BEFORE THE HEARING COMMISSIONERS
AT HAMILTON

IN THE MATTER	of the Resource Management Act 1991 ("**the Act**")
AND	
IN THE MATTER	of the hearing of submissions on The Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments: Block 3

STATEMENT OF EVIDENCE BY ANDREW BARBER
FOR HORTICULTURE NEW ZEALAND

9 JULY 2019

Contents

SUMMARY STATEMENT

1. This evidence addresses the Horticulture New Zealand ("**HortNZ**") submission, further submissions and the Waikato Regional Council's ("**WRC**") Section 42A Report responses to the submissions on the Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments ("**PC1**").

2. Practices and mitigation devices described in an FEP can change during implementation. I support the recognition of this, and that this change is captured within the FEP update rather than a resource consent change.

3. That NZ GAP audited FEPs are the best approach for minimising discharges, rather than all properties being locked into practice based minimum standards.

4. CFEP qualifications need to recognise that horticultural focused qualifications are not as advanced as they are in agriculture. Therefore, more flexibility is required to recognise equivalent qualifications and experience.

5. Benchmarking is a very powerful management tool, but an ineffective compliance tool. Particularly when modelling and benchmarking nutrients CVP has a vast array of variables that make meaningful metrics very difficult to establish and defend to a compliance standard.

6. Crop rotations are an essential part of sustainable long term CVP. The ability to add new CVP land for the purposes of making the land less intensive would have a positive environmental outcome.

7. The industry has done considerable research into mitigating sediment loss, both for the environmental benefits and that soil is their main resource. The most recent MPI SFF Project Don't Muddy the Water has quantified erosion and sediment control measures through trials conducted by Agrilink, NIWA, and Landcare Research.

8. An outcome from the DMTW project was an app which is used to prepare E&S Control Plans as the first step in a paddock risk assessment. Trial evidence has shown 80% reductions in sediment loss following the implementation of erosion control measures and vegetated buffer strips as the sediment control measure. This increases to over 98% reduction, and well below the equivalent pasture paddock, when buffer strips are replaced with sediment retention ponds.

9. E&S Control Plans have been shown to lead to significant change. Implementation of these plans can be assured through the audited NZ GAP programme.

10. The industry is working towards aggregated data that can be used in both individualised benchmarking reports and at a higher level to track GMP progress. Erosion and sediment is well advanced in achieving this goal, with nutrients rapidly following as the weight of research builds to support their development.

QUALIFICATIONS AND EXPERIENCE

11. My full name is Andrew John Barber. I have the qualifications and experience set out in my Statements of Evidence for Blocks 1 and 2.

12. I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. I confirm that the issues addressed in this brief of evidence are within my area of expertise, except where I state I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

13. My evidence covers the following:

    (a) The FEP review;

    (b) FEP versus rule based approaches;

    (c) CFEP requirements;

(d) Compliance versus a management tool;

(e) Crop rotation - a management tool;

(f) Erosion and sediment control – a management tool;

(g) E&S control app supporting change;

(h) E&S Control – Plan to implementation and assurance; and

(i) E&S Control – benchmarking and tracking progress.

14. I have included as the end of my evidence my references.

FEP REVIEW

15. I support the provision of an informal FEP review process that does not trigger a resource consent change (201).

16. Through the implementation of mitigation measures, designs can change. A recent practical example was where two sediment retention ponds (SRP) were planned along a headland, these needed to be amalgamated. The change was captured in the as-built but required that level of flexibility when going from a design on paper to implementation.

FEP RATHER THAN RULE BASED APPROACH

17. I support the use of NZ GAP audited FEP's as they are based on a risk assessment and ability to implement the most appropriate actions. My previous evidence in Block 2 strongly opposed the use of a single tool, in this case a previously mandated 5m vegetated buffer strip. While appropriate in some situations (flat land with very little outfall), it doesn't work in the majority of CVP land where slope and channelised flow make it less effective than other tools such as SRPs.

18. In the Section 42A report paragraph 215, the Officers say that "*any minimum standards will sit in the Plan rules and Appendices, rather than within Schedule 1*". It is not clear where these minimum standards are, and consequently what has happened to the previously proposed setbacks. There is a reference to Schedule C

and a setback, but this is for stock exclusion using fencing. I reiterate my previous Block 2 evidence that the most appropriate mitigation measures should be selected through preparing an FEP rather than specifying one mitigation measure through a minimum standard rule. Assurance that the most appropriate mitigation measures have been selected is achieved based on the evidence presented to an NZ GAP auditor.

CFEP REQUIREMENTS

19. I support the change in the Certified farm Environment Planner to having "relevant" experience but suggest the addition of "or", agriculture and/or horticulture, not both as it is currently worded.

20. There is a need to recognise that in horticulture there isn't the same level of formalised qualifications for nutrient management. Personally, despite holding a Horticultural degree from Massey University, 25 years vegetable experience, contributing to the nutrient management guidelines and involved in research and reporting on nutrient management I may not meet the Certified Farm Environment Planner qualifications.

21. I have not, and do not intend to obtain the *Advanced Sustainable Nutrient Management* qualification from Massey University. This course is not designed for horticulture. This course is described as providing, an advanced knowledge of sustainable nutrient management for common New Zealand pastoral and arable farming systems. A study guide and the Overseer® Nutrient Budgets software will assist participants to develop nutrient management plans for actual pastoral and arable farming enterprises.[1]

22. I support the provision for an equivalent qualification in nutrient management, that is presumably intended to address this

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1 https://www.massey.ac.nz/~flrc/shortcourses/Course_outline_SNM_Advanced_2016.pdf

horticultural issue, however it isn't clear if a general horticultural degree qualifies. To my knowledge there isn't any other nutrient specific qualifications.

23. The provision in c. of the Certified Farm Environment Planner qualifications for "*experience in soil conservation and sediment management"* while vague reflects that there are no sediment management specific qualifications and very few actively working in this area. While "*experience*" is extremely vague, reference in an FEP to the Erosion & Sediment Control Guidelines for Vegetable Production and audited plans should address this issue.

24. In response to Section C3.5.2., paragraph 234 I suggest that a Certified Farm Environment Planner (Commercial Vegetable Production): is a person or entity certified by the Chief Executive Officer of Waikato Regional Council and listed on the Waikato Regional Council website as a Certified Farm Environment Planner (Commercial Vegetable Production) and has as a minimum the following qualifications and experience:

    (a) Tertiary qualifications in horticulture, agronomy or agriculture, and

    (b) More than 2 years' experience working with commercial vegetable cropping systems, and

    (c) A certificate of competence approved by the Waikato Regional Council relating to the relevant aspects of environmental farm plan assessment.

