IN THE MATTER of the Resource Management Act 1991 ("RMA" or "the Act")

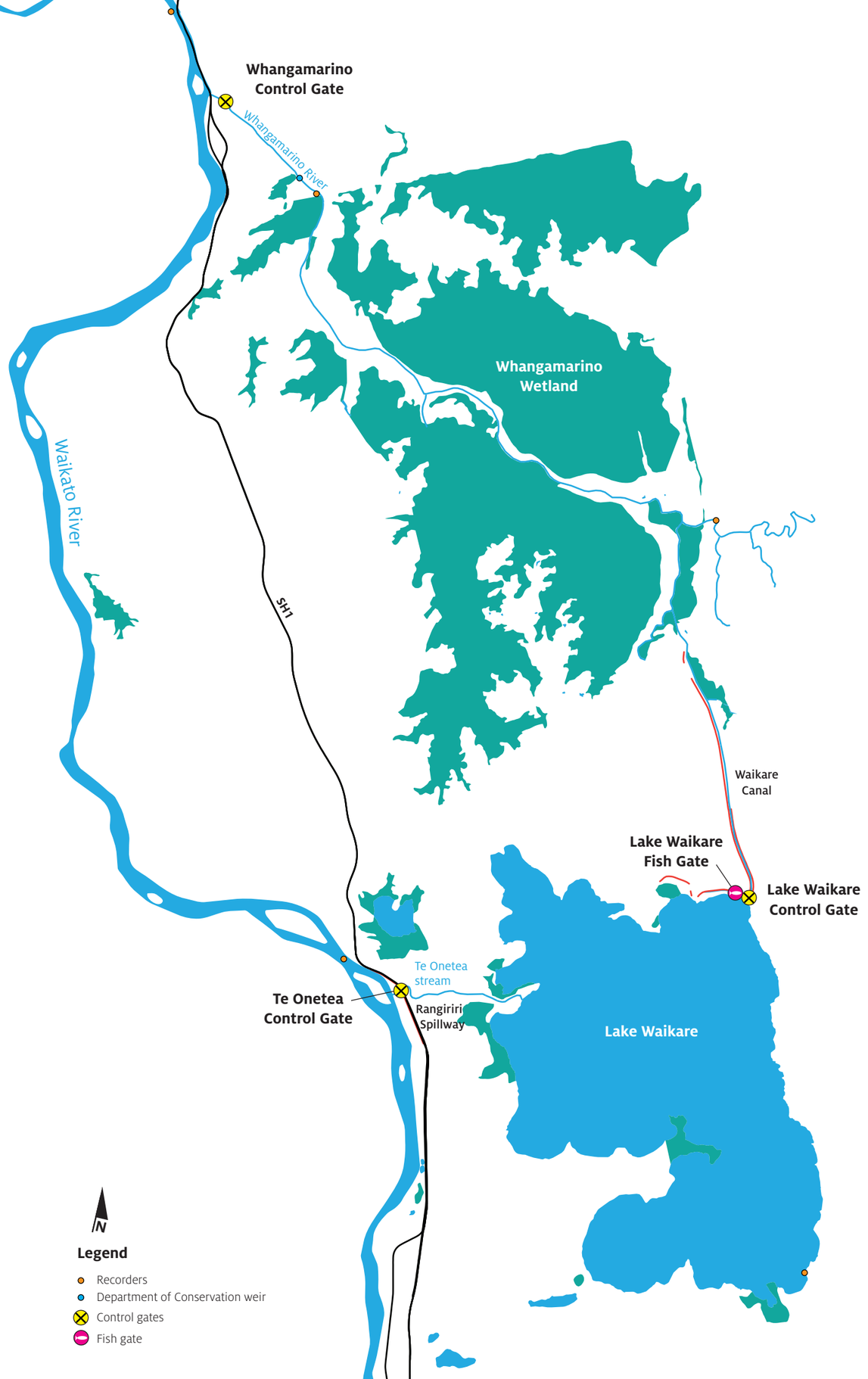
AND

IN THE MATTER of a submission in respect of the **PROPOSED WAIKATO DISTRICT PLAN** by **AMBURY PROPERTIES LIMITED** pursuant to Clause 6 of Schedule 1 of the Act

EVIDENCE OF AJAY DESAI
ATTACHMENTS

ATTACHMENT A

COMMUNITY GATE OPERATION PROCEDURES DIAGRAM



TE ONETEA GATE OPERATION

Action is determined primarily by the relationship between the Waikato River level at the gate and the Lake Waikare level.

Situation	Action
Waikato River level is below Lake Waikare Levels	Te Onetea gate will be closed
Waikato River level is above Lake Waikare Level but below RL 7.00 metres	Te Onetea gate will be open
Waikato River level is above Lake Waikare Level and above RL 7.00 metres	Te Onetea gate will be closed

WAIKARE GATE OPERATION

Action is determined by the relationship between the Lalce Level and the appropriate seasonal Target Level.

Season	Action
April 1 to September 30 RL 5.50 metres	Gate opening/closing levels and apertures are to be set with the objective of keeping the Lake level between RL's 5.40 and 5.60 metres.
October 1 to December 31 RL 5.65 metres	Gate opening/closing levels and apertures are to be set with the objective of keeping the Lake level between RL's 5.55 and 5.75 metres.
January 1 to March 31 RL 5.60 metres	Gate opening/closing levels and apertures are to be set with the objective of keeping the Lake level between RL's 5.50 and 5.70 metres.
Situation	**Action**
Whangamarino Gate is closed	Waikare Gate is then closed. Te Onetea Gate is also closed.
Rangiriri Spillway is operating	Waikare Gate is then closed. Te Onetea Gate is also closed.

WHANGAMARINO GATE OPERATION

Action is determined by the relationship between the Whangamarino River Level and the Waikato River Level.

Situation	Action
Waikato River level is above Whangamarino River Level	Whangamarino gate will be closed, unless agreed otherwise by key parties.
Waikato River level is below Whangamarino River Level	Whangamarino gate is opened.

WAIKARE GATE FISH PASS

Situation	Action
Lake is operating under a flood.	Fish pass gate is closed.
Lake is at or below RL 5.40 meters.	Fish pass gate is closed.
Lake is operating in normal range.	Fish pass gate is opened.

