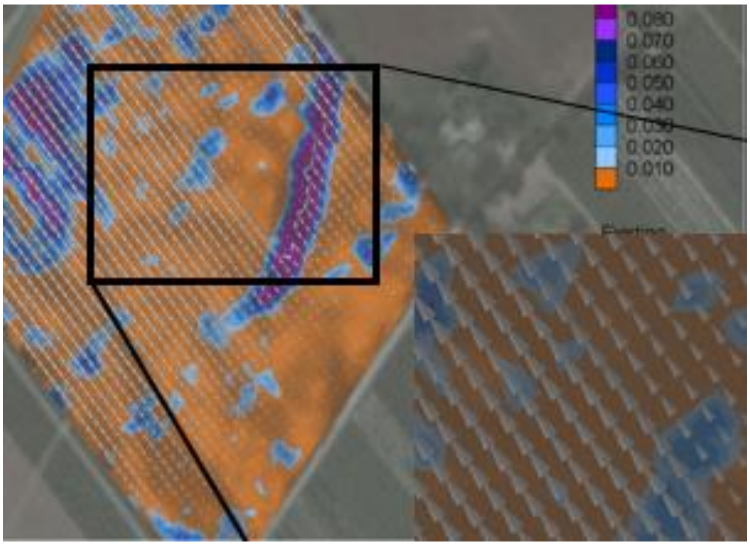
Feasibility Assessment for Land Shaping for Surface Drainage in Orchards

GUIDELINES FOR CONSULTANTS



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Guidelines for Consultants

1 Background to this Report

This report describes a process for assessing the feasibility of land shaping orchard inter-rows to facilitate surface drainage in an orchard block. It provides detail on the steps and lessons learnt from trials in existing orchards where persistent wetness and ponding has caused water logging. This water logging has been shown to contribute to tree health decline, development of ruts, reduced machinery and labour access and increased operations and safety problems.

These guidelines were developed and amended during trials at orchards owned and operated by T&G Global, Bostock New Zealand and MrApple. It outlines the process to assess orchard blocks for suitability, drawing on publicly available LiDAR elevation data from regional councils and other organisations, and using GIS tools including ArcGIS and OptiSurface Drainage.

A companion report has been created that applies to physical on-orchard land levelling. Lessons learned from on practical application are incorporated but we anticipate further amendment as experience grows and other equipment options are adopted.

The work was completed with funding from the Ministry for Primary Industries through the Sustainable Farming Fund and New Zealand Apples and Pears Inc. We are grateful the support of orchardists, farmers and contractors that enabled us to access equipment to conduct our investigations and trials.

We particularly note the support of:

Orchardists

Courtney St George, Andy Jones, Mark Fry and Duncan Park at T&G, Fulton Gillies and Graeme Hodges at Bostocks, Tim and Natalia Egan at Illawarra Orchards, Robbie McCormick, Stella McLeod, and Tony Waites at Mr Apple.

Industry

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Companion Report

Dan Bloomer, Luke Posthuma, Georgia O'Brien and Pip McVeagh (2020) On-Orchard Implementation of Land Shaping for Surface Drainage

2 Introduction

This document outlines the process to identity whether land-shaping will be feasible to remove excess surface water from a block. The process uses publicly accessible LiDAR data and simple GIS tools. Links to LiDAR and rainfall data are included in Section 4. The outputs from this process will indicate the feasibility of using land-shaping to manage poor drainage on an orchard block. When implementing on the Orchard, the operator will re-survey the row with RTK GPS using the Trimble WM-Drain as outlined in the companion report "*On-Orchard Implementation of Land Shaping for Surface Drainage*".

Why consider land shaping in existing orchards?

Inadequate orchard drainage highlighted during harvest and winter spraying periods, is an extreme expression of a common year round problem. Soil softness and constant traffic creates wheel track ruts and muddy conditions increase disease, increase labour costs and hazards and increase storage fruit rots. Despite numerous attempts to rectify puddles, mud and ruts, the problem remains.

