PAPAMOA EAST – A HUMDINGER OF A CATCHMENT

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ABSTRACT

After the flood events of 2013 Tauranga City Council embarked on a programme of 2D modelling and flood hazard mapping of the whole city. This was to enable Council to determine problem areas and inform the most cost effective way to mitigate them.

Papamoa East was an area which experienced property flooding in 2013. It is also an area designated for significant urban growth. Development of a model for this catchment by Aurecon has therefore been made a priority by Council.

The aim of this paper is to be of interest not only to modellers but to all professionals who use model outputs as a tool. This paper describes some of the issues in developing models – focusing on Papamoa East as an example. This will allow users of model outputs to understand both the advantages and limitations of the methods employed including rain on grid.

Papamoa East is a real humdinger of a catchment and has a little bit of everything. This includes an extensive stormwater reticulation network but also a significant open channel. The open channel is also unusual in that it is basically flat with limited ocean outfalls and currently acts as a bathtub with base levels often controlled by the groundwater table.

In the future the catchment is to increase in size by about 30% with the major urban hub of Wairakei to be built on greenfield land that is to be drained into the catchment. As part of this development the bathtub drain is to given a high level overflow to the Kaituna River. How relevant is model validation when the catchment is to change this much?

KEYWORDS

2d modelling, rain on grid, model validation, water level gauge, groundwater, catchment growth.

PRESENTER PROFILE

Robert is a Senior Engineer in Tauranga's Aurecon office, specialising in water resource engineering and hydraulic modelling. He has significant experience in stormwater and floodplain management.

Robert has expertise in hydraulic modelling using a range of software packages both one and two dimensional.

In his earlier days Robert was a weather forecaster with the UK Met Office and the NZ Met Service.

1 INTRODUCTION

Tauranga City Council (TCC) has been engaged in a long-term campaign of building flood models of stormwater catchments across its district for use in flood-hazard-mapping as well as for remedial options analysis. Public reaction to flooding during the April 2013 storm event has precipitated an increased urgency for the construction of mitigation measures in a number of TCC's stormwater catchments. As computer models play an important role in the planning and evaluation stages of TCC's stormwater-management construction designs, TCC has prioritised the model-build process. Papamoa East is an area which experienced property flooding in April 2013. It is also an area designated for significant urban growth and this catchment has therefore been made a priority by Council.

Papamoa East seems, at first sight, to be a fairly straightforward catchment to model but in fact has a unique combination of features that makes it a real humdinger. The paper describes the drivers for the project, the data requirements and then the model build and validation process. In doing so the peculiarities of this catchment are detailed. This paper is not only for modellers but also other professionals who use or rely on models. For example the usefulness of the validation process and the constraints and applicability of the models results are discussed

2 PROJECT DRIVERS

1. Tauranga City Council wishes to have accurate flood mapping to enable it to ensure development and building consent applications can be assessed accurately from a flooding perspective. The current catchment is modelled using a 1D model of the main drainage channel running the length of the catchment. Flood maps have, in the past, been derived from this model by extrapolating flood levels perpendicular to the drainage channel. However this is not very accurate as the storm of April 2013 highlighted, for while levels in the main drainage channel did not rise particularly high, pockets of catchment away from the drain were still badly flooded.
2. Flooding in the catchment in the April 2013 storm requires an accurate model to analyse design options to mitigate flood prone areas.
3. Papamoa East is designated for significant urban growth. As part of this plan for growth a comprehensive stormwater consent has been obtained for this catchment. A condition of this consent is that the model is regularly updated, especially after any flood events. Rather than just updating the limited 1D model, Council have chosen to build a fully coupled 1D-2D model.

3 DATA PROVIDED BY TCC

3.1 SPATIAL DATA

- Two LiDAR aerial survey bare-earth datasets: TCC data (flown at end of 2011 and beginning of 2012) and Western Bay of Plenty data for areas outside the TCC data extent.
- Aerial photography: TCC images (taken at end of 2011 and beginning of 2012) and Western Bay of Plenty images for areas outside the extent of the TCC images.
- Stormwater assets from TCC's GIS database for both public and private assets including: stormwater manholes, stormwater mains, sumps, soakholes, service-lines and open drains.
- Building footprint polygons.

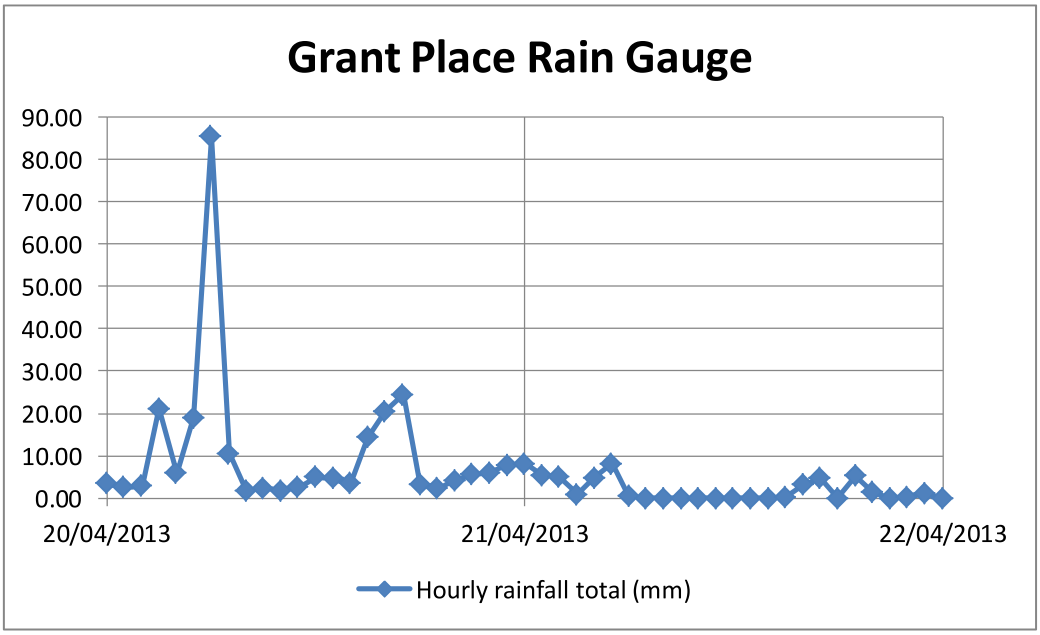
- Road footprint polygons.
- Kerb and footpath edge polylines.
- Road centre lines.
- Impervious/pervious area classification polygons including the following classes:

  "BUILDINGS", "OTHER_IMPERVIOUS", "ROADS", "SAND/GRAVEL", "VEGETATION" and "WATER".
- Property parcel polygons.
- Town-planning zone polygons and classifications.
- Stormwater disposal polygons. This layer provides appropriate means of stormwater disposal in different areas.
- Land use polygons (LCDB3).
- Soil classification polygons.
- Surveyed peak flood levels for the 19th to 22nd April 2013 storm event.
- Rain gauge locations.
- Rapid Flood Hazard Mapping study maximum flood depth map for 50-year and 10-year Annual Recurrence Interval (ARI) storm events.

3.2 TEMPORAL DATA

1. Rainfall time-series for the 19th to 22nd April 2013 storm event from rain gauges in and near to the catchment. For this study the rainfall from the Grant Place gauge was adopted as this is most central to the catchment. The graph below shows the rainfall recorded at this gauge.

