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20/07/2023

47 GOLDING ROAD & 50 PUKEKOHE EAST ROAD, PUKEKOHE

FLOOD MODELLING METHODOLOGY

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Development of 47 Golding Road & 50 Pukekohe East Road, Pukekohe | Flood Modelling Methodology

Dear Aedifice Development n.1 Ltd,

Thank you for the opportunity for Civix to provide an Flood Modelling Methodology for the Development of 47 Golding Road & 50 Pukekohe East Road, Pukekohe.

This report details the flood modelling methodology used in the Development of 47 Golding Road & 50 Pukekohe East Road, Pukekohe.

Please do not hesitate to contact us if you have any questions on this report,

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1. Introduction

This document details the flood modelling methodology utilised by Civix in the modelling of flood plains in the Tuflow modelling package. Modelling is completed via ARCGIS Pro. The full TuFlow modelling package for a project can be provided on request for review as required.

The model has been developed for the purpose of demonstrating that the mitigation measures included within the site mitigate the effects of the development. This means that the existing and proposed scenarios are only different in the ways that the development will affect the site, i.e., change in imperviousness within the site and increased efficiency of the drainage network in the site. Changes outside the effects of the development including Climate Change and development of upstream catchment areas are not legally required to be mitigated within the development, this was a principal established in the Queenstown-Lakes District Council v Hawthorn Estate Ltd (2006) 12 ELRNZ 299; [2006] NZRMA 424 (CA) decision.

2. Model Extent

The extent of the flood model has been set to account for upstream, adjacent and downstream hydraulic features including the plan change to the west (Plan Change 76) that could affect the location and extent of flow into, through and out of the subject site. The location of overland flow paths in Council GIS is also taken into account to ensure flow paths entering the site are captured.

