O'Brien, G. K. A., Bloomer, D. J., Posthuma, L. A. 2020. Back of an Envelope Nutrient Budgeting. In: *Nutrient Management in Farmed Landscapes*. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 33. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 7 pages.

"BACK OF AN ENVELOPE" NUTRIENT BUDGETING

Georgia K A O'Brien, D Bloomer and L Posthuma

LandWISE, Centre for Land and Water, 21 Ruahapia Road, Hastings 4180, New Zealand
Email: georgia@landwise.org.nz

Abstract
Under Gisborne District Council's Tairawhiti Resource Management Plan (TRMP), commercial vegetable and cropping farmers in Gisborne are required to prepare and submit a Farm Environment Plan (FEP) by 1st May 2021. Fertilisers must be applied according to the Fertiliser Association's Code of Practice for Nutrient Management. Growers have sought support for preparation of nutrient budgets that incorporate industry good practice for intensive cropping. For vegetables, "Nutrient Management for Vegetable Crops in New Zealand" by JB Reid and JD Morton published by Horticulture NZ provides recognised guidelines. To help growers incorporate these guidelines into crop by crop nutrient budgets a simple easy to follow one-page nutrient budget template has been developed with input from lead growers and industry experts. This simple approach was developed for and tested by growers and is intended to help them meet these regulatory requirements.

Introduction
Vegetable growers are required to manage diffuse nutrient losses and demonstrate good management practice. Under Gisborne District Council's (GDC) Tairawhiti Resource Management Plan (TRMP), by 1 May 2021 all commercial vegetable growing and cropping activities must have a Farm Environment Plan which has been certified by the Consent Authority. Fertiliser application is permitted provided fertiliser is stored or discharged in accordance with good management practices as identified in the Fertiliser Association of New Zealand's Code of Practice for Nutrient Management (2013).

The Farm Environment Plan (FEP) must specify the magnitude and timing of fertiliser applications throughout the year and the total annual application must be specified. The FEP must demonstrate that the timing and magnitude of fertiliser applications is managed to maximise plant uptake and to minimise loss of nutrients to the environment. In catchments where waterways are degraded due to nutrient related effects, the FEP must demonstrate how a meaningful improvement in nutrient related effects will be achieved in order for their FEP to be certified.

The FEP must also include a "basic nutrient budget for nitrogen and phosphorus which indicates how nitrogen and phosphorus are coming onto the farm, where they are going and the levels that may be lost by leaching or run-off."

Nutrient Budgeting
The process of nutrient budgeting involves documenting nutrient flows on and off-farm including fertiliser use, crop residue management, soil fertility, yield, and any animal grazing history.

For cropping systems, and in particular vegetable production with rapid crop rotations, nutrient budgeting can be complex. Paddocks may be broken up for several concurrent crops and recombined into one management unit within the same year, then split differently the next.

Frequent changes to the land parcels used for cropping means the boundaries of the farm are different from season to season, especially when it includes leased land. For nitrogen, a crop-by-crop nutrient budget is more sensible than a whole farm, or paddock-based nutrient budget. For phosphate, an annual paddock budget that accounts for the crops in the rotation is relevant.

As part of delivering an FEP with objectives to reduce N and P loss, the LandWISE nutrient budget templates are based around published guidelines. Therefore, the amounts of nitrogen or phosphorus required for a specified crop yield with a specified soil fertility level, are drawn from "Nutrient Management for Vegetable Crops in New Zealand" (Reid & Morton, 2019). However seasonal, labour, crop physiology, and economic factors have a significant impact on vegetable production, and the predicted scenario for nutrient management is not always fulfilled. See "Nutrient Budgeting: Worked Example" for further explanation.

Nutrient Management Guidelines

Until 2019, the most recent guidelines for vegetable crops were published in 1989. Since then the priorities of vegetable production have changed and applying excess fertiliser as insurance is no longer an acceptable risk management strategy. The new guidelines recognise the need to minimise the risk of nutrient losses and recommend fertiliser inputs according to expected yield and available nitrogen in the soil. The 2019 guidelines focus mainly on nitrogen and phosphorus inputs, although potassium (K), sulphur (S), calcium (Ca), and magnesium (Mg) are also mentioned. The guidelines include the major vegetable crops grown in New Zealand (potatoes, onions, brassicas, sweetcorn, squash etc.) but some Asian green crops such as pak choy are not included so substitutions are required.