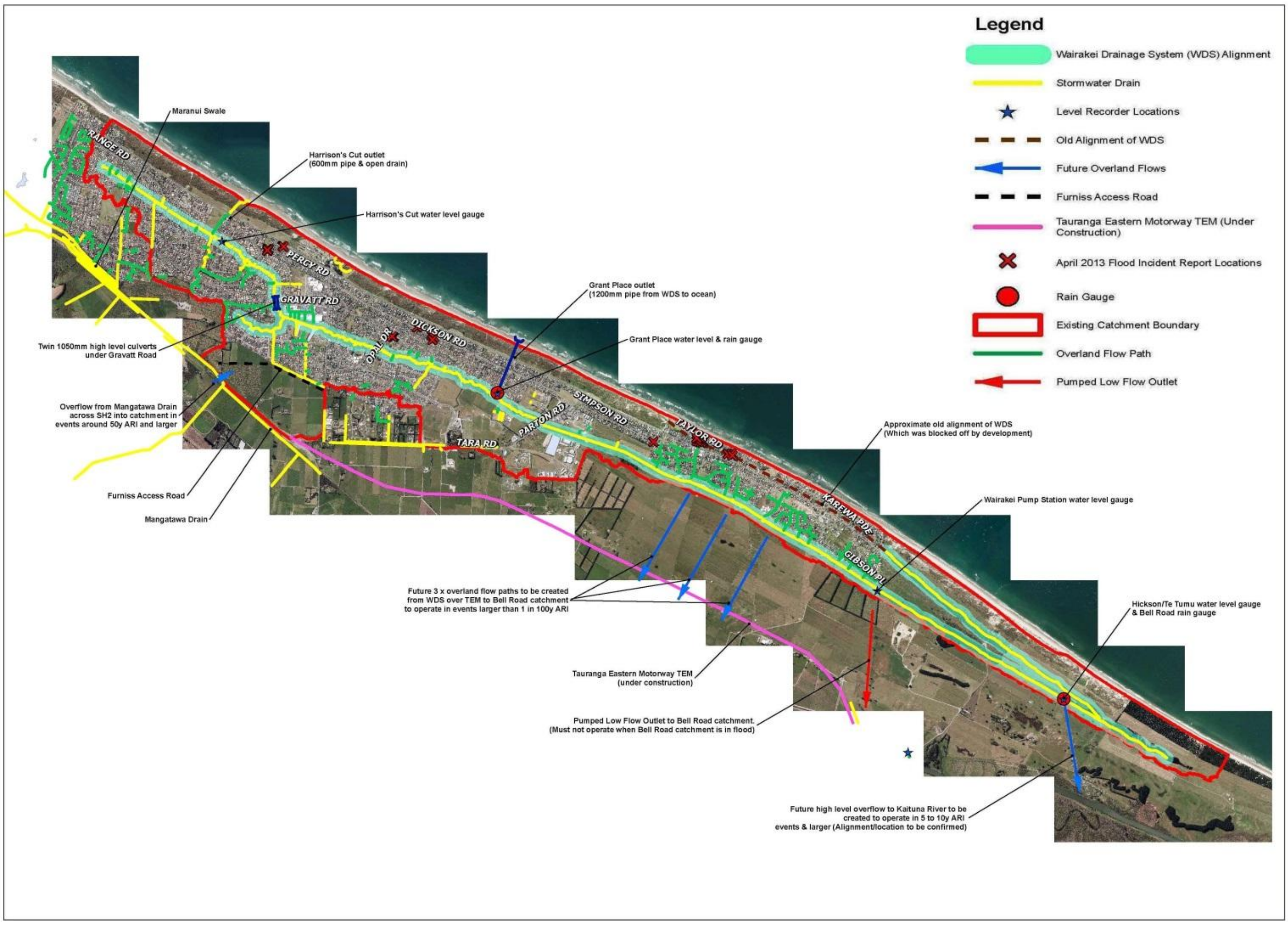
Figure 1 – Grant Place Rainfall



2. Tidal time-series for the 19th to 22nd April 2013 storm event. Data has been collected from four telemetry sites administered by Bay of Plenty Regional Council.

3. Water level data for April 2013 for the Wairakei Stream at the following locations (refer Figure 2):
    - Harrison's Cut
    - Grant Place
    - Wairakei Pump Station
    - Hickson 1B/Te Tumu

Figure 2 – Water Level Recorder Locations



3.3 ADDITIONAL DATA

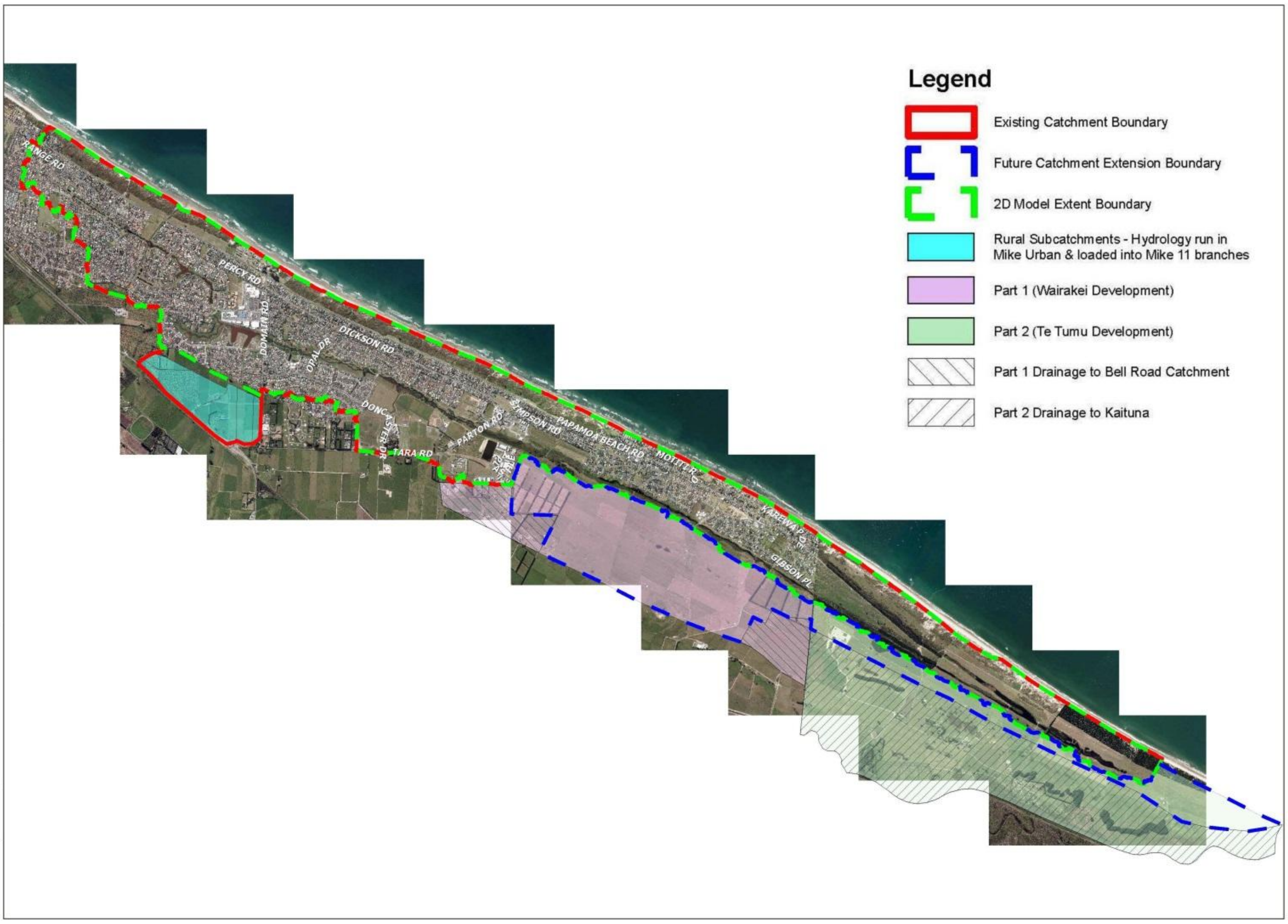
Additional data including culvert (and other features) as-built data was also supplied or surveyed for this project.

4 CATCHMENT PECULIARITIES

4.1 CATCHMENT EXTENTS

The extent of the catchment 1200 ha was derived based on Council's LiDAR and utilising a GIS based watershed analysis. However in future the catchment is designated for significant urban growth. This growth is planned in two stages; Part 1 (Wairakei) adding an additional 390 ha to the catchment is already underway and when this is substantially complete development in Part 2 (Te Tumu) will occur with the catchment growing a further 150 ha. While many catchments have significant urban growth within them, Papamoa East is unusual in that the growth will actually cause the catchment size to increase. Refer to Figure 3 below for changing catchment extents.

Figure 3 – Catchment Boundaries – Existing & Future



4.2 CATCHMENT DRAINAGE

The Papamoa East catchment discharges to a wide open stormwater channel & reserve known as the Wairakei Drainage System (WDS). Having a wide open channel running through a catchment is probably not unusual. What is unusual though is that this system runs parallel to the ocean rather than to the ocean. The WDS has no natural outlet to the ocean this being blocked off by development around 50 years ago. Instead there is a man-made cut (Harrisons Cut at the western end of the WDS and a 900mm diameter pipe outlet in the middle of the catchment refer Figure 2) At the eastern end of the WDS discharge is solely by soakage from the base of the stream. These factors mean that water can actually flow in either direction along the WDS.

