

Your Comment on the Ohoka Residential Subdivision - FTA 231

Please include all the contact details listed below with your comments and indicate whether you can receive further communications from us by email to substantive@fasttrack.govt.nz.

1. Contact Details			
I have authority to comment.			
Organisation name (if relevant)			
First name	John		
Last name	Docherty		
Postal address	██████████ ████ ██████████		
Home phone / Mobile phone	██████████	Work phone	
Email (a valid email address enables us to communicate efficiently with you)	██		

2. We will email you draft conditions of consent for your comment.

☒	I can receive emails and my email address is correct	☐	I cannot receive emails and my postal address is correct
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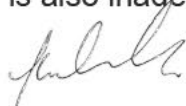
My comments are included below and in the documents that follow
(Please click on the links below for the Roding & Flooding documents.).

ROADING

FLOODING

Thank you for the opportunity to submit my comments.

My submission requests that the proposed development is not allowed to proceed as it will have serious adverse effects on the environment, has not been properly researched and has no national or regional benefits. The documentation provided is also inadequate with missing sections, all in DRAFT and flawed modelling.



1. WATER SUPPLY STRATEGY

Draft document 51. RC255196 DRAFT WATER SUPPLY STRATEGY 260416 OHOKA WATER SUPPLY STRATEGY.PDF refers. (Prepared by INOVO. It is noted that the names of those responsible for the document have either not been provided or have been redacted. This is also a Draft document.)

The document states:-

As noted above, the existing Ohoka supply does not have capacity to provide the demand for the new development. This again highlights the completely inappropriate location of the proposed development.

The proposed water supply is described as follows:-

2.1 Location of Groundwater Abstraction Points

The proposed groundwater abstraction points will be in the form of deep (> 60m below ground level) bores, located within the subject site. The number of bores required is subject to testing, however it is expected that for or five bores will be required to service the development. The plan in Appendix B illustrates 100m set-backs from the external boundaries and indicative locations for groundwater abstraction within the site.

The document refers to the existing bores but only provides details of the consented abstraction limits with no mention of the maximum daily allocation. It is noted that the existing consent for CRC991827 has flow restrictions related to the flow rate in the Ohoka Stream, requiring pumping rates to be scaled back or restricted when the flow rate in the Ohoka Stream drops below 300 l/s. This highlights the limitations of the groundwater supply and the effects it has on the adjacent environment.

It is noted that the document makes no reference to the effect of the proposed extraction on existing wells as are used by the adjacent landowners who rely on these for their water supply. There is no way that the developers can predict what will happen to these wells should the development proceed..

2. SITE MANAGEMENT PLAN

DOCUMENT: RC255196 DRAFT INFRASTRUCTURE AND SITE MANAGEMENT PLAN V2.PDF

This document includes the following statements:-

The Environmental risks associated with these works include:

- *Nuisance by dust and noise during earthworks.*
- *Discharge of sediment -laden stormwater into existing watercourses during rainfall events.*
- *Discharge of sediment-laden water into existing watercourses during dewatering of excavations and trenches.*
- *Discharge of hazardous substances into land or water during construction.*
- *Interception of groundwater leading to flooding of excavations or depletion of existing spring and stream flows.*
- *Disturbances to fish passage, spawning conditions, and stream bank stability when working within streams, i.e., when placing culverts and diverting waterways.*

The document then states *It remains the contractor's responsibility to ensure that sediment is not discharged from the site as a result of their activities.* That is not acceptable. Responsibility and liability for any issues arising from this development, should it be allowed to proceed, must rest personally with the developers and not just the Carter group entity.

The document also states that

During periods of long duration or extreme rain events, flocculation may be required to encourage sediment to settle within the pond. Chemical coagulants and flocculants are commonly used for sediment removal of fine particulates that will not easily settle out of solution and is a recognised method in the Erosion and Sediment Control Toolbox for Canterbury. A chemical management plan outlining the flocculants to be used, dosage and monitoring requirements will be provided and are accepted to become a condition of consent. If aluminium-based flocculants are used, then discharges shall be managed so the pH level of the discharged water stays with the range of 6.5–8.5 and the aluminium level does not exceed 0.055 g/m³.

Given that this water will then be discharged into the adjacent streams this is completely unacceptable. Having this industrial scale activity taking place in this environment must not be permitted.

And:-

It is expected that water table may need to be lowered down to approximately 2.5 m below ground level to allow for dry conditions within excavations and will occur for no longer than 6 months. Dewatering flows are intended to be disposed of to one of the many surface water channels that cross the site..

By discharging this water into the streams and drains, (i.e. 'one of the many surface water channels that cross the site') this will not only allow sediment to be discharged but will also exacerbate flooding during times of heavy rainfall.

And:-

Due to the presence of localised contamination, groundwater quality sampling is recommended to be carried out prior to the works commencing to ensure that discharges to surface water will meet appropriate receiving water criteria. If it were found that the groundwater quality is not suitable for discharge to surface water, then discharge back to ground is considered viable at this site.

What this is saying is that if the water is found to be contaminated it may be put back into the ground. This then risks contamination of the groundwater downstream of the site, This water may then end up in the artesian systems which are used by the wells adjacent to the site.

Again this is a completely unacceptable risk that must not be allowed to occur. This project must not be allowed to proceed.

And:

6.9 Diversion of Waterways

We envisage permanent and temporary diversion of waterways will be necessary as part of the development works, including the construction of outfalls from Stormwater Management Areas into the waterways.

6.9.1 Temporary Diversion of Waterways

Temporary diversion of waterways will be necessary during the removal of existing culverts, placing new culverts and any other works associated with working within streams. Depending on the flow volume of subject water body and duration of the work two methods of diversion will be employed which are discussed below.

The document goes on to say:-

Remove all fish (including eels) from the section of waterway to be dewatered, or worked in. Use suitably qualified or experienced people to undertake this. (This must be farce.)

It is completely unacceptable to divert water from the existing streams. They are part of the ecology of the area, providing water to the plantings along the stream as well as being the home to fish, including the eels which our neighbours feed, and frogs etc. **To contemplate shutting these down is outrageous and shows the complete disregard those involved with this proposal have for the environment, the wildlife and the existing residents of the area, all of whom will be adversely effected by this development.**

And:-

6.13 Construction Noise Management

Work in Progress

A detailed Construction Noise Management Plan (CNMP) is to be completed prior to each relevant stage commences. The methodology outlined in this section is intended to be a general approach to noise management showing that measures can be taken to limit the amount and intensity of noise generated by construction.

6.13.1 Hours of Operation

Construction works, including the movement of trucks to and from the site, are expected primarily take place between the standard working hours given below:

7:00 AM to 7:00 PM – Monday to Friday

8:30 AM to 7:00 PM – Saturday

When works occur outside of these standard hours, the contractor will make all reasonable efforts to ensure the works are carried out using the appropriate methods and equipment to minimize the intensity and duration of noise-generating events. It is expected that some works, such as works in the public road corridor, may have to be undertaken at hours outside of the normal envelope at the discretion of Waimakariri District Council and/or Waka Kotahi.

6.13.2 Noise Levels

The standard in New Zealand for noise limits associated with construction activities is given in NZS: 6803:1999 (superseding NZS: 6803:1984,) specified in the Waimakariri District Council District Plan. Per Waimakariri District Council guidance, significant portions of the site are situated further than > 100m from occupied dwellings, allowing for flexibility in starting some works earlier than would be normally allowed under NZS: 6803:1984.

The proposed noise levels are not suitable for a rural environment, nor is working until 7pm. Also, a minimum separation of 100m is not going to have any significant effect on noise levels as the report would apparently wish someone to believe.

And:-

This document references the following Appendices

APPENDIX A CIVIL ENGINEERING PLANS.....	23
APPENDIX B EROSION, SEDIMENT AND DUST CONTROL DRAWINGS	24
APPENDIX C WETLANDS AND WATERWAYS CHANGES PLAN.....	25
APPENDIX D DEWATERING REPORT	26
APPENDIX E AQUATIC ECOLOGY REPORT	27

These appear as blank pages, except for the headings,. How can one be expected to either comment on or make decisions based on incomplete information. This is completely unacceptable.

3. ADDITIONAL COMMENTS

Please refer to the following documents:-

Submission in regard to Rooding

Submission in regard to Flooding

COMMENT ON PROPOSED ROADING - WHITES ROAD

DOCUMENT: RC255196 DRAFT MASTERPLAN 2021 097B OHOKA RESIDENTIAL DEVELOPMENT.PDF

This document includes the following view along Whites and Bradleys Roads. This gives the impression that there is a significant distance between the edge of the roadway and the drain on the west side of the road. (As shown below the grassed area on the road side of the drain is shown as a flat area considerably wider than the 2.5m gravel path.)



The following photograph shows the existing road and drain. The width of the grass verge is approximately 2.8m at this point, with the verge falling away towards the drain. The contours bear no relation to that shown in the report. A drawing based on measurements made outside the entrance to our property is included below. The drawing shows the actual width of the road.



WHITES ROAD - WEST SIDE LOOKING NORTH - NOTE NARROW 'SHOULDER' CLOSE TO DEEP DRAIN

The following is from my [previous submission](#) for PC31, in respect of the traffic on Whites Road. In the absence of any additional details I assume that these comments still apply to the current proposal..

The Transport Details states the following in regards to Whites Road:-

Cross-Section Description 6.9m wide carriageway with wide grass berms.

This is not an accurate description of the roadway outside [REDACTED] Whites Rd. The width of the sealed carriageway is 6.7m wide, the 'wide grass berm' on the west side is 2800mm from the edge of the seal, which then drops into a deep drain. It is not a 'shoulder' as such. On the east side the berm is some 5400 wide, being bounded on the east by another deep drain. The power poles are some 4450mm from the edge of the seal. During winter the grass berms are often sodden and not suitable for vehicles.

It is noted that Figure 2, (Transport Environment), in the application is misleading as it does not show the drain on the west side of Whites Road that runs from near Tram Road to the culvert shown in Figure 2. A photo showing the drain is shown below.



Figure 2 from PC Application - Looking South. Grass Berm on the West Side, No Drain



West Side of Whites Road Showing the Drain and the 'Wide Grass Berm'

It is noted that Whites Road is used for the movement of livestock on foot, farm vehicles (tractors, balers etc.), by horse riders as well as large truck and trailer units operated by Rangiora Landscape Supplies which frequently travel down Whites Road.

The application includes the following comparison with "AustRoads standard to identify whether improvements are required"

Link	Existing Daily Traffic	Plan Change Daily Traffic	Combined Traffic Volume	Required Carriageway	Existing Carriageway	Comments
Whites Rd	752	3,728	4,480	2 x 3.5m traffic lanes plus 1.5m sealed shoulder.	6.9m carriageway.	Widening of 2.1m required, although widening of 0.3m would be required without the Plan Change.

