# Singleton Horticulture Project

## Baseline flood assessment

Fortune Agribusiness Fund Management Pty Ltd

21 October 2022

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# Executive Summary

## Purpose

Fortune Agribusiness Funds Management Pty Ltd (FAFM) engaged GHD Pty Ltd (GHD) to perform the baseline flood assessment of the 4000 ha of irrigated horticulture on Singleton Station in Northern Territory. The viability of the horticultural development may be sensitive to the extent, depth, velocity and duration of flood inundation due to rainfall.

The objective of this baseline flood assessment is to report the following:

– Identification of available elevation and hydrological data.
– Investigate the hydrological and hydraulic conditions present at the site under existing conditions.
– Mapping of baseline flooding extent, depth, flow velocity and inundation under a range of design rainfall events.
– Interpretation of modelling results and recommendations for the project development.

## Findings of baseline flood assessment

The flood modelling results indicate that flooding at the subject site is consistent with a wide flat terraced floodplain. The actual flood extents are expected to sensitive to distribution of flows in the upper part of the floodplain that may vary with alluvial and aeolian (wind) processes changing the shape of the floodplain and its channels during and between flooding events.

The flood modelling results indicate that flooding is slow moving, with low potential for erosion and little variation in time of inundation across the inundated areas. The potential flood effects of crops are most sensitive to the duration of inundation, which were found to be insensitive to flood hydraulics and are likely mostly dependent of the infiltration properties of the soils, which were inferred from a site soil survey undertaken for the project (McGrath 2020).

Southern Cross Farms (2021) reviewed a preliminary draft of this report. Based on their findings and the interpretation of flood modelling results presented in this report, it is concluded that:

– Flood events up to the 1% AEP design event, with a 30 to 40 hour duration of inundation, up to 0.5 m flood depth event and slow moving water are expected to have minimal impact on the citrus or grapevines. There are some minor localised areas where flooding depths up to 0.7 m are predicted and may temporarily inundate part of the citrus canopy.

Any flood event may impact the annual crops (such as hay, onions and rockmelons) which are not suitable to be submerged for any length of time, however it is understood that these crops are not planned to grown during the wet season when flooding events are more likely.

Based on the findings of this assessment the following is recommended that adaptive flood management measures be adopted, including:

– FAFM take into consideration the potential changes to the upstream catchment and distributions of flows, which may alter flood extents and impact on the proposed development, including construction of small flood levees.
– FAFM consider the potential flooding in selection of crops in flood prone part of the proposed cropping areas.

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# 1. Introduction

## 1.1 Background

Fortune Agribusiness Funds Management Pty Ltd (FAFM) engaged GHD Pty Ltd (GHD) to perform the baseline flood assessment of the proposed 4000 ha of irrigated horticulture on Singleton Station in Northern Territory. The feasibility of the horticultural development may be sensitive to the extent, depth, velocity and duration of flood inundation due to rainfall.

## 1.2 Study purpose and objectives

The objective of this baseline flood assessment is to report the following:

– Identification of available elevation and hydrological data.
– Investigate the hydrological and hydraulic conditions present at the site under existing conditions.
– Mapping of baseline flooding extent, depth, flow velocity and inundation under a range of design rainfall events.
– Interpretation of modelling results and recommendations for the project development.

## 1.3 Scope and limitations

The modelling has been undertaken in accordance with national guideline Australian Rainfall and Runoff 2019 (ARR2019). While ARR2019 provides no quantitative guidance on the seasonal distribution of rare to extreme rainfall events, the climate is sub tropical, with most rainfall occurring in the summer months. Therefore it is more likely for the rare to extreme rainfall events considered in the flood modelling to occur during the wet season than in the dry season, however there remains an inherent possibility of a rare to extreme rainfall during the dry season months.

Due to the relatively short design life of the project, the flood modelling has not considered long term changes in rainfall, such as climate change.

This report: has been prepared by GHD for Fortune Agribusiness Fund Management Pty Ltd and may only be used and relied on by Fortune Agribusiness Fund Management Pty Ltd for the purpose agreed between GHD and the Fortune Agribusiness Fund Management Pty Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Fortune Agribusiness Fund Management Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Fortune Agribusiness Fund Management Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

# 2. Methodology

Flood modelling is a process of estimating the hydraulics (depth, velocity, duration of inundation) of a flood based on design rainfall event. Flood modelling can be essentially separated into two processes:

– Hydrological modelling that converts rainfall to a design flood hydrograph (flow rate over time).
– Hydraulic modelling that converts a hydrograph to hydraulic properties (depth, velocity, duration of inundation).

This section describes the approach and data used for the two modelling processes

## 2.1 Hydrological model

Hydrologic modelling for this study has been prepared using the RORB model (Version 6.45). RORB is a widely used general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce the hydrograph. The model is aerially distributed, nonlinear, and applicable to both urban and rural catchments. It makes provision for temporal and aerial variation of rainfall and losses and can model flows at any number of gauging stations (Nathan 2014).

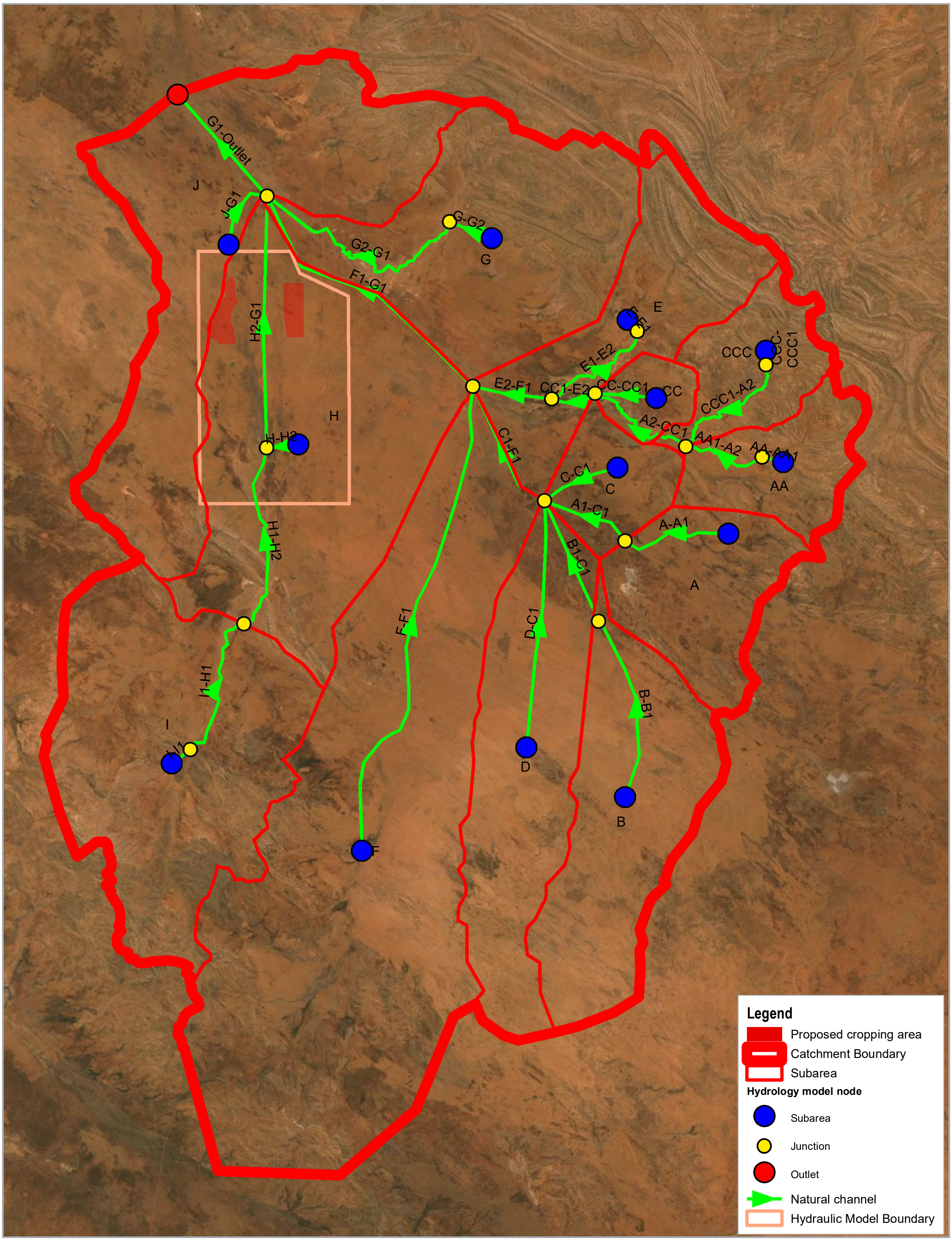
### 2.1.1 Catchment delineation

Catchment areas upstream of Singleton Station were delineated from 1 second Shuttle Radar Topographic Mission (SRTM) Hydrological Digital Elevation Model (DEM-H) for the region extracted from ELVIS data portal (**https://elevation.fsdf.org.au/**). The 1 second SRTM derived DEM-H Version 1.0 is a 1 arc second (~30 m) gridded digital elevation model that has been hydrologically conditioned and drainage enforced (Wilson 2011).