As if this is not confusing enough, the onset of the Part 2 (Te Tumu) development requires the construction of a high level overflow from the eastern end of the WDS to the Kaituna River (to operate in events exceeding about the 5 to 10 year ARI event). To ensure water can travel easily to this high level overflow all the existing road and farm crossing culverts along the WDS need to be upgraded.

It can therefore be seen that updating the model from an existing scenario to a future maximum probable development scenario for this catchment is far from trivial.

4.3 GROUNDWATER AND SOAKAGE

It is noted that almost all residential roofs within this catchment discharge to private soakholes. With the limited outlets to the ocean, the WDS also relies on soakage as a major discharge mechanism especially at the eastern end of the catchment. Furthermore the soakage rate can be impacted by the groundwater table which varies seasonally and may only be 2 or 3 metres from the ground surface. Indeed the water level at the eastern end of the WDS is often controlled by groundwater levels.

4.4 CATCHMENT CRITICAL DURATION

Due to the different outlets – different parts of the catchment have different critical durations. Near Harrison's Cut maximum water levels in the WDS occur in around a 2 hour storm. Between Harrisons Cut and Grant Place the 6 hour storm produces maximum water levels. At the eastern end of the WDS the critical duration is 48 hours. In smaller ponding areas away from the WDS – local factors apply and the critical duration is likely to be around 1 or 2 hours. This has led to requiring multiple runs to obtain the top water levels along the WDS and elsewhere in the catchment. Recently TCC has moved away from having discrete temporal patterns for different duration storms and has now adopted a nested 'Chicago' style temporal pattern covering all durations from 10 minutes to 48 hours streamlining the number of runs required.

4.5 TSUNAMI FOOTBRIDGES

Papamoa East is a low lying coastal area and consequently at risk from Tsunami. It has a growing residential population with the main roads running parallel to the coast and only a few roads connecting inland. The WDS also runs parallel to the coast and creates a barrier for residents fleeing inland by foot. Council has therefore constructed two Tsunami evacuation bridges over the WDS with provisional plans for several more. The peak 100 ARI flood level in the WDS predicted by the old 1D model of the catchment (refer section 2) is around RL 4.6m. The deck of the two bridges built so far are at about this level meaning their soffits are several hundred mm below the 100 year ARI flood level. This is not really an issue for the WDS in its current configuration as it relies mainly on storage within the WDS with only limited conveyance along its length to balance top water levels. However the ultimate development of the catchment requires high flows (around 20 m^3/s) along the WDS to make maximum use of the high level overflow to the Kaituna River. Potential impediment to these flows caused by all structures such as the Tsunami bridges must be considered.

4.6 CATCHMENT FLATNESS AND RAIN ON GRID

Papamoa is an extremely flat catchment. Older areas still retain some slight undulation from the original dune system but in newer areas the dunes have been flattened by earthworks. This extreme flatness makes the delineation of sub-catchments highly difficult. This has been overcome by adopting the rain on grid method in which rain is applied directly onto the 2D grid representation of the ground surface. Instead of sub-catchments being loaded directly into the pipe network the rain on grid method allows rainfall to find its own way to the sumps and then into the network. In steeper catchments the rain on grid method has not always proved successful as often the rainfall runoff runs straight past the sumps with little entering the network. However, rain on grid has worked well in Papamoa East. A major drawback with the rain on grid method is that it substantially increases run times. A 48 hour simulation takes about 2 weeks to run (c.f. about 2 minutes for the simple old 1D model of the WDS).

4.7 CATCHMENT ORIENTATION

The catchment is orientated parallel to the coast which runs from the north-west to the south-east. Most roads (which are the major overland flow paths in the catchment) run parallel or perpendicular to the coast. The WDS also runs parallel to the coast. For this reason the whole catchment was orientated by 27 degrees so that the coast is now orientated east-west. In this way the grid is generally aligned with the flow direction and avoids flow going diagonally across squares. This is preferable as flow cannot flow across grid corners only across grid faces. Rotation of the grid also meant that the overall grid domain size could be reduced with large areas of sea not needing to be incorporated or blocked out from the model.

Catchment orientation does however mean care needs to be taken when viewing or extracting results in GIS as GIS generally does not allow for grid rotation.

4.8 OVERFLOWS FROM OTHER CATCHMENTS

In the May 2005 storm flow from the adjacent Mangatawa Drain to the south of the catchment overtopped the railway and State Highway 2 (SH2) into the Papamoa East catchment (refer Figure 2). No such overflows occurred in the April 2013 event. To complicate matters further construction of the Tauranga Eastern Motorway (TEM) includes upgrades to the relevant section of SH2. This has reduced but not eliminated the risk of overflows into Papamoa East. A model of the Papamoa West catchment (including the Mangatawa Drain catchment) is currently being built and results from this will help quantify the latest overflow volumes in different events.

As a safety measure high level overflows from the WDS over the TEM into the Bell Road catchment have been designed to be incorporated into the design of the Part 1 (Wairakei) development (refer Figure 2). These are to operate in the over-design event (500 year ARI).

4.9 WATER LEVEL GAUGES

Probably one of the most unique features Papamoa East has for an urban catchment is the presence of not 1 but 4 water level gauge recorders. Although this is certainly beneficial it made Papamoa East a real humdinger to validate (refer later section). Normally when catchment modelling the lack of data in most catchments makes 'validation' more straightforward (or in other words - ignorance is bliss).

5 MODELLING APPROACH AND SCHEMATISATION

As the modelling of this catchment uses standard current best practice methods this paper does not intend to give a detailed description of the model build process. However the section below does briefly summarise the modelling approach and schematisation.

The stormwater catchment was represented by three interconnected components: the underground stormwater infrastructure (pipes, manholes and inlets) were represented in Mike Urban and referred to as 1D, the overland surface flow model was represented in Mike 21 and referred to as 2D, culverts and small open drains are represented in Mike 11 and referred to as 1D. The WDS while generally 1D in nature is wide enough to be well represented by the 2D topographical surface and was hence modelled in Mike 21. Harrison's Cut which is the only existing high flow outlet from the catchment was modelled with Mike 11.

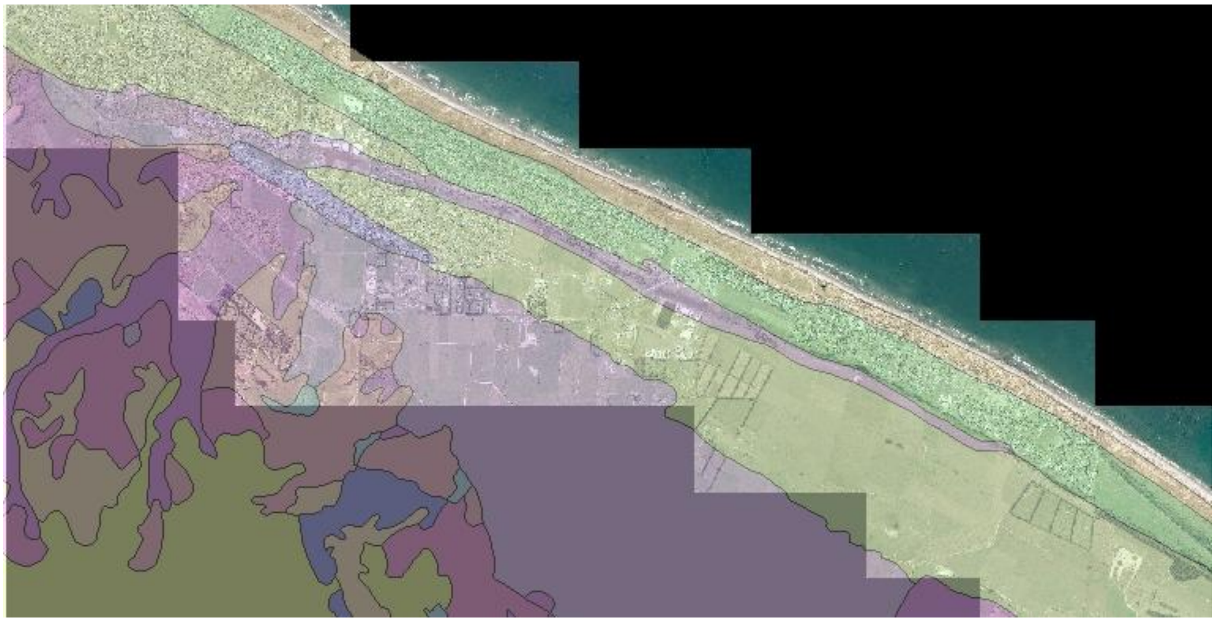
Specifically the following should be noted about the modelling schematisation:

- All public stormwater mains and manholes were included in the model. The pipe network was imported directly from TCC asset data into the Mike Urban model, and all stormwater mains were reviewed and longitudinal profiles used to find and remedy unrealistic or unlikely pipe configurations in the model.
- All sumps and sump leads were also included in the Mike Urban network model. A standard sump chamber depth of 1.2 m was assumed with the lid level taken from the Mike 21 bathymetry at that location. Sump lead slopes were restricted to be between 0.0 and 10.0 %. Lead diameters were taken from TCC asset data.
- Sumps in Mike Urban were linked to Mike 21 based on the sump grate and chamber details in TCC's asset database. The Mike Flood inlet link parameters used for different sump types were based on these details.
- Surcharging of the pipe network resulted in flow exiting the network via the coupled sumps. Manholes were therefore not generally coupled to Mike 21.
- The Mike 21 surface was defined by a watershed analysis in order to create a boundary that is consistent with the rain-on-grid approach. To limit the size of the

grid and hence reduce simulation times the grid was rotated. Rotation of the grid also enabled the grid direction to match the main flow direction along the WDS and overland flow along roads.