A number of artificial drainage solutions are possible. Surface drainage considers how to allow water to rapidly flow off a block rather than infiltrating the soil. Subsurface drainage focuses on reducing the water table to ensure soils are not saturated. Soil ripping creates faster paths for water to move through the root profile to some better drained zone, perhaps assisted by subsurface drainage. Soil sumps create a ready path for surface water to drain directly to underlying highly permeable layers such as gravels.

Precision Land Shaping for Surface Drainage

This document focuses on new precision agriculture technologies to address surface drainage in established orchards. The concept comes from broad-acre cropping farms of levelling blocks to remove excess surface water quickly. By ensuring water can always flow of the block, soils dry out faster and growers can get back onto the ground sooner after large rain events.

This method is not always feasible: it is suited to relatively flat orchards where minor undulation causes localized ponding and soil saturation. Excessive soil movement will create hazards and access difficulties and regardless, there must be an exit point for the excess drainage water.

Note that the purpose of surface drainage is to remove surface water quickly from the row areas after rain events so that subsequent vehicle traffic, whether it be a sprayer, mulcher, or harvest forklift, will not create ruts due to soft soil. This will assist but should not replace sub-surface drainage from an orchard block needed to manage high water tables or slow permeability.

3 Design Process

The purpose of doing an office feasibility survey is to assess whether an orchardist can use natural slope along the orchard rows to quickly remove excess water after rain events.

The process uses LiDAR data to create an elevation dataset that is loaded into OptiSurface. After creating an Elevation model in OptiSurface, a simple drainage analysis model can be run to predict areas of water ponding and the depth of the ponding after a rain event. A series of elevation profiles across the block can be viewed to assess whether it is feasible to use land shaping to remove the surface water ponding the orchard interrows.

1. **Collect local LiDAR data to determine terrain across the block.**
   LiDAR data will create a high density point cloud map of the orchard floor by scanning the orchard canopy.
2. **Create DEM from the LiDAR data.**
   LiDAR data must be converted into a usable map form, starting with converting it into a digital elevation model (DEM)
3. **Create a point layer from DEM.**
   The process described here using the capabilities of OptiSurface software which required data in a point layer format
4. **Export point layer to a shp file in the GPS WGS84 file format.** OptiSurface reads shp point files or text multiplane files in the WGS84 format.
5. **Create OptiSurface Elevation Model.** Draw a boundary around the outside edge of the orchard block. Include farm track areas as these can often act as a dam preventing water from leaving the ends of the rows and create significant rutting issues.
6. **Model surface drainage**
   Understanding the drainage flows and ponding is a critical step in determining what mitigation will be required
7. **Create interrow elevation profiles**
   Elevation profiles allow identification of ponding areas and the depths of cut and fill needed to remove ponding
8. **Assess feasibility of orchard implementation**
   Check the block's terrain to ensure there is somewhere for drainage to escape the block, and that the amount of cut and fill required to remove ponding is reasonable and will not create other problems in the orchard.

3.1 LiDAR Data

LiDAR data will create a high density point cloud map of the orchard floor by scanning the orchard canopy.

NOTE: Check the year that the LiDAR was collected. Most of the LiDAR surveys have been completed in the last 10 years. Remember to check if land levelling was completed on the block if the orchard was developed after the LiDAR data was originally collected.

NOTE: LiDAR data can be found from a range of sources:

- Email info@hbrc.govt.nz to get the required data for the Hawkes Bay. Tiles showing the extent of the Hawkes Bay LiDAR surveys can be found at https://catalogue.data.govt.nz/dataset/hbrc-lidar-extent
- Most other regional LiDAR data can be found on the Koordinates platform with a free user account. https://koordinates.com/. Use a key word and region to find local data.

If the orchard area required is not available in the above two sources, try calling your local council as they typically obtain the LiDAR surveys and should be able to indicate whether any data is available for the block of interest.