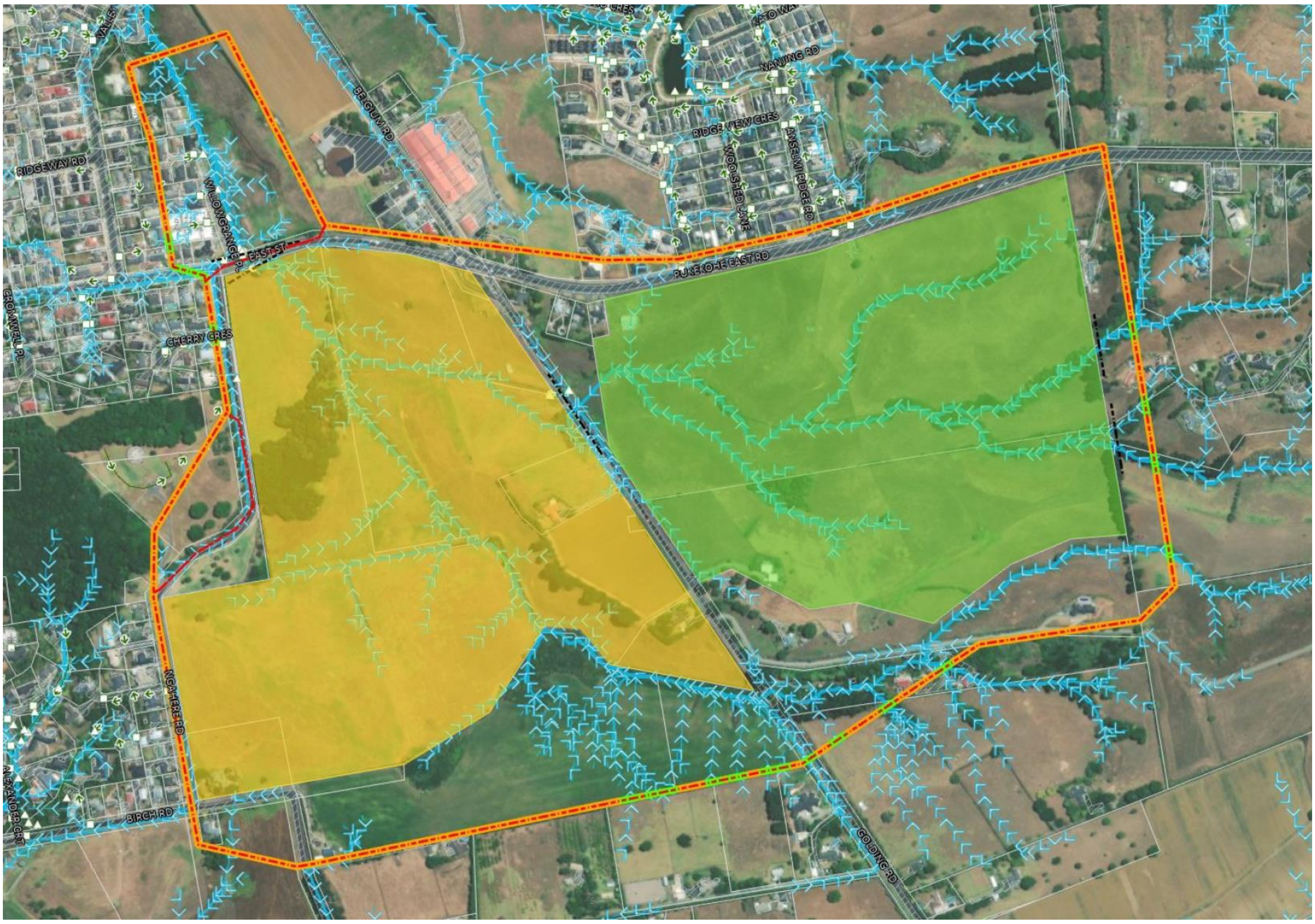


Figure 1 - showing the western Plan Change 76 site (in yellow), subject site (in green) and model extent (in dashed red/orange)

3. Site flows

Site characteristics for the TuFlow modelling are determined based on a Citywide overlay of rainfall depths and soil classifications. The rainfall depths have been found through a linear interpolation for each storm based on the rainfall contour plots in TP108. Rainfall depths are then adjusted for Climate Change to give rainfall depths used in the modelling. Percentage Increase in 24-hour design rainfall depth due to future climate change, assuming 2.1°C increase in temperature is in accordance with Auckland CoP Chapter 4: Stormwater Version 3.0. Below table summarises the rainfall depths used for the site extent.

Table 1: Rainfall depths used for the model

Annual Exceedance Probability (AEP)	Rainfall Depth (TP108)	Climate Change % increase	Rainfall Depth include Climate Change
10%	130 mm	13.2%	147 mm
1%	190 mm	16.8%	222 mm

According to the site geotechnical investigation undertaken by Soil&Rock Consultants (dated March 2022), the soil comprises of a mix of tuff volcanic material as described in Group A (CN=39) and alluvial material as described in Group B (CN=61). The SCS soil classification is then used to determine the permeable curve number of 50 which is the average between the two soil groups found in the site. While a curve number of 98 was used for all impervious areas within the site.

Table 2: Key parameters used in the model for the development site

	Existing Scenario	Proposed Scenario
Rainfall Depth (TP108 – 10% AEP) incl. cc	147mm	147mm
Rainfall Depth (TP108 – 100% AEP) incl. cc	222mm	222mm
Pervious Curve Number	50	50
Impervious Curve Number	98	98
Channelisation	0.8	0.6
Site Imperviousness Percentage	5%	60% (PC76) & 50% (Eastern PC)

Table 3: Demonstrates the total imperviousness of the site

	Area (ha)	Impervious (%)	Impervious Area (ha)	Pervious (%)	Pervious Area
Western Plan Change (PC76)					
Wastewater Pump Station	0.12	100	0.12	0	0
Residential	17.26				
Impervious (Buildings, COALs & Parkings)		70	12.08		
Pervious (Landscape)				30	5.18
Roads	7.28				
Impervious (Pavement)		65	4.73		
Pervious (Berm/Verge)				35	2.55
Drainage Reserve	4.40	0	0	100	4.40
Significant Ecological Area	0.90	0	0	100	0.90
Total Site	**29.96**	**57**	**16.93**	**43**	**13.03**
Eastern Plan Change (subject site)					
Residential	10.20				
Impervious (Buildings, COALs & Parkings)		70	7.14		
Pervious (Landscape)				30	3.06
Roads	5.60				
Impervious (Pavement)		65	3.64		
Pervious (Berm/Verge)				35	1.96
Natural Stream/Riparian	5.40	0	0	100	5.40
Drainage Reserve/Flood Attenuation	5.20	0	0	100	5.20
Open Space Reserve	0.60	0	0	100	0.60
Total Site	**27.00**	**40**	**10.78**	**60**	**16.22**

Refer to Concept Master Plan Drawing A103 for more details on the area classification.

Thus, the proposed impervious coverages have been modelled at 60% of the catchment area for PC76 site while 50% of the catchment area for Eastern PC site. This takes into account the expected development of the Residential Lots (70% impervious cover) as well as the large drainage reserve required. As the 100 year flows are slightly increased in the 100 YR event, any increase in this impervious cover will result in adverse flooding effects downstream. For this reason, we recommend that the residential lots are legally restricted to a maximum of 70% impervious cover to avoid adverse effects on flooding downstream.