Reference: EWDOCS n1348507 v2 Lake Waikare system structures mitigation management plan - Lower Waikato Waipa flood control

ATTACHMENT B

AMBURY DEVELOPMENT FLOOD ASSESSMENT REVIEW REPORT, TONKIN + TAYLOR TO WAIKATO REGIONAL COUNCIL DATED 8TH OF JUNE 2020

Tonkin+Taylor

Job No: 1005528
08 June 2020

Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
Hamilton 3240

Attention: Rick Liefting

Dear Rick

Ambury development flood assessment

1 Introduction

During 2018/19 Tonkin & Taylor Ltd (T+T) was involved in undertaking review work associated with further development (by DHI) of the lower Waikato River model owned by Waikato Regional Council (in DHI, 2020). Because of this involvement, T+T was also asked to conduct review work associated with proposed use of this model to facilitate development analyses for a site near Ohinewai (the "Sleepyhead Estate"). In Figure 1.1 the extent of the river model is shown, together with the approximate location of the Sleepyhead Estate in the wider river system context.

The review work undertaken was aimed only at the flood performance of the proposed development and did not include any review of internal stormwater at the site.

The developer consultant was Woods, who appointed a modeller to liaise with T+T through the review process.

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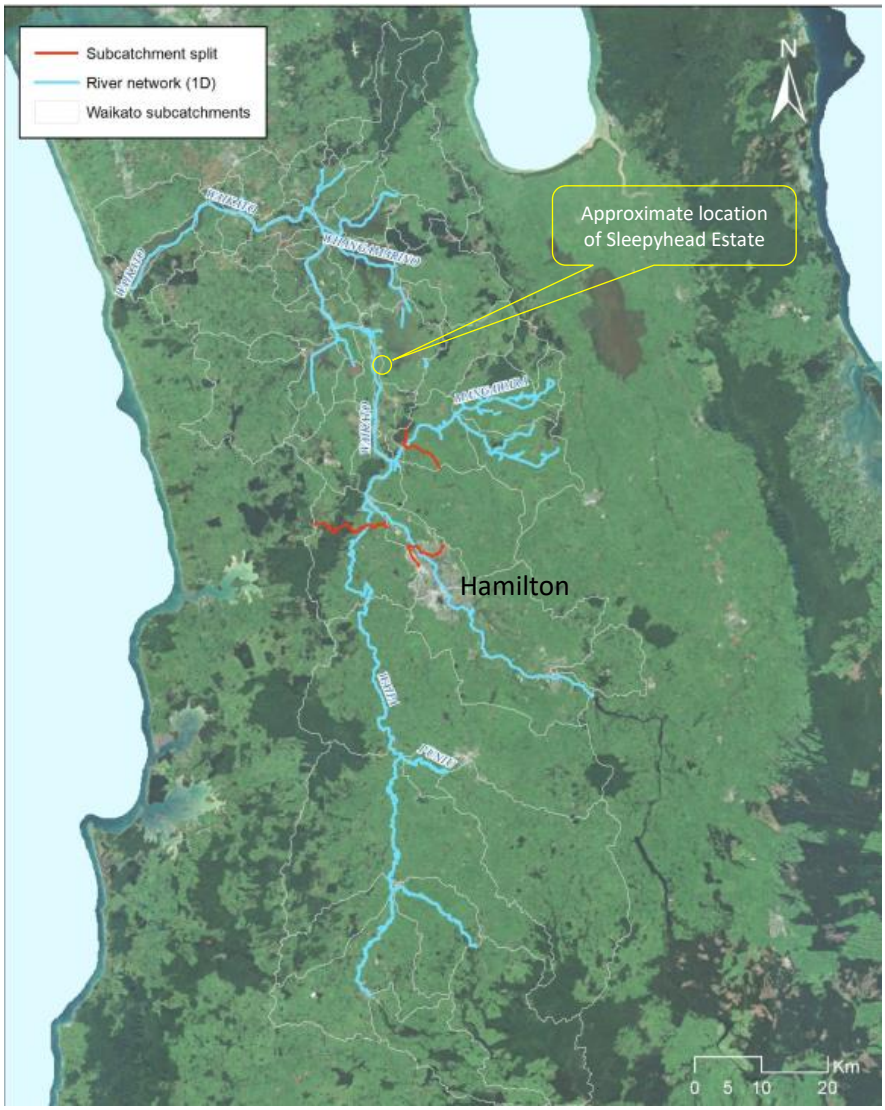

Figure 1.1: Lower Waikato River flood model extents (source: DHI, 2020)

2 Modelling approach adopted

Due to the Sleepyhead Estate site being located close to the Waikato River, it was initially proposed that the WRC river model would be needed to conduct the flood assessment. To this end, WRC provided Woods with a copy of the model, which has wide extent as shown in Figure 1.1. Through discussion, Woods reduced the size of this model to be manageable in the context and scale of the development site, and agreement was reached in how this could be done to preserve technical detail. The resulting model domain is shown in Figure 2.1. This figure also shows some of the relevant model elements, initially deemed necessary to the flood assessment.