COMPLIANCE VS A MANAGEMENT TOOL

25. Benchmarking, harnessing and learning from the collective knowledge of others, is a powerful, well proven tool. Benchmarking and practice change has been well documented by the NZ Sustainability Dashboard Project. In the NZ wine industry members of Sustainable Winegrowing NZ receive individualised benchmarking reports that link to learning resources. These reports are used to engage in meaningful conversations from a basis of better understanding. From this has come accelerated uptake of

improved practices. HortNZ is developing this capability by building upon the lessons learned from the NZ Sustainability Dashboard Project and to apply this to CVP nutrients and sediment.

26. In Nutrient Management Plans, management practices are recorded against a list of GMPs. Over time metrics can be used to show progress towards GMPs. These could be aggregated to create meaningful benchmarks. Suitable practice-based metrics could include:

(a) Frequency of soil tests;

(b) Soil organic matter;

(c) Nitrogen availability;

(d) Frequency of fertiliser applications;

(e) Area in cover crops (including pasture and arable).

27. Benchmarking reports have been socialised at a recent industry workshop (24/5/19). The development of a CVP Dashboard benchmarking tool is in its infancy. However, it is being built upon a solid foundation of proven success of achieving practice change through the NZ Sustainability Dashboard Project.

28. Appropriately tuned metrics used in individualised dashboard reports leads to practice-based change. These metrics however should not be used as the point of compliance.

29. For example, while N-surplus has been used in the draft individualised nutrient benchmarking reports, from a technical perspective it is not a useful compliance metric. Preliminary results from research conducted by Plant & Food Research shows that crop type and its associated N-surplus is poorly correlated to nutrient leaching.

30. A proposed erosion and sediment individualised benchmarking report, and tracking good management metrics, is described in the final section of my evidence.

CROP ROTATION – A MANAGEMENT TOOL

31. Adding additional cover crops or break crops to a CVP rotation is a very effective tool for reducing discharges (nutrient & sediment). Anecdotally the use of cover crops has increased significantly over the past 10 year and continues to increase. This is done for a range of reasons including cultural disease control (reducing the reliance on agrichemicals), but primarily it improves soil quality by increasing soil organic matter.

32. The ability to add new CVP land for the purposes of making the land less intensive would have a positive environmental outcome by reducing average contaminant discharges.

33. Reduced contaminant nutrient discharges are achieved through lower or no fertiliser inputs into alternate non-commercial vegetable crops. These crops are used to trap back into the organic pool excess nutrients from a previous crop.

34. Sediment discharges are also reduced through the use of cover crops, particularly over winter when the ground is saturated and at its most vulnerable to erosion (98).

EROSION & SEDIMENT CONTROL – A MANAGEMENT TOOL

35. The vegetable industry has been working on erosion and sediment control for many years. This work culminated in the Erosion & Sediment Control Guidelines for Vegetable Production (Barber, 2014). Since then the industry has continued to work on minimising erosion and capturing sediment. The MPI SFF project Don’t Muddy the Water (DMTW) having quantitatively determined the efficiency of various sized SRPs (Barber et. al., 2019), has continued on by joining the dots between research, guidelines, E&S Control Plans, reporting, implementation, and assurance through NZ GAP. This is being used as the template for the current nitrogen work.

36. Don’t Muddy the Waters was a 4 year long Sustainable Farming Fund (SFF) project (407925) focussed on erosion and sediment control on cultivated horticultural land. The research on sediment retention pond efficiency was conducted by Agrilink (Andrew

Barber), Bryant Environmental Solutions (Steve Bryant), and NIWA (Murray Hicks). Landcare Research (Les Basher) conducted sediment mitigation trials using vegetated buffer strips, and erosion mitigation measures using wheel track ripping and dyking.

37. Based on an estimated erosion rate, using an app developed in DMTW, unmitigated erosion rates can be compared to pasture, the current CVP situation, and against enhanced practice using vegetated buffer strips, and enhanced practice using sediment retention ponds (SRP).

38. The industry is actively working to significantly reduce sediment loss. The evolving Erosion & Sediment Control Plans, their associated benchmarking reports, and assurance through NZ GAP will play a key role in reducing sediment loss.

E&S CONTROL APP SUPPORTING CHANGE

39. The primary purpose of the DMTW app was as a management tool to assist in the first step of the E&S Control Plan – a paddock risk assessment. The app will estimate the rate of erosion and sediment loss with and without a range of mitigation measures.

40. The erosion rate is calculated using the Revised Universal Soil Loss Equation (RUSLE) (Renard, et al., 1997). The annual rainfall-runoff erosivity factor R was determined for 35 places in NZ by NIWA (Klik et al., 2015). More details about the RUSLE and its factors is included at the end of this statement.

41. The erosion rates calculated by the RUSLE are based on long term average rainfall. While erosion rates will vary enormously, even between two paddocks that are side by side, this app gives a very good guide to a paddocks average erosion rate and level of risk. At the DMTW trial site the app estimated an unmitigated erosion rate of 71 t/ha/year. During Year 2 (2016/17) the erosion rate from the two paddocks were measured to be 75 t/ha and 37 t/ha respectively. Firstly, in this particular year the actual erosion rate and the app closely aligned for one of the paddocks, giving us greater confidence in the app. Secondly, the large difference between

paddocks highlights the large natural variation, even across two very similar paddocks that are side by side.

42. To complete the story of the example above, the extremely high trapping efficiency of the SRPs resulted in the discharge of just 0.4 t/ha, an efficiency of greater than 99% (Barber et. al., 2019).

43. The sediment loss rate calculated in the DMTW app were used to create a lookup table (below) for use by Jacobs (Stuart Easton table 6) in their catchment scale soil loss assessments under various scenarios.

Hamilton		Modelled Average Erosion Rates (t/ha/yr)			
Slope (%)	Slope (°)	Pasture	Unmitigated cultivation	Cultivation with buffer strips	Cultivation with Sediment Retention Ponds
0	0	0.0	0.5	0.1	0.0
1	0.6	0.2	3.3	0.6	0.0
3	1.2	0.7	11.7	2.2	0.0
5	2.9	1.4	22.3	4.3	0.1
10	5.7	3.5	57.3	11.0	0.2
15	8.5	6.6	108.8	20.9	0.4

Erosion & sediment modelling assumptions:

Soil type = Clay Loam
Slope length = 150m
Cover crops included in mitigation
Wheel track ripping included in mitigation

Buffer strip width = 5m
Buffer strip slope = 5%
Buffer strip effectiveness = 80%

44. While erosion rates on cultivated land can be high, that is the very reason why retaining the soil by using a range of erosion and sediment control practices is so important. As can be seen in the table above sediment loss from a paddock with 10% (5.7^0) slope can be as high as 57 t/ha (4.8mm), but through the use of erosion control and a 5m buffer strip this can be reduced by 80%. Where appropriate, replacing the buffer strip with an SRP drops sediment loss to just 0.2 t/ha (0.017mm), a greater than 99% reduction. This extremely low rate of sediment loss is just 5% of what the paddock would average had the paddock been in pasture (3.5 t/ha = 0.3mm).