AustRoads Guide To Road Design Part 3 Geometric Design (2021) includes the following table:-

Table 4.5: Single carriageway rural road widths (m)

Element	Design AADT				
	1–150	150–500	500–1000	1000–3000	> 3000
Traffic lanes ⁽¹⁾	3.7 (1 x 3.7)	6.2 (2 x 3.1)	6.2–7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Total shoulder	2.5	1.5	1.5	2.0	2.5
Minimum shoulder seal (2),(3),(4),(5),(6)	0	0.5	0.5	1.0	1.5
Total carriageway	8.7	9.2	9.2–10.0	11.0	12.0

- 1 Traffic lane widths include centrelines but are exclusive of edge-lines.
- 2 Where significant numbers of cyclists use the roadway, consideration should be given to fully sealing the shoulders. Suggest use of a maximum size 10 mm seal within a 20 km radius of towns.
- 3 Wider shoulder seals may be appropriate depending on requirements for maintenance costs, soil and climatic conditions or to accommodate the tracked width requirements for Large Combination Vehicles.
- 4 Short lengths of wider shoulder seal or lay-bys to be provided at suitable locations to provide for discretionary stops.
- 5 Full width shoulder seals may be appropriate adjacent to safety barriers and on the high side of superelevation.
- 6 A minimum 7.0 m seal should be provided on designated heavy vehicle routes (or where the AADT contains more than 15% heavy vehicles).

As noted above parts of Whites Road carriageway are 6.7m wide. Based on the table in PC31 the width required would be 10m (2.1m widening) but the Required Carriageway is shown as being 2 x 3.5m + 1.5m sealed shoulder. which equals 8.5. Table 4.5 from the AustRoad guide states that the total shoulder should be 2.5m and that the total carriageway should be 12m wide. To achieve that would be difficult and would require the removal or relocation of the rural delivery letter boxes and would remove the 'wide grass berms' used by pedestrians and those riding horses.

The plan change fails to take into account the limitations on widening the road, which is constrained by the drains on both sides of the road in some areas. Catering for the increased traffic while maintaining the 'rural character' and amenity that exists now is simply not possible.



THIS DRAWING, BASED ON ACTUAL MEASUREMENTS, SHOWS THAT THERE IS NO SPACE TO WIDEN WHITES ROAD TO 16m WITHOUT ESSENTIALLY REMOVING THE GRASS VERGE ON THE EAST SIDE OF THE ROAD. THE ROAD WILL BE VERY CLOSE TO THE DEEP DRAINS ON BOTH SIDES OF THE ROAD WHICH IN ITSELF IS A SAFETY HAZARD.

SUBMISSION REGARDING THE PROPOSED
OHOKA DEVELOPMENT BY CARTER GROUP (FTA231)
COMMENTS ON PDP PREDICTED FLOODING LEVELS

Prepared by J Docherty
Date: 12/10/26
Status: R0

1. INTRODUCTION

This document has been prepared to show the deficiencies in the flood modeling which have been included in the documentation prepared by the Carter Group in support of their Fast Track application. (Documents *Fast Track Application – Stormwater Management for 531 & 535 Mill Road, Ohoka* dated May 2026 and *Flood Effects – 531 and 535 Mill Road, Ohoka* dated April 2026 (rev B) refer. It is noted that the Flood Effects Document Rev B has a status of Post-Client Review / Final **Draft**. [highlighting added.]

I am a professional engineer with over 53 years experience. My qualifications are B.Sc. (Physics & Mathematics); B.E. (1st Hons. Mechanical). While I am currently practising in the building services field I was previously employed at Central Laboratories, Ministry of Works & Development, for 10 years. During this time I was appointed as the Aerodynamics Engineer. My work involved overseeing model testing of buildings in the wind tunnel, full scale validation of wind velocities in Wellington City, full scale measurements of airflows and pressures in the Kaimai Rail Tunnel and full scale measurements to test the ventilation system in the Terrace Tunnel against the design. I was also responsible for developing all of the data acquisition and analysis software used for both wind tunnel and full scale testing.

As a building services engineer, over the last 30 years I have spent and still spend a considerable amount of time reviewing designs and rectifying issues caused by other professional engineers. This confirms that having an engineering qualification is no guarantee that the work produced is correct. I have also been engaged as an expert witness.

The review is based on the following:-

- 1.1.1 a comparison of flooding which occurred on properties at [REDACTED], immediately opposite the proposed development site, and that shown on the pre-development flooding maps included in the Carter submission. (The south branch of the Ohoka Stream flows through [REDACTED].)
- 1.1.2 comparison of the rainfall recorded at the ECAN Threlkelds Road site, which is some 2.8km to the North East of these properties, during events in 2014 and 2022, and those used in modeling. Data on the 2023 event is also included. (A full analysis of the rainfall data is included in this document.)

2 **SUMMARY**

The main findings are:-

1. The modelling provided predicts flood levels during events with significantly higher rainfall than has been experienced to date which are lower than those which have occurred and are documented. This brings into question the validity of the modelling and the conclusions reached.
2. The failure of the model to predict events accurately is conceded by PDP where they state that the modelling **"Underestimated the peak flow for the 2014 event by approximately 20%."**
3. While the information contained in this document relates to [REDACTED] the failure of the model has serious implications for all of the properties in Ohoka that are now adversely effected by flooding. What the model does do is to highlight the major issues with storm water in the area that exist now and the unsuitability of the site for the proposed development.
4. In light of the serious adverse effects of flooding the relief sought is that the application be declined in full.

3 COMMENTS ON THE PDP DOCUMENTS

3.1 Review of Modelling

The PDP document states the following:-

The model was calibrated and validated against three significant historical flood events (June 2014, July 2022, and July 2023) by comparing modelled hydrographs with recorded flow data from the Cust Main Drain at Threlkelds Road. Further site-specific validation for the Ohoka area involved comparing modelled flood extents and depths from the July 2023 event with available site photography. Sensitivity analyses were also undertaken on key model parameters, confirming the robustness of the model predictions. The validated model was then used to simulate design flood events under both pre-development (existing) and post-development conditions, including the proposed subdivision layout, earthworks, and internal infrastructure.

June 2014: A peak flow of almost 120 m³/s was recorded in the Cust Main Drain (20 to 50-year event) and 40 mm of rainfall was recorded over six hours at Threlkelds Rd (approximately 2.5 km East of Ohoka);

July 2022: A peak flow of just over 100 m³/s was recorded in the Cust Main Drain (20-year event) and 35 mm of rainfall was recorded over six hours at Threlkelds Rd); and,

July 2023: A peak flow of around 90 m³/s was recorded in the Cust Main Drain (10 to 20-year event) and 63 mm of rainfall was recorded over six hours at Threlkelds Rd);

External subdivision flooding

Adjacent Properties & Buildings: No existing habitable dwellings are predicted to experience an increase in average flood levels greater than 20 mm. The vast majority (over 1100) of surrounding building footprints experience no material change (< ±10 mm).

Modelled flood depths and extents for the July 2023 event were compared against available flood photography from the site to confirm satisfactory local-scale performance. Key model settings (such as calibrated infiltration parameters) from Stage 1 were incorporated into the V02 model.

The validation model for Stage 1 is referred to as "V01" whilst stage 2 is referred to as "V02".

Previous modelling concluded:-

The effects on flood flow vary throughout the subdivision. The model predicts that flow over the south-eastern boundary of the subdivision (Whites Road) is increased by 300 L/s (36.1 m³/s to 36.4 m³/s). Flow over the north-eastern boundary of the subdivision (Mill Rd) decreases slightly by approximately 40 L/s. Peak flow over Mill Rd is around 8.7 m³/s;

It is noted that as per Figure 4. V02 Model extent and boundary conditions, the downstream boundary only extends to Jacksons Road.

4.3 V02 - Ohoka Site model states

The V02 model provide a more detailed assessment of the model performance in the Okoka area. The V02 model was validated using photos taken during the July 2023 event which were compared to the predicted flood extent.

Previous flooding assessments (Section 1.2.1) found that effects were generally confined to locations near the proposed development. Therefore, this validation exercise has focussed on those critical locations which include dwellings and property downstream of Whites Road and the Ohoka Township (adjacent to Mill Rd).

A detailed comparison between the model results and the flood photos is provided in Appendix B. The main observations from the validation are:

A good match was achieved for the critical ponding location across Whites Road (at 401 Whites Road).

The model flood extent within the proposed site is greater than the flood photos at certain locations along Whites Road.

- o Specifically at the areas north of the Ohoka Stream and south of the Ohoka South Branch;
- o This is potentially influenced by the height of the grass which may mask ponding within the photos.

A good match was achieved along the Bradleys and Mill Road boundaries of the proposed development.

There is no mention of the flooding on the Whites Road side of the proposed development, which is the downstream boundary and also the lower side of the development. The PDP report also states (7.3.3):-

- South of Mill Road and East/Downstream of Whites Road: The most noticeable changes occur immediately adjacent to the subdivision's eastern and southern boundaries, as expected due to the modification of flow paths through the site. These changes, comprising both small increases and decreases in flood level, generally dissipate rapidly as floodwaters move further east. Pockets of change exceeding 10 mm are located close to the subdivision boundary.

4.3.1 Conclusion

The model validation was considered successful, and no modifications were necessary before proceeding to the design stage. As noted in the validation of the V01 model, the model appears to be slightly conservative.

It is difficult to reconcile that conclusion with their own statement that one conclusion of the modelling (4.2.2) was that the modelling **"Underestimated the peak flow for the 2014 event by approximately 20%."**

It is also noted that when considering the longer return events the report states (7.3.2):-

No major lifeline utilities or designated critical transportation routes are located within the areas predicted to experience material changes in flood levels due to the development. Local roads such as Whites Road and Mill Road, while important for local access, are not considered as critical lifeline routes. However, the effect on Whites Road, adjacent to the proposed subdivision, was specifically considered:

- In the pre-development 200-year ARI scenario, the maximum flood depth on this section of Whites Road is approximately 155 mm;
- In the post-development scenario, this increases slightly to approximately 185 mm (+30mm); and,

Some of which have been used by PDP.

If the water depth on Whites Road is 185mm this would mean that all properties on the east side of Whites Road would be inundated. This would flood the transformer that supplies a number of properties on the east side of Whites Road and would severely damage other infrastructure on these properties. (e.g. Mainpower's electrical termination boxes where the incoming mains connect to the individual properties. These are all located at ground level.) While it is acknowledged that the 155mm depth would also be serious any increase in this predicted depth cannot be dismissed by the well used cliché of 'less than minor'.

PDP's *Flood Effects* Draft documents states:- *Minor increases in shallow flood depths on adjacent local roads (e.g., Whites Road) are not considered significant and do not unduly compromise passability for most vehicles in extreme events.*

What the report fails to say is that any flooding on Whites Road will result in water flowing into the properties on the east side of Whites Road, all of which are lower than the road, as the whole area drops from west to east.

(The property [REDACTED] has a fall of some 300mm from the gate at the end of a 500m long drive from Whites Road to the house site. The fall from the entrance on Whites Road to the entrance at the gate is over 300mm, hence the house site is some 800mm below the level of Whites Road.)