The total catchment area upstream of the Singleton Station was calculated to be approximately 13,802 $km^2$, which includes the floodplains of Taylors Creek and Wycliff Creek. The upstream catchment area was subdivided into thirteen subareas for the purpose of preparing the RORB hydrological model.

Figure 2.1 shows the extent of the catchment boundary as well as sub-areas and reaches used to develop the hydrological model. The figure also shows the hydraulic model extent which is discussed with more details in Section 2.2.

Following preliminary review of the hydraulic modelling results, it was determined that the potential flooding of the subject site was not expected to be significantly impacted by Wycliffe Creek, and therefore this part of the hydrological model was not used in the hydraulic modelling. The hydrological and hydraulic modelling focuses on Taylors Creek.




Paper Size ISO A4

0 5.5 11 16.5 22

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 53

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**Fortune Agribusiness Funds Management Pty Ltd (FAFM)**
**Singleton Station Horticulture Developement**
**Flood Modeling study**

**Hydrology model**

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|---|---|
| Project No. | **43-12525955** |
| Revision No. | **2** |
| Date | **19 Feb 2021** |

**FIGURE 2-1**

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Data source: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: Hanieh Kosari

## 2.1.2 Key parameters

**Intensity Frequency Duration (IFD) data**

The hydrologic modelling for this assessment has been prepared in accordance with the methods and procedures outlined in national guideline: *Australian Rainfall and Runoff: A guide to flood estimation* (ARR2019; Babister 2019). Intensity-Frequency-Duration (IFD) data for the site were sourced from the Australian Bureau of Meteorology 2016 Intensity-Frequency-Duration (IFD) dataset (BOM 2020) for the Singleton Station Site on 14 October 2020 for the co-ordinates of: Latitude: -20.866, Longitude: 134.11.

A copy of the IFD data for the site is provided in Appendix A.

**Initial and Continuing Losses**

Recommended values for initial and continuing loss are not provided by the ARR Data Hub (Babister 2016). Therefore, initial and continuing loss values adopted for the hydrological model respectively according to the previous study in Northern Territory for Amaroo Phosphate (GHD, 2017). These parameters are considered valid given the naturalised state of the catchment, and relative location of the two sites.

Adopted initial and continuing loss rates are presented below in Table 2.1.

*Table 2.1 Initial and continuing losses*

| Parameter | Value |
|---|---|
| Initial Loss (mm) | 40 |
| Continuing Loss (mm/hr) | 5 |

**RORB Kc Parameter**

The RORB hydrological model uses a constant “Kc” parameter to route hydrographs through the catchment. The RORB model recommends a number of equations, which derive the value of Kc based on upstream catchment area for different regions of Australia.

Table 2.2 below provides a summary of the estimates of the Kc Parameter for the site, using various equations for Kc recommended in the RORB manual and ARR 2019 Guidelines.

*Table 2.2 RORB Kc parameter*

| RORB Equation | Catchment Area ($km^2$) | Kc |
|---|---|---|
| RORB default equation (Whole of Model) | 13802 | 258.46 (m=0.8) |
| RORB default equation (Study Area) | 3323 | 126.82 (m=0.8) |
| ARR2019 Equation 7.6.25 (Arid areas of NT) | 3323 | 41.4 |

For the purposes of this assessment the RORB default equation has been adopted. Sensitivity assessments to regional relationships are presented in Section 3.3 of this report.

**Catchment Imperviousness assumptions**

For the purposes of this study, and based on a review of aerial imagery, the catchment is considered to be 100% undisturbed. A 0 % impervious fraction has therefore been adopted for the purposes of this study.

**Areal reduction factors**

Areal reduction factors have been determined using the procedures outlined in ARR2019. The purpose of areal reduction factors is to allow the spatial variability of rainfall across a large catchment that makes it likely that the average intensity of rainfall is less than the maximum intensity at one particular point location. Areal reduction factors for the critical storm durations are presented below in Table 2.3.

*Table 2.3 Areal reduction factors*

| Storm | Areal Reduction Factor |
|---|---|
| 20% AEP_24 hrs_TP 2921 | 0.77 |
| 5% AEP_24 hrs_ TP 2922 | 0.76 |
| 1% AEP_24 hrs_ TP 2918 | 0.75 |

### 2.1.3 Design ensemble

The RORB model was compiled using the above data and simulated for the 20%, 5% and 1% AEP design flood events in order to determine flooding conditions at the site.

### 2.1.4 Hydrological model results

For each AEP, the RORB model has been simulated using the key parameters described above in this section. The results of the RORB hydrological model summarised in Table 2.4 for the critical storm duration. The critical storm duration has been determined from comparison of median values of simulated storm ensembles simulated for each storm duration, for each design AEP.

*Table 2.4 RORB hydrological model results*

| AEP (ARI) | Critical Duration | Median Flow ($m^3/s$) | Median Temporal Pattern |
|---|---|---|---|
| 20% (5 year) | 24 hours | 383 | 2921 |
| 5% (20 year) | 24 hours | 1419 | 2922 |
| 1% (100 year) | 24 hours | 3130 | 2918 |

### 2.1.5 Model validation

The Regional Flood Frequency Estimation (RFFE; Rahman et at 2012) is a peak flow estimation tool based on the regionalised regressions of stream gauges. Since there is no Regional Flood Frequency Estimation Model available for the Taylors Creek at NT region it is not possible to validate estimated peak flow output of the RORB model. Therefore, both hydrology and hydraulic model results are compared to a satellite image flood extent following an actual rainfall in Section 3.2.

## 2.2 Hydraulic model

The hydraulic modelling for this assessment has been undertaken using the two dimensional (2D) modelling using the TUFLOW (Version 2020-01-AB) software. TUFLOW is a 2-D unsteady flow hydrodynamic modelling tool developed by WBM-BMT (BMT 2020). TUFLOW solves the depth-averaged 2D shallow water equations for flows such as for the free-surface flows occurring from floods and tides based on the creation of an appropriate-resolution DEM, surface inflows, surface roughness and boundary conditions. TUFLOW is recognised as an industry standard 2D hydrodynamic modelling package within Australia and is well-suited to the modelling of the waterways and floodplains within the study area.

### 2.2.1 Model grid size

A 10 m grid size was adopted for the purposes of this assessment, based on a desktop review of site topography and field investigations.

### 2.2.2 Topographic data

The TUFLOW model was prepared using available 1 m gridded LiDAR data for the study area (265 $km^2$), supplied by FAFM. The LiDAR topographical data was supplemented with data from the Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) for areas beyond the available LiDAR coverage of the site. The SRTM data and LiDAR data were used to compile a Digital Elevation Model (DEM) for the study area. Relative to LiDAR, SRTM is a low accuracy data source with random errors inherent in the measurement technology. Due to the random nature of errors in SRTM, it is not possible to use the LiDAR to provide a systematic correction of these errors.

### 2.2.3 Hydraulic model extents

The hydraulic model extents included an area extending approximately 25 km upstream of the site, and extended some 5 km downstream of the proposed development area. The upstream hydraulic model extents were located based on review of the available SRTM coverage of the area, and review of vegetation extents and indications of overland flow paths evident from a review of aerial imagery for the area.

The upstream hydraulic model extent was therefore selected such that these overland flow paths and distributions of flow could be reflected within the model and realistic flow distributions could be represented within the hydraulic model upstream of the study area. Figure 2.2 shows the hydraulic model extent.