If no LiDAR data is accessible, an elevation survey can be made using by driving up and down the rows using a high accuracy GPS system. GPS antennas need to be able to communicate with multiple satellites so in dense orchard areas, raise the antenna above the vehicle or survey in the Autumn/Winter period when the trees have no leaves.

3.2 Create Digital Elevation Model

This step is done in a GIS program. The steps described here are for ArcGIS, but QGIS or other software could be used.

- Draw a boundary for the area to be analysed
  Ensure that you draw a reasonably large buffer (5m) around the row ends as you are wanting the modelled water flows to fully leave the orchard rows and move away from the trees.
- Convert the LiDAR data into a digital elevation model (DEM)

NOTE: Optisurface modelling works best below 30,000 data points, ideally less than 20,000 points.

3.3 Create Digital Point Layer

A 1 m DEM can cover approx. 3 ha (check area with measure tool) without overloading OptiSurface.

- Create boundary for analysis
- Crop out area of DEM to boundary using **clip**.
  Check 'use input features for clipping geometry'
  Leave 'maintain clipping extent' unchecked.)
- Create point feature from the DEM using **Raster to Point**
- Open attribute table for point layer and ensure the point file has < 20,000 data points

3.4 Export Point Layer

OptiSurface reads .shp point files or Trimble Multiplane .txt files in the WGS84 format. If your LiDAR data is in the NZTM2000 format, the following steps outline how to create a file to load into Optisurface.

- In the attribute table, **add fields** and name them Lat_UTM, Long_UTM or similar, **calculate** geometry for each column, choose *NZGD 2000 UTM* (Projected C S, UTM, NZ, NZGD2000 UTM Zone XX)
- Export attribute table to table, add *.csv* to end of file name
- **Identify Master Benchmark (MB) point and convert coordinate of MB from NZTM2000 to WGS84**
- Select MB point and export to feature class (the MB point can be any point and will be the only point in the layer)
- Open attribute table for MB, in the attribute table, **add fields** and name them Lat_UTM, Long_UTM or similar, **calculate geometry attributes** and select output *NZGD 2000 UTM Zone XX* as for latitude and longitude.
- Open attribute table for MB, in the attribute table, **add fields** and name them

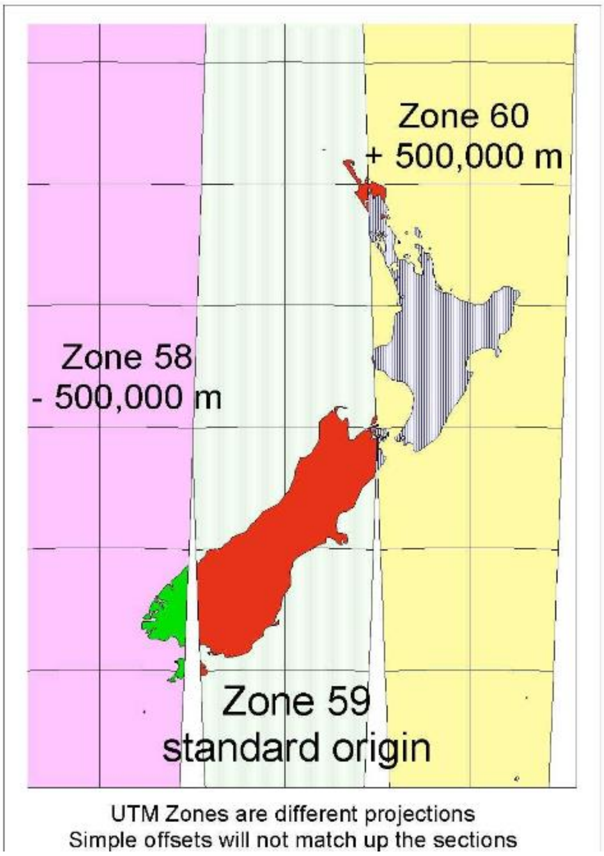

Figure 1 New Zealand UTM Zones

Lat, Long or similar, **calculate geometry attributes** and select output as GCS WGS 84 for latitude and longitude.