It should also be noted that the PDP modelling uses the *Canterbury LiDAR 1m* as provided by *data.linz.govt.nz*. Using data with 1m resolution is not particularly accurate, in spite of PDP stating that *This surface was considered to be an appropriate resolution for the purposes of this model.*

Checking of the levels shown from this website, using levels taken on our property, confirms that the LiDAR data cannot be relied upon to predict flood levels at lower resolution, (i.e. less than 1m), referred to in the PDP reports. The comparisons of the predicted flooding and that which has occurred on our property with considerable lower rainfall confirms this.

That flooding is a significant issue in this area, and on the proposed development site, is highlighted in the report as follows:-

Flood depths for the 50-year and 200-year post development runs are shown in Figures A4 and A5, Appendix A. Figure A4 shows:

Flood depths on the majority of proposed internal roads are predicted to be less than 300 mm, generally maintaining vehicular access. However, depths may exceed 300 mm on the proposed road connecting the polo field area to Whites Road, and on a section of internal road south of Stage 10. These areas would likely be impassable to light vehicles. Further detailed design of road profiles and local drainage will aim to optimise passability, though complete passability in all areas during a 50-year event may not be necessary if safe alternative access/egress is available and critical infrastructure is protected;

Some ponding exceeding 300 mm is predicted within the proposed retirement village area and potentially other designated open spaces or low-lying areas. It is anticipated that these depths will be managed through the detailed design of the internal stormwater network, overland flow paths, and site grading to ensure they do not adversely affect habitable buildings or critical access;

Building platforms are generally free of flooding (less than 50 mm). There is some nominal flooding (up to 100 mm) on several lots although finished floor levels will be set above this event meaning habitable dwellings will not be inundated; and,

Areas within the retirement village footprint and lower-density residential Stages 10 and 11 show potential for depths exceeding 300mm in localised depressions or flow paths prior to detailed earthworks design. These are expected to be refined during detailed design to ensure compliance with FFL requirements and site drainage objectives.

That the report states that flooding with depths which may exceed 300mm are predicted demonstrates how unsuitable this site is for any development.

Any measures to mitigate this flooding will inevitably result in additional water being discharged to the local drainage on the site which will result in higher flows through the existing streams and what they describe as 'overland flow paths'. What does that mean - that the water will just flow into neighbouring properties and across the adjacent roads? The fact that PDP concede that changes are required to the design of the stormwater systems and the design of spaces within the proposed development highlights the unsuitability of the site for development, the poor planning that has been completed to date and surely negates the optimistic conclusions of the modeling.

On these grounds alone this development will result in Adverse Impacts and must not be allowed to proceed.

4 COMMENT

Photos of flooding on properties on the east side of Whites Road, immediately opposite the proposed development are included for the 2014 and 2022 events together with modelling from PDP which shows the predicted pre-development water levels for 50 year and 200 year events. Comparison of the photos, the modelling and the rainfall data, clearly shows that the levels predicted by PDP for the longer term events are occurring with significantly less rainfall than that used in the modelling.

It is noted that PDP state in their report when referring to rainfall in July 2023 :- *Critical rainfall duration for Ohoka is likely to be around 6-hours, therefore the rainfall event for the Ohoka catchment was likely between a 20-year and 50-year event.*

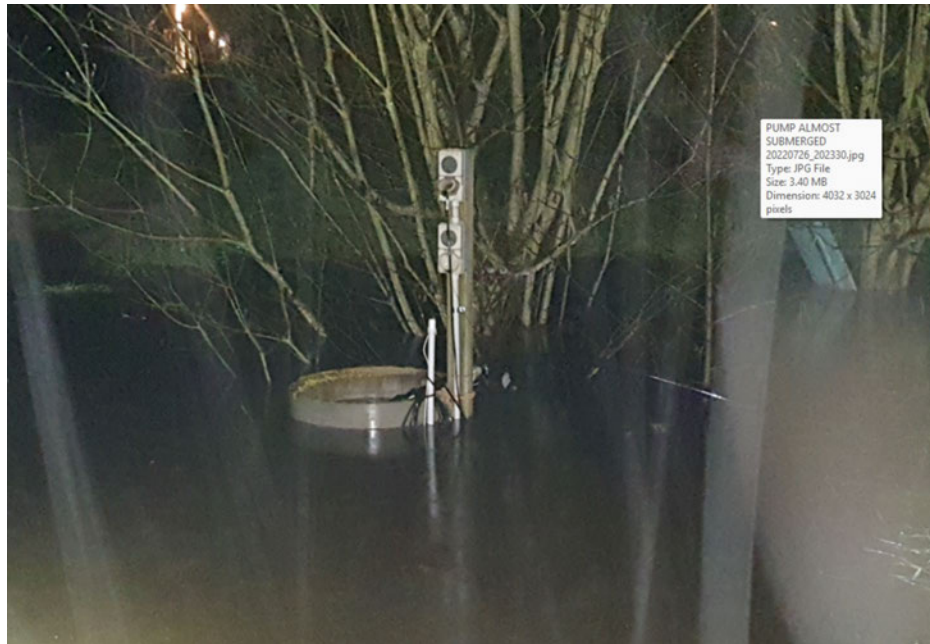
No mention is made of the underground flows and local springs on our and adjacent properties which add to the flooding on these properties.

What this modelling also fails to take account of is that once flooding occurs in Ohoka it takes a significant amount of time for flood waters to recede due to the poor drainage from the area, which is constrained by the ground conditions and conditions downstream, the water flowing into and through areas which are also flooded. That has not been considered in the modelling which uses Jacksons Road as the 'downstream boundary' and takes no account of the effect of obstructions in the streams downstream of the site and the effect of high levels within the Cust & Kaiapoi Rivers.

The following photo shows water on the 21st of July 2022, prior to the flooding event on the 25th & 27th of July. Prior to this rainfall had occurred on two occasions, with the total for July up until midnight on the 24th of July being 110mm. The last rainfall prior to this was a total of 26mm over 26 hours. Having this amount of water ponding before a flooding event exacerbates the flooding. This has not been taken into account in the modelling.



On our land it takes at least five days, often more, to clear the water from the swale on the east side of the property by pumping it into a retention pond, from where it flows into the Ohoka South Branch stream. How quickly the water drains from the pond depends on the water depth in the stream. Water continues to flow into the sump from another drain for days after that. Any significant additional rainfall during this time will overwhelm the swale, and as the photo below shows, during flooding the 810 mm high sump is also almost flooded.



As an example of local restriction to the flow from the area, the Ohoka South Branch Stream has not been maintained for over 20 years resulting in obstructions accumulating and impingement on the flow area by tree roots and the like, reducing the capacity of the stream. We asked that we be allowed to clear an obstruction from the South Branch after a large tree, which had 'extended' its root base well into the stream, resulting in significant reduction in the flow area, had been blown over, to be removed but we were advised by the Council that was not permitted. We also have had a neighbour install significant drainage from their property into the stream adding to the flooding risk. There is no mention of these issues in the modelling, nor is there any mention of the capacity assumed for these vital drainage paths.

Extracts from the PDP reports regarding boundary conditions are included below.

An earlier PDP report included the following:-

4.1 Model Sensitivity

At this stage, only the model sensitivity to the downstream boundary has been tested. If this model is used for prediction of absolute water levels, for example, setting minimum floor levels, then further sensitivity testing will be required.

The sensitivity to the downstream boundary was assessed by decreasing the normal depth boundary by an order of magnitude (1 in 200 to 1 in 2000). This assessment showed that the downstream boundary effect, at a distance of 100 m upstream, is a difference in flood elevation of 3 mm. Therefore, the model is not considered sensitive to this downstream boundary.

There is no mention of the effect of raising the normal depth boundary, which is surely more important than lowering it.

The latest report includes the following figure which indicates that there are no effects due to the boundary conditions. That defies logic. If the flow from the area is restricted the water levels inside the boundary must increase.

8.5 Sensitivity of flood levels to downstream boundary

The effect of the downstream boundary on the flood levels was tested by reducing the normal depth slope from 0.005 to 0.001 within the model. This resulted in localised differences along the downstream boundary but had no effect on the flood levels within the site or area of investigation. The sensitivity results for the downstream boundary test are shown in Figure 27.

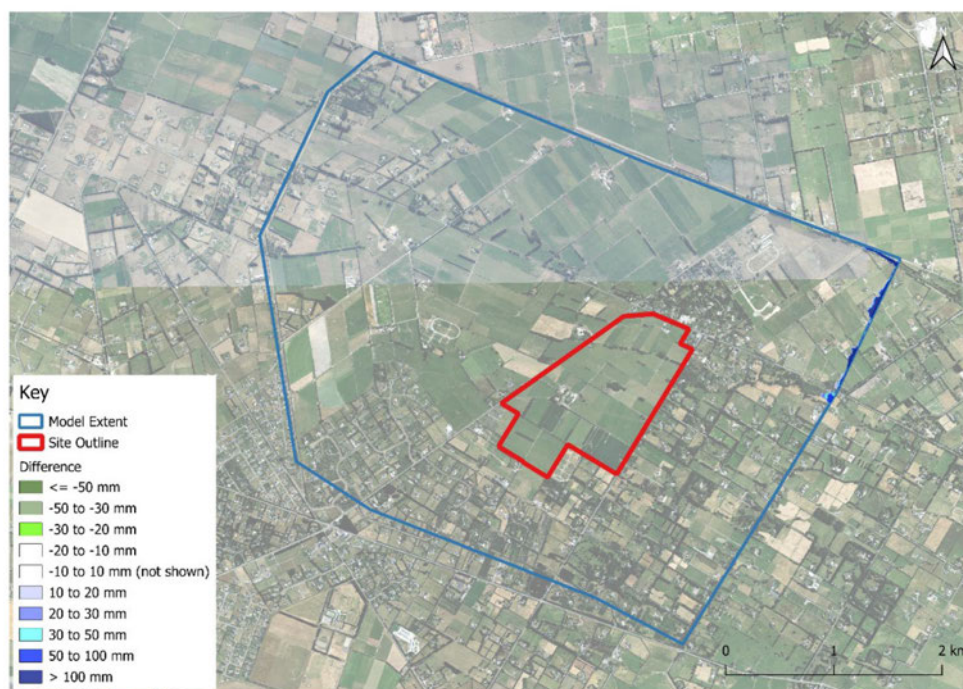


Figure 27. Difference between the downstream boundary normal depth slope of 0.005 and normal depth slope of 0.001.

5 RAINFALL DATA FOR THE THREE SIGNIFICANT EVENTS

An analysis of rainfall data from the nearby Cust Drain rainfall gauge for events in 2014, 2022 & 2023 was carried out. This is included as Appendix A. These events resulted in significant flooding in Ohoka. The rainfall which occurred in these events is compared to the 50 and 200 year rainfall data used by PDP.