- The existing rural area of the catchment west of Domain Road was excluded from the Mike 21 grid to limit the grid size and minimise run times. This area was modelled using lumped hydrographs loaded into Mike11 farm drains in the area (refer Figure 3).
- Surface storage and areas of natural ponding were accounted for in the Mike 21 model. (Apart from the aforementioned rural area in which it was included as 'additional storage' in the Mike 11 model).
- Underwater bathymetry for the WDS was not available so a uniform bed level of RL 1.5m (but RL 1.0m at the far eastern end) was assumed in all areas of permanent ponding giving a permanent water depth of about 0.5 to 1m.
- Designated overland flow paths (e.g. through lowered walkways) were burnt into the grid.
- Buildings were represented by increased roughness.
- The infiltration map (applied as a potential evaporation map) was generally based on the impervious area classification polygons provided by TCC. However the band of poorly drained soil (refer Figure 4) also informed the infiltration map.

Figure 4 – Catchment Soil Types



- Private soakholes (e.g. most residential roofs in this catchment discharge to soakage) were not explicitly modelled. Instead the infiltration parameters discussed above were modified so that building roofs had an infiltration rate similar to that of the standard domestic soakhole (divided by the roof area per soakhole).
- Public soakholes were incorporated into the Mike Urban model using a constant Q-H relationship with a negative Q (out of the system) applied.
- Coastal boundaries were modelled in MIKE 21 by linking coastal cells to a fictitious Mike 11 channel with a tidal boundary. This reduced the number of wet cells by enabling the bulk of the open-water ocean cells to therefore be blocked out.
- Two large capacity inlet structures (at Harrison's Cut and Grant Place outlets) used specific schematisation.

- The low flow pump from the Wairakei to the Bell Road catchment was excluded from the model as this is a baseflow management tool and is not designed to operate in large flood events.

6 VALIDATION

One of the project objectives was to verify that the constructed model is capable of reproducing flooding experienced in the catchment during the April 2013 storm event. Such validation is an important process which can highlight any problems with the model so that these can be rectified hence increasing confidence in the reliability of the model. (It is noted that in May 2005 large overflows from the adjacent Mangatawa catchment occurred – refer section 4.8 – making this event less suitable for validation.)

As discussed earlier this catchment is unusual in having not one but four water level recorders to validate against. This along with the complexity of the flood model and the high number of variables made the validation process a complex but interesting process. It is therefore discussed in detail below.

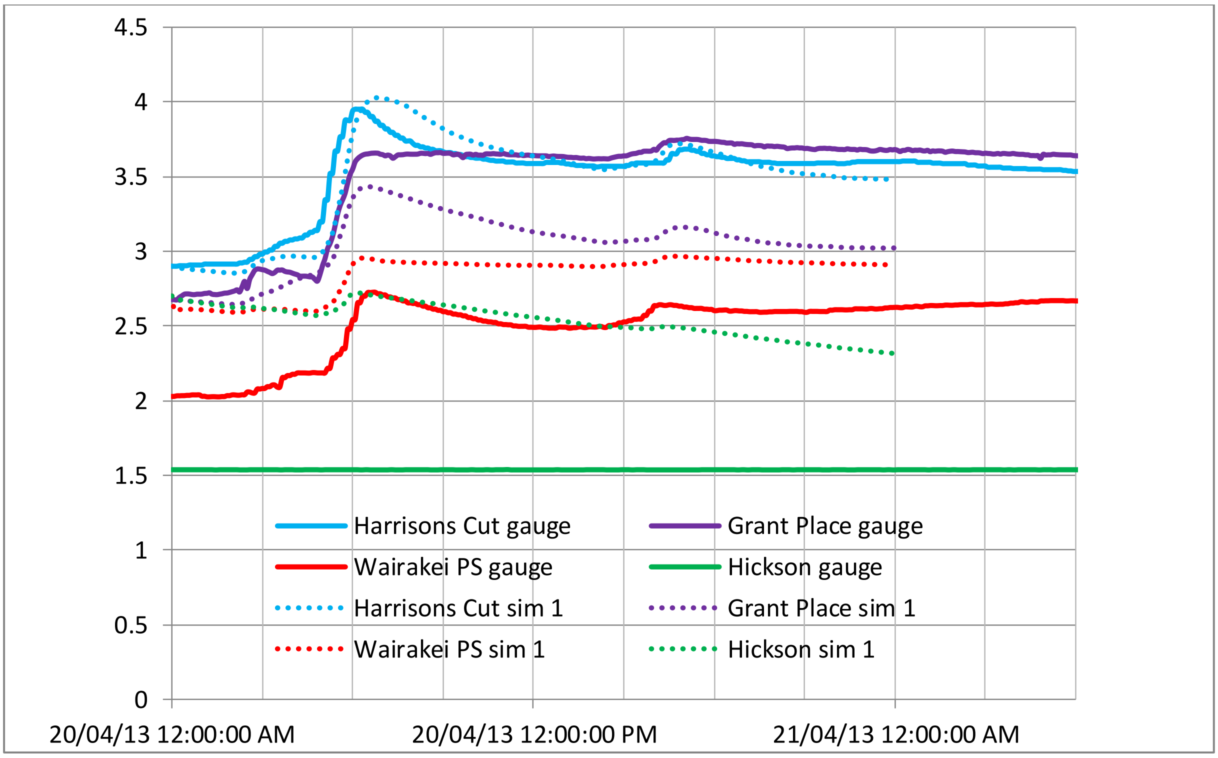
6.1 VALIDATION TO WATER LEVEL GAUGE DATA

Five simulations were run. The changes made between successive runs are detailed below.

Simulation 1

At the time this simulation was run water level data from TCC's four water level recorders along the WDS was not available so initial water levels were estimated. By completion of the first simulation water level gauge data had been provided by TCC. Estimated initial water levels were correct at the western end of the WDS but too high at the eastern end (Wairakei Pump Station and Hickson) as can be seen in Figure 5 below.

Figure 5 – Simulation 1 Results



Simulation 2

Initial water levels at the eastern end of the WDS were reduced to the observed gauged levels. Results from the first simulation also showed modelled water levels at the Grant Place receding far more quickly than gauged. It was believed this showed that soakage from the base of the WDS was much lower than being modelled. The leakage rate for the band of poorly drained soils (refer Figure 4) was therefore set at 1mm/h. It is noted that the far eastern end of this band does not align very well with the WDS. After speaking to geotechnical engineers and Regional Council staff it was decided this was probably not realistic. The area of leakage = 1mm/h was therefore expanded north to cover this section of drain. Refer Figure 6 below which shows the zone of poorly drained soils (brown hatch) and area set to 1mm/h leakage (red) which has been expanded north to cover the WDS.