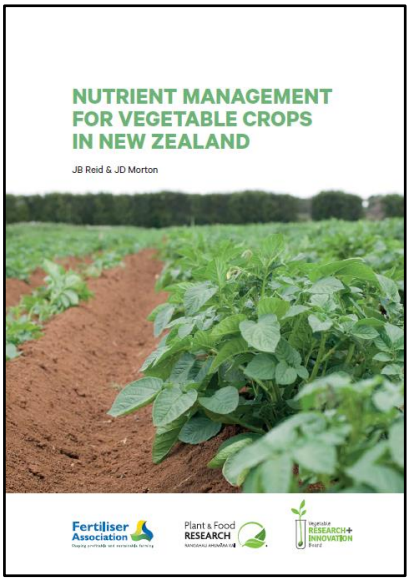

Figure 1. Cover of Nutrient Management for Vegetable Crops in New Zealand (Reid & Morton, 2019).

Nitrate Quick Test

Good management decisions around nitrogen and fertiliser use require soil testing. First developed by the University of California Davis, the Soil Nitrate Quick Test is an affordable, accurate and accessible way to monitor soil nitrogen status through the season.

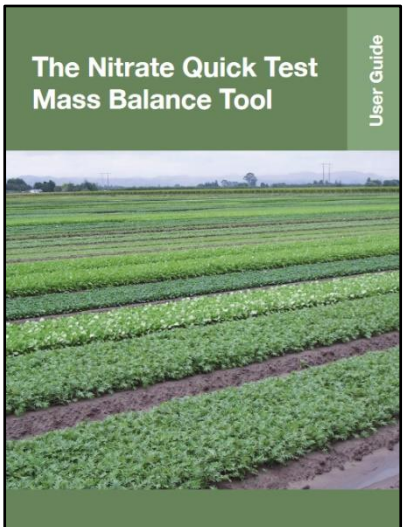

Figure 3. Cover of The Nitrate Quick Test Mass Balance Tool by FAR.

The LandWISE Nutrient Budget template for nitrogen incorporates Nitrate Quick Testing results before planting, in-season where appropriate and after harvest. The first step is to obtain a representative soil sample for the full rooting depth. A sieved soil sample is mixed with and extract solution and after a settling period (15 minutes – 2 hours) a test strip is dipped into the soil solution. The test strip has a colour

Figure 2. Using the Nitrate Quick Test Strips. Photo Credit: Matthew Norris, Plant and Food Research

indicator, which can be compared after 1 minute to a visual scale of nitrate (NO_3^-) concentrations.

Calibration trials by Plant and Food Research confirmed the test strips accuracy for New Zealand cropping systems. This work supported the development of a user guide and mass balance tool for the Foundation for Arable Research (FAR). Using the Mass Balance Tool growers can convert the nitrate concentration results into available kg N/ha and make decisions about side-dressing crops or adjust base fertiliser rates before planting.