Appendix A includes three graphs which show the hourly rainfall from the Cust Drain, (Threlkelds Rd), site for the two days in 2014, 2022 and 2023 during which extensive flooding occurred in Ohoka. The main features of these events may be summarised as follows:-

EVENT	DURATION OF RAINFALL	PEAK INTENSITY	TOTAL FOR EVENT
9 th - 11 th June 2014	~24 hours	7.5mm / hr	133.5 mm
25 th - 27 th July 2022	~27 hours	8.5mm / hr	97.5 mm
22 nd - 24 th July 2023	~30 hours	16mm / hr	129 mm

Of note is the significant difference in intensities of the rainfall, the 2023 event having a peak intensity almost twice that in 2022.

The intensity in the HIRDS RCP8.5 2031-2050 1 hour data has an intensity of 15.8mm/hr for an ARI (Annual Recurrence Interval) of 5 years. For the 50 year ARI the intensity is 29.6mm/hr and 34.6mm for a 100 year ARI. These are significantly higher than the intensities that have been recorded to date.

The variation in intensities recorded to date highlights the unpredictability of these events. What happens in future cannot be predicted with any accuracy. (Refer to the paper prepared by Professor Matthew Wilson included as Appendix D.)

It is also noted that PDP made the following comments on these events [highlighting added]:-

*June 2014: A peak flow of almost 120 m³/s was recorded in the Cust Main Drain (20 to 50-year event) and **40 mm of rainfall** was recorded over six hours at Threlkelds Rd (approximately 2.5 km East of Ohoka);*

*- July 2022: A peak flow of just over 100 m³/s was recorded in the Cust Main Drain (20-year event) and **35 mm of rainfall** was recorded over six hours at Threlkelds Rd); and,y*

*- July 2023: A peak flow of around 90 m³/s was recorded in the Cust Main Drain (10 to 20-year event) and **63 mm of rainfall** was recorded over six hours at Threlkelds Rd);*

PDP also state that the Threlkelds Road recorded the highest peak intensity at approximately 15mm/hr around hour 28. The figure in the ECAN data is 16mm /hr at 4am on the 23/07/23.

23/07/2023 02:00	6.50
23/07/2023 03:00	10.00
23/07/2023 04:00	16.00
23/07/2023 05:00	12.50
23/07/2023 06:00	1.50

5.1 HIRDS Data

The HIRDS V4 RCP 8.5 (2081-2100) data is reproduced below. (It is noted that the data downloaded from the DataHub site did not include rainfall depths for 200 years ARI, the longer ARI values being 100 and 250 years.)

(Note that some of the shorter and longer periods have been deleted from the table below.)

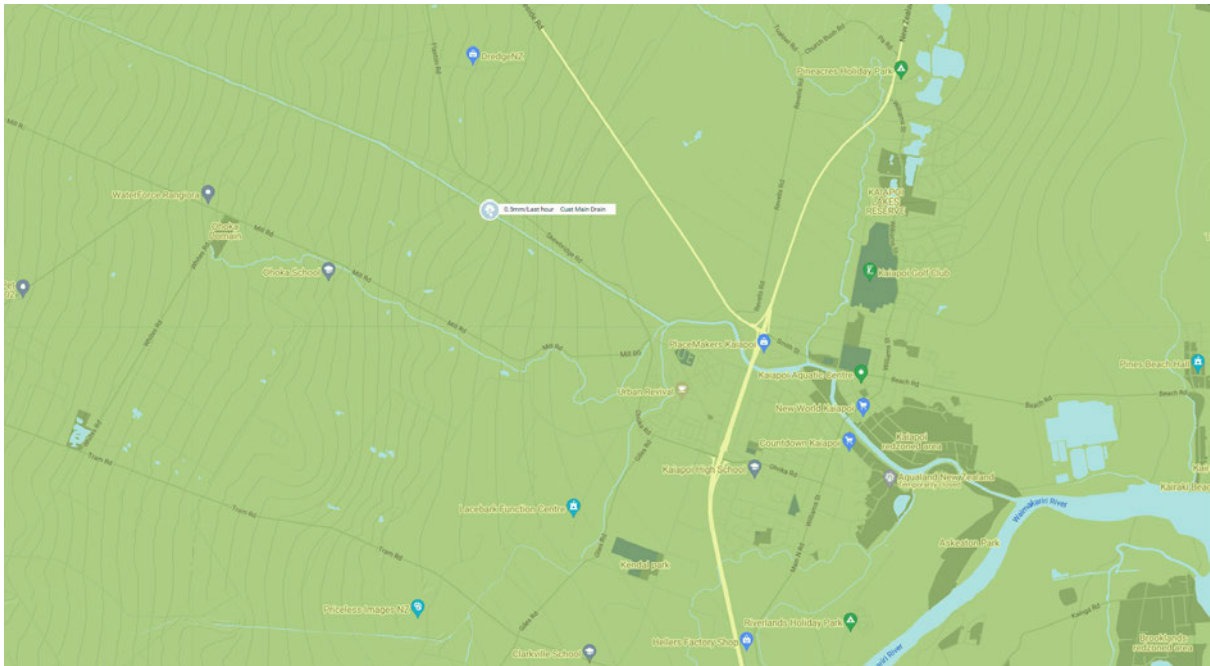
Rainfall depths (mm) :: RCP8.5 for the period 2081-2100								
ARI	AEP	30m	1h	2h	6h	12h	24h	48h
1.58	63.30%	8.06	11.7	16.8	29.3	40.2	53.9	68.6
2	50.00%	9.17	13.2	19.1	33	45.3	60.2	76.5
5	20.00%	13.2	18.9	27	46.2	62.9	82.5	104
10	10.00%	16.5	23.5	33.4	56.5	76.4	99.8	125
20	5.00%	20.1	28.5	40.2	67.6	90.8	118	147
30	3.30%	22.4	31.6	44.5	74.4	99.7	129	160
40	2.50%	24.1	33.9	47.6	79.5	106	137	170
50	2.00%	25.5	35.8	50.2	83.4	111	143	177
60	1.70%	26.6	37.3	52.3	86.8	116	148	183
80	1.30%	28.5	39.9	55.7	92	122	157	193
100	1.00%	30	41.9	58.4	96.3	128	163	201
250	0.40%	36.4	50.3	69.7	114	150	190	232

ARI is the Average Recurrence Interval, which is the average length of time (in years) between flood events of a specific magnitude. e.g. A "100-year ARI flood" means that a flood of that size occurs, on average, once every 100 years.

AEP is the Annual Exceedance Probability, which is the statistical chance that a flood of a specific size will happen or be exceeded in any single year.

6 HISTORICAL RAINFALL DATA

ECAN provide daily and hourly rainfall totals for a site (Threlkelds Road), located adjacent to the Cust Main Drain, which is relatively close to Ohoka. (The station is some 2.8 km from the intersection of Mill Road & Whites Road. Refer to the map below.)



Data from this site is available from 1/11/2005. The daily rainfall data has been processed to provide 48 hour rainfall totals in addition to the 24 hour totals. For the period up until the 6th of October 2026 the maximum 24 hour rainfall recorded was 95mm on the 20/02/2018, while the maximum 48 hour total was 132.5mm on the 9th & 10th of June 2014, 53mm falling on the 9th and 79.5mm on the 10th. The maximum rainfall recorded on the 23rd of July 2023 was 92.5mm with a 48 hour total of 129mm, 36.5mm being recorded on the 22nd of July.

The 24 hour rainfall depths from the Cust Drain site show that the rainfall for 90% of the predicted five year event in 2081 - 2100 was exceeded on seven occasions in the period 2005-2022 and 90% of the predicted 48 hr five year event was exceeded on six occasions. This would suggest that the five year predictions are likely to be exceeded more frequently in future.

The maximum daily rainfall recorded during the rainfall events in July 2022 was 81.5mm on the 26/07/22 with the 48 hour total being 97.5mm on the 25 & 26/07/2022. 71.5mm was recorded on the 12/07/2022 and 20.5mm on the 21/07/2022. The total rainfall recorded for July 2022 was 235.5mm. The PDP report notes that *'the return period of this flood event, for Ohoka, was likely between 10 and 20 years'*

The event on the 22nd & 23rd July 2023 resulted in rainfall of 36.5mm falling on the 22/07/2023 and 92.5mm on the 23/07/23, a 48 hour total of 129mm. This event had the highest intensity with the maximum hourly rainfall being 16mm for the period ending at 04:00 on the 23rd July.

Thus, while all of these events were significant, the comparison with the model data is as follows:-

EVENT	24hr rainfall (mm)	48 hr rainfall (mm)
NIWA 5 year return event	82.5	104
NIWA 50 year return event	143	177
February 2018 (24hr max)	95	95
9 th & 10 th June 2014 ¹	113.5	132.5
25 th & 26 th July 2022	81.5	97.5
23 rd & 24 th July 2023	92.5	129

1. 113.5mm fell in the 24 hour period from 15:00 on the 9th June 2014.

Given that the extent of flooding that occurred in July 2022, when the 24hr rainfall was only 57% of the 50 year return event, and the 48hr total was only 55% of the same event, was in line with the model predictions in some parts of our property for a 50 year event, it would appear that the modeling is inaccurate and cannot be relied upon. Even more extensive flooding occurred in June 2014 when the 24hr total was 113.5mm, 80% of the 50 year return event, while the 48hr total was 75% of the 50 year return event total.

There is no doubt that the effects of a fifty year rainfall event when the predicted 24 hour rainfall is 143mm and the 48 hr total is 177mm, would be disastrous, and certainly not in line with the relatively minimal flooding predicted by PDP.

(As we were away during the 2023 event we have no record of the effect on our property however information provided by others in the district indicated that considerable flooding occurred in the village area.)

7 CLIMATE CHANGE & SEA LEVEL RISE

7.1 Sea Level Rise

The PDP report mentions sea level rise once, (7.2.1 3(e) iii), but does not state what allowance has been made. That information must be provided.

Expert evidence provided by David Deleazarza on 15th June 2026 (*Second Statement of Evidence of David Patrick Deleazarza (response to Expert Panel request for further information regarding climate change provisions in stormwater and flood models)*) in relation to the Belfast to Pegasus project (FTAA-2512-1157) includes the following:-

The adopted sea level rise allowance of 1.0m remains broadly consistent with recent projections over the design life of the infrastructure. While the most extreme climate scenarios project higher sea level rise, the adopted value is similar to the median projection for the SSP3-7.0 scenario and remains within the projected uncertainty range of the lower emissions scenarios.

As the systems that drain water from Ohoka flow into the Kaiapoi River, the Waimakariri River and then the sea this will have a significant impact on the capacity of the drainage from the area. A rise in the sea level of a metre cannot be ignored. How has this been accounted for when the modelling uses Jacksons Road as the eastern boundary ?