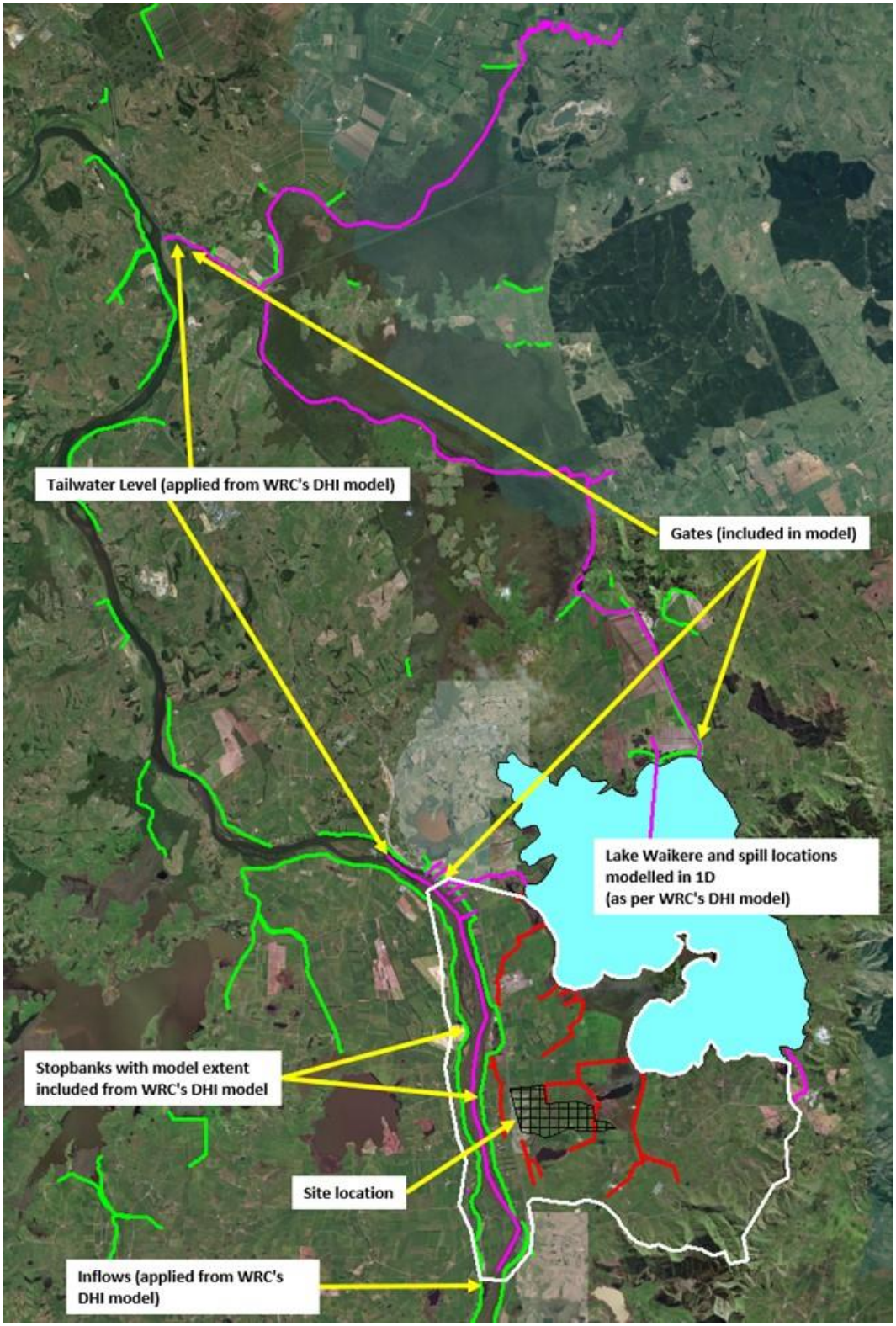

Figure 2.1: Reduced model extent (Woods, 2019)

The agreed approach (between T+T and Woods) was to apply boundaries from the DHI model at the upstream and downstream extents of the reduced model. This reduced model could then be used to simulate the effects of the proposed development on wider area flooding under several design event scenarios.

2.1 Flood scenarios

DHI provided model results for a 1% Annual Exceedance Probability (AEP) event, for three different climate change scenarios (these were present-day, future RCP6.0 and future RCP8.5). DHI were also asked to run the model for three additional RCP6.0 events, of 50%, 20% and 10%AEP.

Through the model development process, it was identified that two key parameters in the WRC model must be taken into account for the development. These were:

- The flood response (water level) in Lake Waikare during a flood, as this poses a backwater effect on drainage from the proposed development.
- The flood response in the Waikato River adjacent to the site, as this may cause stopbank breach that could affect the site.

The local drainage network collects stormwater from the local catchment and discharges into Lake Waikare. Under flood conditions, river flooding and associated lake levels would overwhelm/inundate the network regardless of the development. Given that the model was developed for the purpose of extreme flood assessment, there was no need to include the local drainage network.

Key outputs from the model related to assessment of the effect of the proposed development on flood levels in the immediate vicinity.

2.2 Lake Waikare flood levels

WRC (2020) provided information on lake operation and history of the flood control scheme. In Figure 2.2 the flood scheme elements are shown. Lake Waikare was designated as a flood storage lake since the early 1960's when the Lower Waikato – Waipa Flood Control Scheme was initiated. Since 1965, the lake level has been lowered and controlled within a specific range to ensure availability of flood storage for a Waikato River 1% AEP flood. This was achieved by isolating the lake from the river to the west and from the Whangamarino catchment to the north[1]. This isolation was achieved by constructing a stopbank along the river to contain the 1% AEP flood with 600 mm freeboard, and by constructing a stopbank along the northern foreshore of the lake at an assessed 1%AEP lake level plus 600 mm freeboard. The flood storage required was assessed to be approximately 77 million cubic meters, a volume that would raise the lake level from an average level at the start of the design 1% AEP event of 5.65 mRL (MVD53 datum) to 7.37 mRL at the end of the event[2]. Following this assessment, the northern foreshore stopbank was constructed to a crest elevation of 8.0 mRL.

It should be noted that additional lake storage capacity between 7.37 mRL and 8.0 mRL is assessed to be 42 million cubic meters[3]. While no modelling of climate change scenarios have been undertaken, a conservative approach of increasing spillway flows by 30% could add 14.4 million cubic meters to the Lake. This could raise the lake level from 7.37 mRL to 7.65 mRL, which is still 0.35 m below the crest elevation of 8.0 mRL. The reason for adopting the conservative level of 8.0 mRL is to allow storage for the unlikely event of a large scale breach/ wash out of the Eastern

[1] In its natural state, the Lake was connected to the Waikato River by Te Onetea and Rangiriri Streams, and Lake levels rose and fell with the river levels. The farmland properties between the river and lake flooded regularly on annual basis included SH 1. The natural sill along the Lake's northern foreshore, which had an average level of 6.50 m RL was also overtopped annually discharging into the Whangamarino wetland.

[2] Lower Waikato Waipa Flood Control Scheme Review, Part A – Hydraulic/Hydrological Evaluation, Waikato Valley Authority Technical Report N0. 25 1983.

[3] Lake Waikare Storage Volumes, May 2004, Discovery Marine Surveyors, WRC Document No. 2227930

Stopbank upstream of the Spillway, in which case an uncontrolled flow could be diverted into the lake.