Use **convert coordinate notation** to change from DD (decimal degrees) to DMS (degrees minutes seconds). Select MB point file, input coordinate system should be NZTM by default, name output feature class, select output coordinate system to be *GCS_WGS_84*, input coordinate format – select *shape*, output coordinate format select *DMS 2* (degrees minutes seconds placed in a column each).

- Contain less than 20,000 data points
- Text file
- Tab delimited
- Coordinates for Master Benchmark in WGS84 DMS format e.g. MB S38:39:41.44713194 / E177:57:22.03487170
- Column 1 is ObjectID, column 2 is X distance, column 3 is Y distance, column 4 is elevation.
- Create header in top row

File as below:

0001	0.000	0.000	10.000	MB S39:36:4.568 / E176:49:37.643	0.000
2	-18.75	14.50	9.889560		
3	-18.77	14.48	9.885872		
4	-20.64	12.94	9.926131		

3.5 Create OptiSurface Elevation Model

OptiSurface is a GIS modelling software package that calculates likely ponding areas following a specified rain event according to the topography of the modelled area.

To import data into OptiSurface, the simplest method is to export the grid points in a .shp file with the Longitude, Latitude, and Elevation in the WGS84 format. When exporting the .shp file, ensure that the layer is a point layer, and not a polygon or raster layer. On importing the block into OptiSurface – draw a boundary around the orchard block. You will then see an Existing Elevation image with contour lines.

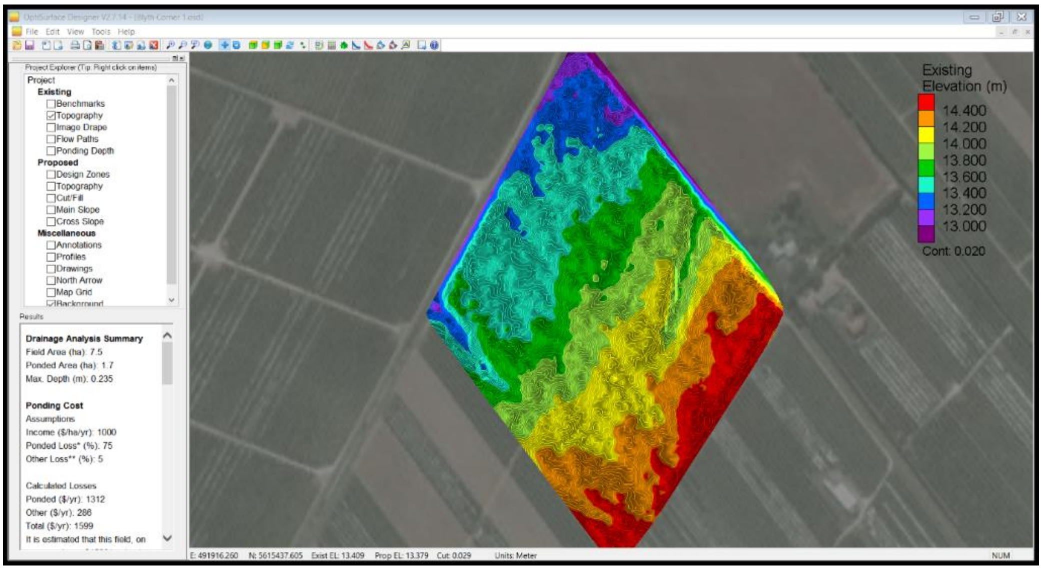

Figure 2. Optisurface Elevation Model

3.6 Model Surface Drainage

Understanding the drainage flows and ponding is a critical step in determining what mitigation will be required.

Using the Drainage Analysis Tool under "**Tools**" in OptiSurface, select the existing surface and process.

- For grid spacing, use the block's row width. Select the "***Furrows or Beds Restrict Water Flow Direction***" box and use the default height of the inter-row under the trees.
- Select the degree angle for the orchard rows using the "**Pick**" box.
- Select **OK** and run the analysis.