7.2 Climate Change

Commentary from NIWA's Climate Summary for July 2023 includes:- *July was a wet month for eastern and southern parts of the South Island. Rainfall was above normal (120-149% of normal) or well above normal (>149% of normal) in eastern parts of Canterbury and Otago. July was also noted as being New Zealand's 4th-warmest July on record* highlighting the effects of climate change.

According to NIWA, The World Meteorological Organisation stated that the first three weeks of July 2023 were the warmest on record and that it was "extremely likely" that July would be the hottest month on record. That was confirmed on the 4th August 2023 on the WMO website as follows:- *"Earth just had its hottest July on record. Sea ice was the lowest on record. For the fourth consecutive month, the global ocean surface temperature hit a record high."* The following statement was also made by Samantha Burgess, Deputy Director of the Copernicus Climate Change Service (C3S).

We just witnessed global air temperatures and global ocean surface temperatures set new all-time records in July. These records have dire consequences for both people and the planet exposed to ever more frequent and intense extreme events," Samantha Burgess, Deputy Director of the Copernicus Climate Change Service (C3S), told a media briefing at the United Nations in Geneva.

To ignore this is foolish and unforgivable. Models based on what cannot be reliably predicted due to the rapid changes in the climate are fundamentally flawed.

Evidence presented by Ben Throssell (PDP) previously, (para 37 of his submission to the Independent Hearings Panel dated 6th July 2023), included the following:- *The 24 hour storm was selected as this is approximately the critical time of concentration for the coastal parts of the district from rainfall originating in the foothills behind Oxford and Okuku."* These areas are to the **west** of Ohoka.

Reference to NIWA's historical weather data states that the 2014 event was related to a significant storm which resulted in widespread flooding, including in Rangiora. NIWA's summary of the event is as follows:- [highlighting added.]

*A complex low pressure system extended from the mid-Tasman Sea to the northwest of the North Island, bringing a moist **northeasterly** flow over NZ. This resulted in severe gales in many northern North Island areas, with Auckland being particularly hard hit. Meanwhile, a slow-moving high to the southeast of the South Island pushed colder air onto the island. This clashed with the warmer air coming from the **northeast** over North Canterbury and the Kaikoura Coast, resulting in heavy rain.*

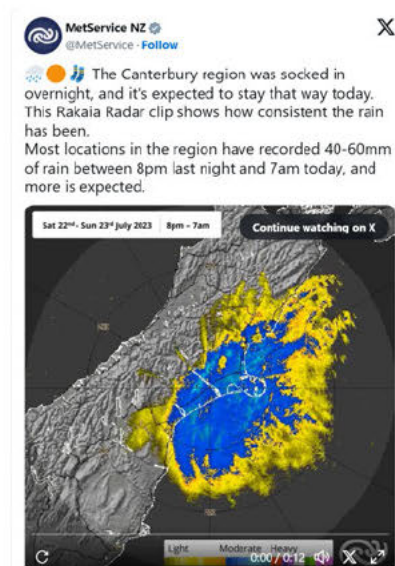
NIWA's comment on events in July 2022 were as follows:- [highlighting added.]

*There was a multitude of drivers behind the wet and warm weather during July. The overall air pressure pattern saw higher than usual pressures to the northeast and southwest of the country and was associated with more northerly quarter air flows (warm and wet airmass origin). This dominant pressure set up allowed for consecutive low-pressure systems to approach from the northwest which were supplied with flows of tropical moisture from the Coral Sea. The high pressure to the northeast of the country blocked the lows from moving away quickly and prolonged rainfall. **This pattern was quite different from the southerly and south-westerly systems which are more characteristic of NZ winters.***

This, and the following from the MetService confirm that the weather patterns are changing significantly. This makes predicting future events more difficult, and must raise significant doubts about the accuracy of any modelling. While some of this rain will no doubt fall in the foothills to the west, resulting in increased flow into the rivers flowing to the east, the key driver of flooding is the precipitation that occurs in and adjacent to Ohoka.

The MetService provided a clip from weather radar which clearly shows the rain event on the 22nd & 23rd July 2023 with the rain coming from the **east**. A report regarding this event stated *The severe system leading up to July 27 was driven by a slow-moving low-pressure system directing a saturated **easterly** flow onto the South Island.*

A screenshot of the article is provided below. (Unfortunately attaching the full clip proved to be unreliable. The video is included in the ZIP file attached to this submission.)



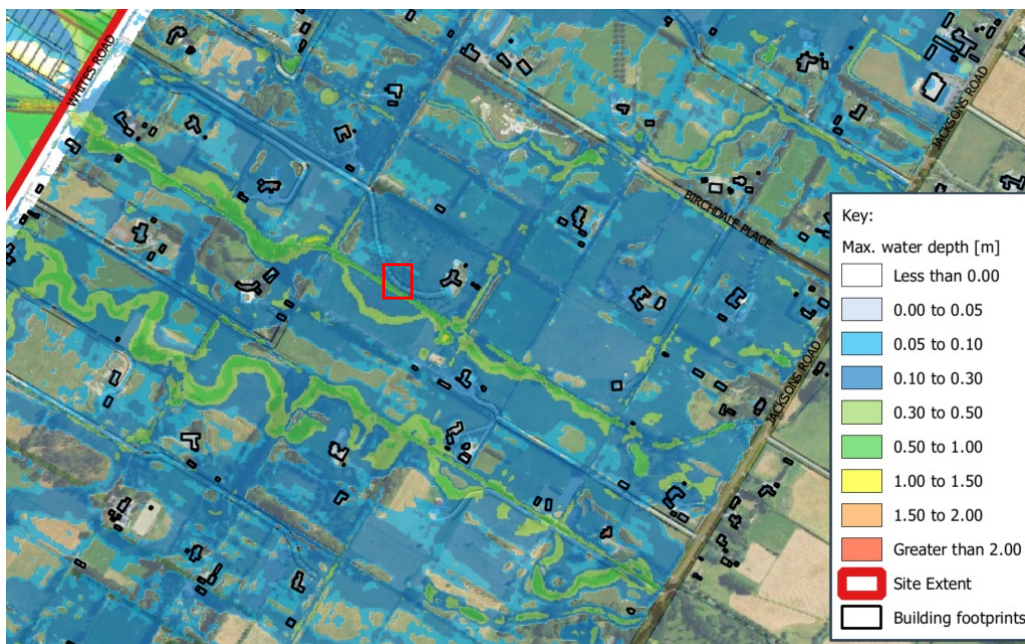
8 PHOTOS OF FLOODING

The following photos show flooding which occurred in June 2014. The bridge in this photo, which is submerged, is just behind the container that is visible, is **1100mm** above the bottom of the stream. PDP predict that the 200 year event will result in a depth between **500 and 1000mm**. (Refer to the figure below and the area in the red box.) This clearly shows the discrepancy between the model and reality.

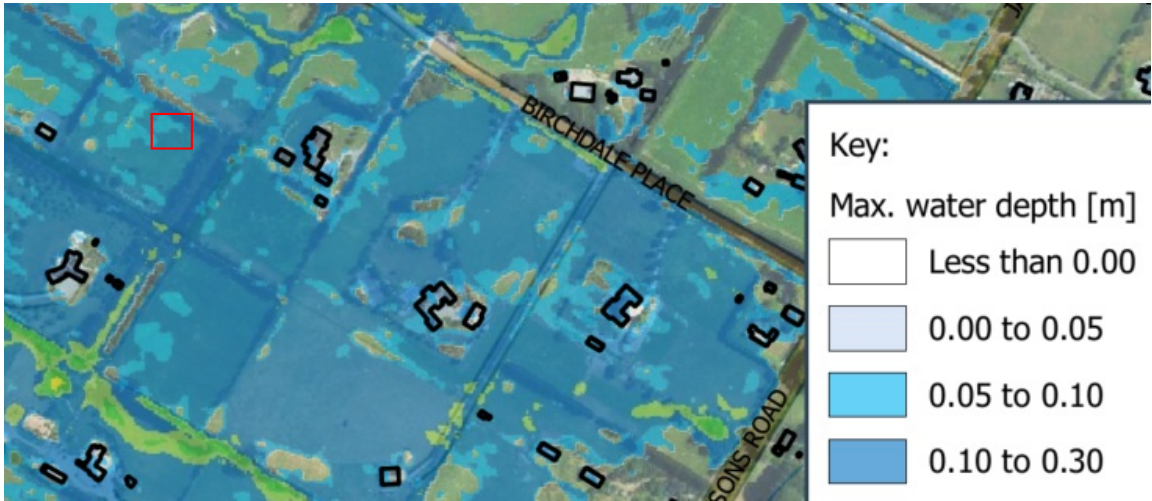


The following figure is as follows:-

Figure A5, Post-development flood depths for the 200-year event with climate change (D02_200YR_Post). Depths less than 50mm not shown.



The following photo taken at [REDACTED] shows a water depth of about 65mm on the 26th of July 2022. The PDP prediction (red box) is for a depth of between 50 to 100mm during the 200 year event.



This photograph taken on the evening of the 26th July 2020 shows water flowing down our drive from the west . This water comes from runoff from adjacent properties, the pond near our gate which is fed from a spring and precipitation. At this time Whites Road had no surface water or flooding on it. If as the model predicts Whites Road would have over 150mm of water on it this entire area would be completely inundated.



Further photos are included in Appendix B.

CONCLUSIONS

1. As is noted in the summary the modelling does not accurately predict flooding on the properties at [REDACTED], with the documented levels that have occurred in past events being higher than those predicted by the model for events with significantly higher rainfall. As such the model cannot be relied on to accurately assess the risk to the site and more importantly the surrounding properties.
2. The information contained in the applicant's documents confirm that the proposed development site will have water levels of 300mm or more at times. This confirms that the site is completely unsuitable for the proposed use.



J W Docherty

(B.Sc (Physics & Mathematics). B.E. (1st Hons)(Mech))

APPENDIX A - ECAN RAINFALL DATA - CUST MAIN DRAIN

The following graphs were prepared using data downloaded from the ECAN website for the Cust Main Drain (Threlkelds Road) station from 2005 - 2026. This data was imported into a database and processed to calculate the 48 hour totals. Two sets of 48 hour data were calculated in order to ascertain the maximum values which typically occurred either side of a peak 24 hour rainfall event. This data was then exported to an Excel spreadsheet and plotted along with the rainfall data predicted by NIWA and used in the 5 & 50 year return periods for 2081-2020 for both 24 hour and 48 hour events.

The first graph, (Figure A-1), shows the 24hr (daily) totals. The maximum winter totals were 92.5 mm on the 23rd July 2023, 81.5 mm on the 26th July 2022 and 79.5 mm on the 10th June 2014.

The second graph, (Figure A-2) shows the 48 hour totals, where the maximum 48 hour total was 132.5mm on the 9th & 10th June 2014, 129mm on the 22nd & 23rd July 2023 and 124.5 mm on the 16th & 17th July 2013 and 115.5mm on the 30th May 2021. .

Three additional graphs (figures A_3,4 & 5) show the hourly totals for the three events referred to in this document.