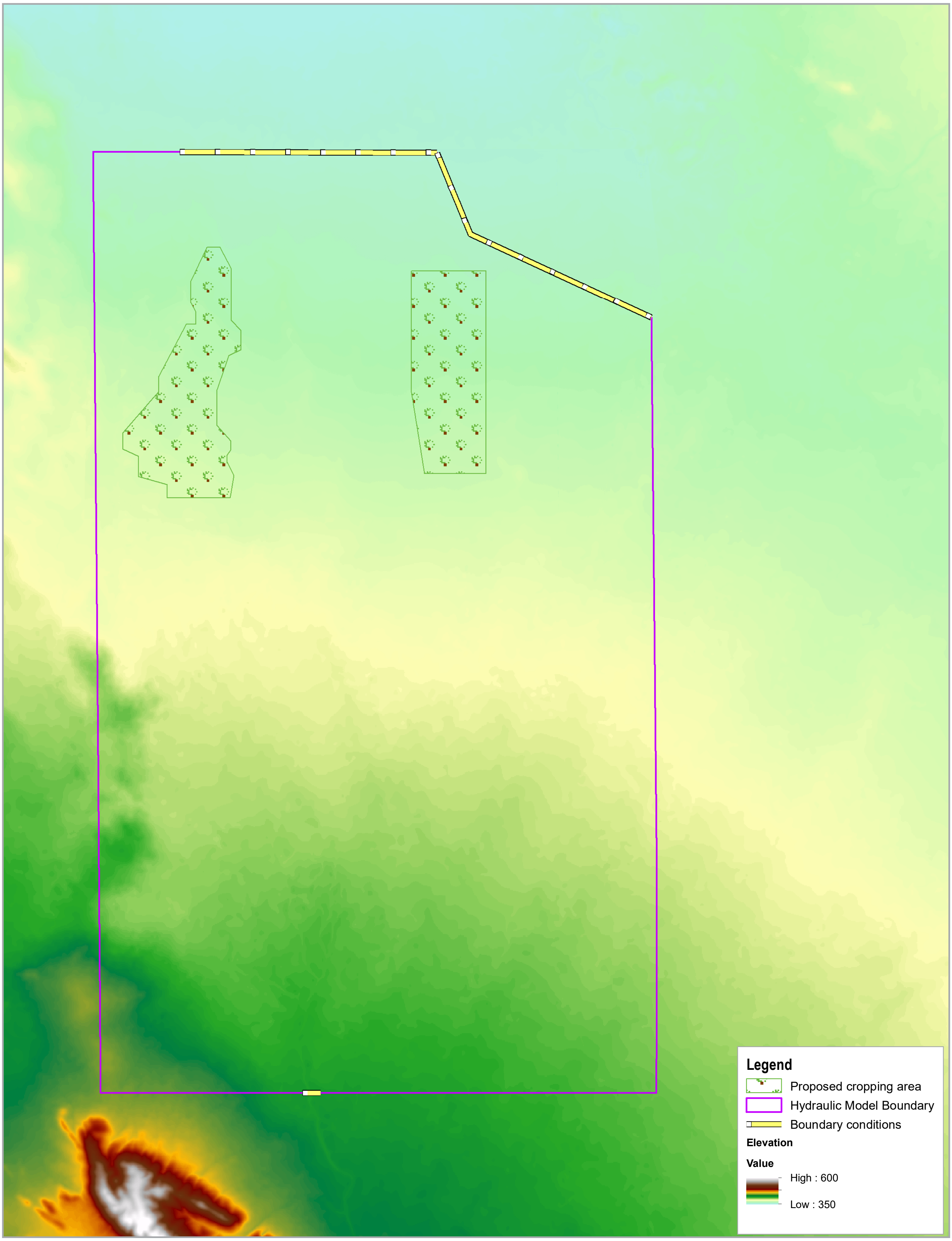
### 2.2.4 Hydraulic model roughness

Aerial imagery for the subject area has been reviewed. The site is considered to be sparsely vegetated. On this basis a single Manning's "n" hydraulic model roughness value of 0.04 has been adopted for the entire hydraulic model extent for the purpose of this assessment (U. S. Geological Survey 1989).

### 2.2.5 Boundary conditions

Hydrological model inflows, prepared using the RORB software and described above in Section 2.1 have been applied to the upstream extents of the hydraulic model. The upstream boundary condition was selected as Discharge versus Time (QT).

The downstream extent of the hydraulic model was located at the lowest edge of the hydraulic model. The downstream boundary condition was configured as a Height versus Discharge (HQ) boundary, based on the typical flood plain gradient of 0.1%.

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Map Projection: Transverse Mercator
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|---|---|
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| Revision No. | **1** |
| Date | **19 Feb 2021** |

**FIGURE 2-2**

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### 2.2.6 Permissible velocity

Permissible velocities for various channel lining material have been determined from Fischenisch (2001) and are presented below in Table 2.5. Where these values are exceeded (refer to flood mapping in Section 3.1), mobilisation of soils within the floodplain and throughout the study area are therefore expected to occur.

*Table 2.5 Median particle size – critical shear stress and velocity*

| Median particle class name ds (mm) | Permissible velocity (m/s) |
|---|---|
| Short grass | 0.9 |
| Long grass | 1.2 |
| Fine colloidal sand | 0.5 |
| Sandy loam | 0.5 |
| Alluvial silt | 0.6 |
| Silty loam | 0.5 |
| Firm loam | 0.8 |

Table 2.5 shows the vegetation (both short and long grass), provides additional protection from erosion, compared to the various bare soil types considered.

### 2.2.7 Flood tolerance of crops

Table 2.6 summarises Southern Cross Farms (2021) advice on perennial and annual crops flood survivability.

*Table 2.6 Crop tolerance to flooding – permissible velocity and ponding time*

| Crop type | Permissible velocity (m/s) and ponding time |
|---|---|
| Perennial crops | |
| Citrus | Low velocity, 30-40 hr event to depths of 0.5 m |
| Dried Grapes | Low velocity, 30-40 hr event to depths of 0.5 m |
| Annual crops | |
| Hay, Onions, Rockmelon | No tolerance to flood |

# 3. Modelling results

The TUFLOW hydraulic model was simulated for a range of events using the TUFLOW (Version 2020-01-AB) GPU engine. The results of the simulations are summarised below in the following sections for the 20%, 5% and 1% AEP design flood events.

## 3.1 Flood depth, velocity and duration of inundation

Figure 3.1 to Figure 3.6 show maximum flood depth and flood velocity in the study area for 1%, 5% and 20% AEP events. The results are summarised in Table 3.1, with reference to six zones within the proposed cropping area. The results are discussed and interpreted in the remainder of this section.

*Table 3.1 TUFLOW flood modelling results summary*

| Design event | Proposed cropping area | Peak depth over irrigation areas (m) | Peak velocity over irrigation areas (m/s) |
|---|---|---|---|
| 1% AEP | Western area– northern | 0.6 | 0.6 |
| | Western area – central | 0.5 | 0.6 |
| | Western area - southern | 0.5 | 0.6 |
| | Eastern area – northern | 0.6 | 0.6 |
| | Eastern area – central | 0.6 | 0.6 |
| | Eastern area - southern | 0.7 | 0.6 |
| 5% AEP | Western area – northern | 0.3 | 0.2 |
| | Western area – central | 0.3 | 0.3 |
| | Western area – southern | 0.3 | 0.3 |
| | Eastern area – northern | 0.3 | 0.2 |
| | Eastern area – central | 0.3 | 0.3 |
| | Eastern area – southern | 0.3 | 0.4 |
| 20% AEP | Western area – northern | 0.2 | 0.3 |
| | Western area – central | 0.2 | 0.3 |
| | Western area - southern | 0.2 | 0.3 |
| | Eastern area – northern | 0.2 | 0.2 |
| | Eastern area – central | 0.2 | 0.3 |
| | Eastern area - southern | 0.2 | 0.3 |

### 3.1.1 Depth and extent

Table 3.1 shows that modelling flood depths in the cropping areas are generally up to 0.6 m, with up to 0.7 m depth in some area for the 1% AEP event. The modelled extent includes the main channel of Taylors Creek (immediately to the east of the western cropping area) and the overbank area (immediately to the west of the eastern cropping areas). The location of the cropping areas avoids deepest flow path predicted by the modelling.

### 3.1.2 Velocity

Velocities are generally low, relative to the permissible velocities considered in Section 2.2.6. Therefore, the potential for erosion is considered low.

### 3.1.3 Duration of inundation

For this study, the TUFLOW model has been set to run for 100 hours to allow sufficient time for the flood extent to reach the downstream boundary. As the TUFLOW model does not consider soil infiltration and evaporation, duration of inundation can be interpreted as how long water stays on the ground without considering soil infiltration and evaporation, with an upper limit set by the simulation duration.

Preliminary model results showed very little variation in the time of inundation across any particular flow path cross section. This suggests that there is very little short duration flooding as the peak of the flood passes, and that once flooded, that area would remain flooded until the flood waters evaporate or infiltrate to the soil. Therefore, the duration of inundation modelling results are not reported, and instead, the duration of inundation is estimated based on soil characterisation from the soil survey and the peak depth of inundation simulated in the modelling.