NOTE: Varying the Furrow/Bed Height can help identify the depths of cut and fill required.

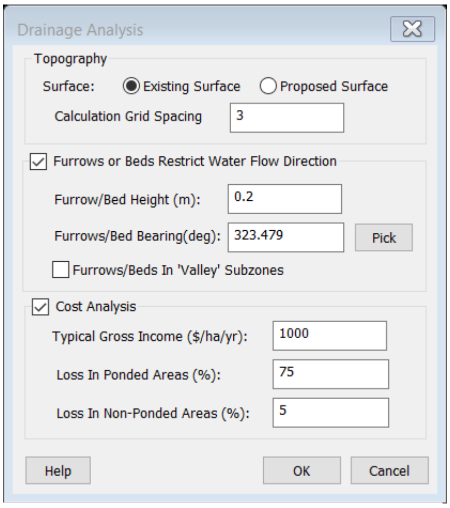

Figure 3. Drainage Analysis Criteria

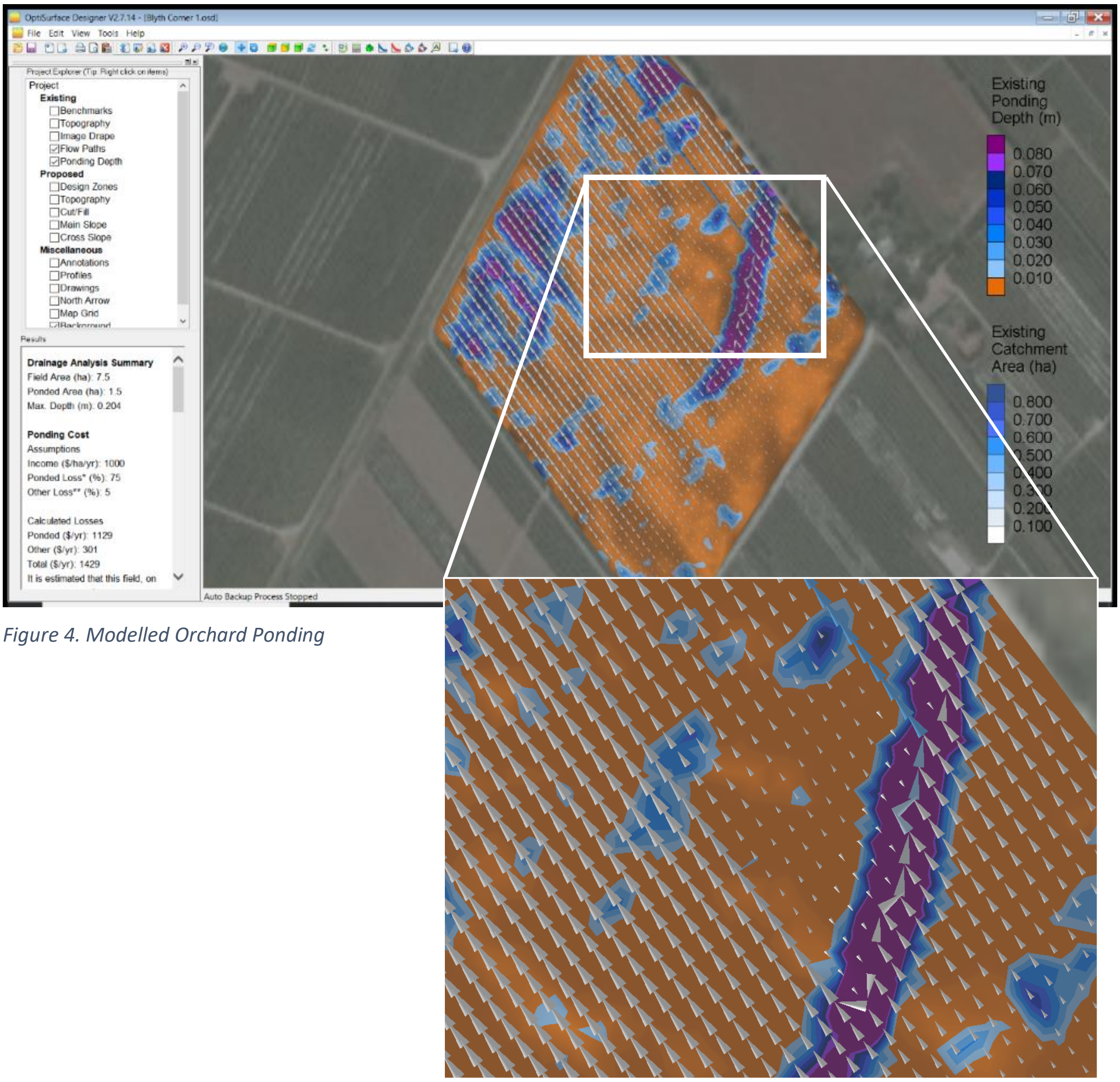

Figure 4. Modelled Orchard Ponding

3.7 Create Elevation Profiles

Elevation profiles allow identification of ponding areas and the depths of cut and fill needed to remove ponding.

- Select the **Profile tool** and create a **profile line** across the block.
    - The profile will show how much fall there is across the block, if there are any significant depressions in the block and how deep these depressions are.