45. Using a range of E&S Control mitigation measures, the trials conducted in DMTW showed total phosphorus loss can be reduced by more than 98% (Barber et al., 2019). The main contamination pathway for phosphorus is overland flow. Leaching trials conducted by Plant & Food Research found phosphorus was being leached from a Pukekohe site at an average of just 0.12 kgP/ha/year (Norris et. al., 2019). This contrasts with between 10.4 and 17.2 kgP/ha/year lost from unmitigated overland flow and going as high as 194 kgP/ha when unmitigated bedload is included.

46. Once mitigated using an SRP, phosphorus discharge ranged between 0.7 to 3.3 kgP/ha, greater than 85% of which was on the suspended sediment, with the balance (0.1 to 0.2 kgP/ha) being the dissolved component in the discharged stormwater. Just like was observed with sediment, these phosphorus discharge levels are significantly less than on an equivalent pasture paddock.

E&S CONTROL – PLAN TO IMPLEMENTATION AND ASSURANCE

47. I provided evidence in my Block 2 Statement about the effectiveness of erosion and sediment control measures in CVP. This has been validated through the DMTW project, where the results for both erosion and sediment control have been incorporated into the app described above.

48. The evidence below shows how the dots have then been joined from the research and guidelines, through to E&S Control Plans, implementation, and assurance.

49. A case study from the DMTW project is the best way of demonstrating what has been achieved. Attached as Appendix A is an E&S Control Plan. The photographs are pre and post implementation. The Plan and its progress towards full implementation has been audited by NZ GAP.

50. An E&S Control Plan begins with a property description and map.

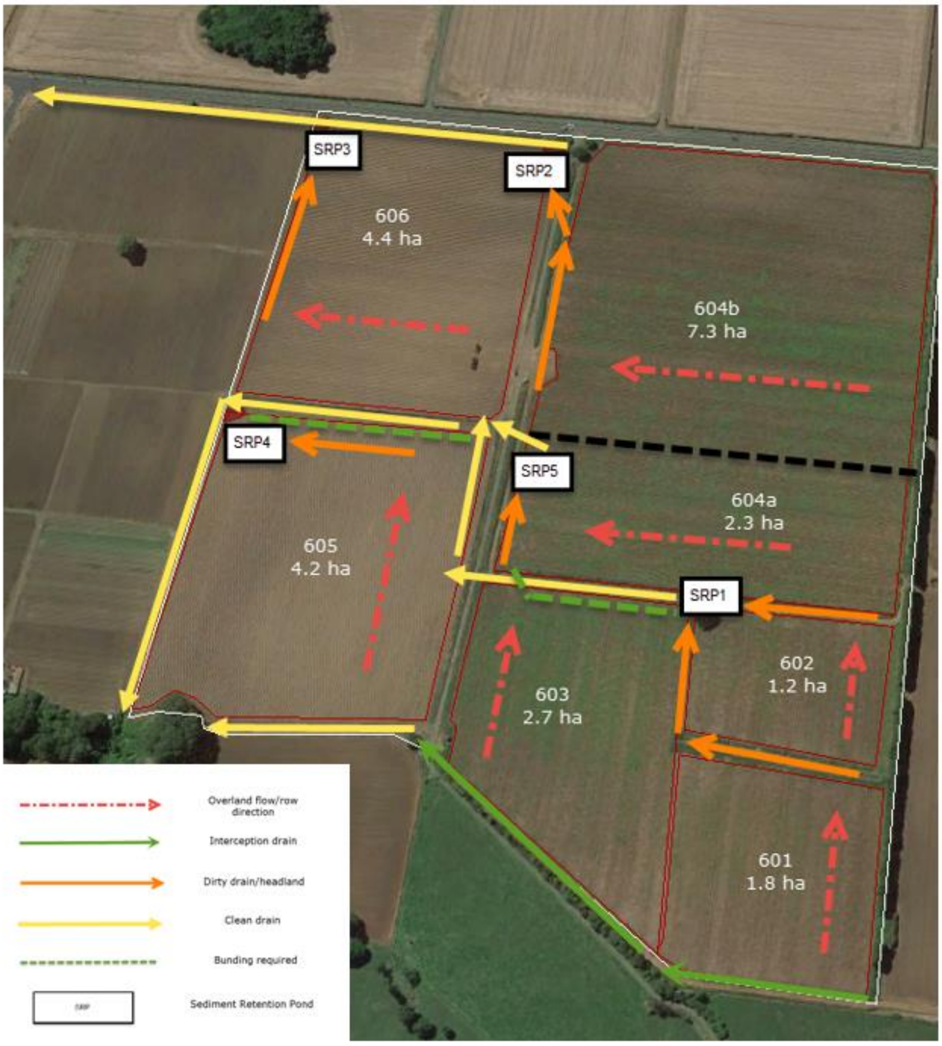


Figure 4. Paddock map of Farm A post action plan.

51. Using the DMTW app, a risk assessment is conducted and a priority ranking developed for the subsequent action plan. Table A2 on the attached E&S Control Plan below shows the risk assessment. All paddocks, except for 605, have existing SRPs albeit undersized.

Table A2. Erosion and sediment loss estimates for Farm A

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 (%)
601	125	0.9	68%	High	3	0.7	83%
602	105	0.8	68%	High	5	0.6	83%
603	95	0.7	68%	High	2	0.2	91%
604	20	0.2	68%	High	4	0.1	91%
605	60	45.9	0%	High	1	0.2	83%
606	25	0.2	68%	High	6	0.1	91%
Total	**50**	**8.4**	**56%**	**High**	-	**0.2**	**89%**

*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.

52. As can be seen in Table A2 (attached) the current E&S control practices (except 605) have achieved sediment losses of less than 1.0 t/ha (3rd column). The current mitigation measures have ensured that sediment loss is less than had the paddocks been in pasture where the average sediment loss would have been 2.9 t/ha (not shown).