4. Upstream Catchment Inflows

The upstream catchment areas are set based on the area accumulation model in the Citywide GIS layer. Catchment lengths are determined through the model designer tracing the catchment length in GIS, this is then draped on the Citywide LIDAR layer and the equal area slope calculated to give the upstream catchment slope.

Soil classifications are determined based on soil mapping information available at Auckland Council and also national datasets. These datasets have been combined to provide an SCS soil classification across the city.

The catchment factors and then used to calculate inflow Hydrographs using the SCS Curve runoff method, as recommended in TP108.

For the upstream catchments, the impervious percentage of 5% has been used in both existing and proposed scenarios which is based on the current upstream catchment condition, i.e., greenfield. All new Greenfields developments upstream of the site are expected to have to comply with the same flood mitigation requirements for this development, which requires peak runoff to be maintained at existing levels, therefore the 5% impervious coverage should be representative of future flows in a Maximum Possible Development (MPD) scenario. As noted in the introduction to this report, the development is only required to mitigate the effects of the development itself, not upstream development, therefore the impervious coverage upstream of the site should be consistent between the existing and proposed scenarios.

Note there is an existing 225mm dia. culvert pipe under Golding Road which is likely to be upgraded to a 525mm dia. culvert pipe for the MPD scenario. This will not have any impact to 1% AEP flood modelling as pipe size is below 600mm and therefore, assumed to be fully blocked.

Table 4 TuFlow Upstream Catchment Details and flows incoming to the model

Input ID	Imp. Area	Perv. Area	Tot. Area	Length	Slope	Runoff Depth	Peak Flow
Units	m2	m2	m2	m	%	mm	m3/s
AIN001	882	16765	17647	347	7.40%	106	0.323
AIN002	986	18729	19715	107	13.10%	106	0.385
AIN003	137	2611	2748	20	5.10%	106	0.054
AIN004	164	3110	3274	40	5.60%	106	0.064
AIN005	149	2836	2985	20	4.40%	106	0.058
AIN006	156	2966	3122	40	7.10%	106	0.061
AIN007	161	3068	3229	100	10.30%	106	0.063
AIN008	1992	1328	3320	40	2.80%	170	0.098
AIN009	118	2252	2370	40	4.40%	106	0.046
AIN010	136	2587	2723	80	7.60%	106	0.053
AIN011	1051	19964	21015	320	4.40%	106	0.375

Input ID	Imp. Area	Perv. Area	Tot. Area	Length	Slope	Runoff Depth	Peak Flow
Units	m2	m2	m2	m	%	mm	m3/s
AIN012	120	2272	2392	20	9.60%	106	0.047
AIN013	2804	53270	56074	432	5.90%	106	0.968
AIN014	2307	43825	46132	285	9.00%	106	0.884
AIN015	9619	182770	192389	1284	5.30%	106	2.407
AIN016	73573	49049	122622	363	4.60%	170	3.587
AIN017	1859	35319	37178	321	8.20%	106	0.693
AIN018	219	4156	4375	100	6.20%	106	0.086
AIN019	1117	21218	22335	133	15.00%	106	0.437
AIN020	51742	34495	86237	363	4.60%	170	2.523
AIN021	4124	2750	6874	150	4.70%	170	0.203
AIN022	5230	3486	8716	198	3.80%	170	0.258
AIN023	375	7131	7506	78	13.00%	106	0.147
AIN024	397	7546	7943	141	2.60%	106	0.155
AIN025	110	2093	2203	14	4.40%	106	0.043
AIN026	6001	114020	120021	646	4.80%	106	1.817
AIN027	23511	15674	39185	467	8.00%	170	1.146

5. Levels and Landuse

Model levels are determined based on topography survey (for the site extent including the streams) and Auckland CityWide 1m 2019 LIDAR information (for outside of the site). A tin is prepared for the existing and proposed scenarios and used to create the level raster used by the TuFlow modelling engine.

To determine the manning values and to model the existing and proposed buildings in the catchment an analysis of buildings and surfaces is undertaken. Firstly, the model determines the location of existing and proposed buildings in the catchment and deactivates these cells in the 2D domain, unless the building is flagged as being on poles in the GIS data.

For the remaining active areas of the model, the manning n value is set based on the surface type. Manning N values used in this model are given below in Table 5.