Nutrient Budgeting: Worked Example

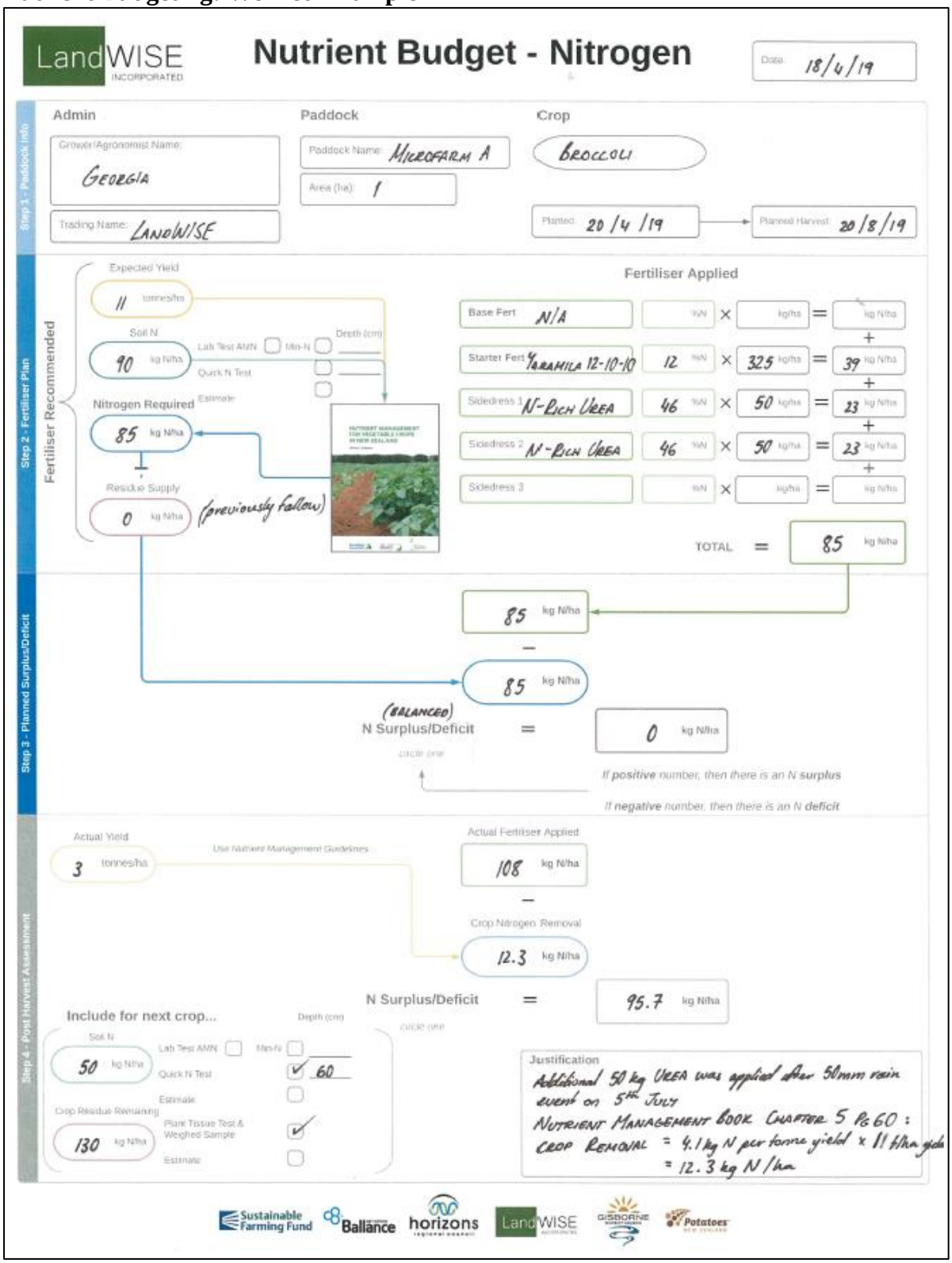

Figure 4. Worked example of a nitrogen nutrient budget for a Broccoli crop.

Figure 4 shows a worked example of using the "Nutrient Budget – Nitrogen" template for a Broccoli crop. The grower plans to apply the recommended rate of Nitrogen for a Broccoli crop of 11 tonnes/ha with a soil N level of 90 kg/ha based on an AMN test to 15cm. The previous crop residue value would normally come from the previous nitrogen nutrient budget for the paddock/management unit. Because this paddock has been in fallow for 5 months prior

to planting, the likely nitrogen input from crop residue breaking down is low and 0 kg N/ha has been included. Split fertiliser applications have been planned to minimise the risk of nitrogen loss in drainage (leaching).