Other than the direct rainfall on the lake surface and its natural catchment runoff, the lake inflows and outflows are controlled as follows:

1 Lake inflows from the Waikato River:

a Te Onetea Control Gate

- Te Onetea Stream joins Lake Waikare with the Waikato River approximately 1.0 km south of Rangiriri village. The stream flow is throttled by a (1.8 m x 1.8 m) box culvert under SH 1, and runs approximately 2.4 km to discharge into Lake Waikare's western foreshore. The Te Onetea Control Gate is installed at the culvert inlet structure to control inflow when the Waikato River level is above lake level. The gate is closed to prevent lake outflows to the river when river level is lower than lake level. The control gate operation is authorised by Consent and the rules of operation aim at allowing flows from the Waikato River into the lake for lake level control and environmental benefits. Note that Te Onetea Stream Gate is closed when river level reaches 7.0 mRL.

b Rangiriri Spillway

- Rangiriri spillway is 1.2 km long and has been constructed within the stopbank that separates the Waikato River from Lake Waikare. The spillway crest elevation is set at a river level (8.8 mRL to 9.2 mRL) that equates to around 2% AEP flow of 1,350 m^3/s. When this flow is exceeded, flow is diverted over the spillway, across SH 1 into the lake. The total diverted flow volume in a design 1% AEP flood event has been assessed to be approximately 48 million cubic meters.

2 Natural lake inflows:

a Lake surface

- The lake surface area is approximately 35 km^2 at 5.6 mRL and increases to approximately 60.0 km^2 at 8.0 mRL. The 3-day rainfall depth for 1% AEP design event has been assessed to be 180 mm. This depth is added directly to an assumed starting lake level of 5.65 mRL, and on its own can raise lake level to 5.83 mRL.

b Lake catchment

- The lake catchment is approximately 181 km^2, with approximately 80% of the catchment contributing runoff to the Matahuru Stream that discharges at the south eastern end of the lake. The volume of catchment runoff in the design event was assessed to be 29 million cubic metres, including the Matahuru base flow over an 8-day period. While this period is longer than the rainfall event duration, this is the time that it typically takes for the Waikato River level to adequately drop to the point at which time stored water within the lake can be released back into the river via the Waikare Control Gate.

3 Lake outflows:

a Waikare Northern Outlet Control Gate (Waikare Gate)

- The Waikare Gateis located at the north eastern edge of Lake Waikare within the northern foreshore stopbank. The gate is operated to control lake levels within a specific seasonal range (between 5.4 mRL and 5.75 mRL). The operation of this gate is authorised by Consents with the aim of maintaining lake levels within the range, so that adequate storage for a design flood described above is available at all times. The operational rules require the Waikare Gate be closed during a flood event. Flood conditions are generally described as Waikato River levels being above 7.0 mRL at Te Onetea (eg. Te Onetea Gate is closed), above 4.0 mRL at Whangamarino River outlet

south of Mercer. Above this level the Waikato River is able to flow back into the Whangamarino wetland (eg. Whangamarino Control Gates are closed).

b Waikare Northern Foreshore Spillway

- The Waikare Northern Foreshore Spillway is a 73 m long spillway set at 7.36 mRL (eg. 1% AEP design flood level of the lake) is located at the western end of the northern foreshore stopbank. Under extreme flood conditions in excess of 1% AEP, the Waikare Gate remains closed, and the spillway is designed to divert water from the Lake into the farmland to the north and eventually into the Whangamarino wetland. The spillway overflow is limited and lake levels would continue to build up until it exceeds 8.0 mRL, at which time overflow from the lake can potentially occur across the northern foreshore stopbank. It should be noted that a flood event that causes the lake to be filled up to elevation 8.0 mRL would be catastrophic in that most of the area from Huntly to Tuakau would be inundated. No specific modelling of such a scenario has been undertaken. However, the flood scheme is designed so that the areas along the left bank (western side) of the river will be overtopped first, mainly to protect SH 1 and small urban settlements along it.

Note that all technical information relating to the Lower Waikato flood control Scheme including stopbanks, spillways, control gates, system and assets design, and operational requirements has been collated from WRC asset information system and operational documents.

Because of this behaviour, it was found that use of the hydraulic model was not needed for tailwater effects assessment on the proposed development. Furthermore, internal stormwater management would be undertaken to ensure that runoff from the proposed development would not enter Lake Waikare at a rate higher than it would from the undeveloped land.

By the above argument it was found that the model, initially provided by WRC and then reduced in extent by Woods, would not be required for effects assessment, including projected impacts of climate change on future lake levels

WRC has requested Woods undertake a volume based assessment on projected climate change water levels for Lake Waikare.