53. Paddock 605 was ranked as the highest priority, which is then reflected in the action plan / construction schedule in Table 7. The benefit of the E&S Control Plan is that work can be staged over several years. In this case the construction of the new SRP4 is planned before April 2020. Work on other properties had a higher priority. A quicker temporary step was to construct a silt fence (see picture below).

Table 8. Construction schedule

Action	Completion date
Install silt fence in existing SRP4 IF construction of a new SRP4 in paddock 605 cannot be completed before April 2019.	April 2019
Construct a new SRP4 in paddock 605.	April 2020

Paddock 605 with overland flow discharging into a drain without going through an SRP.

54. The full E&S Control Plan included 12 actions to be conducted between 2019 and 2021. Other actions included re-digging an interception drain, new bunding, and moving or expanding existing SRP's. A conservative estimate of the cost for the changes on this 24 ha property is $30,000 ($1,250/ha).

55. The changes once fully implemented will reduce sediment loss from 8.4 t/ha down to 0.2 t/ha. Apart from paddock 605, the biggest difference is to reduce the already very small suspended sediment discharges. $25,000 of the estimated cost is to reduce suspended sediment loss from 0.3 t/ha to 0.2 t/ha. At this level of refinement, the CVP are working well beyond what is seen in any other sector.

56. The pictures below show before and after photographs of an installed SRP.

Above – Earth bund trapping bedload sediment (~100m^3).

Right – Construction of a 0.5% decanting SRP (~200m^3) following the E&S Control Plan.

57. The second to last phase of the process following implementation, was sign off by NZ GAP that the grower had a plan in place that conformed to the E&S Control Guidelines, and that their actions aligned to their plan.

58. The final phase is ongoing maintenance, which is again outlined in E&S Control plan.

Maintenance schedule

- Ensure SRPs are dug out and maintained every 6 months – 1 year, or more frequently if sediment reduces the capacity by more than 20%.
- Ensure snorkel and spillways are working correctly with an inspection every 6 months or after every large rainfall event.
- Ensure that bunds have not been penetrated by water channels with an inspection every 6 months or after every large rainfall event.
- Ensure culverts remain unblocked with an inspection every 6 months or after every large rainfall event.
- Ensure all drains, including interception drains are clear, with an inspection every 3 months or after every large rainfall event.

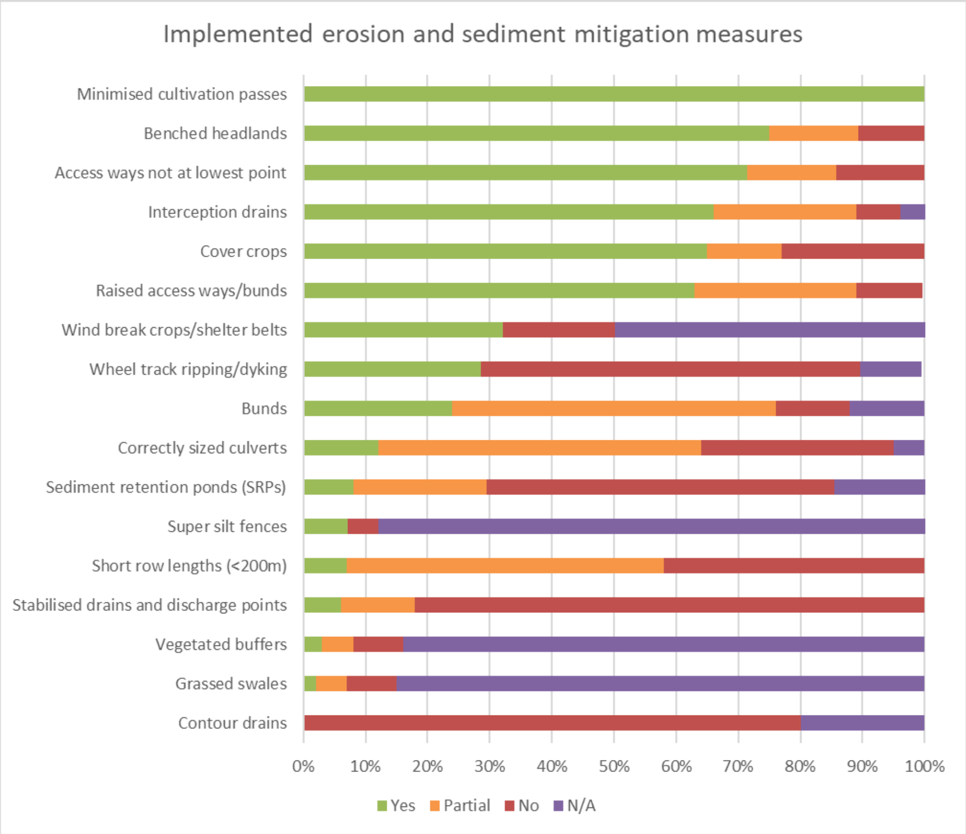
E&S CONTROL – BENCHMARKING AND TRACKING PROGRESS

59. Following on from the DMTW project, E&S Control Plans are being prepared and their metrics are being aggregated for individualised benchmarking and industry tracking purposes.

60. In paragraphs 18 and 21 I referred to the success of the wine industry's benchmarking reports that lead to practice base changes. Below is an example of what an individualised erosion and sediment control report for the case study property described above could look like.

61. An example Erosion and Sediment Control Report is attached as Appendix B.

62. At a national or regional level, Good Management Practices collected through the E&S Control Plans could be aggregated and tracked as shown in the example below.



Andrew Barber
9 July 2019

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APPENDIX A

Erosion & Sediment Control Plan

Farm A

March 2019

Prepared by Andrew Barber & Henry Stenning for:

Grower A

AGRI LINK

EMPOWERING SUSTAINABLE GROWTH

Erosion & Sediment Control Plan

Farm A

March 2019

Prepared by Andrew Barber & Henry Stenning

Agrilink New Zealand

Prepared for Grower A and MPI SFF Project 407925

Contents

1 Business details

Business name: Grower A

NZGAP number: x

2 Property details

Location address: x

Local authority name: Waikato District

Land area: x m2

Legal description:

Certificate of title: x

3 Advisor details

Advising business: Agrilink NZ

Primary advisor name: Andrew Barber, BHort (tech) Hons

Secondary advisor name: Henry Stenning, BSc

Area of expertise: Erosion and sediment control

Phone: 027 498 3620

Email: andrew@agrilink.co.nz

4 Maps and property details

The property is located at _____________.

The total catchment area of Farm A is 30 ha. It is divided into six paddocks, described in Table 1, with a total cropping area of 24 ha.