A soil survey of the proposed cropping areas was undertaken (McGrath 2020), which characterised the soil as predominately a sandy clay loam subsoil in western part and predominately a sandy loam subsoil in the eastern part. More generally, the site has been described as well drained with infiltration rates are expected to be relatively high (GHD 2020) and with excellent soil infiltration rates (Southern Cross Farms 2021).

Infiltration rates were estimated based on the conservative lower bound of the range reported by FAO (2001), based on a sandy loam classification for all areas of 20 mm/hour. Based on the modelled peak depth of flooding summarised in Table 3.1, the duration of inundation is estimated in Table 3.2.

*Table 3.2 Infiltration rate and duration of inundation*

| Design event | Proposed cropping area | Soil classification | Depth of flooding (m) | Infiltration rate (mm/hour) | Duration of inundation (in hours) |
|---|---|---|---|---|---|
| 1% AEP | Western | 4 | 0.6 | 20 | 30 |
| | Eastern | 2 | 0.7 | 20 | 35 |
| 5% AEP | Western | 4 | 0.3 | 20 | 15 |
| | Eastern | 2 | 0.3 | 20 | 15 |
| 20% AEP | Western | 4 | 0.2 | 20 | 10 |
| | Eastern | 2 | 0.2 | 20 | 10 |

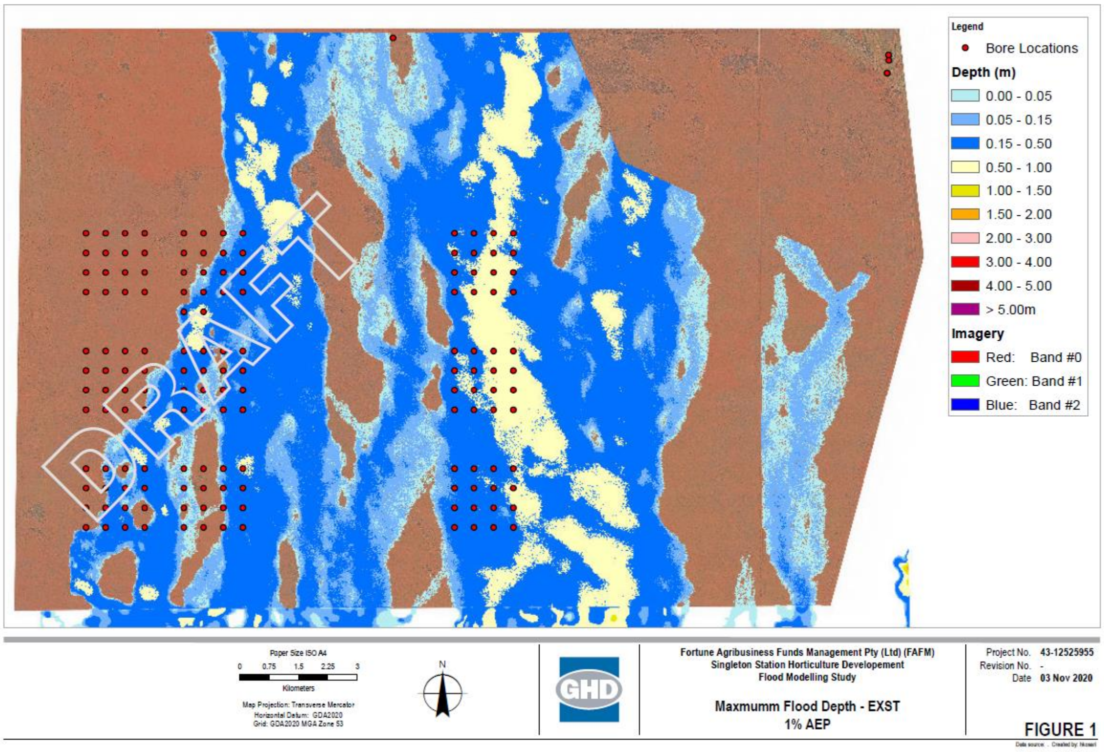



*Figure 3.1 Maximum flood depth - 1% AEP*

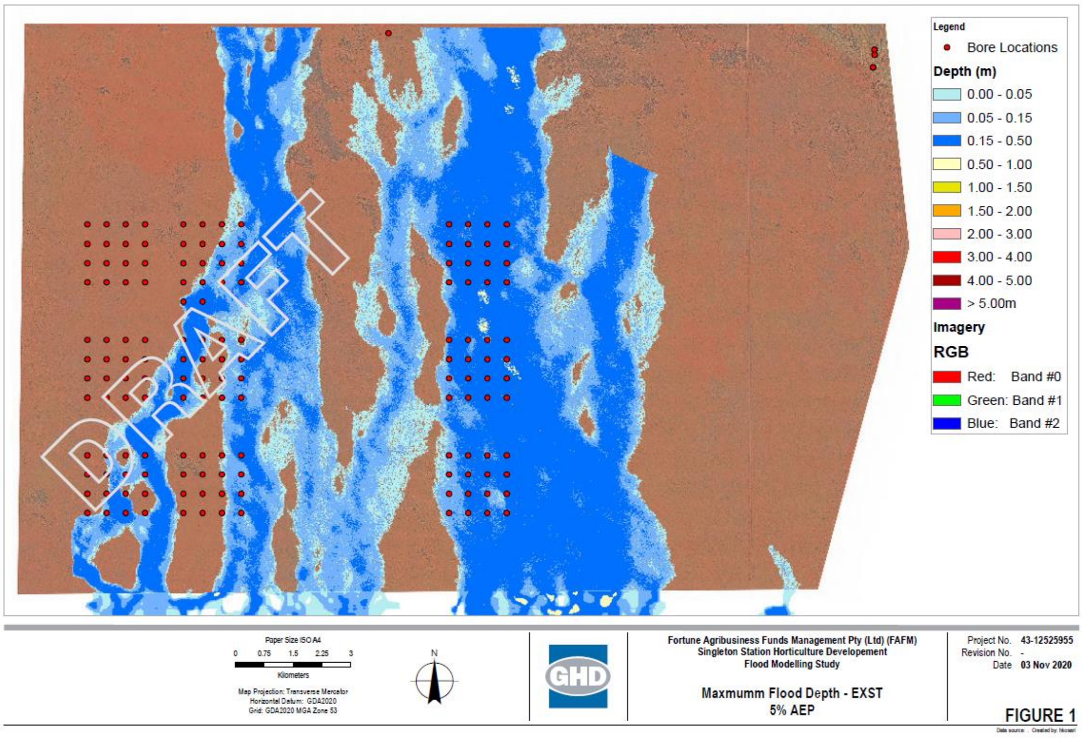



*Figure 3.2 Maximum flood depth - 5% AEP*

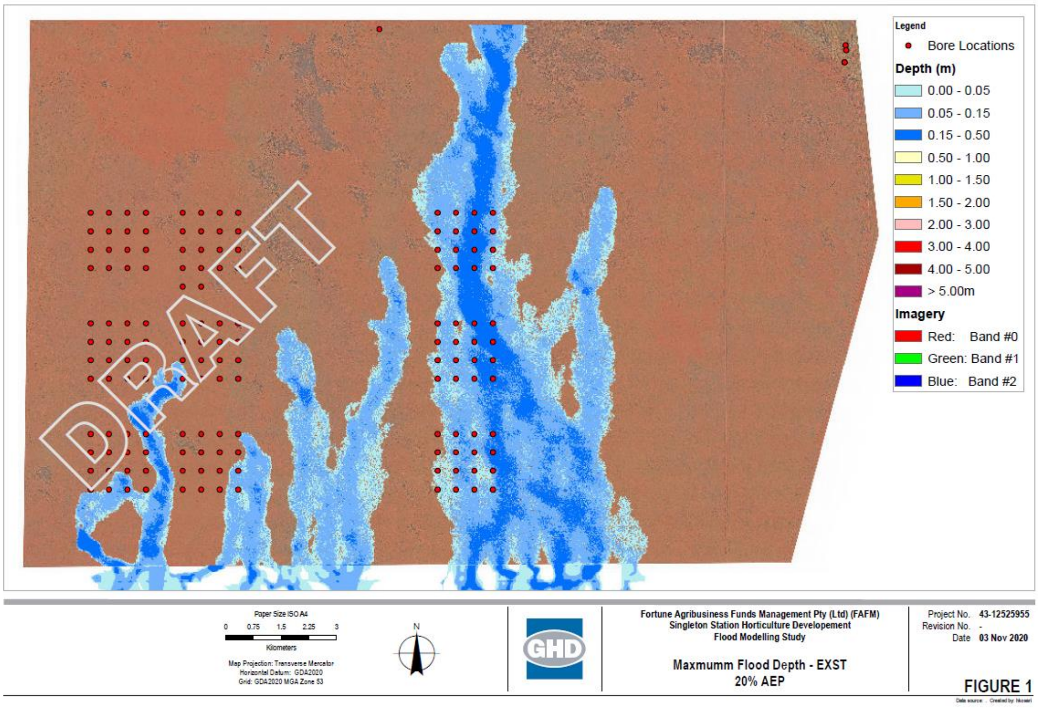



*Figure 3.3 Maximum flood depth - 20% AEP*

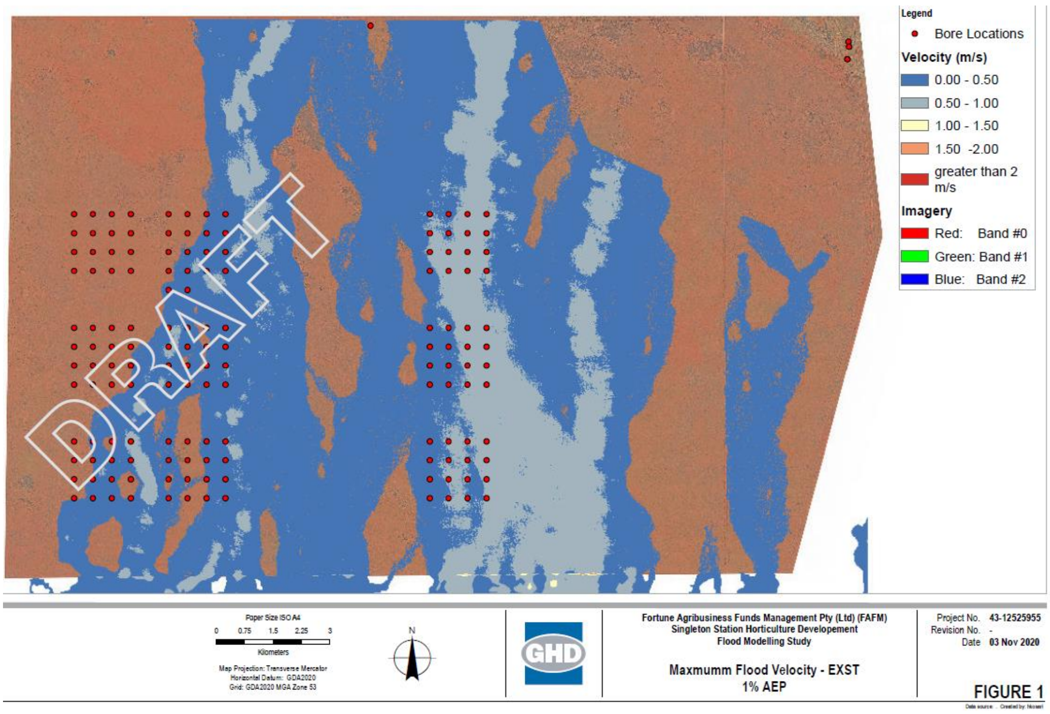



*Figure 3.4 Maximum flood velocity – 1% AEP*

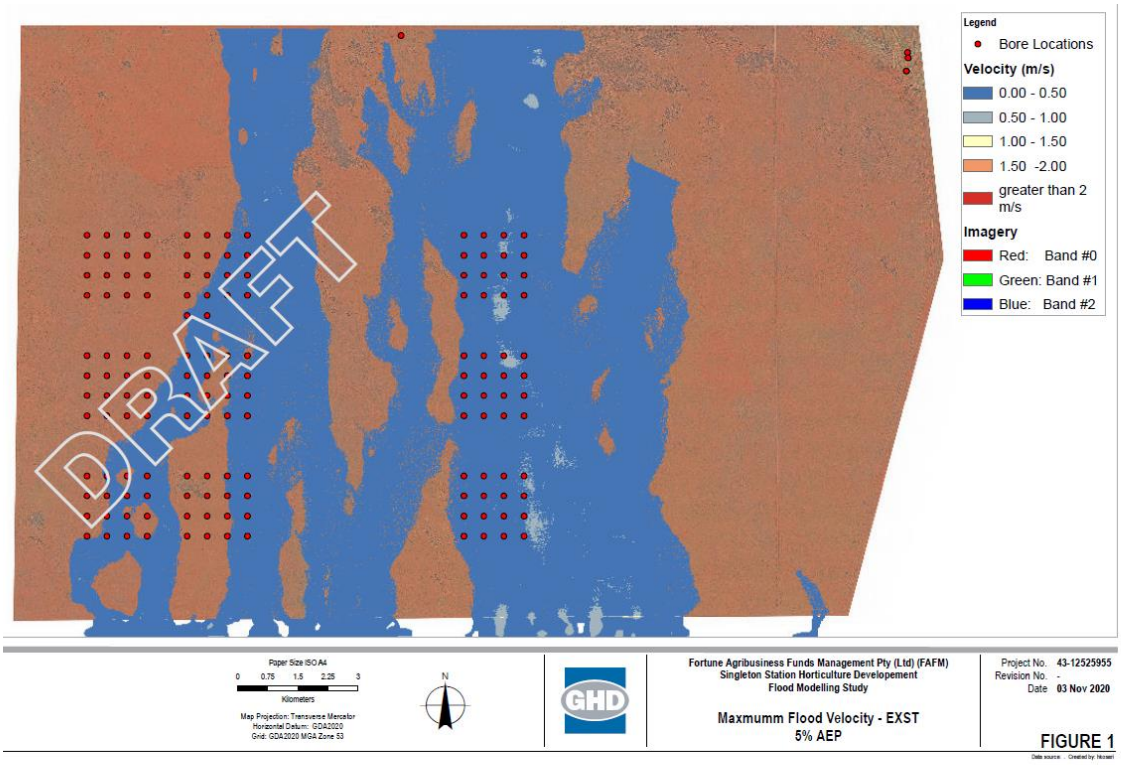



*Figure 3.5 Maximum flood velocity – 5% AEP*

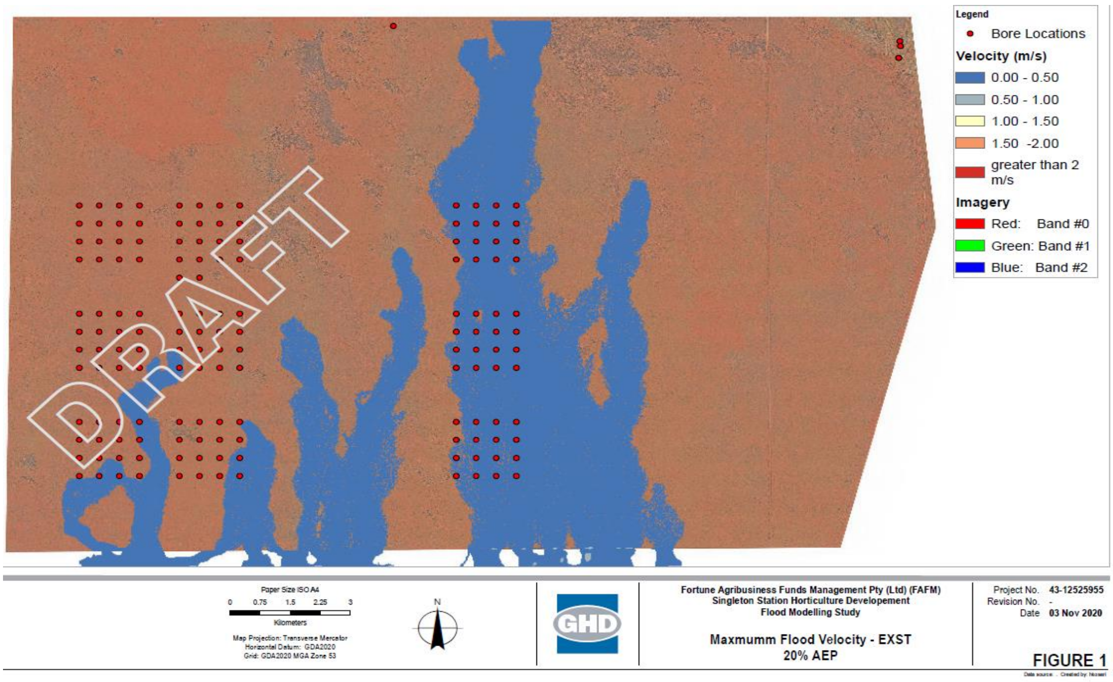



*Figure 3.6 Maximum flood velocity – 20% AEP*

## 3.2 Flood extent comparison

In the absence of site specific observations or regionalised estimates in this relatively remote and arid part of Australia (refer to Section 2.1.5), methods for validating the model are very limited. One observations of flooding was identified by FAFM, being satellite imagery take on 25 March 2011, showing apparent flood inundation in the dark areas, as shown in Figure 3.7.