Table 5 TuFlow Landuse Mannings N Values

Landuse Description	Grass	Pave Road	Pave Lot	Pipe	Stream	Building	Retaining Wall
Mannings N Value	0.040	0.02	0.020	0.014	0.050	0.150	0.100

6. Pipes

Pipe assets that are sufficiently sized to not be considered 100% blocked as per the Auckland Council Modelling Guidelines are included in the model as 1D assets with 1D to 2D connections made at the manhole locations. Blockage factors are applied based on the guidance in the Auckland Council Stormwater Code of Practice. To ensure flow is captured at the manhole locations, the level raster for the model is adjusted at manhole locations to lower levels around the manhole. This ensure the manhole is filled up prior to overland flow proceeding downstream of the manhole location. Inlet losses are modelled via an inlet loss on the pipe model link, rather than the manhole model node. An inlet loss value of 0.5 is used in the model on the links. No head discharge relationship is applied on the manhole itself.

7. Outflows

Outflows from the modelled area are modelled using a manning N value channel set at a 1% grade. The TuFlow software automatically determines the ground profile along the outlet location and develops a stage storage relationship using the Manning N values from Table 5. These are then used to control outflow from the model. In general, the model extent will include significant downstream hydraulic features, so the effect of the outflow stage storage should be reduced.

8. Afflux Plots

Where pre and post development scenarios are being modelled our outputs present these results as afflux plots as well as with the results of the pre and post models in the 55000 drawing series. These drawings have three panes, the left-hand pane is the existing model results, the middle pane is the proposed modelling results and the right-hand pane is the afflux results which is the differences between the pre and the post modelling results. An afflux plot is similar in nature to a cut-fill plan, using the existing and proposed water level surfaces.

The output existing and proposed drawings show the model depth via colours, flow directions at the time of peak flow and peak depth and velocity values are labelled across the drawing to provide further information on modelling results. The afflux plots are also labelled with the depth difference and velocity differences between the pre and post modelling scenarios.

9. Model Health

To determine the accuracy of the modelling, we consider the model health parameters shown below as well as any surrounding flood level information from council where available to determine that the results presented in our analysis are accurate. The results of the modelling undertaken are shown below in **Error! Reference source not found.Error! Reference source not found.**, in general, a Final Cumulative ME of less than 5% is considered good and less than 10% is considered adequate for land development assessment purposes.

Table 6 TuFlow Model Run Statistics

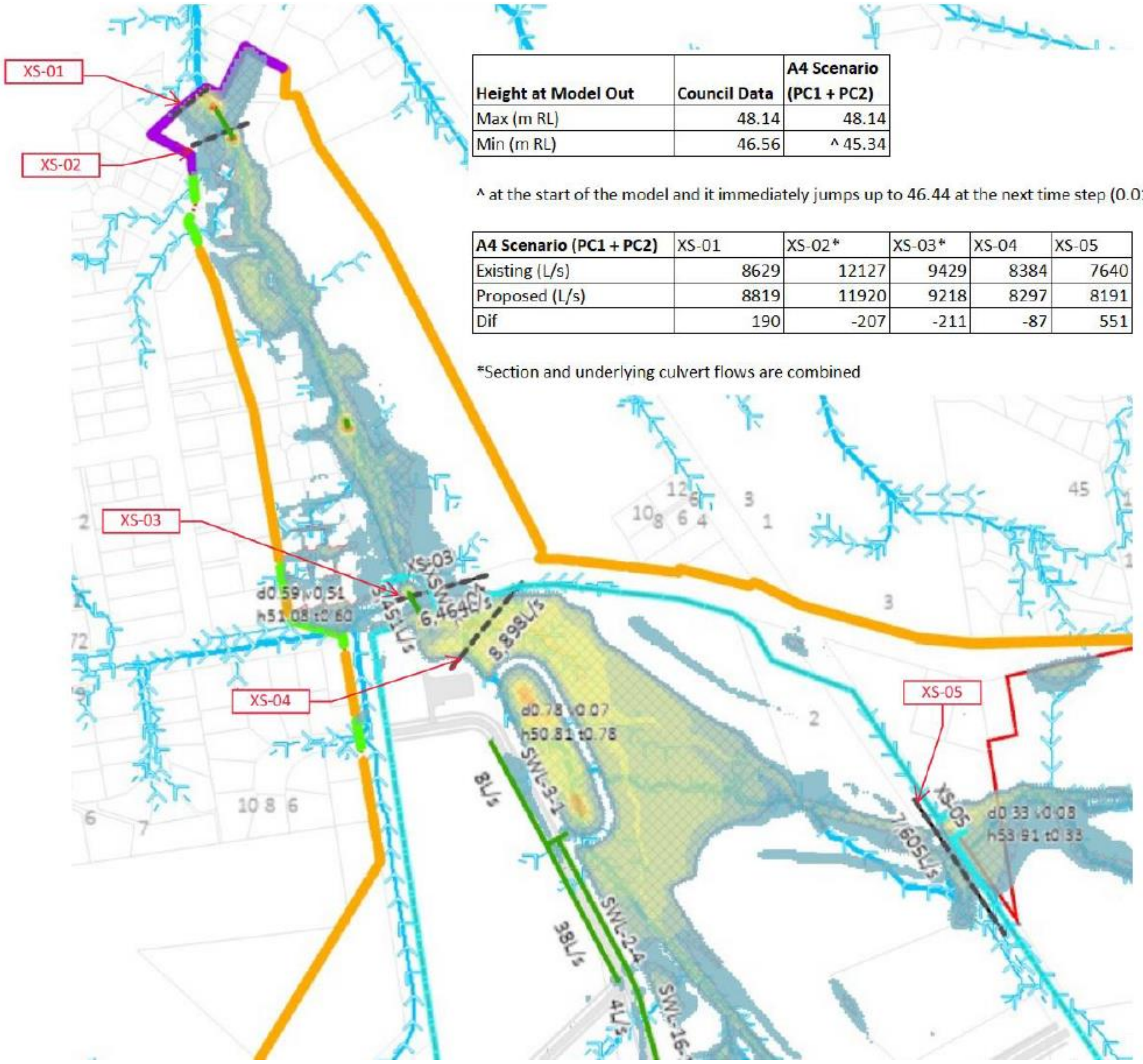
Item	Units	03_Ex_100_PC1	04_Pr_100_PC1	07_Ex_100_PC2	08_Pr_100_PC2
Warnings During Simulation		0	1	0	0
Total Volume Out	m^3	208,439	228,435	208,439	242,335
Volume Error	m^3	672 or 0.2%	622 or 0.1%	672 or 0.2%	613 or 0.1%
Final Cumulative ME	%	0.00%	0.00%	0.00%	0.00%