The soil type according to Landcare Research S-map reports is a clay, Onewhero*f*, a Typic Oxidic Brown Soil. Physical observation showed the soil to be very light and friable.

Figure 1. Current paddock map.

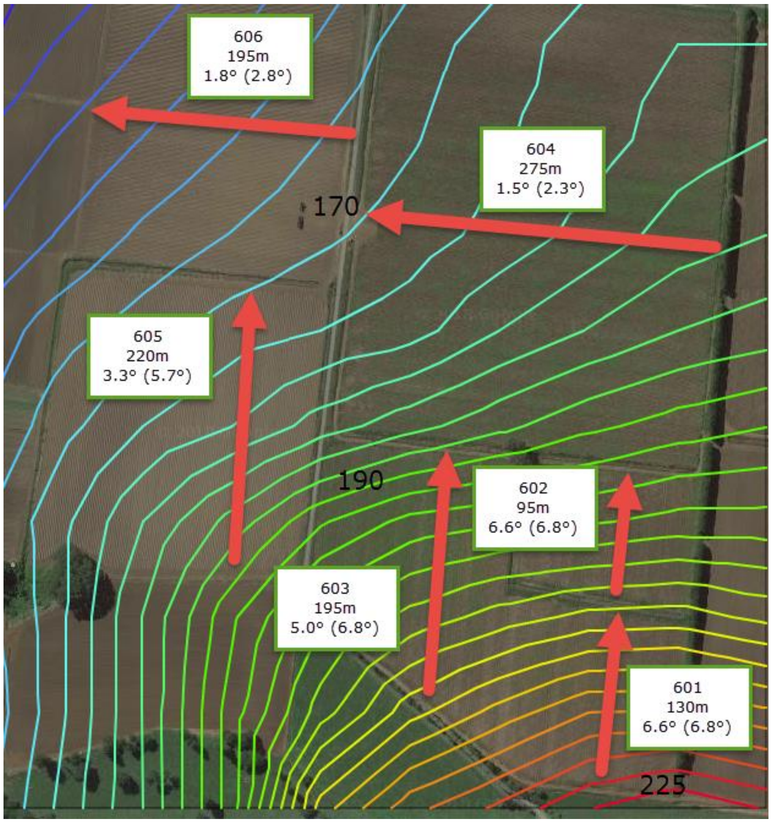


Figure 2. 5m contour map

Figure 3. Soil map from S-maps (Landcare Research)

The current overland flow direction and area of the paddocks, as well as SRP locations, are shown on the map (Fig.1), with the overland flow directions after action plan mitigation measures shown in Figure 4.

Table 1 describes the current overland flow situation. One of the identified issues is where SRP1 & 2 lead into drains which in turn leads to SRP3. Essentially clean water is discharging into dirty water and needs recleaning. This currently causes SRPs 3 to become overloaded, due to accepting overland flow from a much larger catchment area than they were designed for.

Appendix 2 contains erosion rates and priority rankings for each paddock. Together these form the Erosion Risk Assessment.

Appendix 3 contains the existing SRP sizes and catchments before implementation of the action plan.

Table 1. Paddock descriptions and flow direction

Paddock name	Land use	Paddock area (ha)	Water origin	Water destination
601	Cropping – Outdoor vegetables	1.8	Direct rainfall and from overland flow from the southern pasture – although an interception drain should divert most or all of this uphill water.	SRP1 then through drain and culvert under the drive/road, then along the drain alongside paddock 605.
602	Cropping – Outdoor vegetables	1.2	Direct rainfall and from paddock 605 – although the drain to the north should divert most or all of this uphill water.	SRP1 then through drain and culvert under the drive/road, then along the drain alongside paddock 605.
603	Cropping – Outdoor vegetables	2.7	Direct rainfall and from overland flow from the southern pasture – although an interception drain should divert most or all of this uphill water.	SRP1 then through drain and culvert under the drive/road, then along the drain alongside paddock 605.
604	Cropping – Outdoor vegetables	9.6	Direct rainfall and from paddock 603.	Along the bunded and benched headland, then through culvert under the drive/road into SRP2, which discharges into a drain leading to SRP3.
605	Cropping – Outdoor vegetables	4.2	Direct rainfall and from overland flow from the southern paddock – although an interception drain should divert most or all of this uphill water.	Headlands, through a 2m vegetated buffer, then into the drain alongside the paddock.
606	Cropping – Outdoor vegetables	4.4	Direct rainfall only.	SRP3.

5 Implement control measures for stopping or controlling water entering that paddock

Table 2. Implementation of mitigation measures based on NZGAP Template 6C, Section 1

Ref	Good/Best Management Practices	Currently implemented?				Date to be completed	Evidence/Comment/Agreed Action (justify if "Partial", "No" or "n/a")	Level
		Yes	Partial	No	N/A			
1	Interception drains		✓			April 2020	Re-dig southern boundary interception drain and connect to culvert going under shared driveway/private road.	GMP
2	Correctly sized culverts		✓			April 2020	Look at connection of interception drain to shared driveway culvert, monitor culvert size – if it becomes blocked again then increase its size.	GMP
3	Benched headlands	✓						GMP
4	Bunds	✓						GMP
5	Grassed swales (controlled overland flow through the paddock)				✓			GMP
6	Other (specify):				✓			

6 Implement erosion control measures to keep soil on the paddock

Table 3. Implementation of mitigation measures based on NZGAP Template 6C, Section 1

Ref	Good/Best Management Practices	Currently implemented?				Date to be completed	Evidence/Comment/Agreed Action (justify if "Partial", "No" or "n/a")	Level
		Yes	Partial	No	N/A			
1	Minimised cultivation passes	✓						GMP
2	Wind break crops/shelter belts (wind erosion)			✓				GMP
3	Using short row lengths (<200m recommended) (>1 degree slope)		✓				Paddocks 605 and 606 have row lengths greater than 200m.	GMP
4	Cover crops/break crops (>1 degree slope)	✓						GMP
5	Wheel track ripping / Wheel track dyking (>1 degree slope)			✓			Wheel track ripping was implemented but caused greater erosion due to soil composition, so has been stopped.	GMP
6	Contour drains (>1 degree slope)			✓			Other measures are used instead.	GMP
7	Other (specify):			✓		April 2020	It is necessary to leave an uncultivated 1m setback from drains to protect them and stop soil frittering into them.	