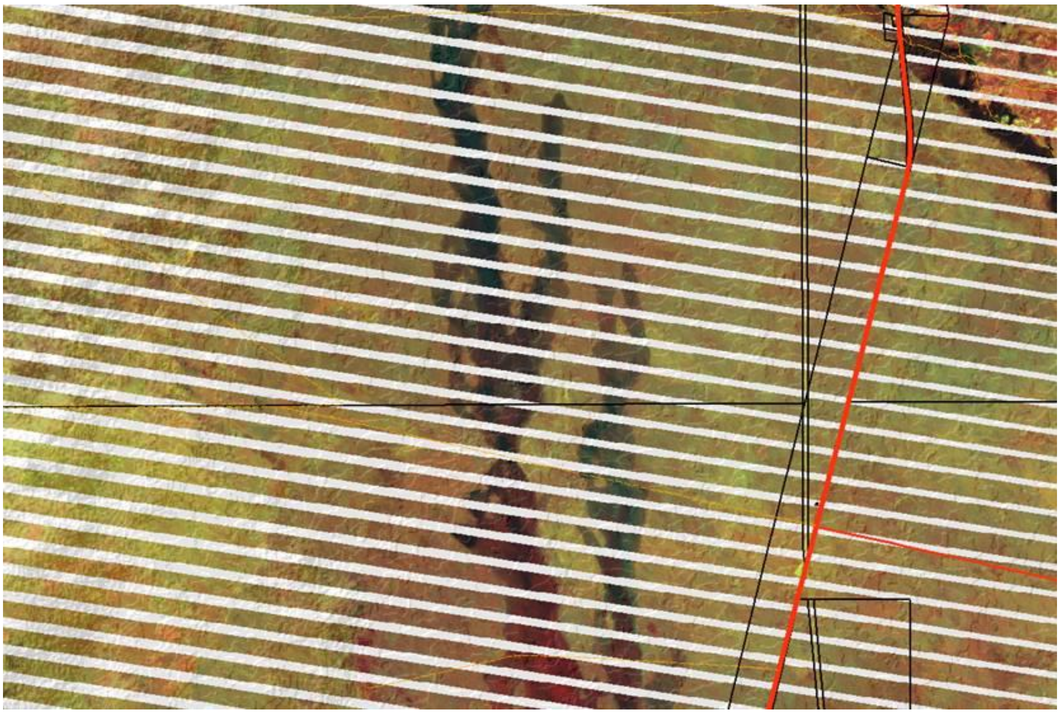
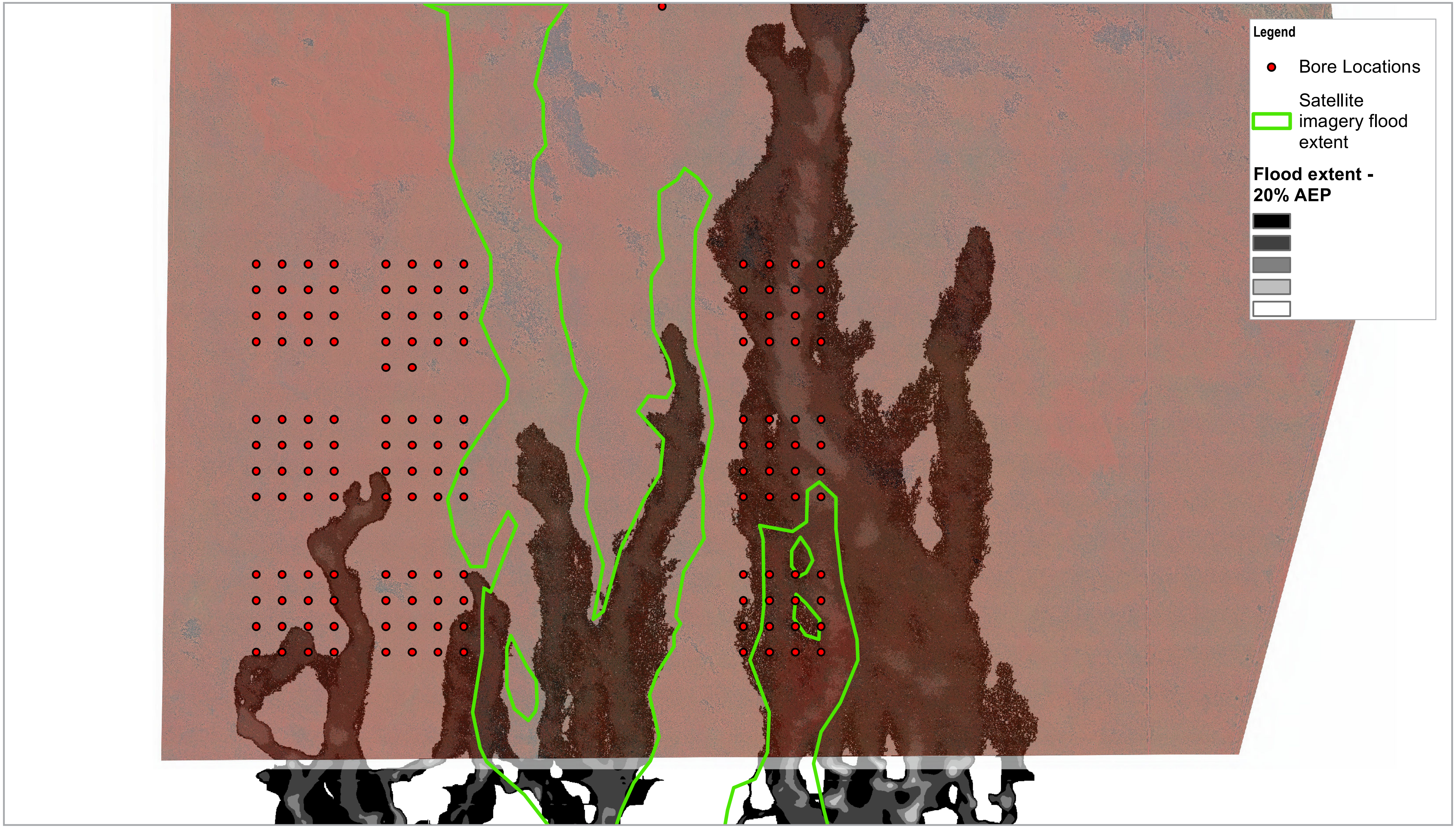


*Figure 3.7 Satellite imagery provided by FAFM*

The imagery shown in Figure 3.7was taken four days after the last major rainfall event of the 2010-2011 wet season, with 88 mm of rainfall recorded on 21 March 2011 at Barrow Creek rain gauge, located in the headwaters of Taylors Creek. This was the highest daily rainfall total recorded at the gauge since 20 December 2010, but followed a wet season. This depth approximately corresponds to the 20% AEP design rainfall depth for the peak flow critical duration for the catchment (refer to Section 2.1). The four day delay between the observed rainfall and the satellite image approximately corresponds to the travel time observed in the modelling of about 120 hours (5 days) from the onset of rainfall and flooding downstream.

Figure 3.8 shows a comparison between design 20% AEP flood extent and a satellite image of flood extent. The observed and simulated flood extents have similar total widths and areas of flood extent and include both the main channel of Taylors Creek, and the overbank flow path to the east, although with differing widths of flood extent immediately upstream of the subject area. The comparison of the design event with the satellite imagery provides a favourable comparison which suggests that the hydraulic model is appropriately representing flow distributions in the study area.

This validation is limited as the flood extents captured in the satellite imagery may not be representative of the flood peak which occurred during the storm event, and direct comparisons of design storm events to historical flood events are not appropriate as the antecedent rainfall conditions, spatial distribution of rainfall and temporal distribution of real events can vary significantly from design storm events. Inconsistencies in flood extents may also be attributable to changes, or uncertainty in the upstream portion of the Taylors Creek floodplain, which is discussed in Section 3.3 below.