Figure 6 – Poorly Drained Soils

Poorly drained soils **Zone expanded north to match drain alignment**

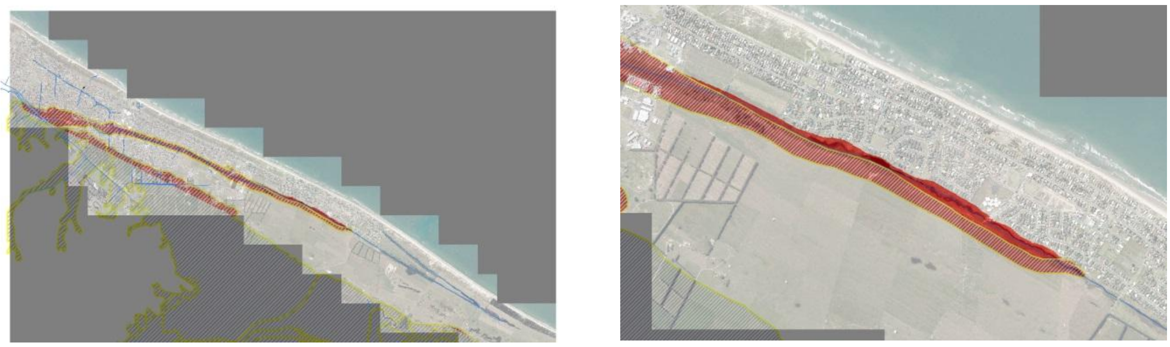
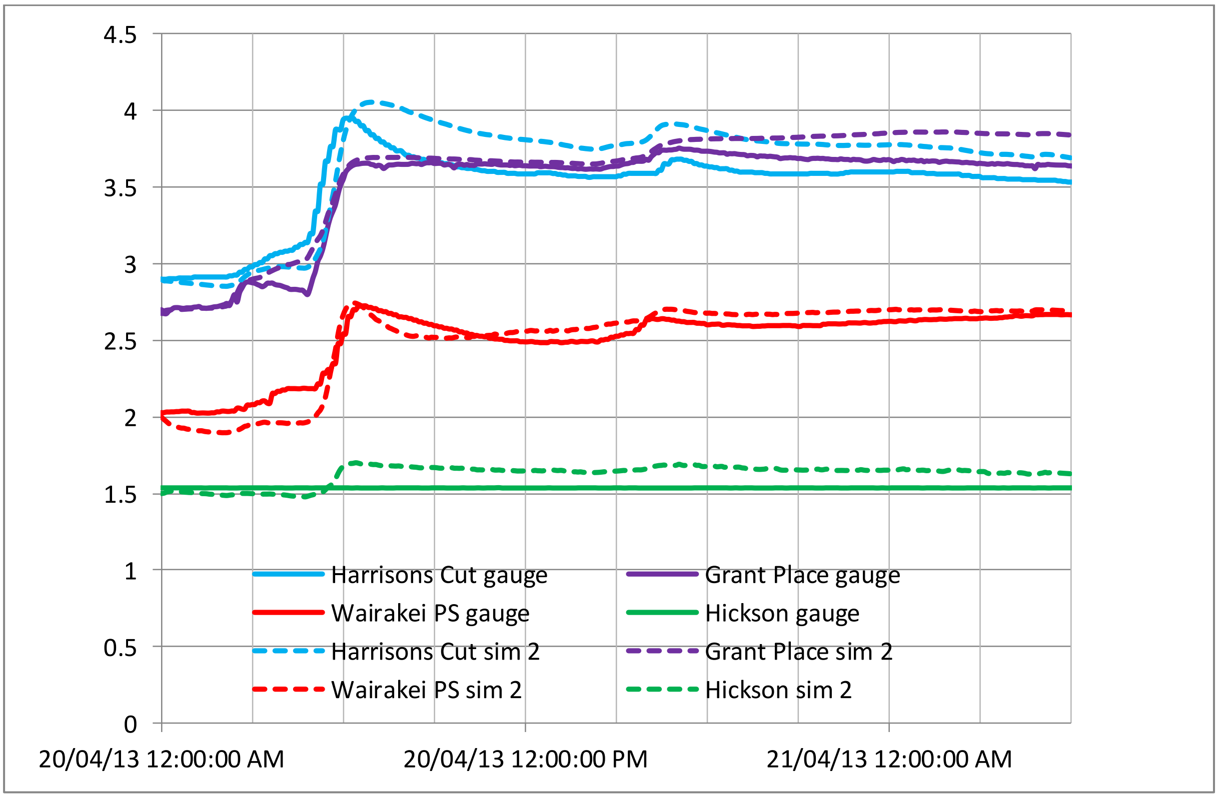


Figure 7 – Simulation 2 results



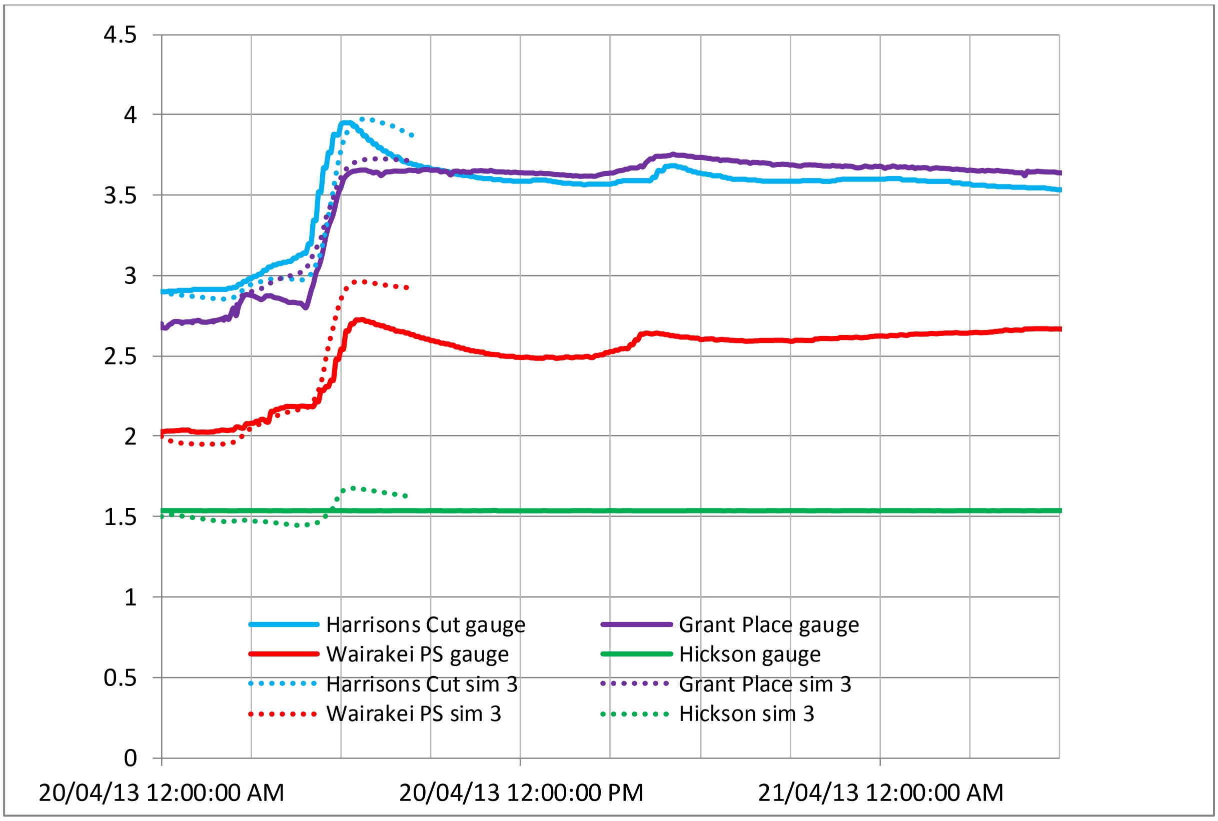
Simulation 3

Reducing the leakage rate along the base of the WDS gave a much better match at the Grant Place gauge as can be seen in Figure 7 above. However the modelled flood level at Harrison's cut gauge was now found to be around 200 to 300mm above the gauged level. It was thought this may be because the Harrison's cut channel had more capacity than was being modelled. The model was therefore changed with the channel now being modelled in Mike 11 using surveyed cross-sections rather than being modelled in Mike 21 using LiDAR data.

The results at Hickson's gauge at the far eastern end were also discussed. Gauge levels at this location do not change throughout the simulation run (actually they do not rise until about 48 hours after the rainfall event) compared to modelled levels which rise about 6 hours into this event. At this stage TCC provided some additional survey data of culvert sizes and inverts within the rural eastern part of the catchment. Unfortunately some culvert diameters were missing from this survey. The consultant who undertook this survey advised that the culverts missing diameter information were generally small – 300 or 450 mm. The model was therefore updated with this survey information with 450mm being adopted for unknown culvert diameters.