The first 3 steps of this nutrient budget cover the pre-planting stage. The paddock information is noted, the fertiliser plan is detailed, and the anticipated surplus/deficit is calculated. The surplus/deficit value acts a guide and paddock and seasonal factors will play a role. The aim is to plan to be close to the recommended rate, but on-farm trial data might justify a lift or decrease of the target rate relative to the "Nutrient Management for Vegetable Crops in New Zealand" recommendations.

The fourth step of the nitrogen budget is the post-harvest assessment when the actual inputs and outputs are described. The amount of fertiliser applied has increased from the original plan after a 50mm rain event on 5th July, a week after applying the second side-dressing. The grower tested the soil to full rooting depth using the nitrate quick test and found available N levels to be low. Their response to this test was to re-apply 50kg/ha of urea (23kg N/ha) to replace the nitrate lost in drainage (leached). Unfortunately, due to late-season disease the grower only harvested 3 tonnes/ha of broccoli, as the rest of the crop sustained damage to the broccoli heads and was not marketable. The remaining residue was mulched and left in the paddock.

As a result of these in-season and unpredicted factors, the final nitrogen balance is a surplus of 95.7kg N/ha. Some of this surplus is due to the increased fertiliser applied, and some to loss of crop yield due to disease. However at least 45 kg N/ha (about half) is due to crop factors built into the budget model in Reid and Morton (2019). If the post-harvest scenario was unchanged from the plan there would still be a surplus of 45 kg/ha of nitrogen because a broccoli crop leaves behind a large amount of N-rich crop residue. This residue will slowly break down and release available N, however not always at a predictable rate.

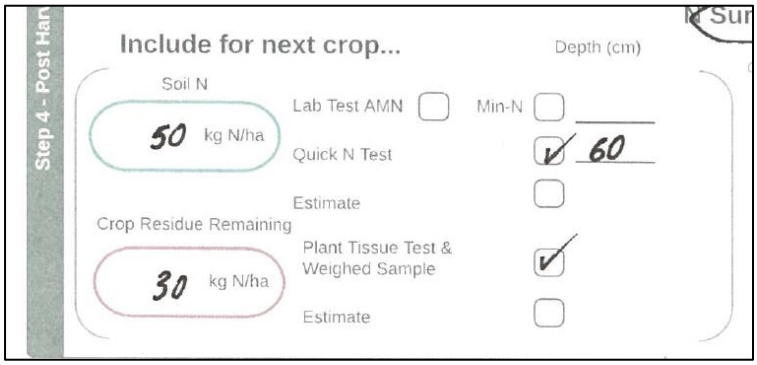

Figure 5. Soil and residue N for the next crop.

In the example shown in Figure 5, the soil N has been determined by taking a nitrate quick test post-harvest, as well as weighing and lab testing a sample of the crop residue left in the paddock after harvest. This additional information enables the grower to make a more informed fertiliser plan for the next crop they plant.

The "Crop Residue Remaining" is intended to be substituted into the "Residue Supply" box for the next crop's nitrogen budget, assuming that crop is planted within a short timeframe. However, the breakdown of residue to available N and its partitioning to soil organic matter, available N and losses is uncertain so this should be treated as a guide.