FIGURE A-1

ECAN RAINFALL DATA - CUST DRAIN 2005-2026

24hr rainfall totals in mm

Maximum (Winter) - 92.5mm 23/07/23; 81.5mm 26/07/2022; 79.5mm 10/06/2014
& NIWA PREDICTED RAINFALL FOR 5 & 50 YEAR ANNUAL RECURRENCE INTERVALS. RCP8.5 2081-2100
Highest daily totals were in Summer, 95mm on 20/02/2018 & 94mm on 15/12/2021.)

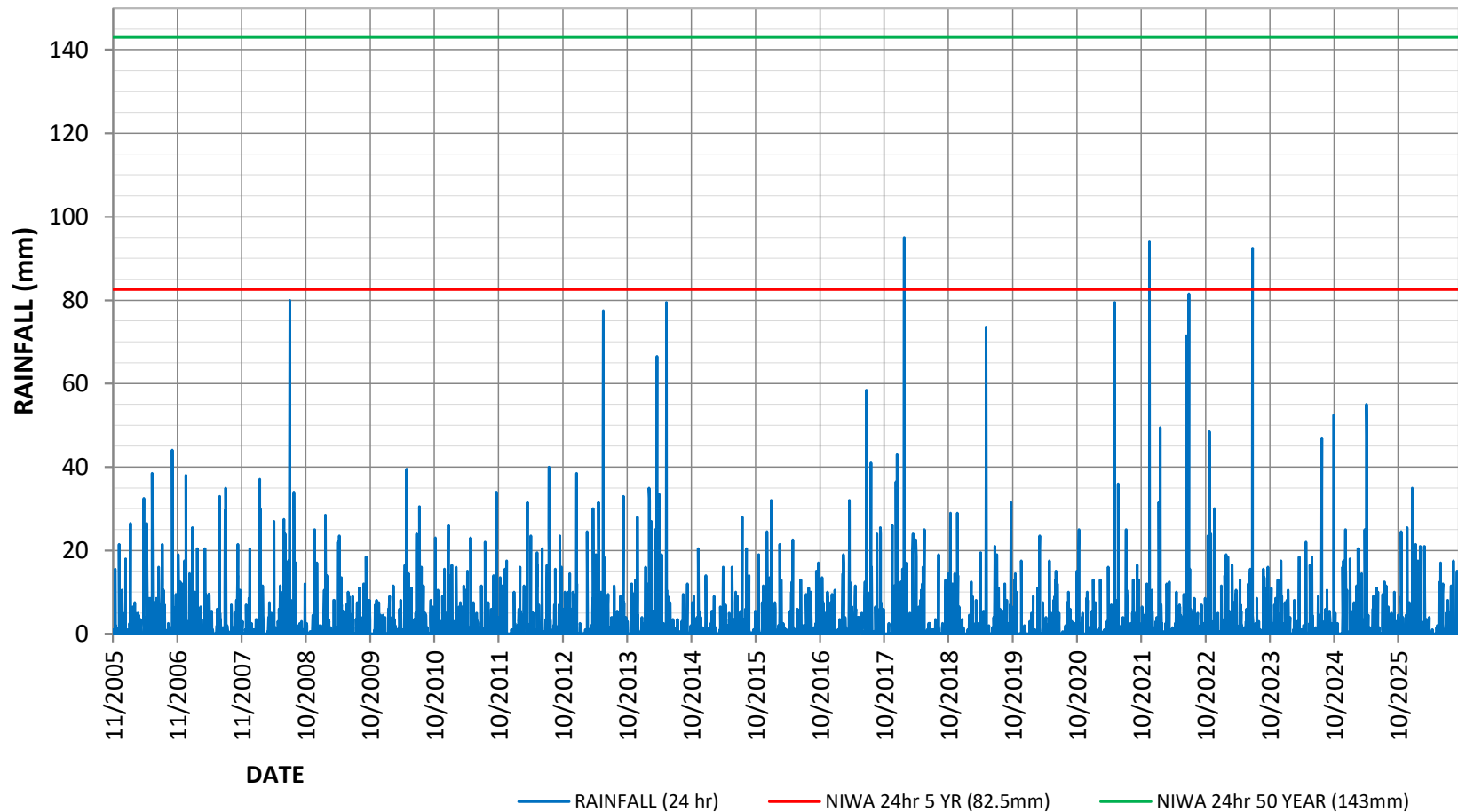


FIGURE A-2

ECAN RAINFALL DATA - CUST DRAIN 2005-2026
48hr rainfall totals in mm (calculated from daily totals)
Maximum 132.5 mm - 9 & 10th June 2014. (115.5mm - 30/05/2021).
& NIWA PREDICTED RAINFALL FOR 5 & 50 YEAR ANNUAL RECURRENCE INTERVALS. RCP8.5 2081-2100

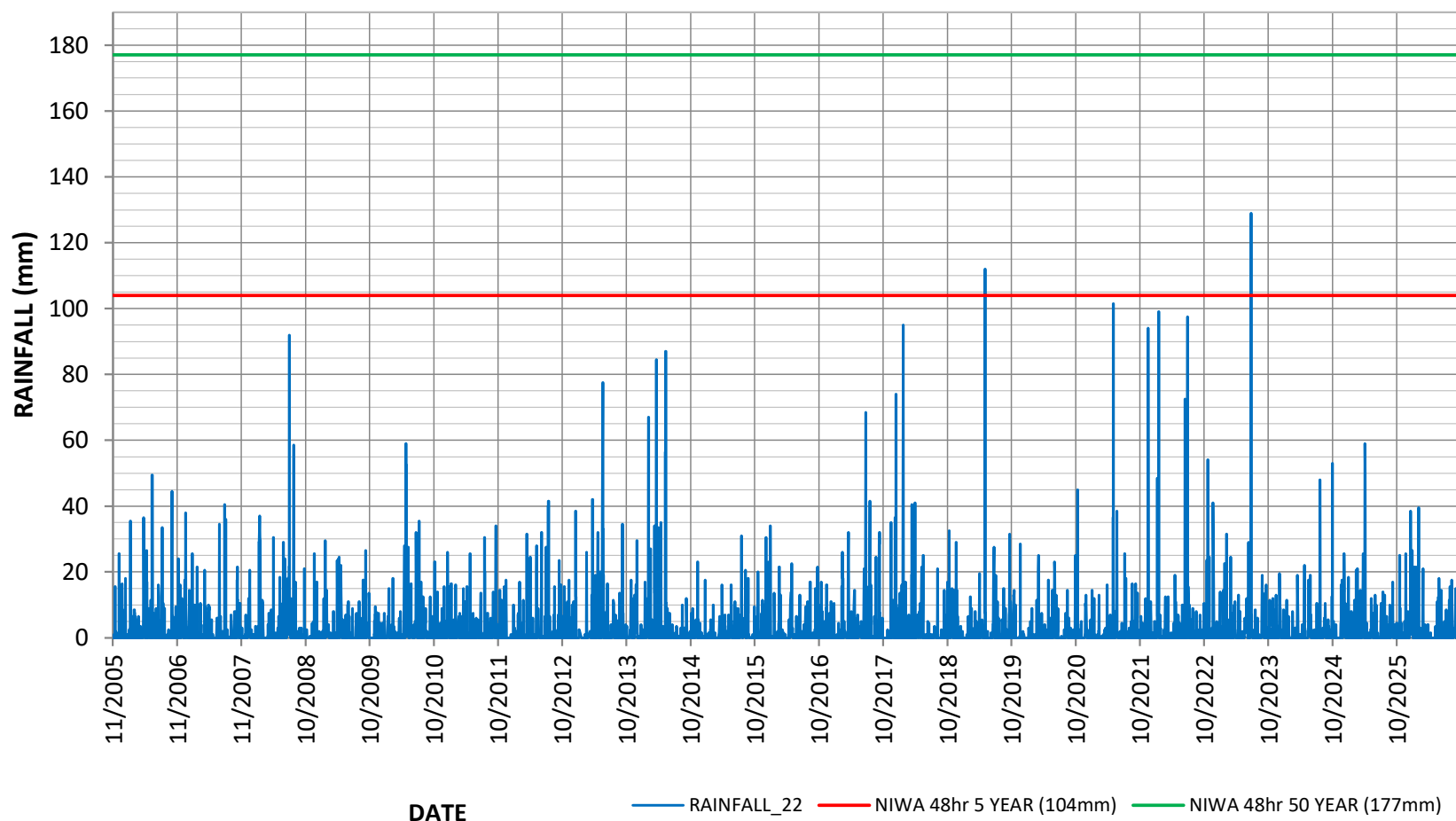


FIGURE A-3

Hourly Rainfall Data from Threlkelds Road Site 323610
9th -11th JUNE 2014 (Total = 133.5mm)