7 Implement sediment control measures to manage the water and solids that move off paddock

Table 4. Implementation of mitigation measures based on NZGAP Template 6C, Section 1

Ref	Good/Best Management Practices	Currently implemented?				Date to be completed	Evidence/Comment/Agreed Action (justify if "Partial", "No" or "n/a")	Level
		Yes	Partial	No	N/A			
1	Ensure accessways are <u>not</u> at the lowest point	✓						GMP
2	Raised access ways / Bunds		✓				A bund needs to be constructed along the northern edge of 603 to keep water out of the clean water drain and direct it to the benched headland along 604 and into SRP2. Bunds need constructing to ensure all overland flow from paddock 605 goes into SRP4 and not into the drain.	GMP
3	Vegetated buffers / Riparian margins / Hedges		✓				SRPs are used in preference of these measures. However, the farm is bordered by buffer strips and hedges.	GMP
4	Super silt fences			✓			SRPs are used in preference of these measures.	GMP
5	Stabilised drains and discharge points		✓			April 2020	Some drains need further stabilisation.	GMP
6	Decanting earth bunds	✓						GMP
7	Sediment retention ponds		✓			April 2020 – April 2022	Some SRPs need expansion/modification, according to Table 5. Work to be staged out to April 2022.	GMP
8	Other (specify):			✓				

8 Actions

1. A new SRP4 should be constructed in the north-western corner of paddock 605, with the existing pseudo-SRP being re-structured as a clean drain accepting the flow from paddocks 601 and 602. The spillways and snorkel from the new SRP should be directed into this drain. Prior to construction of this, a silt fence should be installed in the existing SRP4 as a temporary measure
2. The interception drain along the southern boundary needs re-digging. The culvert it leads to on the south-western edge of paddock 603 also needs digging out.
3. A new SRP1 needs to be constructed at the north-western edge of paddock 602. It should end just to the west of the culvert leading from the drain coming from paddock 601. The emergency spillway and snorkel should be placed at the western end of the new SRP, so that the existing SRP1 acts as a drain.
4. The current SRP2 should be expanded to 1.0% in size, accepting overland flow from paddock 604b via the existing culvert. Outflow from the snorkel will enter the clean drain along the northern boundary of paddock 606. The emergency spillway (11m) to be constructed along the northern edge so as to discharge into the clean drain.
5. The clean drain leading from SRP2 should continue past paddock 606 and into the neighbouring leased site, where it will terminate at the north-western corner. The existing SRP3 will need to be reconfigured as a drain, with outlet pipes being removed.
6. A new SRP3 should be constructed to accept flow from paddock 606, with the outflow entering the clean drain running along the northern boundary of paddock 606.
7. The new SRP5 should be constructed by the culvert at the south-east boundary of paddock 604 to accept flow from paddocks 603 and 604a. The outflow from this SRP will then enter the existing culvert leading to the clean drain running along the eastern and northern boundaries of paddock 605.
8. Bunds along the northern edge of 603 should be installed above the clean drain originating from SRP1 so that overland flow is directed across the access way into SRP5.
9. Bunds along the northern and western boundaries of paddock 605 should be installed so that overland flow from paddock 605 does not enter the clean drain.
10. For future best practice, do not cultivate within 1m of drains.

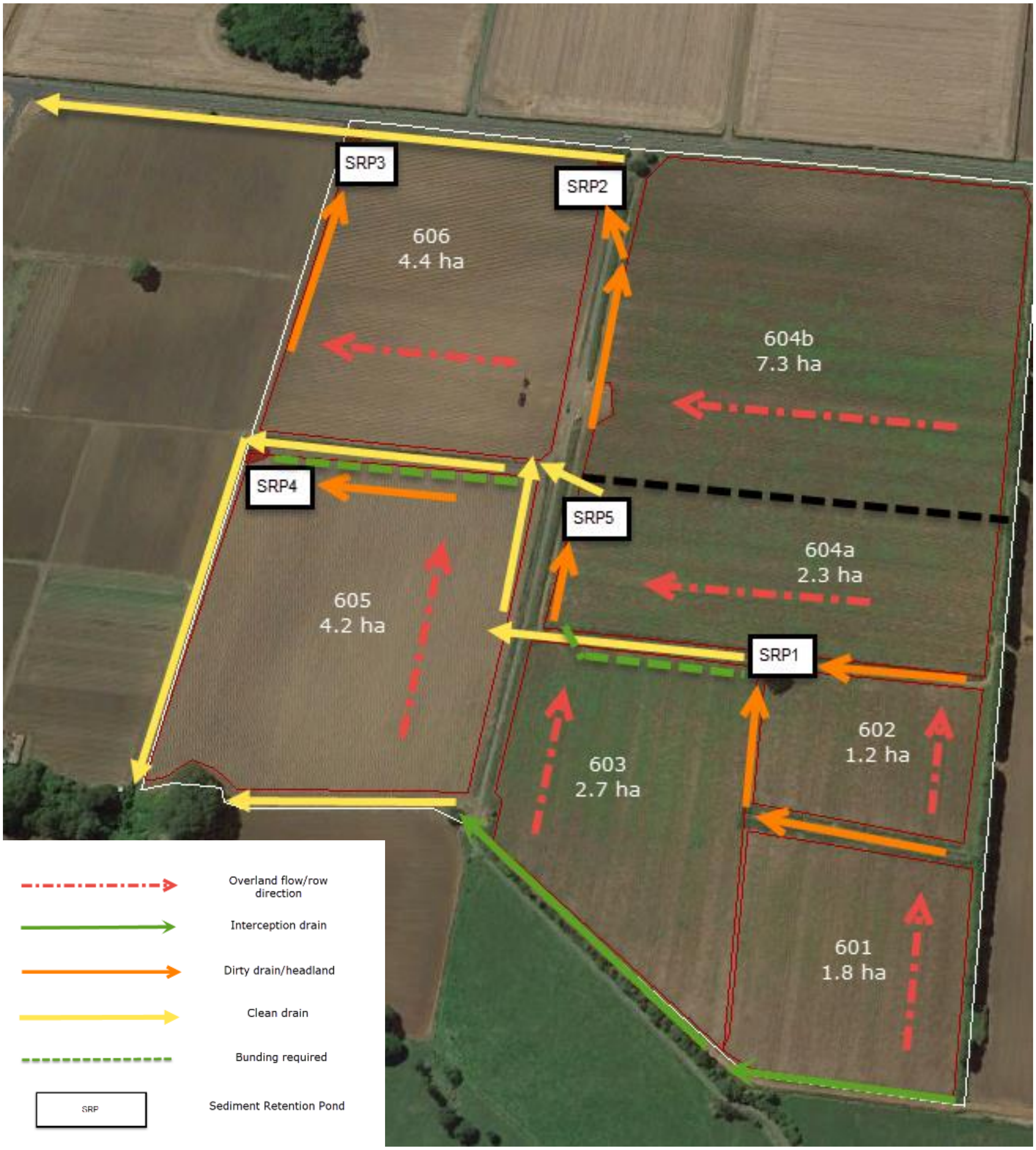


Figure 4. Paddock map of Farm A post action plan.