Another change was made to correct an error made for the soakage rates for public soakholes. The rate had been mistakenly input as m^3/hour rather than m^3/s and the rate was therefore 3600 (60mins x 60s) too high. This was corrected and the model was re-run. A loss of internet connectivity meant the remote software license could not be connected with and the run terminated prematurely. Fortunately this did not occur until after the event peak.

Figure 8 – Simulation 3 results

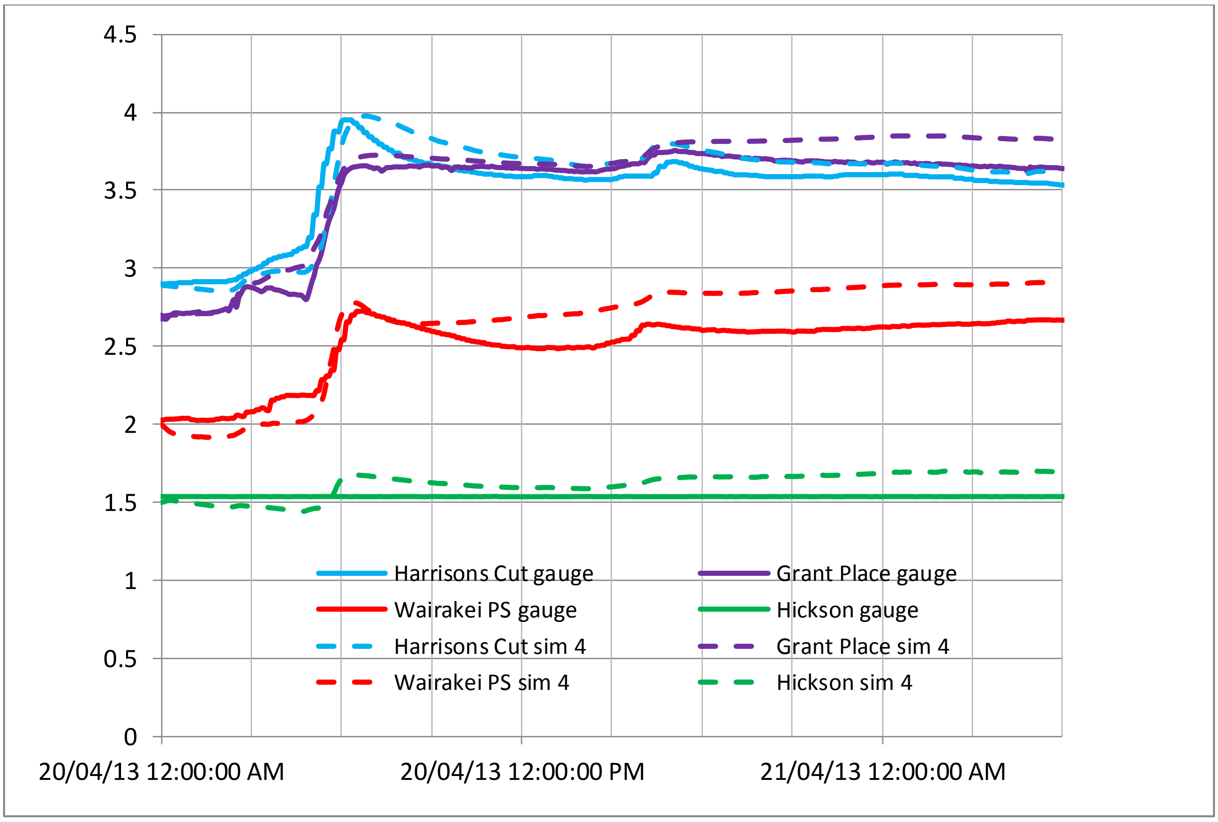


Simulation 4

The results from simulation 3 (refer Figure 8) showed that the modelled peak at Wairakei PS was now too high. The culvert immediately downstream of Wairakei PS was therefore changed back from 450mm diameter (as estimated by the earlier surveying consultant) to the value of 1m diameter used in simulations 1 and 2 (a survey of these culverts was at this point commissioned).

Another issue that appeared was that peak modelled water levels values in the Taylor Road area were now too high (refer to results in Table 1 at the end of this section). Although the soakage rate for public soakholes had been reduced by 3600, using the standard soakage rate for the soakage field in Taylor Reserve at the western end of Taylor Road is probably too conservative. This is because the soakage field here consists of many soakage pipes interlinking soakholes. The soakage rate in this area was therefore increased again. Results for simulation 4 are shown in Figure 9 below. These show a much better match of the peak at Wairakei Pump station than for simulation 3 although like at Grant Place the model does not drain down as quickly as observed.

Figure 9 – Simulation 4 Results



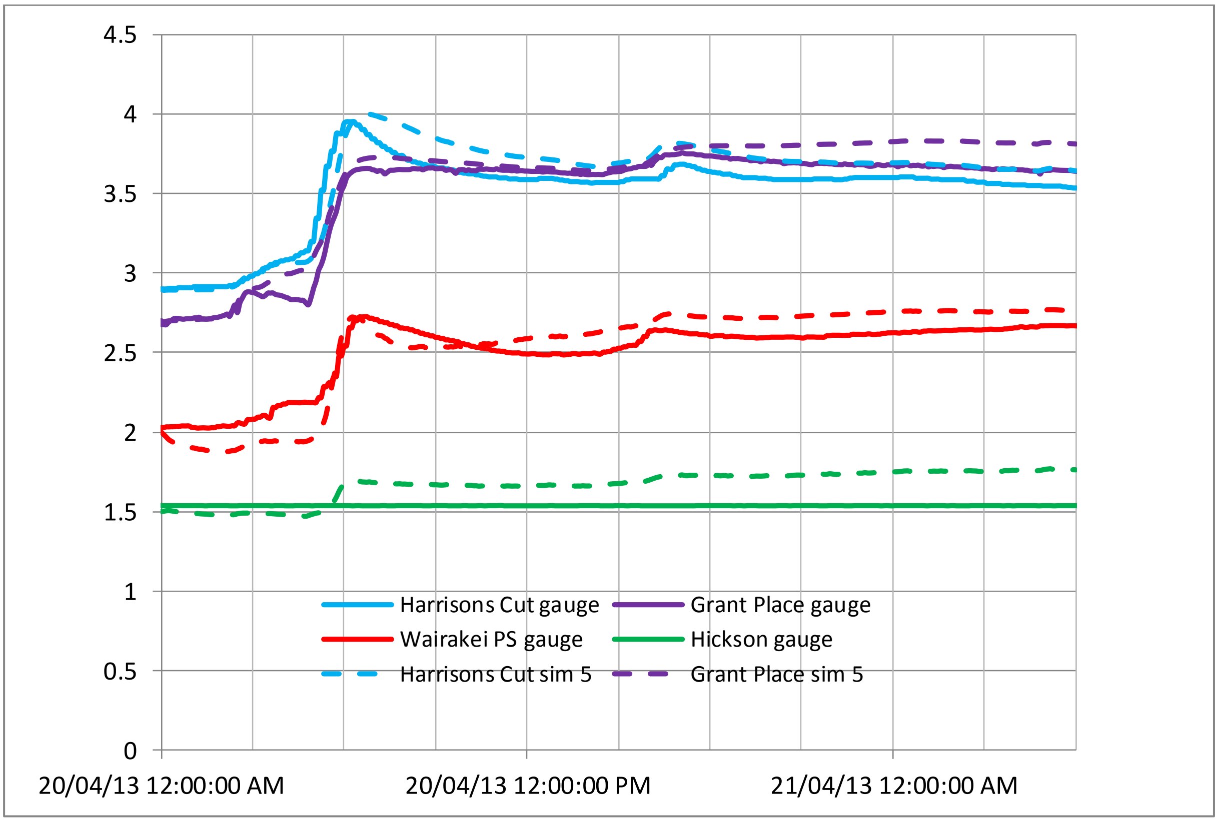
Simulation 5

After simulation 4 the model was peer reviewed by DHI. Simulation 5 includes the model modifications recommended by DHI most of which were of a minor nature. The most significant comment was regarding the leakage rate from the base of the Wairakei stream in the western part of the catchment (northwest of Gravatt Road). It was suggested by DHI that given the persistent elevated groundwater table in this area (> RL 2.9m) that infiltration from the base of the stream in this area would be minimal. The leakage rate for this part of the Wairakei stream was therefore reduced from 26 mm/h to 1 mm/h.

