber, 2012). Larger ponds have the capacity to reduce more sediment but become impractical and too expensive to install on horticultural land. Smaller ponds have the capacity to remove all bedload, and reduce a large proportion of suspended sediment, but were extremely variable. This puts the 0.5% pond in a sweet spot of having enough capacity to significantly reduce suspended sediment, whilst not being too large and expensive to install.

The ability for SRPs to reduce phosphorus leaving paddocks in runoff water was also important to document, with freshwater contaminants being a current priority for regional councils and central government. Reductions were in line with the sediment reductions.

Work carried out in the extension phase of the project, including workshops and the implementation of FEPs has also had a positive influence within the industry, encouraging further implementation and refinement of E&S control practices.

## 4.2 Flat land and erosion mitigation trials

On the vegetated buffer strip trials very little sediment was measured in the silt fences on both flat and sloping land. This suggests the overall erosion rate and loss of soil from the fields has been very low. However, there were no large storm events during the trial, which would probably have generated much more sediment. Most soil that that had been mobilised was redeposited within the lower, more gently sloping parts of the paddock. Most of the observed runoff and erosion occurred in the compacted wheel tracks and headlands, but occasionally the crop beds were affected. The grass buffer strips appear very effective at trapping sediment, at least in small rainfall events, and there was no evidence of sediment passing right through the buffer strips. However, to maximise the performance of grass buffer strips, flatter fields may need to be recontoured to ensure that water does not pond and channelising of runoff from ponded areas (which compromises buffer strip performance) is avoided.

There was evidence that cultivating wheel tracks by ripping or dyking reduced sediment generation at Onewhero but not at Pukekawa, probably due to soil differences between the sites. In addition, at Onewhero results were inconclusive because the two replicate plots of the dyking and ripping treatments produced very different results, suggesting that within-field topography had as much influence on the amount of sediment delivered to the bottom of the field as treatment of the wheel tracks. Based on these and previous trials the cultivation of the wheel tracks does reduce surface runoff and erosion. However, these trials were unable to provide conclusive results on the relative reduction in erosion rates from ripping and dyking treatments and the applicability of both techniques to the more erodible soils at the Onewhero site.

The Gisborne trial did not produce reliable data for calculating erosion rates from flat land due to two very large runoff events possibly bypassing the traps. There was limited visual evidence of either scouring in the wheel tracks or deposition in the headland, which suggest that despite the high intensity events there was very little erosion. This also aligns with flow and sediment load data provided by Gisborne District Council.

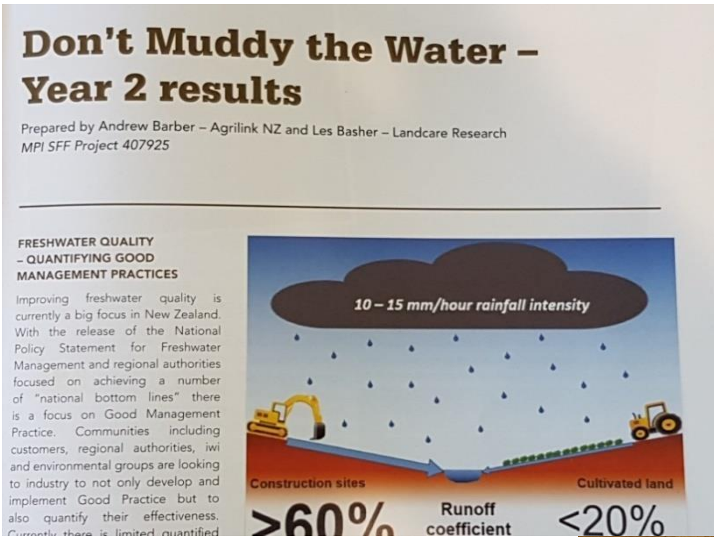
# 5 Dissemination

Interim and final results of this project have been presented in multiple workshops, publications, and on the tv programme Rural Delivery. The results from this project are currently being used to support further work into the implementation of Farm Environment Plans (FEP's), individualised benchmarking reports, and to demonstrate change using aggregated industry data (see Section 3.2.1).

Workshops and presentations include:

- FAR and Hort NZ (31/5/16): Andrew Barber presented project background and work to grower event '*Understanding and managing environmental risk.'*
- Pukekohe (18/8/16): Andrew Barber presented project progress at grower workshop.
- Waihao Wainono Community Catchment Group, ECan and FAR (4/5/17): Andrew Barber presented project background and initial results, with the field day reported in the Otago Daily Times.
- Rural Delivery (20/6/17): Andrew Barber and Harry Das were filmed by Showdown Productions for Rural Delivery Series 13, for their story on reducing erosion on cultivated land.
- HortNZ (1/9/17): Andrew Barber presented project progress and background to Environmental Ambassadors grower group.
- Potatoes NZ (8/8/18): Agronomists forum presenting the latest trial results.
- Levin (30/5/18): Andrew Barber and Les Basher from Landcare Research presented the results of vegetated buffer strip trials to growers from the Levin area.
- Pukekohe (09/05/19): Andrew Barber and Damien Farrelly from NZGAP presented the project results, and how these results can drive implementation of erosion and sediment control via FEP's and be accredited by assurance schemes such as NZGAP's Environmental Management System (EMS).
- Levin (31/05/19): Presentation to MPI and MfE staff on the use of mitigation measures to reduce discharges.
- Pukekohe (24/06/19): Grower and industry workshop on integrating nutrient and sediment management plans into FEPs and regional council rules.
- Future Presentations:
    - Horticulture NZ (31/07/19): National Conference - Hamilton, poster and equipment display
    - Potatoes NZ (13/08/19): Conference, Christchurch
    - Waikato Regional Council, NZ Landcare Trust and Whakaupoko Landcare Group (19/11/19): "Landcare Networking Field Day 2019"

The project has also been written up in The Grower (October 2017 and June 2019) and FAR Arable Extra (Issue 124), with further workshops planned for Potatoes NZ in July and Waikato Regional Council in November 2019.



**Don't Muddy the Water – Year 2 results**

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FRESHWATER QUALITY – QUANTIFYING GOOD MANAGEMENT PRACTICES

Improving freshwater quality is currently a big focus in New Zealand. With the release of the National Policy Statement for Freshwater Management and regional authorities focused on achieving a number of "national bottom lines" there is a focus on Good Management Practice. Communities including customers, regional authorities, iwi and environmental groups are looking to industry to not only develop and implement Good Practice but to also quantify their effectiveness.



**Figure 7.** Clockwise from top left:

1. Year 2 results presented in the NZ GROWER.
2. Potatoes NZ agronomist workshop.
3. Presentation of buffer strip trial results in Levin
4. Presentation of SRP trial results in Pukekohe
5. Presentations to MPI and MfE staff
6. Industry FEP workshop.

# 6 References


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# 7 Appendix

## a. SRP trial images

**Figure A1.** Excavation of Pond 1 at the beginning of the project in December 2015.

**Figure A2 (Left).** Bedload accumulation measurement by mobile laser survey. **Figure A3 (Right)**. Volume of sediment in Pond 1 following flooding in March 2017.

**Figure A4.** Monitoring equipment provided by NIWA.

**Figure A5.** Floating decant installed in Pond 1.

**Figure A5-A6.** A grower installing an SRP, following directions from a Farm Environment Plan prepared as part of the project extension.

**Figure A7-A8.** Erosion control workshop held at the trial site in Pukekohe.