    - Running your mouse cursor along the profile will show the elevation, distance from row end and angle of the soil surface.
    - A fitted straight line can be added to the block to show average slope across the block.

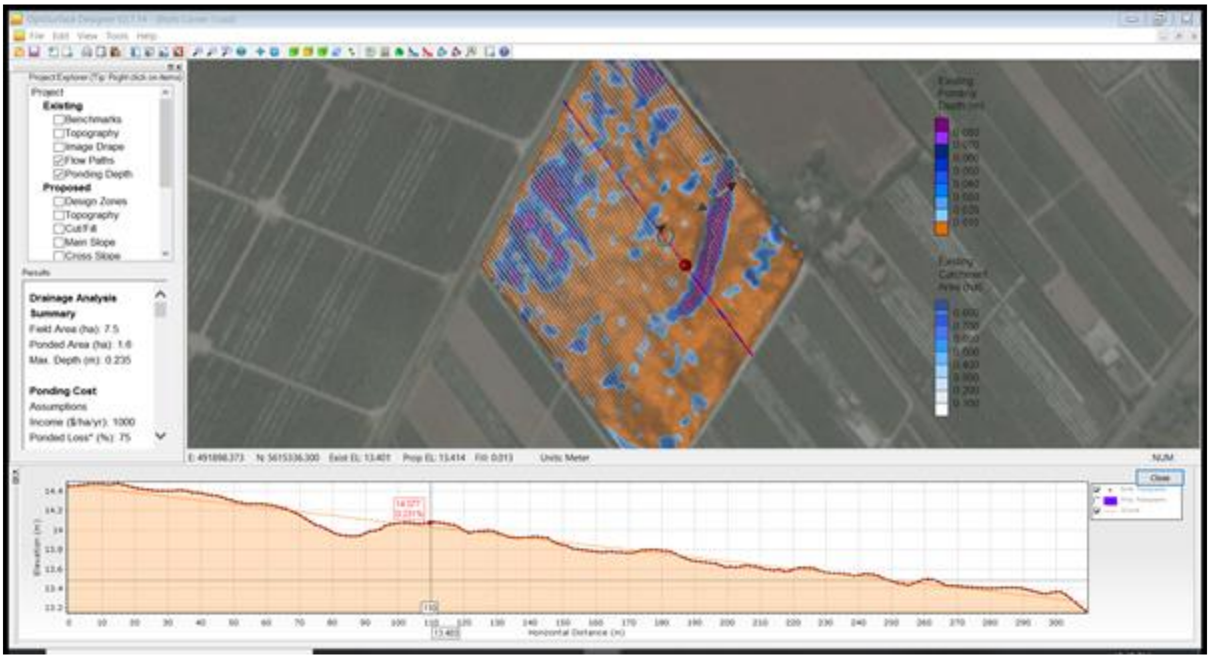

Figure 5. Row Elevation Profile: selection on map

3.8 Assess Feasibility of Orchard Implementation

When assessing the feasibility of implementing on the orchard, three key factors are to identify are:

- Elevation and slope direction across the block
- Presence of an escape for water drained from the block
- Depth of deepest depressions along the orchard row
- Height of any steps that will be created between the interrow and the under tree zones.