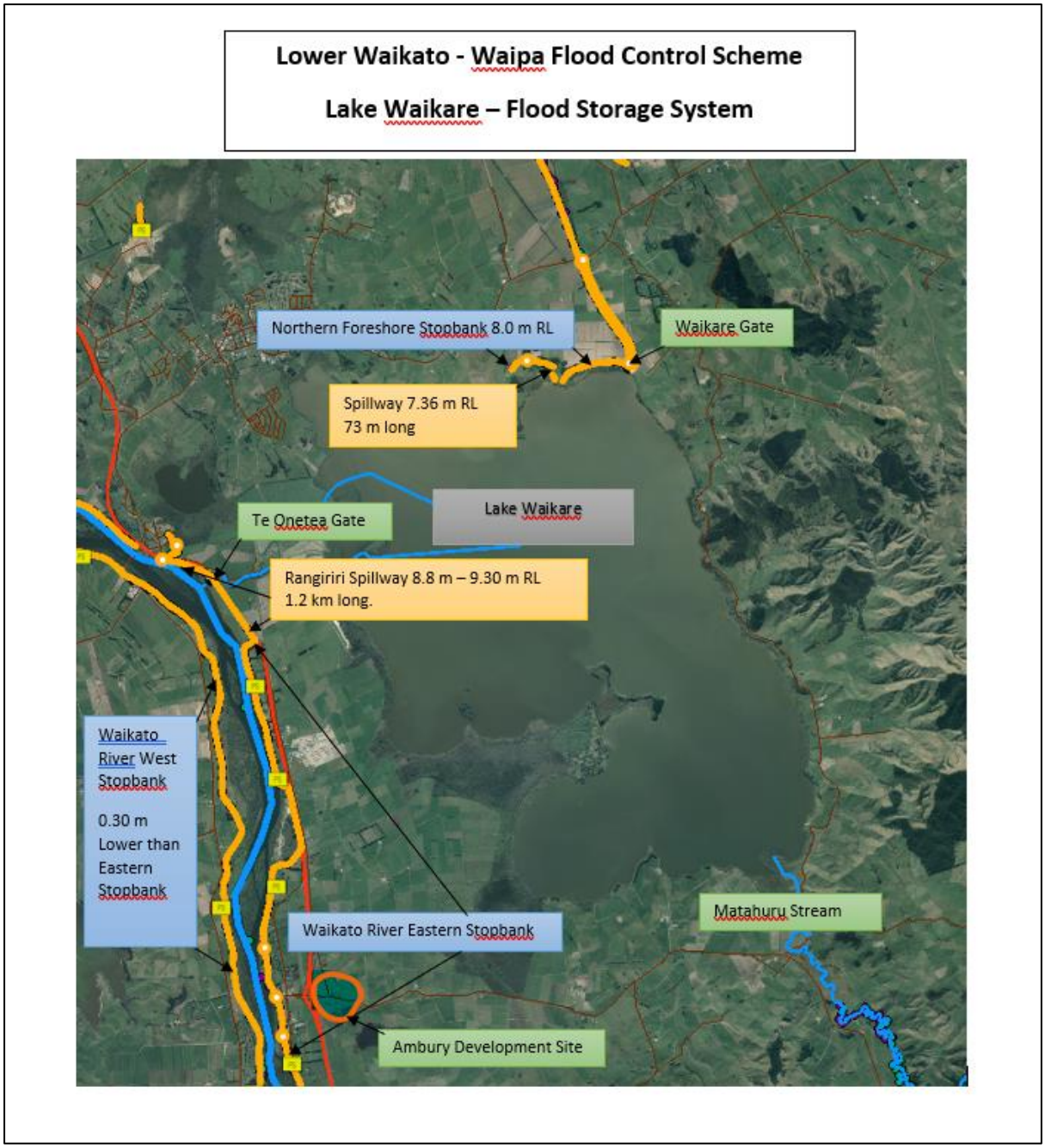

Figure 2.2: Lower Waikato – Waipa Flood Control Scheme at Lake Waikare (source: WRC 2020)

2.3 Stopbank breach

Two potential stopbank breach locations were identified that could have effect on the proposed development. These sites were selected based on several factors, including the following:

- Maximum water level differential across the stopbank (from inside to outside);
- Breach location relative to the subject site.

Breach locations were confirmed with WRC river engineers. In order to simulate the effects of stopbank breach, the peak 1%AEP river level (of 10.20 mRL) was applied as a steady state boundary to a breach scenario model. This breach scenario model was developed based only on the Digital Elevation Model (DEM) covering the land between the river and Lake Waikare. A tailwater level of 8.0 mRL was applied at Lake Waikare.

The breach simulations showed that unsafe conditions were not reached anywhere within the proposed development site.

3 Resilience considerations

Work undertaken by Woods, with review input undertaken by T+T for and on behalf of WRC, has demonstrated the following, with respect to the proposed development at Sleepyhead Estate:

- The proposed development is unlikely to have any effect on flood levels in the immediate area of the development;
- The proposed development will not increase water levels in Lake Waikare under flood event conditions;
- The proposed development will not be subject to a flood hazard from the Waikato River system;
- Under possibly stopbank breach scenarios, unsafe conditions will not be attained within the proposed development.

As a result of the above, the proposed development is unlikely to create new flood hazards not already present prior to development. Overall resilience in terms of flood related hazards will therefore not be adversely impacted by the proposed development.

WRC has requested Woods to provide proposed cut and fill volumes to better quantify likely impacts.

4 Applicability

This report has been prepared for the exclusive use of our client, Waikato Regional Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Mark Pennington	Glen Nicholson
Water Resources Engineer	Project Director

MSP
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5 References

DHI (2020), *WRC Lower Waikato 2D Modelling: Huntly, Ohinewai and Horotiu Model Build*, report prepared for Waikato Regional Council, February 2020.

Woods (2019), Personal communication between Ajay Desai (modeller for Woods) and Mark Pennington (reviewer from T+T for and on behalf of Waikato Regional Council). This personal communication was recorded in a series of emails and meeting minutes, collected between August and December 2019. Some of these communications have been included as Appendix A.

WRC (2020), *Pers. Comm. With Ghassan Basheer, Principal Technical Advisor, Regional Resilience, Integrated Catchment Management, Waikato Regional Council.*

Appendix A: Meeting minutes

ATTACHMENT C

QUANTIFICATION OF THE LOSS IN FLOOD STORAGE COMPARED TO THE TOTAL STORAGE AVAILABLE WITHIN LAKE WAIKARE

To

Mercury Energy
Fraser Graafhuis
Level 3/17 Grantham Street
Hamilton 3204

From

Woods
Ajay Desai – Stormwater Modeller
Pranil Wadan - Principal Engineer

W-REF: P19-140
13 February 2020

Memorandum

88 Lumsden Road/231 Tahuna Road – Stormwater Modelling process adopted

This memo has been written to summarise the stormwater modelling undertaken to prepare the Flood Assessment Report to support the proposed development at 88 Lumsden Road and 231 Tahuna Road. Both addresses are part of the development site held by the New Zealand Comfort Group (NZCG). The proposed development site lies to the east of the Waikato Expressway and the Waikato River. The site location is indicated in green in Figure 1. The site is located to the east of the stop banks along the Waikato River.

NZCG are intending to develop both sites to include light industry, factory outlet shops, a service centre and community focused shops/activities and a medium density residential development.

The flood modelling strategy was formulated to understand the risk of flooding to the proposed development and quantify the effects of development on the water levels on neighbouring sites and receiving environment.

Following on the previous meeting with Mercury and in addition to the technical memo provided, we have produced this memo explaining the revised approach which was necessary as their technical issues with WRC's Waikato River model that was to be used for this assessment.