Paper Size ISO A4

0 0.75 1.5 2.25 3

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 53

N

GHD

**Fortune Agribusiness Funds Management Pty (Ltd) (FAFM)**
**Singleton Station Horticulture Developement**
**Flood Modelling Study**

## Comparison of 25 March 2011 satellite imagery to 20% AEP flood extent

Project No. **43-12525955**
Revision No. **-**
Date **03/11/2020**

# FIGURE 3-8

Data source: . Created by: hkosari

## 3.3 Sensitivity analysis

### 3.3.1 Peak flow estimate

As discussed in Section 2.1.4, whilst the default Kc RORB equations has been adopted to derive the Kc parameter for this study, Book 7, chapter 6 of ARR 2019 provides a number of regional relationships for Kc. For the Arid regions of Northern Territory, the ARR 2019 guidelines recommend equation 7.6.25. A sensitivity assessment was therefore undertaken on the hydrological model results using the regional relationships. The results of the sensitivity assessment yielded a smaller Kc value, resulting in the magnitude of the design median flood peak increasing by approximately 130% for the 5% AEP design event.

Given that model results appear to already slightly overestimating the aggregate flood extent compared to observed events (refer to Section 3.2), the default value was retained. This is consistent with the broad nature of the floodplain, meaning that floodplain storage effects are likely to result in significant attenuation of the flood peak from the upper catchment. It is therefore expected that the behaviour is dominated by the storage capacity of the floodplain, and change in peak flow would not significantly change the total runoff volume and hence the flood extents at the proposed development area.

### 3.3.2 Upstream model extent

The ground elevation profile at the upstream edge of the subject area shows that Taylors Creek has a perched channel, where the main channel is above the surrounding floodplain. Flows in excess of the main channel capacity are therefore expected to “spill” from the main channel into the lower floodplains to the east and west of Taylors Creek in larger events. Distribution of flows into the eastern and western floodplains from the main Taylors Creek channel is therefore highly dependant on an accurate representation of the channel in these areas.

The available high-accuracy LiDAR topographic data for the study area does not extend far enough upstream to cover the area where breakout flows from Taylors Creek are expected to occur, and as such, lower accuracy SRTM topographic data has been used to represent the topography in this area. The qualitative difference between an observed and simulated flood event discussed in Section 3.2, may be attributable to this issue. Therefore, a sensitivity analysis was performed to assess the effect of three different upstream boundaries on the flood extent at the study area.

The 1% AEP flood event (as the ‘worst case’) was rerun with the design hydrograph introduced to the hydraulic model at three different locations much closer to the subject area. Figure 3.9 shows the ground elevation profile at upstream boundary location and three different lengths considered for upstream boundary conditions in the model. There is about 3 m difference in ground elevation between the invert of the main channel of Taylors Creek on the left, and the overbank area on the right of the profile.

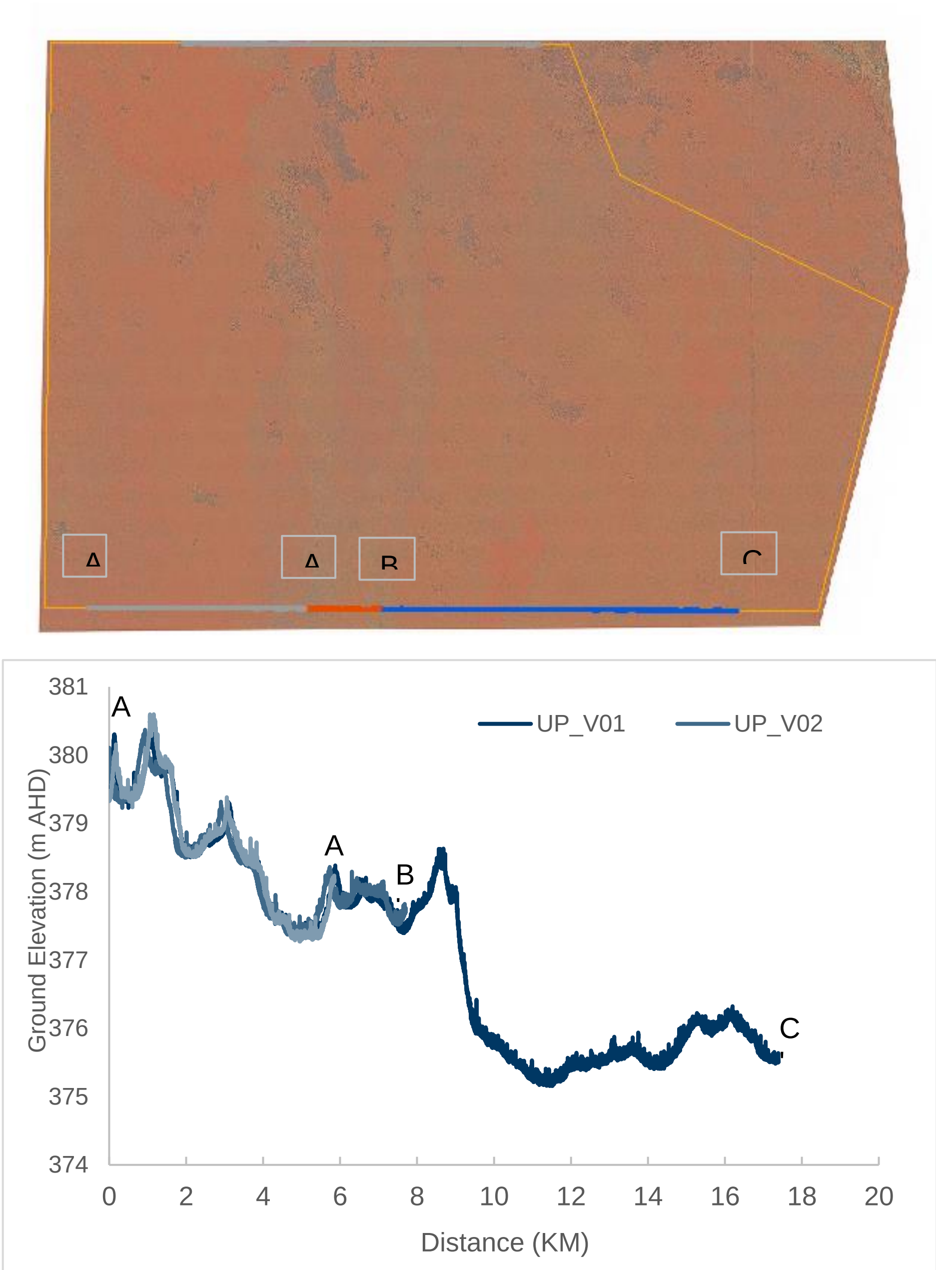



***Figure 3.9*** ***Ground elevation profile at three upstream boundary locations***

Figure 3.10 shows potential 1% AEP flood extents under the three different upstream conditions.

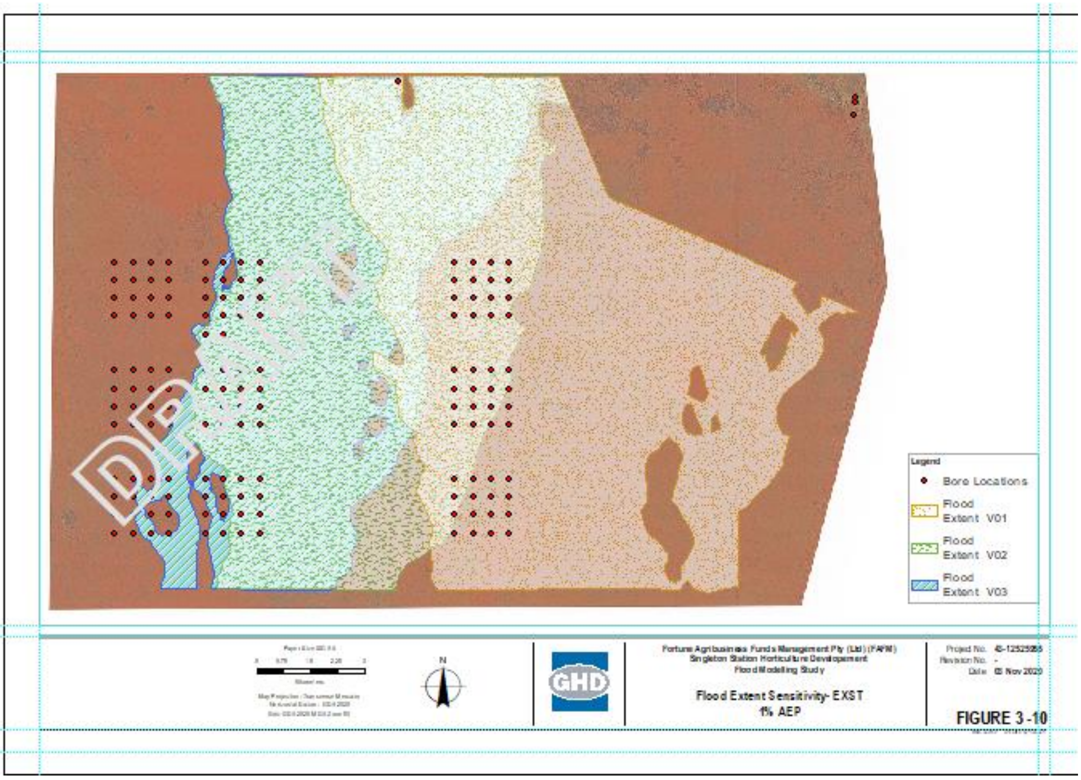



*Figure 3.10 AEP flood extents under three different upstream conditions*

Figure 3.10 shows that the flood extent at the subject site is sensitive to where the flood water is distributed in the headwater. Flooding on eastern area for the 1% AEP event is unlikely to occur if the flood is entirely contained in the main channel of Taylors Creek all the way down to the subject area. This is considered unlikely, as it is inconsistent with flood modelling results and the observed flooding in March 2011 (refer to Section 3.3.1).