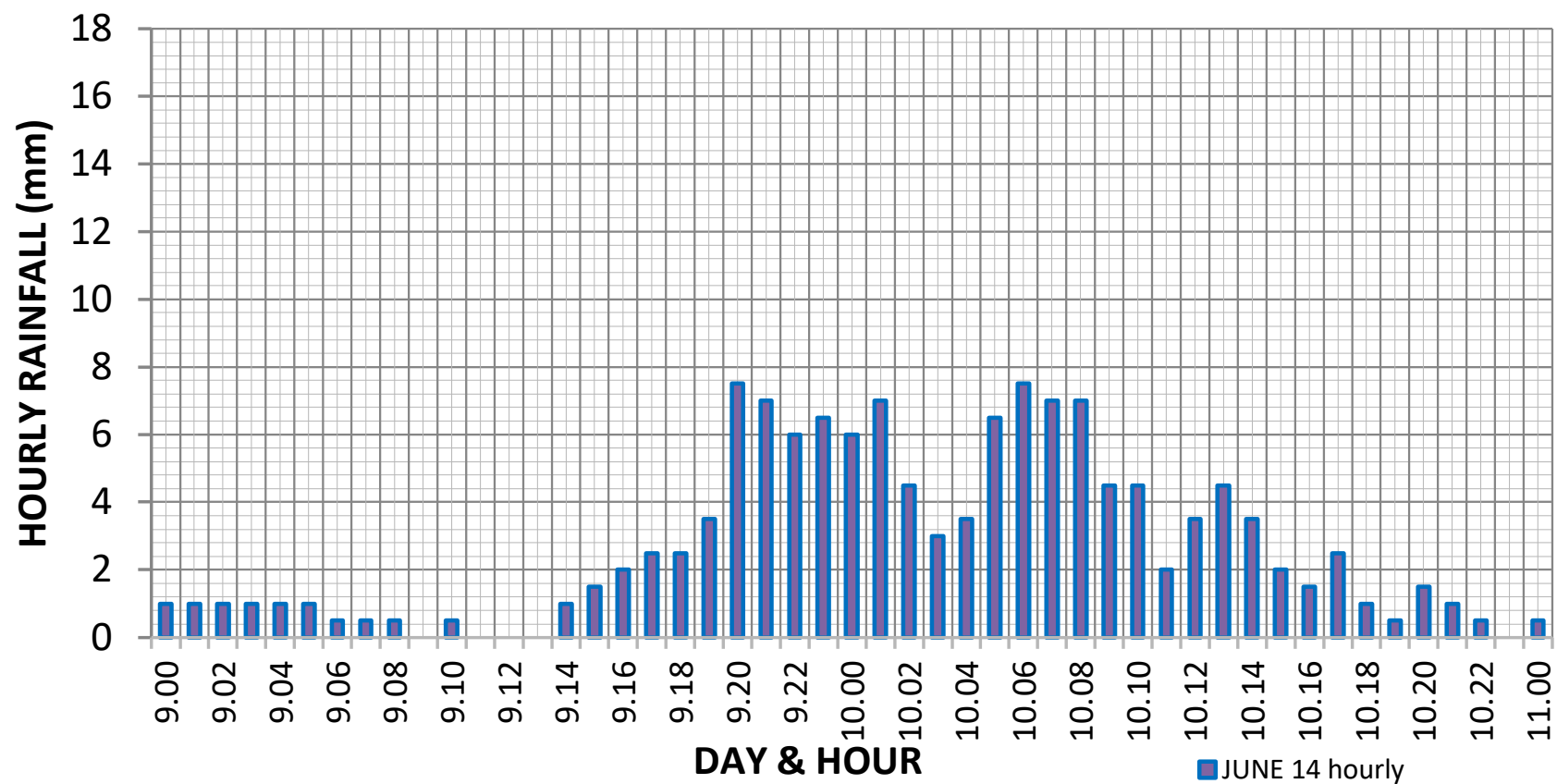


FIGURE A-4

Hourly Rainfall Data from Threlkelds Road Site 323610
25th - 27th JULY 2022 (Total = 97.5mm)

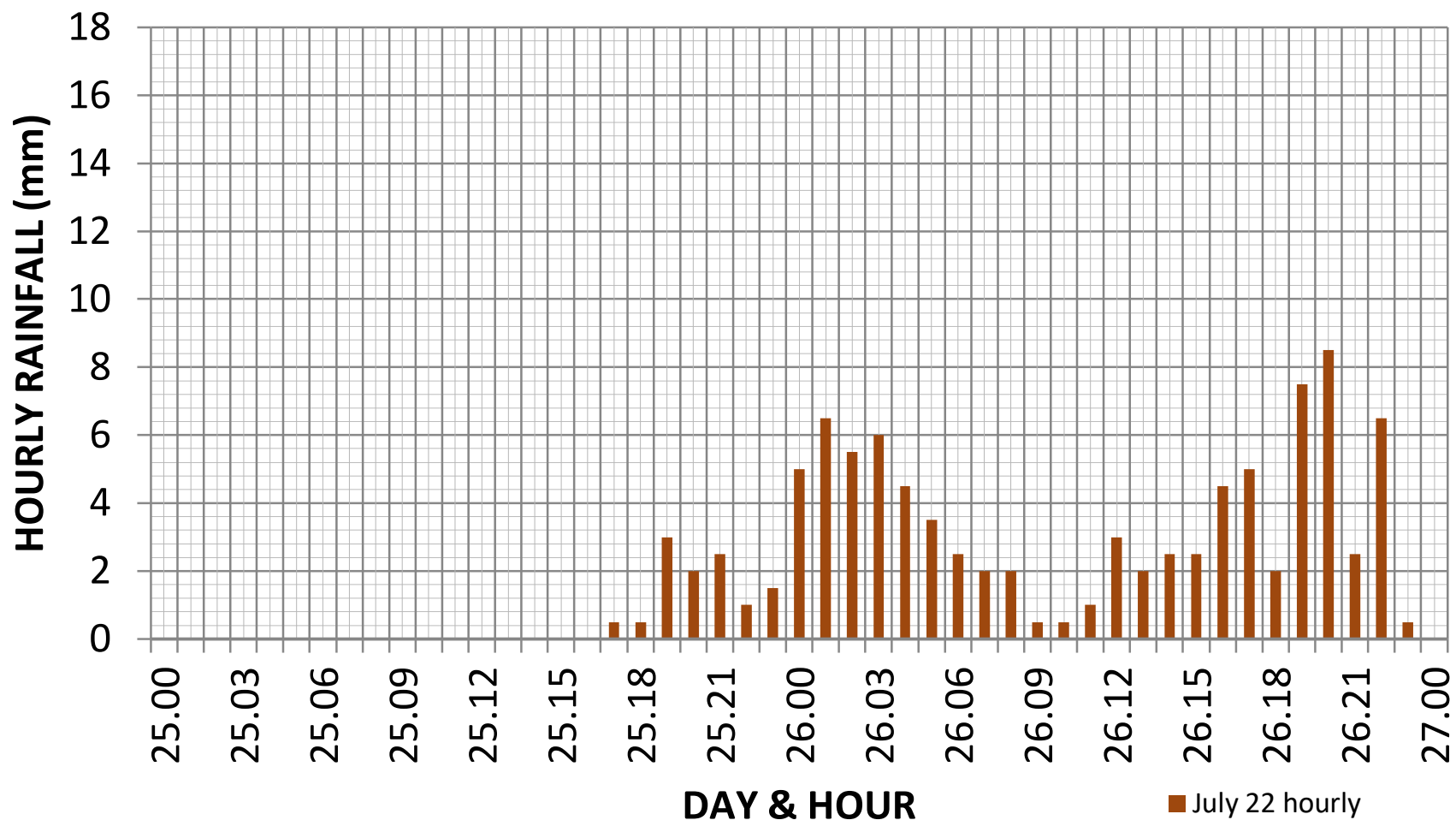
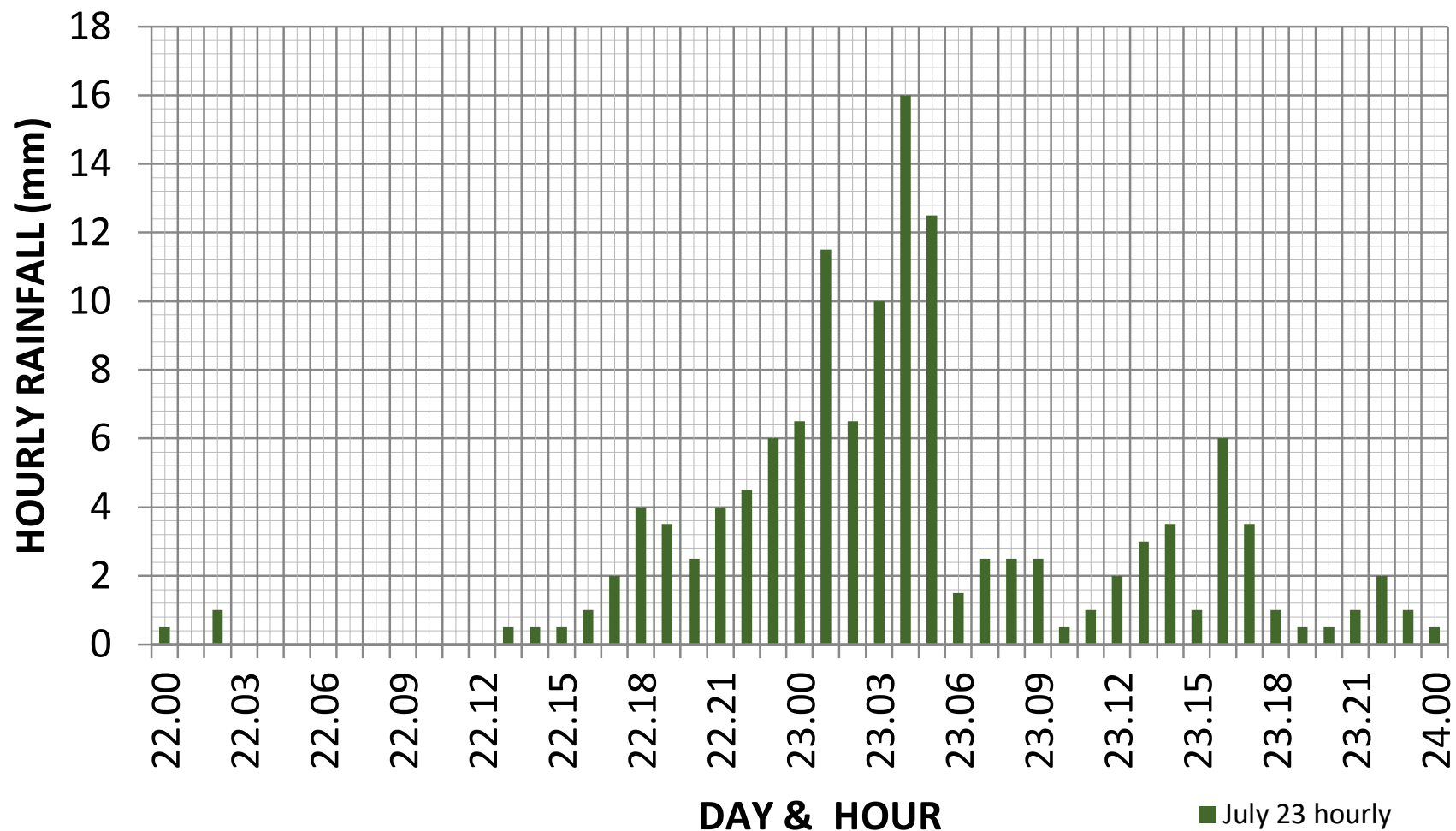


FIGURE A-5

Hourly Rainfall Data from Threlkelds Road Site 323610

22nd - 24th JULY 2023 (Total = 129mm)



APPENDIX B - ADDITIONAL PHOTOS

The following pages show various photos of flooding on the properties. Two videos are also attached in the Zip file.

APPENDIX B - PHOTOS OF FLOODING - JULY 2022 & JUNE 2014 - 336B&C WHITES ROAD

The following photos show some of the flooding that occurred in July 2022 and June 2014.

JULY 2022



OHOKA STREAM SOUTH BRANCH - FLOODING INTO 336B & NEIGHBOUR'S PROPERTY



GENERAL FLOODING



FLOODING DEPTH ~ 190mm



SUMP - HEIGHT 810mm



SUMP ALMOST SUBMERGED DUE TO FLOODING FROM OHOKA SOUTH BRANCH
(WATER DEPTH > 750mm)

JUNE 2014

The following photos show the flooding on June 2014 when the rainfall recorded at the Cust Main Drain site was 53mm on the 9th June and 79.5mm on the 10th June. (i.e. 48 hour total 132.5mm.) It is noted that some of these photos were taken **after** the peak of the flooding. The rainfall was 75% of that used in the model. Was the 2014 event classified as a 1 in 50 year event ? There seems to be no evidence of that being the case.