1. Model and Development Extents

The proposed development and area downstream towards Lake Rotokawau and Lake Waikare falls under the Lower Waikato Zone Management Plan designed to provide protection with floodplains of Lower Waikato and Waipa rivers. The assets related to Lake Waikare include Lake Waikare Control Gate, Te Onetea Control gate, Rangiriri Spillway, Whangamarino Control Gate and Wool Scourers to Fosters Landing Stop bank (along River Waikato near Rangiriri Spillway).

Based on the gate operation procedures provided by WRC, Lake Waikare Control Gate operates between 5.4mRL and 5.7mRL based on seasonal variations and Te Onetea Control Gate would be closed when water levels within Lake Waikare exceed 7mRL suggesting there would be no interaction between Lake Waikare and River Waikato above 7mRL.

The Waikare spillway operates when the levels in Lake Waikare exceed 7.37 m as detailed in the Lower Waikato Zone Management Plan and as confirmed by WRC's Technical Reviewer, the maximum water level that the Lake can achieve before the spillway along the north is operative would be ~8mRL.

The proposed development is approximately 1.79sq. km (179ha.) and accounts for approximately 0.86% of the total contributing area of 208 sq.km (20800 ha.) to Lake Waikare. The proposed development discharges to Lake Rotokawau which ultimately drains to Lake Waikare.

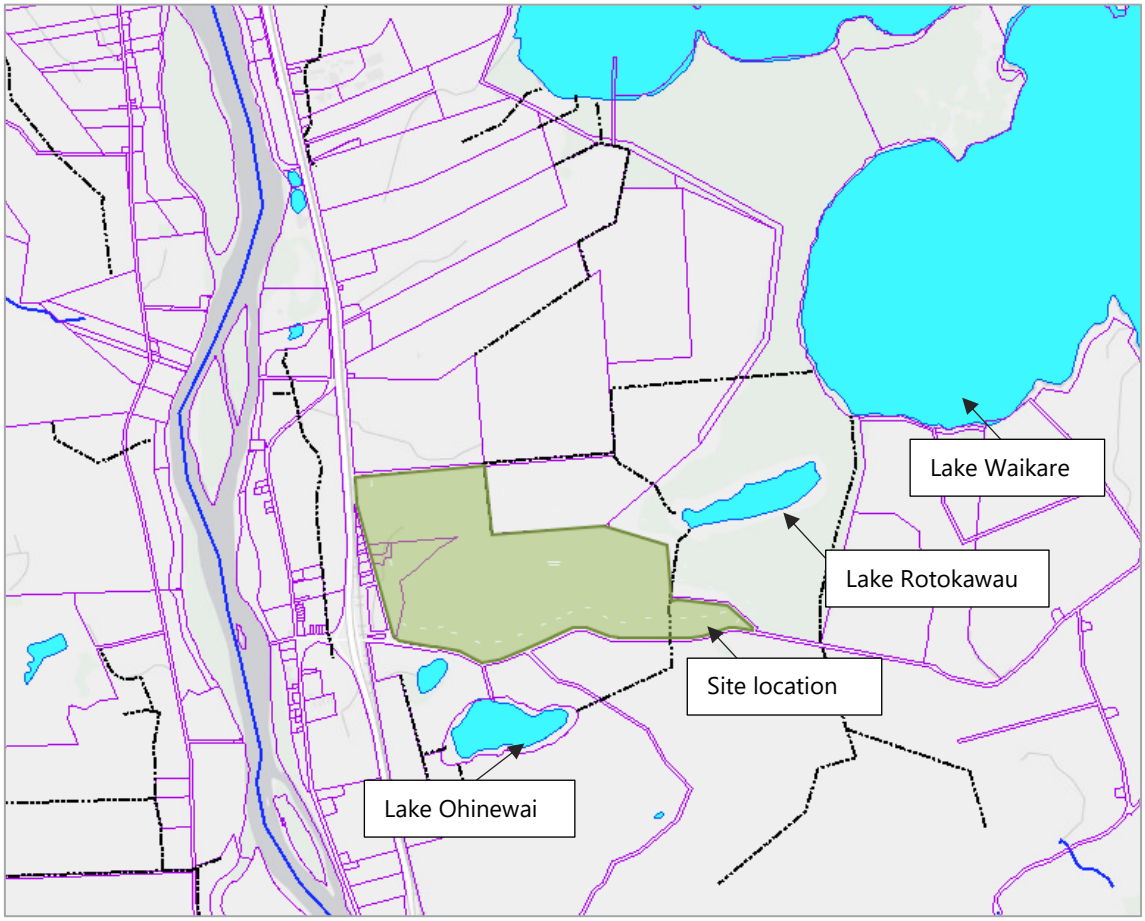


Figure 1: Site location

2. Modelling approach adopted

2.1. WRC's Waikato River Flood Hazard Model

The Flood Hazard Model (Waikato River Model) prepared by DHI for WRC was provided as a draft by WRC which was studied and considered to be used for this assessment, but significant issues were identified in the model and reported back to WRC.

This issue was related to the peak water level attained by Lake Waikare which was approximately 8.5mRL which is significantly higher than the maximum water level that can be expected which is less than 8mRL as confirmed by the WRC Technical Experts. The model results showed the 100yr peak water level in excess of 8mRL which is above Lake Waikare Spillway level and the storage at Lake Waikare and Lake Rotokawau was not accounted for.

This was discussed with WRC's Technical reviewer and confirmed as inappropriate. Based on above criteria it was agreed to develop a local model for Flood Assessment and use a conservative water level of 8mRL for Lake Waikare where the proposed site discharges.

It was also agreed that the River model be used for extracted necessary data to understand the stop breach assessment to highlight risk to the proposed site from stop bank failure.

2.2. Model Build process and key parameters

2.2.1. Model Extents

The model extent has been defined to include all areas contributing to Balemi and Tahuna Drains which discharges to Lake Rotokawau and Lake Waikare. This has been based on overland flow path assessment completed using the LiDAR data provided by Waikato Regional Council.

5Based on the direction given by WRC, 8mRL water level was used as downstream tailwater levels for the Flood Assessment. In discussion with WRC, the local model developed using Mike by DHI which would enable them to incorporate the model and associated results within the River Waikato model when reviewed and signed off.

Modelling was based on data provided by WRC including the draft River model and latest DEM data and incorporated all the discussions/agreements made between Woods and WRC's Technical Reviewer. All model scenarios were agreed with WRC and peer reviewed by their Technical Reviewer throughout the process. Approach is based on the SCS Unit Hydrograph method, as specified in the Waikato Stormwater runoff modelling guidance (TR2018/02).