10. Results

The extent of the flooding in the existing and proposed development scenarios are shown in drawing 55000 series. Refer to Appendix A - Tuflow Flooding Results of this report.

The afflux indicates that there is no increase in flooding downstream of the site.

The peak flow from the subject site (PC2) exits through 8 Pukekohe East Road, overtops Golding Road and enters Western Plan Change site (PC76). The overtopping flow on Golding Road has been taken as the control point for the subject site as shown on Figure 2 below.



Height at Model Out	Council Data	A4 Scenario (PC1 + PC2)
Max (m RL)	48.14	48.14
Min (m RL)	46.56	^ 45.34

^ at the start of the model and it immediately jumps up to 46.44 at the next time step (0.016667 hrs)

A4 Scenario (PC1 + PC2)	XS-01	XS-02*	XS-03*	XS-04	XS-05
Existing (L/s)	8629	12127	9429	8384	7640
Proposed (L/s)	8819	11920	9218	8297	8191
Dif	190	-207	-211	-87	551

*Section and underlying culvert flows are combined

Figure 2 – Showing the key locations of significant flow entering / exiting the site

Thus, the 100 year pre and post flows are managed within the PC76 and the subject site.

Note, the flow depths within the public road reserve are generally below 200mm. Flow depth x velocities are generally below 0.6 m2/s, which is considered acceptable.

Refer to Appendix A - Tuflow Flooding Results for the Pedestrian and Vehicle Hazard extents.

Refer to Stormwater Management Plan for more details.

11. Limitations

- This assessment contains the professional opinion of Civix Staff relating to this development. Civix Staff used their professional judgement and acted in accordance with the standards of care and skill normally exercised by professional engineers providing similar services in similar circumstances. No other express or implied warranty is made as to the professional advice contained in this report.
- We have prepared this report in accordance with the brief provided and following our terms of engagement. The information contained in this report has been prepared by Civix for the client and is exclusively for its client use and reliance. It is not possible to make an assessment of this report without understanding the terms of engagement under which it has been prepared, including the scope of the instructions and directions given to and the assumptions made by Civix. The assessment will not address issues which would need to be considered for another party if that parties' particular circumstances, requirements and experience were known and, further, may make assumptions about matters of which a third party is not aware. No responsibility or liability to any third party is accepted for any loss or damage arising out of the use of or reliance on this assessment by any third party.
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