8.1 Culverts

There are 8 identified culverts in Farm A. A culvert is judged to be large enough if it can handle overland flow from its receiving area in a 20% Annual Exceedance Probability (AEP) rainfall event.

- Culvert 1 is located at the end of the interception drain in the south-western corner of paddock 603. This need digging out as it is currently buried by soil. The catchment area for the interception drain and therefore for the culvert is estimated at 16ha. This means the current culvert is undersized and so needs to be monitored. If necessary, a larger culvert should be installed.
- Culvert 2 is large enough for its receiving area.
- Culvert 3 is large enough for its receiving area.
- Culvert 4 is large enough for its receiving area.
- Culvert 5 is large enough for its receiving area. However, it has no headwall height. Ideally it should be placed lower, or have soil placed on top of it to increase the headwall height.
- Culvert 6 is large enough for its receiving area. However, it has no headwall height. Ideally it should be placed lower, or have soil placed on top of it to increase the headwall height.
- Culvert 7 is large enough for its receiving area.
- Culvert 4 is large enough for its receiving area.

8.2 Sediment Retention Ponds (SRPs)

Our recommendations are based on the Erosion and Sediment Control Guidelines for Vegetable Production. These recommend a minimum SRP size of 0.5%, or 50m^3/ha for catchments under 5 ha and 1% for catchments greater than 5 ha. These guidelines are supported by the on-going sector and MPI SFF research project Don't Muddy The Water.

For SRP sizes and catchments pre-action plan implementation refer to appendix 3.

Table 5. Sediment Retention Pond catchments and sizes for Farm A following action plan

SRP Number	Catchment area post action plan (ha)	Catchment paddocks post action plan	Required volume (%)	Required volume (m^3)	Potential dimensions (m)*		Spillway width (m)
					3:1	5:1	
1	3.0	601, 602	0.5%	150	24 x 7	30 x 6	4.5
2	7.3	604b	1.0%	730	45 x 14	54 x 12	11.0
3	4.4	606	0.5%	220	25 x 9	34 x 7	6.6
4	4.2	605	0.5%	210	27 x 8	33 x 7	6.3
5	5.0	603, 604a	0.5%	250	28 x 9	35 x 7	7.5

* Guideline only, actual dimensions will depend on site specifics. Assuming standard depth of 1.5m

Farm A is going to require large scale rerouting of overland flow using bunds, as well as enlargement/construction of all sediment traps. These modifications are explained in the map below (fig.5) and in the actions section.

Table 6. Sediment Retention Pond Snorkel Sizes and Quantity for Farm A

SRP Number	Hole size (mm)	Total number of snorkels	Total number of holes per snorkel	Number of lines of holes per snorkel	Number of holes per line	Distance between holes (mm)
1	10	2	30	5	6	175
	12	1	40	5	8	132
2	10	3	48	6	8	132
	12	3	35	5	7	150
3	10	2	36	6	6	175
	12	2	25	5	5	210

SRP Number	Hole size (mm)	Total number of snorkels	Total number of holes per snorkel	Number of lines of holes per snorkel	Number of holes per line	Distance between holes (mm)
4	10	2	36	6	6	175
	12	2	25	5	5	210
5	10	2	48	6	8	132
	12	2	35	5	7	150

- *Note – the bottom 30% of the snorkel shouldn't have any perforations in order to allow sediment to settle. Start drilling from the distance between holes from the top of the snorkel (e.g. the first hole is 200mm from top of snorkel where the distance between the holes is 200mm).

8.3 Construction schedule

Table 7. Construction schedule

Action	Completion date
Install silt fence in existing SRP4 IF construction of a new SRP4 in paddock 605 cannot be completed before April 2019.	April 2019
Construct a new SRP4 in paddock 605.	April 2020
Re-dig the interception drain along the southern boundary as well as dig out the culvert at its western end.	April 2020
Construct new SRP1.	April 2020
Construct bunds along northern boundary of paddock 603 so that overland flow from paddock 603 does not enter clean drain.	April 2020
Construct SRP5.	April 2020
Install bunds along edge of drain in paddock 605 so that overland flow from paddock 605 does not enter clean drain.	April 2020
Ensure all retention pond spillways are lined with geotextile cloth.	April 2020
Dig drain at the northern edge of paddock 606 leading into neighbouring property.	April 2021
Expand SRP2.	April 2021
Construct new SRP3	April 2021
Ensure all retention pond spillways are lined with geotextile cloth.	April 2021

8.4 Maintenance schedule

- Ensure SRPs are dug out and maintained every 6 months – 1 year, or more frequently if sediment reduces the capacity by more than 20%.
- Ensure snorkel and spillways are working correctly with an inspection every 6 months or after every large rainfall event.
- Ensure that bunds have not been penetrated by water channels with an inspection every 6 months or after every large rainfall event.
- Ensure culverts remain unblocked with an inspection every 6 months or after every large rainfall event.
- Ensure all drains, including interception drains are clear, with an inspection every 3 months or after every large rainfall event.

9 Appendix

Appendix 1 – Site pictures

Figure 7. From top left clockwise: i) Overgrown and shallow interception drain along southern boundary. ii) Blocked culvert from southern boundary interception drain. iii) Culvert leading to SRP2.

Figure 8. From top left clockwise: i) SRP3. This SRP will need to be separated from the SRP2 outflow drain. ii) Bunding at bottom of headland in paddock 604. iii) An example of cultivation too close to a drain.

Appendix 2 – Erosion rates

Table A1. Estimated baseline soil erosion

Paddock	Slope (degrees)	Erosion (t/ha/yr)	Total erosion (t/yr)
601	6.6	125	225
602	6.6	105	125
603	5.0	95	260
604	1.5	20	190
605	3.3	60	250
606	1.8	25	110
Total erosion (t)		**50**	**1,160**

Table A2. Erosion and sediment loss estimates for Farm A

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 (%)
601	125	0.9	68%	High	3	0.7	83%
602	105	0.8	68%	High	5	0.6	83%
603	95	0.7	68%	High	2	0.2	91%
604	20	0.2	68%	High	4	0.1	91%
605	60	45.9	0%	High	1	0.2	83%
606	25	0.2	68%	High	6	0.1	91%
Total	**50**	**8.4**	**56%**	**High**	**-**	**0.2**	**89%**

*****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.

Appendix 3 – Existing SRP catchments and sizes

Table A3. Existing Sediment Retention Pond catchments and sizes for Farm A

SRP Number	Current catchment area (ha)	Current catchment paddocks
1	5.7	601, 602, 603
2	9.6*	604
3	14.0	604, 606
4	4.2*	605

*SRP2 and SRP 4 are currently fully integrated into the drain system, with SRP2 outflow ending up in SRP3. They are therefore not acting as true SRPs.