Modelling uses HiRDS v4 RCP6.0 rainfall depths as suggested by WRC and a normalised 24-hour temporal rainfall and profile has been adopted as specified in TR2018/02. Rainfall depths corresponding to RCP6.0 for the period 2081-2100 were uplifted with allowance for Climate Change instead of the historic rainfall depths as a conservative approach.

2.2.2. Stop breach scenario (Emergency Management Plan)

Stop bank breach assessment was completed to understand the flood risk to the proposed development from river flows. The draft results from River Waikato model was reviewed and used to ascertain the maximum water level that the river may reach which would be highly conservative knowing that there are inconsistencies between the real-life assets and the model data.

This assessment involved running a steady state analysis for 24hrs with the maximum water level of 10.2mRL and 8.0mRL applied along the River and Lake Waikare respectively with a 30m to understand risk with overland flow paths directed towards the proposed development.

2.2.3. Lower tailwater level scenario

Additional modelling was completed outside of the agreed scenarios with WRC to understand if there are any flood risk of the proposed development on the receiving environmental when the Lake Waikare has a water level within its regular operating level of 5.4 – 5.65mRL which would be a lower tailwater level to represent an everyday scenario in addition to the conservative approach scenarios modelled.

WRC are kept involved and informed throughout the project as Woods are working collaboratively with Mark Pennington who has been appointed as the reviewer by WRC.

3. Modelling Results

3.1. Effects assessment modelling

The model results indicate that there is no increase in water levels or flood extents in neighbouring properties with the proposed development in comparison to the pre-development model except for one overland flow path around Lumsden Road which exhibits some ponding. This is caused by the model representation in this area which does not include the culvert under the existing road. This results in 'no flows' through the culvert and flows backing upstream with no downstream conveyance. This culvert under Lumsden Road will be addressed at detail design stage and designed to maintain the predevelopment flood levels.

The flood extents and water levels are governed by the water levels within Lake Waikare and Lake Rotokawau with no increases accounted from the proposed development. This can be confirmed with the model runs completed with water levels of 8mRL as well as 5.4mRL for Lake Waikare.

3.1. Stop bank breach modelling

The Stop bank breach scenario model showed flooding along State Highway 1, North Island Main Trunk railway and all properties along Ohinewai North Road and Ohinewai South roads leading towards the proposed development.

Proposed roads to be clear of any flooding which would assist in the evacuation from the factory site and there is no risk of flooding to the residential and commercial zones.

An assessment of the proposed depths and velocities against the Austroads Floodways Safety Criteria shows that the north western property boundary around the factory is not trafficable by large passenger vehicles. Safe egress from the site is possible to the south of the site, which remains unaffected in the breach scenario.

It is proposed that evacuation plan will be drafted at detailed design of the factory to ensure that employees are provided safe egress to higher ground.

4. Lake Waikare Storage and Flow Analysis

4.1. Storage Analysis

Table 1 gives the comparison of the displacement volume for the proposed development against the total storage within the area contributing area of Lake Waikare (includes storage within Lake Waikare but does not include storage within Lake Rotokawau – data unavailable). This suggests that total storage lost in terms of volume is less than 0.5% for extreme events (100yr with Climate Change and higher) and no loss in storage at operating level for Lake Waikare as per the gate operation procedures.

Storage within the contributing area to Lake Waikare is calculated using the LiDAR DEM provided by WRC and cross-sectional storage area provided by the River Waikato model.

Table 1: Storage analysis

Flood Level	**Displacement Volume** *(Fill within development area)*	**Storage at level in Lake Waikare** *(provided by WRC)*	**% of storage lost**
mRL	**m^3**	**m^3**	
5.4	200.0	47159005.4	0.00%
5.65	550.0	55874866.7	0.00%
6.3*	**47300.0**	**81992353.7**	**0.06%**
7.0	236500.0	117670811.4	0.20%
7.27	352400.0	132618795.7	0.27%
7.37**	**400700.0**	**138275873.1**	**0.29%**
8.0	783000.0	175157224.6	0.45%

**Between 11-20 July 1998, Lake Waikare steadily increased from 5.60m to peak at 6.29m, highest recorded flood level*

***The design flood level of the Lake Waikare/Whangamarino Wetland Gate Settings scheme (when lake floodwaters actually flow over farmland and into the wetland) is 7.37m*

4.2. Time of concentration analysis

The time of concentration for local storm runoff was compared against the time to peak from the upstream contributing area based on SCS Unit Hydrograph method, as specified in the Waikato Stormwater runoff modelling guidance (TR2018/02). The analysis used the following approach –

- time of concentration for the flows from the development would be less than 10minutes as it is located immediately upstream of the receiving environment, i.e. Lake Rotokawau / Lake Waikare
- Simplistic calculations for time of concentration from the two catchments discharging to Lake Waikare is tabulated below