Nutrient Budgeting: Worked Example Annotated

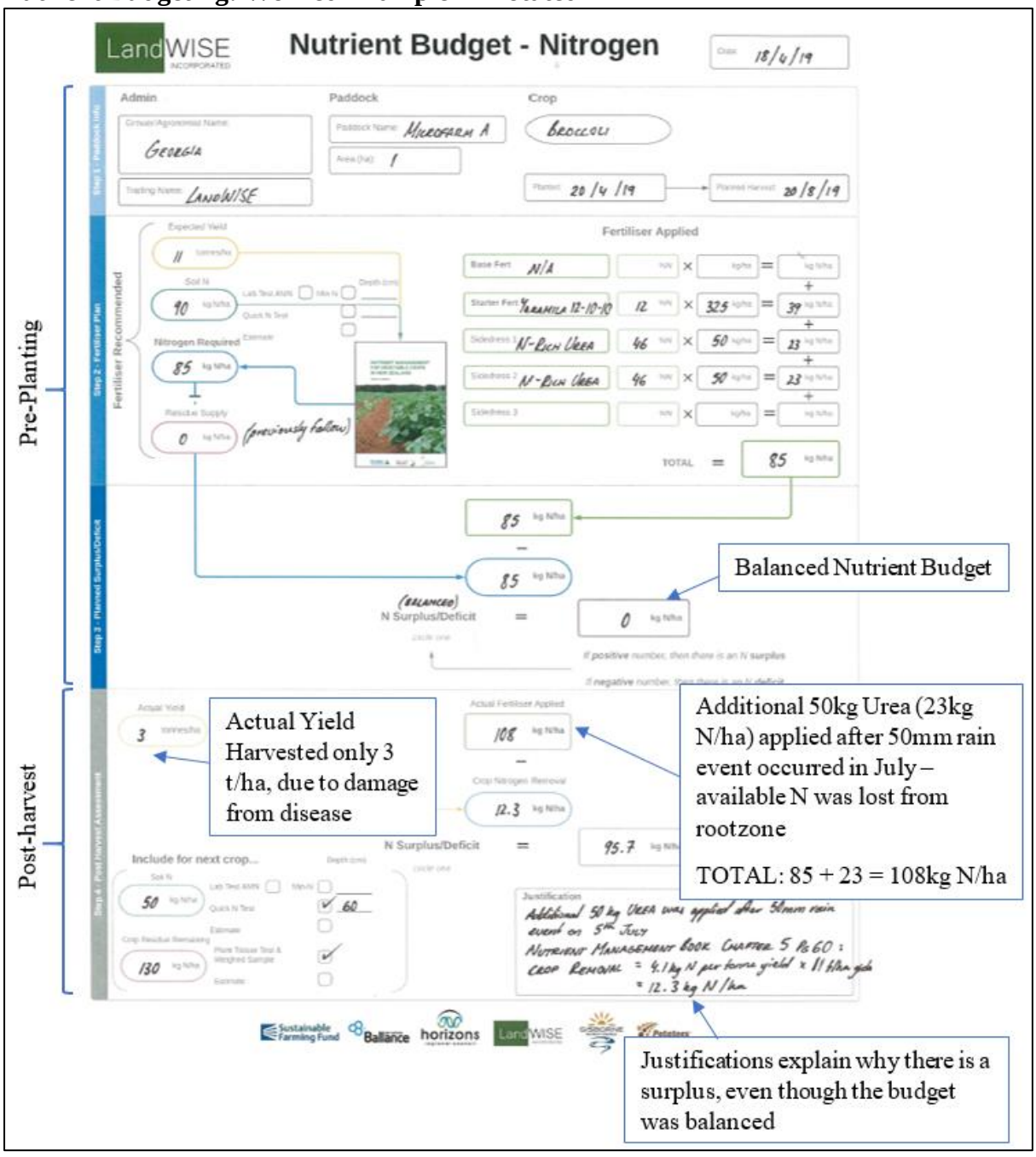

Figure 6. Worked example of a nitrogen nutrient budget for a Broccoli crop – with annotations.

LandWISE Nutrient Budgeting Templates

High resolution copies of the A4 Nutrient Budget Templates can be found on the LandWISE website (www.landwise.org.nz/resources/tools/landwise-nutrient-budgeting-tool/) or obtained by contacting the author.

The LandWISE Nutrient Budget Templates were developed as part of "Future Proofing Vegetable Production". We gratefully acknowledge the MPI Sustainable Farming Fund and project partners Horizons Regional Council, Ballance AgriNutrients, Potatoes NZ and Gisborne District Council for funding this work.

References

Mathers, D., Norris, M., & Hunt, A. (2019). *The Nitrate Quick Test Mass Balance Tool*. https://www.far.org.nz/assets/files/blog/files//e7b9c43f-c4f6-52cb-b0f9-1e9e6539bb91.pdf

Reid, J. B & Morton, J. D. (2019). "*Nutrient Management for Vegetable Crops in New Zealand*". Horticulture New Zealand on behalf of Vegetables Research and Innovation Board and Fertiliser Association of New Zealand, Wellington.