Two other changes initiated by Aurecon were also made. Information on the soakage system in Taylor Road (Taylor Road Soakage Investigations – Opus 2002) indicated that the soakage rates in the Mike Urban soakholes here should be increased. The other significant change was the update of the Mike 11 culvert dimensions of the farm crossings in the eastern rural (Part2 Te Tumu) end of the catchment in accordance with the Aurecon survey of these culverts.

It can be seen by comparing the simulation 4 and simulation 5 results (Figures 9 & 10) that the change in leakage rate does not noticeably impact on levels at Harrison's Cut gauge. This is probably due to levels here being controlled by the outlet dimensions rather than the leakage rate. The change in farm crossing culvert dimensions has decreased modelled levels at the Wairakei PS gauge but increased levels at the Hickson gauge. This is consistent with larger culverts allowing more flow to travel eastwards. Although the modelled results at Hickson do not match gauged levels this may be the result of a blocked farm culvert upstream of the gauge. The change in soakage rates in the Taylor Road soakholes has decreased flood levels here (refer Table 1). Overall it is believed that simulation 5 provides a good match with the gauged data.

Figure 10 – Simulation 5 Results



6.2 VALIDATION TO FLOOD INCIDENT REPORTS

The simulations 1 to 5 focused mainly the flood levels along the WDS. However as flooding occurred in localized hollows outside of the WDS, additional validation in external areas was also required.

Modelled peak flood levels have been extracted at all the locations reporting flooding in April 2013. These are presented in Table 1 below. The difference between modelled and surveyed (modelled minus surveyed) has a maximum value of plus 500mm and a minimum value of minus 200mm. Generally modelled levels are higher than surveyed. It is noted that most of the flood incident locations occur within 400m of the coast where the older style of development with houses sometimes below the road level occurred. This zone along the frontal dunes however is also likely to have the coarsest sand grain size and higher leakage rates. This may indicate that 'leakage' rates are higher within this zone than those assumed. Thought was given to trialing increased soakage rates in the frontal dunes and decreasing soakage rates away from the dunes (to give a similar total runoff into the WDS) but there was not enough validation data away from the frontal dunes to warrant such model complexity (sticking to the principle of 'keep it simple').

In the Taylor Road area there are specifically designed soakage systems both in Taylor Road and in Taylor Reserve. We do not have any information about the soakage system in Taylor Reserve but have tested both large and small values of soakage here and results suggest that that it has a large capacity (refer simulation 4 discussion in section 6.1). A report on the soakage system in Taylor Road (Taylor Road Soakage Investigations – Opus 2002) has been used to update the soakhole soakage rates in Mike Urban in simulation 5. The Opus report suggests that that the road soakage system cannot cope with rainfall events greater than the 2 year event. Given this limited capacity the exact modelling of the Taylor Road soakage system is unlikely to have much impact on the results in larger flood events.

Table 1– Modelled peak flood levels at flood incident report locations

ID	ADDRESS	SITE_DESCRIPTION	Floor_ Level	Ground_ Level	Bathymetry	GL minus bathymetry	Surveyed Flood_Level	sim 1	sim 1 diff	sim 2	sim2 diff	sim 3	sim 3 diff	sim 4	sim4 diff	sim 5	sim5 diff
1	15 OPAL DRIVE	SHED (photo 3)	4.88	4.86	4.76	0.10	4.90	4.89	-0.010	4.89	-0.010	4.89	-0.010	4.89	-0.010	4.89	-0.010
2	15 OPAL DRIVE	FRONT DOOR STEP (photo 2)	5.00	4.97	4.85	0.12	4.99	4.88	-0.111	4.88	-0.111	4.88	-0.111	4.88	-0.111	4.88	-0.110
3	85 PERCY ROAD	CESS PIT		5.68	5.79	-0.11		6.27		6.27		6.27		6.27		6.27	
4	85 PERCY ROAD	FLOOR LEVEL FRONT HOUSE	5.89		5.80			6.27		6.27		6.27		6.27		6.27	
5	85 PERCY ROAD	SPOT HEIGHT	0.00	5.88	5.80	0.08		6.27		6.27		6.27		6.27		6.27	
6	85/3 PERCY ROAD	FLOOR LEVEL BACK HOUSE	5.95		6.51			6.54		6.54		6.54		6.54		6.54	
7	85/3 PERCY ROAD	SPOT HEIGHT BACK HOUSE		5.95	6.51	-0.56		6.27		6.27		6.27		6.27		6.27	
8	85/3 PERCY ROAD	CESS PIT BACK HOUSE		5.95	5.99	-0.04		6.27		6.27		6.27		6.27		6.27	
9	116A SIMPSON ROAD	GARAGE	4.64		4.68		5.14	4.94	-0.200	4.94	-0.199	4.94	-0.199	4.94	-0.199	4.94	-0.200
10	5 TAYLOR ROAD	TOP OFGRASS (photo 1)	0.00		2.49		2.89	2.91	0.015	2.91	0.018	3.19	0.304	3.13	0.236	3.10	0.210
11	5 TAYLOR ROAD	GARAGE	2.78		2.66		2.84	2.91	0.065	2.91	0.068	3.19	0.354	3.13	0.286	3.10	0.260
12	5 TAYLOR ROAD	BOTTOM STEP LEVEL (photo 2)	3.05		2.66		2.93	2.91	-0.025	2.91	-0.022	3.19	0.264	3.13	0.196	3.10	0.170
13	5 TAYLOR ROAD	WOODEN STEP LEVEL (photo 3)			2.60		2.63	2.91	0.275	2.91	0.278	3.19	0.564	3.13	0.495	3.10	0.470
14	5 TAYLOR ROAD	FIRST STEP (photo 5)			2.64		2.83	2.90	0.073	2.91	0.076	3.19	0.364	3.13	0.295	3.10	0.270
15	5 TAYLOR ROAD	UNDERSIDE OF STAINED TIMBER (photo 6)			2.22		2.85	2.90	0.054	2.91	0.057	3.19	0.344	3.13	0.275	3.10	0.250
16	7 TAYLOR ROAD	BACK FENCE (no photo)	3.24	2.67	2.51	0.16	2.85	2.90	0.054	2.91	0.057	3.19	0.344	3.13	0.275	3.10	0.250
17	9A TALYOR ROAD	GARAGE (photo 1)	2.61	2.58	2.32	0.26	2.91	2.90	-0.005	2.91	-0.002	3.19	0.284	3.13	0.215	3.10	0.190
18	9B TAYLOR ROAD	HOUSE FLOOR LEVEL (photo 2 & 3)	2.82		2.61			2.90		2.91		3.19		3.13		3.10	
19	9C TAYLOR ROAD	HOUSE FLOOR LEVEL (photo 4)	2.82		2.66			2.90		2.90		3.19		3.13		3.10	
20	20B MOTITI RD	LIVING ROOM (photo 2)	2.99	2.91	2.79	0.12	3.16	3.22	0.057	3.22	0.057	3.22	0.065	3.22	0.065	3.22	0.060
21	20B MOTITI RD	KITCHEN DOOR (photo 3)	3.05		2.63		3.25	3.22	-0.033	3.22	-0.033	3.22	-0.025	3.22	-0.025	3.22	-0.030
22	24 MOTTI ROAD	FRONT DOOR	2.69		2.63			3.23		3.23		3.24		3.24		3.24	
23	26 MOTITI RD	BACKDOOR PAVERS (photo 5)	2.69	2.53	2.45	0.08	3.05	3.23	0.183	3.23	0.183	3.24	0.190	3.24	0.190	3.24	0.190
24	486 PAPAMOA BEACH RD				5.55		5.80	6.03		6.03		6.04	0.244	6.04	0.244	6.04	0.240
25	488 PAPAMOA BEACH RD	BLOCK WALL			5.64		5.75	6.03		6.03		6.04	0.294	6.04	0.294	6.04	0.290
26	111 DICKSON ROAD	FRONT BOUNDARY WALL		5.72	5.63	0.09	5.72	5.93		5.93		5.93	0.212	5.93	0.212	5.93	0.210
27	134A DICKSON ROAD	ENTRANCE GATE		5.51	5.36	0.15	5.66	5.93		5.93		5.93	0.272	5.93	0.272	5.93	0.270
28	138 DICKSON ROAD	GROUND FLOOR FLAT	5.74		5.55		5.63	5.94		5.94		5.94	0.314	5.94	0.314	5.94	0.310
29	138 DICKSON ROAD	REAR FLAT	6.54	6.45	6.41	0.04	6.56	6.59		6.59		6.59	0.029	6.59	0.029	6.59	0.030

7 DISCUSSION

7.1 APPLICABILITY OF VALIDATION RESULTS

A Mike Flood model of the Papamoa East catchment has been built and incorporates the stormwater drainage reticulation, the large open channel running the length of the catchment and a representation of overland flow and flood storage surface. All components of the model are dynamically interconnected.