FLOODING JUNE 2014





OHOKA SOUTH BRANCH - BRIDGE SUBMERGED



'CLOSE UP' OF SUBMERGED BRIDGE IN OHOKA SOUTH BRANCH



FLOODING DUE TO OHOKA SOUTH BRANCH OVERFLOWING THE BANKS



FLOODING ADJACENT TO SOUTH BRANCH



ANOTHER VIEW OF FLOODING AT 336 & 336B WHITES ROAD, ADJ SOUTH BRANCH



ANOTHER VIEW OF THE SAME AREA



SOUTH BRANCH SHOWING FLOODING IN PROPERTY TO THE SOUTH OF 336B



WATER FLOWING INTO SOUTH BRANCH FROM ADJACENT PROPERTY TO THE SOUTH



OHOKA SOUTH BRANCH SHOWING THE AFTER EFFECTS OF FLOODING.

APPENDIX C - METSERVICE RAIN RADAR VIDEO 22nd & 23rd JULY 2023

A video showing the rain event in July 2023 is included in the Zip file sent with this document. This shows the rain coming from the east. As has been noted by NIWA the weather patterns have changed with increasing rain events coming from the north east. The origin of these systems over warmer water results in higher moisture content than occurs with colder southerly systems which used to predominate.

(The video was to be embedded in the pdf but that proved to be unreliable.)

APPENDIX D - UNCERTAINTIES IN FLOOD RISK ASSESSMENTS

The following document prepared by Professor Matthew Wilson highlights the uncertainties involved in predicting future rainfall events.

On 1 July 2025, NIWA merged with GNS Science to become Earth Sciences New Zealand



Explainer: Uncertainties in flood risk assessments

University of Canterbury's Professor Matthew Wilson, one of the ~~Mā~~ *Mā te haumarū* *ō te wai* research team, gives us some insight on uncertainty.



Hazards

University of Canterbury's Professor Matthew Wilson, one of the [*Mā te haumarū*](#) [*ō te wai*](#) research team, gives us some insight on uncertainty.

Flood risk and other planning practitioners worldwide often use the outputs from flood modelling as part of their decision making. For instance, to determine flood hazard zones, design mitigation measures or assess the potential impacts of climate change on the flood hazard. However, these outputs contain uncertainty, which is not often quantified or characterised, yet can make the decision-making process more challenging and less reliable.

To account for uncertainty, planners may take a precautionary approach, such as adding a freeboard amount to required floor levels in flood zones or designing flood infrastructure such as stopbanks (levees) to a 1% annual exceedance probability (i.e., the 100-year average recurrence interval). However, this approach is questionable in an era of changing risk under climate change. For example, is the freeboard amount used sufficient to prevent serious damage from future floods? Will the area at flood risk increase? Will a current 100-year flood become a 50-year flood in future?

Some of these questions are aleatoric in nature: they will always be present and cannot be reduced. This includes issues such as the internal variability of the climate system, which



implies that even if we had complete information about the future climate state, its chaotic nature means our flood risk assessments will still be uncertain. Other uncertainties are epistemic and are deterministic and subjective; the uncertainty contained in a flood risk assessment depends on how good (or bad!) the data are which are used within the analysis. Improving input data accuracy and model representations should, at least theoretically, reduce the inherent uncertainty in the predictions obtained and is something we always aim for.

Yet, even if we use the best possible data and model representations, uncertainty will still result from a complex combination of errors associated with source data, sampling and model representation. These uncertainties “cascade” through the risk assessment system (Figure 1a), reducing our confidence in any individual prediction and leading to variability in predicted depth and extents across multiple predictions which account for these errors. These uncertainties, here represented as variability in predicted depths and flows, further cascade through to the analysis of flood impacts (Figure 1b). Uncertainty in predicted depths and flows combine with errors from data such as those for buildings and infrastructure, and the statistical models used to quantify damage (e.g., via depth-damage curves). The end result is uncertainty in quantified damage for flood scenario, creating issues for the decision-making processes such as determining whether to invest in improved mitigation measures.

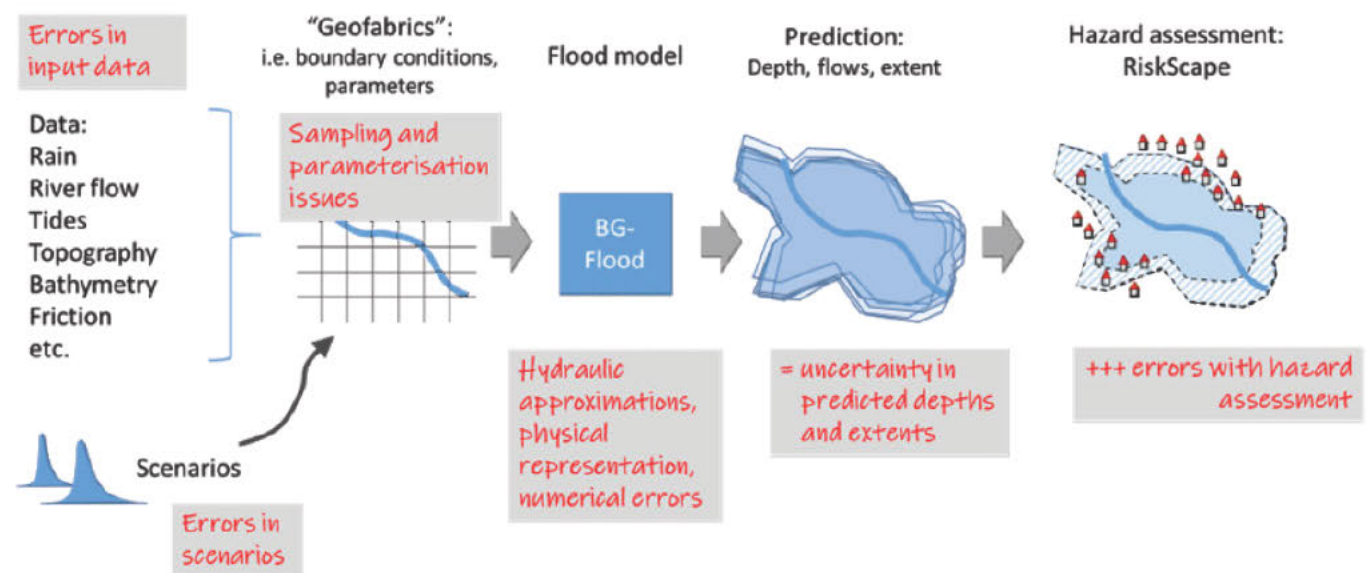


Figure 1(a): Errors from multiple sources “cascade” through the analysis system, resulting in uncertainty in predicted depths and extents and the derived hazard assessment.

This technical uncertainty is situated within social, economic and political contexts. While we wish to reduce uncertainty as much as possible (e.g., by using better data and models), it will always be present. If we do not develop a clear understanding of uncertainty, and communicate this appropriately, then this is likely to lead to doubts in both decision-makers and the wider public.

public. For example, given uncertainty, a decision-maker may question how their decision would be received by others, or what might happen for different options, or whether their action would actually make a difference. The wider public is likely to question what this means for them: if it would flood again soon, if the next flood might be larger, if they should move, if they can get insurance and what happens if they can't.

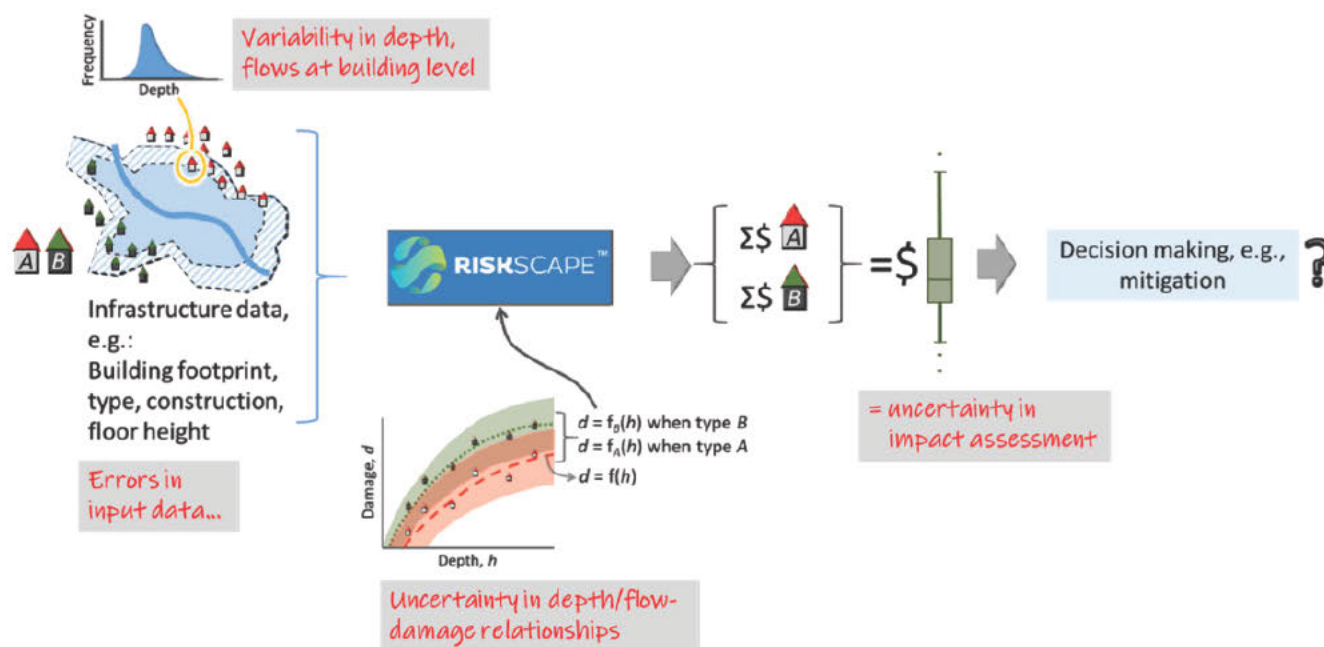


Figure 1(b): Analysis using the uncertain hazard assessment creates a further cascade, leading to uncertainty in the impact assessment and causing issues in decision making.

Although robust assessments of uncertainty would clearly be helpful, the need to run many thousands of simulations leads to a high computational demand and, consequently, they are not usually completed, especially at a national scale. In this research programme, one of our current PhD projects is developing a generalised uncertainty estimation method using machine learning which will enable rapid estimation of the reliability of flood risk estimates for sites, without the need to complete a full uncertainty analysis. A second PhD project is investigating the feasibility of using a hybrid hydrodynamic/ machine learning model to reduce the numerical modelling load and enable probabilistic modelling, to increase the number of scenarios which can be assessed, thereby enabling us to quantify uncertainties caused by our representation of storm rainfall. We will be soon be advertising a third uncertainty PhD project, which will focus on the implications of uncertainty in impact assessments on the planning process.

Further, we are engaging with regional and district councils regarding how we may best represent uncertainty within the maps and data outputs produced. If you are interested in engaging in this or any aspect of this important but challenging problem, please reach out to the project team.