It is more likely that the distribution of the flood extent across the whole floodplain may vary with alluvial and aeolian (wind) processes changing the shape of the floodplain and its channels during and between flooding events. Therefore, the potential for flooding in relatively frequent events (similar or more frequent than the 20% AEP event) of the eastern proposed cropping area.

# 3.4 Flood effects on crops

The primary damage to plants from flooding or ponding is oxygen deprivation (Wiebold 2020). The extent of the damage of flooding on plants is related to at least three factors:

– The temperature of the water. This is likely to independent of the flooding extent.
– The amount of water motion. The flood modelling results suggest that potential flooding would be generally slow moving, minimising the oxygenation of the flood water. This is likely to be independent of the flood hydraulics.
– The duration of the flood. Generally, the oxygen level in a saturated soil reaches the point that is harmful to plant growth after about 48-96 hours (Wiebold 2020). Based on the flood modelling results, the duration of inundation is expected to be a function of the flood extents and of the time for the water to infiltrate into the sub soil, rather the flood hydraulics. Based on infiltration estimates, the duration of inundation for flood events more frequent than the 1% AEP are expected to be less than 35 hours. This result is similar for all proposed cropping areas.

Southern Cross Farms (2021) reviewed a preliminary draft of this report. Based on their findings and the interpretation of flood modelling results presented in this report, it is concluded that:

– Flood events up to the 1% AEP design event, with a 30 to 40 hour duration of inundation, up to 0.5 m flood depth event and slow moving water are expected to have minimal impact on the citrus or grapevines. There are some minor localised areas where flooding depths up to 0.7 m are predicted and may temporarily inundate part of the citrus canopy.

– Any flood event may impact the annual crops (such as hay, onions and rockmelons) which are not suitable to be submerged for any length of time, however it is understood that these crops are not planned to grown during the wet season when flooding events are more likely.

# 4. Summary and conclusion

FAFM engaged GHD to perform the baseline flood assessment of the proposed 4000 ha of irrigated horticulture on Singleton Station in Northern Territory. The viability of the horticultural development may be sensitive to the extent, depth, velocity and duration of flood inundation due to rainfall.

Hydrological and hydraulic models were prepared for the proposed cropping areas at Singleton Station encompassing the site area and upstream catchment areas of Taylors Creek. Key findings from the hydrological and hydraulic assessment are as follows:

– The results of the hydraulic modelling show that extents and depths of flooding at the subject site are consistent with what would be expected of a broad flat perched floodplain, with generally shallow overland flood extents, with limited areas of deeper flooding in the vicinity of better defined flow paths.
– The flood extents from this assessment were compared against available Satellite imagery of historical events in the area, which showed a favourable comparison.
– Peak velocities of the flood waters are expected to be relatively slow moving, with velocities of up to 0.6 m/s expected at the location of the proposed irrigation areas in the 1% AEP flood event. The generally slow nature of flows at the subject site, results in a limited potential for erosion and little variation in time of inundation across the inundated areas
– The potential flood effects on cropping are likely to be primarily due to the duration of inundation over cropping area. Duration of inundation was estimated to be less than 35 hours for events more frequent than the 1% AEP. The results were found to be generally insensitive to flood hydraulics and are strongly dependent of the infiltration properties of the soils.

The assessment has identified that flood extents at the site have the potential to be sensitive to distribution of flows in the upper part of the floodplain as flows overtop the banks of Taylors Creek. Limited accuracy of the topographic data available for the areas of Taylors Creek upstream of the subject site may affect the overall distribution of flows and therefore flood extents at the subject site. Flow distributions may also vary due to alluvial and aeolian (wind) processes changing the shape of the floodplain and its channels during and between flooding events. A sensitivity assessment was undertaken for the site, which showed that distribution of flows across the upstream floodplain may significantly alter the extents of flooding at the subject site. Whilst such changes to the distributions of flood waters at the site are considered unlikely, they warrant consideration given the potential impacts of the proposed development.

Based on the findings of this assessment the following is recommended that adaptive flood management measures be adopted, including:

– FAFM take into consideration the potential changes to the upstream catchment and distributions of flows, which may alter flood extents and impact on the proposed development, including construction of small flood levees.
– FAFM consider the potential flooding in selection of crops in flood prone part of the proposed cropping areas.

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# Appendices

# Appendix A

## IFD Design Rainfall Depth (mm)

Annual Exceedance Probability (AEP)

| Duration | 63.20% | 50% | 20% | 10% | 5% | 2% | 1% |
|---|---|---|---|---|---|---|---|
| 1 min | 1.68 | 1.94 | 2.75 | 3.3 | 3.85 | 4.57 | 5.12 |
| 2 min | 2.96 | 3.41 | 4.83 | 5.8 | 6.75 | 7.96 | 8.88 |
| 3 min | 4.13 | 4.76 | 6.74 | 8.08 | 9.4 | 11.1 | 12.4 |
| 4 min | 5.19 | 5.98 | 8.47 | 10.2 | 11.8 | 14 | 15.6 |
| 5 min | 6.15 | 7.09 | 10 | 12.1 | 14 | 16.6 | 18.6 |
| 10 min | 9.95 | 11.5 | 16.3 | 19.5 | 22.7 | 27 | 30.3 |
| 15 min | 12.7 | 14.6 | 20.7 | 24.9 | 28.9 | 34.4 | 38.6 |
| 20 min | 14.7 | 17 | 24.1 | 28.9 | 33.7 | 40 | 44.9 |
| 25 min | 16.4 | 18.9 | 26.8 | 32.2 | 37.5 | 44.6 | 50 |
| 30 min | 17.8 | 20.5 | 29.1 | 34.9 | 40.6 | 48.3 | 54.1 |
| 45 min | 20.8 | 24 | 34 | 40.9 | 47.6 | 56.5 | 63.4 |
| 1 hour | 22.9 | 26.4 | 37.4 | 45 | 52.4 | 62.2 | 69.8 |
| 1.5 hour | 25.6 | 29.6 | 42 | 50.6 | 59 | 70.1 | 78.7 |
| 2 hour | 27.5 | 31.7 | 45.2 | 54.4 | 63.5 | 75.6 | 85 |
| 3 hour | 30 | 34.7 | 49.5 | 59.8 | 70 | 83.6 | 94.2 |
| 4.5 hour | 32.5 | 37.7 | 54 | 65.4 | 76.8 | 92.3 | 104 |
| 6 hour | 34.4 | 39.9 | 57.5 | 69.9 | 82.2 | 99.2 | 113 |
| 9 hour | 37.3 | 43.4 | 63.1 | 77.1 | 91.2 | 111 | 127 |
| 12 hour | 39.6 | 46.2 | 67.8 | 83.2 | 98.8 | 121 | 139 |
| 18 hour | 43.4 | 51 | 75.8 | 93.7 | 112 | 138 | 160 |
| 24 hour | 46.6 | 55 | 82.7 | 103 | 124 | 154 | 178 |
| 30 hour | 49.4 | 58.5 | 88.8 | 111 | 134 | 167 | 194 |
| 36 hour | 51.8 | 61.6 | 94.2 | 118 | 143 | 179 | 209 |
| 48 hour | 56 | 66.9 | 104 | 131 | 160 | 201 | 235 |
| 72 hour | 62.2 | 74.9 | 118 | 151 | 186 | 235 | 275 |
| 96 hour | 66.5 | 80.5 | 129 | 166 | 205 | 259 | 303 |
| 120 hour | 69.4 | 84.2 | 136 | 176 | 219 | 276 | 323 |
| 144 hour | 71.2 | 86.6 | 140 | 182 | 228 | 287 | 335 |
| 168 hour | 72.2 | 87.9 | 143 | 186 | 233 | 293 | 343 |

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