For good water flows across a block, the orchard row should have at least 0.1% slope at any point along the row. As can be seen in figure 4, this could include certain lengths of the row having a steeper slope, but a minimum slope should be maintained to ensure the water will flow down the row after a rain event.

When assessing cutting humps or filling hollows, consider that staff will be working across the orchard so cuts and fills should be minimised. Steps between interrow and undertree of more than 100mm may create significant trip hazards for workers. Where deeper hollows are filled, or large humps removed some additional work may be required to smooth the transition point.

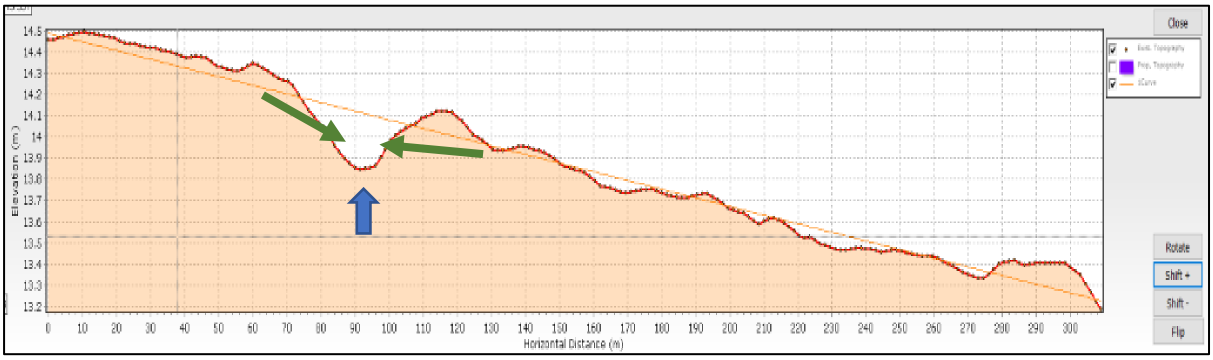

Figure 6. Row Elevation Profile: Cut and Fill Option 1

In Figure 6, the blue arrow shows a point where the existing profile is about 250mm below the average slope line. The green arrows show where soil cut from humps either side can be used to fill the hollow and allow drainage. However, the completed new grade will still have a step between the interrow and under tree which could be shaped manually to remove the hazard. Alternatively, move more cut material down-slope.

If there are a few very depressions, consideration should be given to alternative methods of removing excess water from these areas. Options may include either subsurface drainage through the hollow, sumps, or small areas resigned to regular rutting.

When considering water movement across the block, orchards setup on planted ridges will limit water flow across an orchard block. This will likely result in all the water flowing along just one row and not flowing across the orchard block. This needs to be included in any modelling exercise.

4 Accessing Modelling Data

4.1 LiDAR data

Email info@hbrc.govt.nz to get the required data for the Hawkes Bay. Tiles showing the extent of the Hawkes Bay LiDAR surveys can be found at https://catalogue.data.govt.nz/dataset/hbrc-lidar-extent

Most other regional LiDAR data can be found on the Koordinates platform with a free user account. https://koordinates.com/. Use a key word and region to find local data.

4.2 Climate Data

OptiSurface has options to assess the severity of the local rain events on the orchard block. The data for 1:10 or 1:20 year events might be used for an orchard scenario.

NIWA has created a High Intensity Rainfall Design System (HIRD tool @ https://hirds.niwa.co.nz/).

- Enter the block's address and localised rainfall data will be brought up.
  The tool gives rainfall depth and intensity data for events under current climate conditions and with expected climate change.