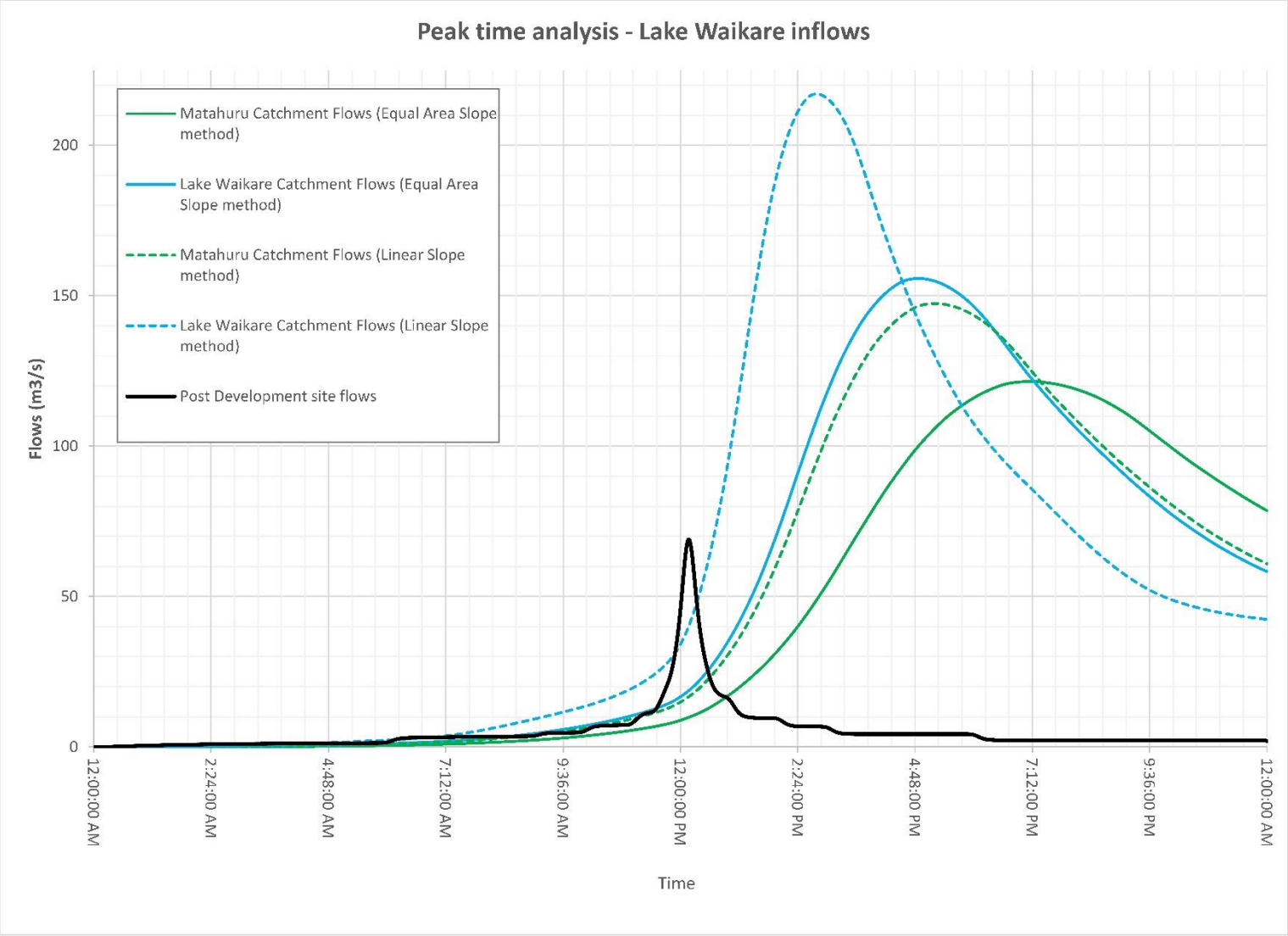
Table 2: Time of concentration calculations

Contributing Catchment	Notations (units)	Matahuru Catchment	Lake Waikare catchment
Area	**A (ha)**	10335	10480
Catchment length	**L (km)**	18.9	7.87
Catchment Slope (Equal Slope Area method)	**Sc (m/m)**	0.008	0.004
Catchment Slope (Linear Slope method)	**Sc (m/m)**	0.021	0.023
Initial Abstraction	**Ia (mm)**	0	0
Channelisation Factor	**C**	1	1
Curve Number (assumed)	**CN**	39	39
Time of concentration (Equal Slope Area method)	**Tc (hrs)**	9.2	6.4
Time of concentration (Linear Slope method)	**Tc (hrs)**	6.8	3.7

The general approach is to pass flows forward from the proposed development (1.79 sq. km) before the upstream flows reach Lake Waikare (206 sq. km). Holding flows back could results in coinciding of peak of the storm resulting in higher risk to the proposed development as well as neighbouring properties. Modelling undertaken indicates that flows from this development can be passed forward without impacting on predicted flood levels at Lake Waikare / Lake Rotokawau. This can be seen from Figure 2 below.

The time of concentration for River Waikato (425m long) with upstream contributing area of 14,250 sq km is in the order of 2-3 days, much greater than that compared to the flows discharging directly to Lake Waikare. River Waikato flows contribute to Lake Waikare via Rangiriri Spillway in extreme events and as suggested earlier, best practicable option for Lake Waikare would be pass flows forward to accommodate these spill flows for extreme events.

Figure2: Time of concentration analysis


Peak time analysis - Lake Waikare inflows
Matahuru Catchment Flows (Equal Area Slope method)
Lake Waikare Catchment Flows (Equal Area Slope method)
Matahuru Catchment Flows (Linear Slope method)
Lake Waikare Catchment Flows (Linear Slope method)
Post Development site flows
Flows (m3/s)
200
150
100
50
0
12:00:00 AM
2:24:00 AM
4:48:00 AM
7:12:00 AM
9:36:00 AM
12:00:00 PM
2:24:00 PM
4:48:00 PM
7:12:00 PM
9:36:00 PM
12:00:00 AM
Time

5. Conclusion

Modelling indicates that there is no increase in water levels or flood extents within the proposed site or any of the neighbouring sites. This is a result of total site area within the proposed development (1.79sq. km) being insignificant when compared to the downstream floodplain extents (34.66 sq. km) and the total contributing area to Lake Waikare (208 sq. km).

The loss in storage with fill in the development area within the flood plain based on different levels suggest that these would be negligible when compared to the total storage within Lake Waikare and its contributing area. In addition, pass flows forward would be a more suitable approach for this proposed development, to avoid coinciding of peak of flows from the proposed development and upstream contributing areas. This has been confirmed with the modelling approach adopted to test two tailwater levels for Lake Waikare –

- 8mRL – conservative water level (maximum that the Lake can attain)
- 5.4mRL – minimum water level that the Lake reaches as per WRC's Gate procedures

This local model is the best available tool for testing effects of the proposed development and understanding the flood risk. Further modelling would be needed to further understand the effects and risk using the River Waikato model when available which accounts for –

- storage within Lake Waikare
- performance of Control Gates (under the Lower Waikato Zone Management Plan)
- provides a varying tailwater level applied for the proposed development discharge locations instead of a conservative constant water level as used in the modelling
- appropriate climate change allowance applied to Historic Rainfall depth corresponding to RCP6.0 rather than to rainfall depths corresponding to RCP6.0 for the period 2081-2100

This modelling would be completed at detail design stage when the Final Waikato River model would be available with associated reporting.