The model has been run for the April 2013 storm event. Top water levels from the model have been compared with four water level gauges along the WDS and after a number of simulations a good match has been obtained although modelled levels are slightly higher than observed (refer Figure 10).

Modelled top water levels have also been compared to surveyed levels at a number of flood incident locations through the catchment. Generally modelled levels are higher than surveyed (refer Table 1). This may indicate that infiltration/leakage rates are higher than those assumed. However, it is noted that most of the flood incident locations occur within 400m of the coast where the older style of development with houses below the road level sometimes occurred. This zone along the frontal dunes however is likely to have the coarsest sand grain size and higher infiltration/leakage rates than the catchment average. Results from these flood incident locations should therefore not necessarily be used as a guide to catchment wide infiltration parameters.

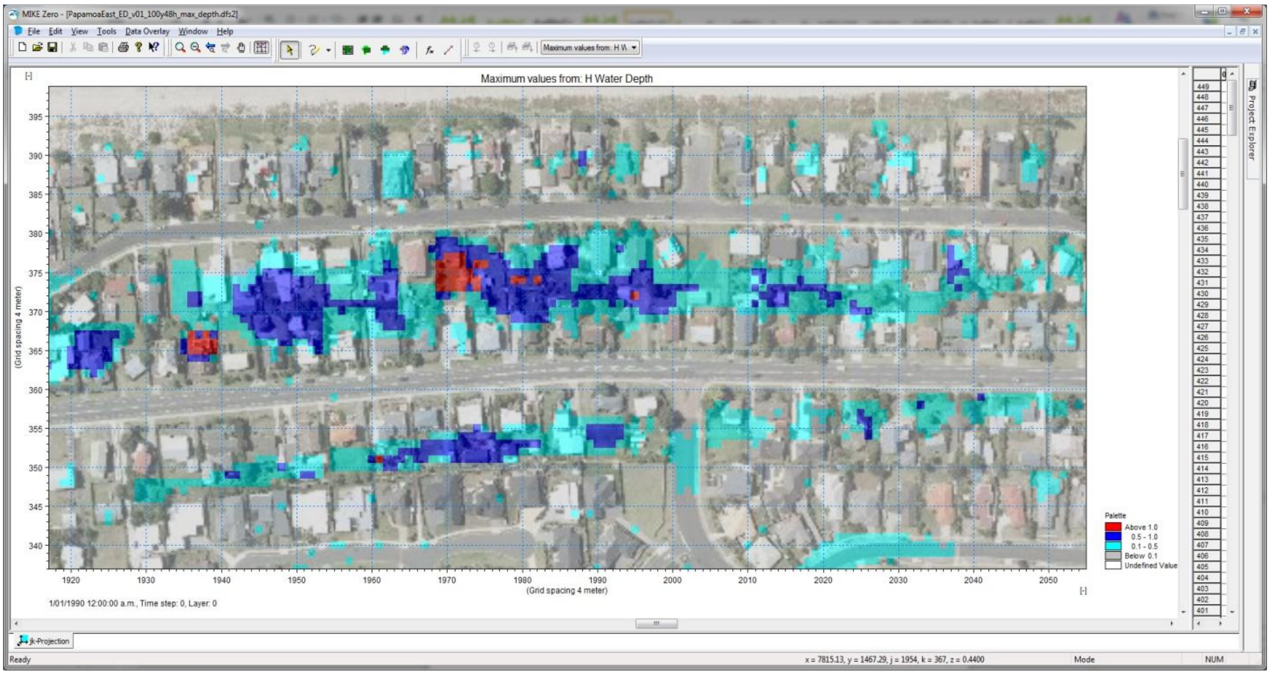
As discussed previously, thought was given to trialing increased soakage rates in the frontal dunes and decreasing soakage rates away from the dunes (to give a similar total runoff into the WDS) but there was not enough validation data away from the frontal dunes to warrant such model complexity.

It is also noted that the April 2013 storm occurred after a prolonged dry period and infiltration/leakage rates may be lower in another event with wetter antecedent conditions and a higher groundwater table. This is of particular concern at the eastern end of the WDS which relies heavily on soakage. The modelled rate of soakage from the base of the eastern end of the WDS for the validation event was 26 mm/h. This is far greater than the value of 0.004 to 0.04 m3/day (0.167 to 1.67 mm/h) recommended by a report done by Tonkin and Taylor in (2006). The value of 0.167 to 1.67 mm/h has been determined from more than one storm and is therefore believed to be more robust than from the atypically dry antecedent conditions of the April 2013 validation event used for this study. It is therefore recommended that for design events the infiltration/leakage rate in the eastern end of the drain be reduced to match the values recommend by Tonkin and Taylor (2006).

7.2 MODEL LIMITATIONS AND APPLICABILITY

The use of Mike 21 and rain on grid to model overland flow means the user of the model can drill down anywhere in the catchment (down to the individual 4m by 4m grid squares) to determine peak flood levels, flood depths or flood velocities at any given location. The extremely detailed and visual results that the model produces are much more user friendly than the results from the old 1D model. Figure 11 gives an example of the detailed output available from the new 2d model.

Figure 11 – Example of 2D model output



The human tendency for 'seeing is believing' can lead to the danger that the user believes that these latest results are reality and forget that they are only the model's best estimate of reality. It is therefore important that the user of the results (who is often not a modeller) is made aware of the model's limitations and applicability:

- As with any model, this model still includes assumptions and simplifications of the complex real world processes, but the flow and ponding above ground is now much better represented than with the earlier Mike 11 1D model of the catchment.
- On a broad scale the model build provides a reasonable representation of flood depths and extents for the April 2013 event. The model is therefore useful for broad-scale planning measures and also for testing of stormwater mitigation designs and options.
- The model is a snapshot of the catchment when the LiDAR was flown in 2012 and does not include any development undertaken since then. It may therefore not be applicable where flows from newly developed areas impact on results.
- It should be noted that localised ponding depths may vary significantly where overland flow is obstructed or blocked (e.g. by obstacles, debris, solid fences or sheds etc.). Results could also be impacted in places by kerb heights which are not necessarily fully resolved by the 4m DEM used in this study. Maximum flood depths on a property by property basis should therefore be used with caution.
- Results in the Taylor Road area will be affected by the soakage capacity of the soakage systems in Taylor Road and also in Taylor Reserve. Use of the model in this area should be used with caution. Further refinement and/or testing of the model is recommended in this area prior to using it for testing mitigation options. Field testing of the capacity of existing soakage systems could be beneficial.
- Long term water levels in the WDS are highly influenced by groundwater levels/flows. As the Mike Flood model does not include a groundwater component this makes it unsuitable for long term, continuous or low flow simulations. For large storm events however such groundwater impacts are likely to be minor. Hence the model should only be applied to storm event modelling only.

8 CONCLUSIONS

This paper describes the model build and validation for the Papamoa East catchment. Papamoa East is a real humdinger of a catchment due to the unique combination of a number of factors including changing catchment size, catchment flatness, and limited outlets to the ocean. The validation data available has also added to the project complexity.

The model has validated well against the four water level gauges in the catchment and reasonably well against the 29 flood incident reports for the April 2013 event. However this is just one flood and it is possible an equally good validation for this event could have been achieved with a different combination of factors (e.g. increasing soakage near the coast and decreasing soakage away from the coast). It is also noted that the April 2013 event occurred after an extremely long dry spell and low groundwater levels. Higher groundwater levels in a different event may see the catchment respond in a much different way. Hence while validation is an extremely important process and can be useful in removing errors from a model it does not mean that a validated model is 'perfect'. Indeed more conservative soakage parameters in the eastern end of the WDS have been recommended for modelling design events to allow for wetter antecedent conditions and higher groundwater levels.

The use of Mike 21 and rain on grid to model overland flow means the user of the model can drill down anywhere in the catchment (down to the individual 4m by 4m grid squares) to determine peak flood levels, flood depths or flood velocities at any given the location. The extremely detailed and visual results that the model produces are much more user friendly than the results from the old 1D model. However the human tendency for 'seeing is believing' can lead to the danger that the user believes that these results are reality and forget that they are only the model's best estimate of reality. It is therefore important that the user of the results (who is often not a modeller) is made aware of the model's limitations and applicability.

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10 REFERENCES

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