APPENDIX B

Erosion & Sediment Control Report

Season	2018/19		
Farm Name	Example farm		
NZGAP Number	1	Farm ID	1-4
Region	Auckland / Upper Waikato		

How does this affect me?

This report summarises this farms erosion and sediment control efforts, using data collected from a survey.

The report is based on the Horticulture New Zealand 'Erosion & Sediment Control Guidelines'
http://www.hortnz.co.nz/assets/Uploads/Auckland-Waikato-ES-Control-Guidelines-1-1.pdf

It is important to note that the results presented here are approximate, the best way to assess erosion risk involves a site inspection by an erosion control expert.

1 Overview

Average whole farm sediment loss with current practice:	7.9	t/ha/yr
Average whole farm sediment loss with enhanced practice:	0.25 or 2.99	t/ha/yr

Good Management Practice acheived

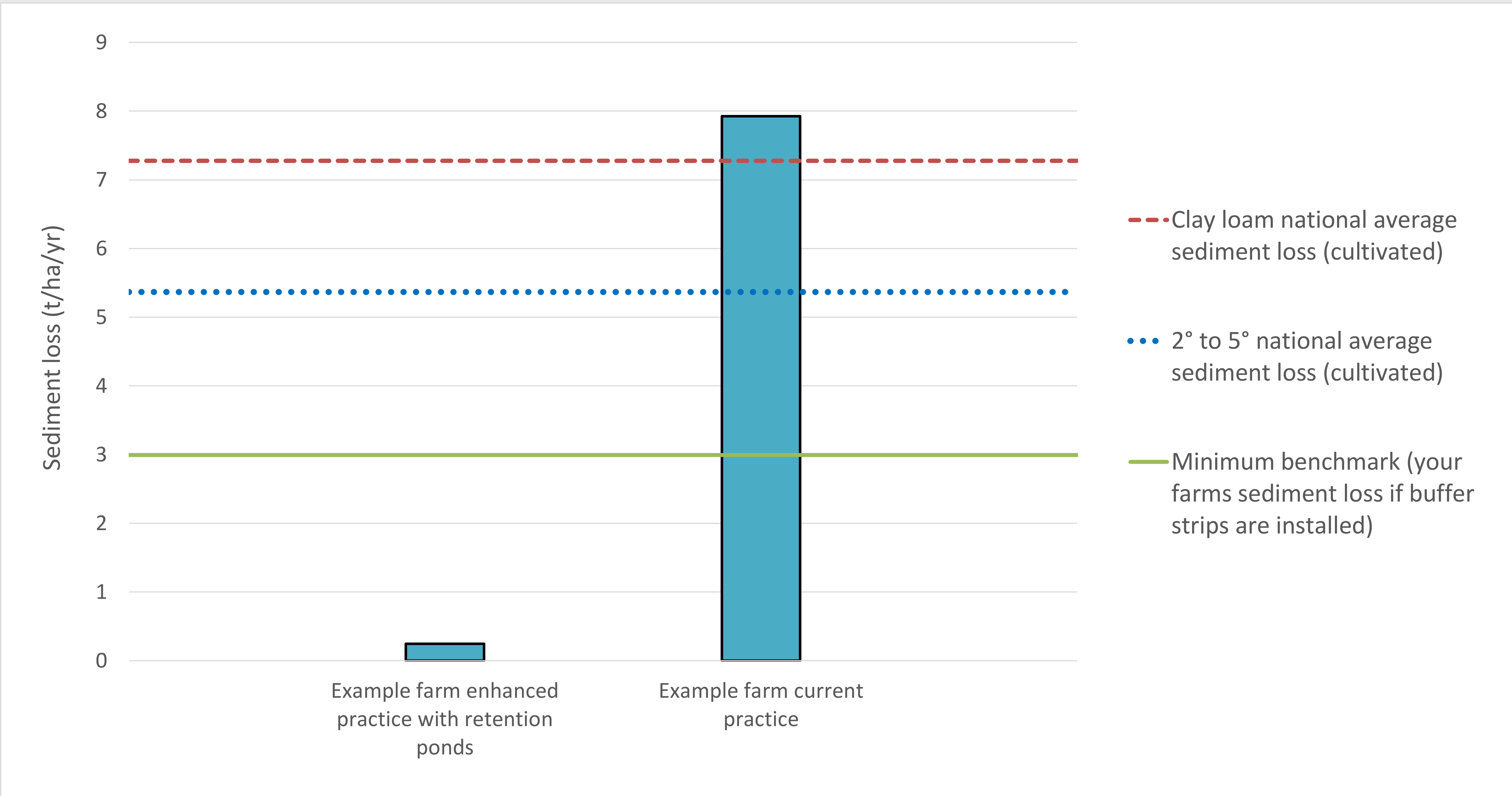
2 Paddock erosion

			Current situation		If enhanced practice was implemented		
Paddock name	Paddock area (ha)	Unmitigated sediment loss (t/ha/yr)	Sediment loss (t/ha/yr)	Suspended sediment reduction (%)	Sediment loss (t/ha/yr) with sediment retention ponds installed	Sediment loss (t/ha/yr) with vegetated buffer installed	Standard currently met:
601	2.0	123	0.88	68%	0.69	7.52	Good Management Practice achieved
602	1.0	104	0.75	68%	0.58	6.35	Good Management Practice achieved
603	3.0	95	0.68	68%	0.53	5.79	Good Management Practice achieved
604	10.0	21	0.15	68%	0.05	1.31	Good Management Practice achieved
605	4.0	57	45.9	0%	0.32	3.51	Significant improvement needed
606	4.0	24	0.18	68%	0.14	1.50	Good Management Practice achieved
-	-						
-	-						

Best management practices are based on slope. On gently sloping or flat land, vegetated buffer strips are recommended for best practice to prevent in-field ponding (retention ponds can still be implemented however, and where possible should be). Best practice for sloped land is based on retention ponds with a minimum size of 0.5% for paddocks less tha 5 hectares, and 1.0% for paddocks greater than this.

3 National benchmarks

Soil type at Example farm	Clay loam	Average slope at Example farm	2.9



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Version: Soil metrics report (6) 09-07-19