
STANMORE BAY

Hydrological and Hydraulic Modelling

Prepared for
Rodney District Council

June 2006

Stanmore Bay

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REFERENCES

Stanmore Bay Catchment, Opus international Consultants, October 2003
TP108, Guidelines to Stormwater Runoff Modelling in the Auckland Region, April 1999

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1 INTRODUCTION

1.1 Introduction

A report was completed for the Council in October 2003 by Opus International Consultants (OIC) which examined stream discharges, flood hazard area and some of the possible solutions to mitigating flooding problems in Stanmore Bay. This report provides the background knowledge to the hydrological and hydraulic modelling in that report and subsequent work. The earlier work used the HEC-HMS and HEC-RAS software to generate results while the more recent work has used MIKE11 and MOUSE software. Once built, the models were peer reviewed by Geoff Wilson who made suggestions that were subsequently incorporated into the model. The peer review is attached as Appendix C.

1.2 Existing Drainage System

Stanmore Bay in the Whangapararua Peninsula is 474ha in area. It has steep upper areas and a large floodplain discharging to the sea. There are 3 principle drains and watercourses. These are called the Vipond Stream flowing from west to east, Brightside drain flowing from south-west to north-west and Stanmore stream flowing south to north. These 3 branches will form the backbone of the modelling.

There are still large areas that can be developed to maximum possible development (MPD) which will be examined for the long-term drainage design of the system. Further layout plans and description of the drainage system can be found in the body of the Stanmore Bay ICMP report prepared by URS.

2 METHODOLOGY

2.1 Modelling Software Utilised

The modelling software used is required to incorporate the following hydrological and hydraulic capabilities:

Hydrology: The model converts rainfall into runoff taking into account losses that include evaporation and infiltration. It should also allow for different land use.

Hydraulics: The model uses the surface flow at the point of entry to the drainage system and conveys flows within the system. It determines the peak transient flood levels along the open channel sections (if necessary) to a mappable standard. It should account for energy losses at culverts and permit storage on floodplains.

The software packages MOUSE and MIKE11 fulfil both of these requirements. The Danish Hydraulic Institute in Copenhagen has developed these packages. They are widely used within New Zealand by a number of territorial local authorities and consultants for work of this nature. MOUSE produces flow hydrographs and MIKE11 performs the hydraulic analyses.

MOUSE uses the rain depth distribution, the catchment area and land-use run-off factors to calculate flows to a point in a subcatchment. The resulting flows are temporal (not steady) during the duration of the storm event. This is better than the Rational Method as the flows are allowed to change through the flood event.

MIKE11 accounts for the dynamic effects of subcatchment inflows and channel storage.

MIKE11 produces flows, velocities and water levels throughout the drainage system based upon the cross sections and a longitudinal grid system. It can calculate backwater effects for a constantly changing flow and downstream control conditions.

Finally these software packages are available on the open market to allow transparency of use from one user to the next.

2.2 Hydrological Analysis

The whole study area was divided into 16 subcatchments based on the OIC breakdown. The areas they used were re-checked using the Council's GIS and some adjustments were made to the areas. Figure A5 in Appendix A shows the subcatchments. Some of the OIC subcatchments were amalgamated to fit with the MIKE11 inflow points.

The rainfall pattern used was that recommended in the Auckland Regional Council's (ARC) Technical Publication No.108 (TP108).

Initially the MOUSE Model A method was used to generate runoff but after consideration and comparison with the TP108 methodology using the SCS curve number technique the latter was used. The parameters were determined from model calibration work and those recommended in TP108.

The TP108 information was input into MOUSE to generate transient flows to points within the open channels. The MOUSE flows were then transferred to MIKE11 so that the hydraulic analysis may then calculate flows and water levels in the open channel system.

2.3 Hydraulic Analysis

2.3.1 Set Up

The modelled network is shown in Figure A1 in Appendix A. There are 2 outlets to the sea. These are Stanmore stream to the east and the diversion outfall in the central area.

Cross section data was extracted from the OIC HEC-RAS model. Supplementary survey was used at the Vipond stream diversion area, Stanmore stream at Red Hibiscus Road and contour plans along Brightside Road. Brightside Road straddles Brightside drain and Vipond stream and therefore overflows had to be modelled. This was done using artificial

overflow channels using weirs at the road levels and using storage cells to imitate ponding.

The gradient and dimensions of the upper Brightside drain were based on the 2m contour plans so that a reasonable diffusion of run-off to entered the channel instead of a concentrated inflow immediately upstream of the Whangapararoa Road culvert.

Details of the hydraulic structures, the diversion pipes, were extracted from as-built plans.

2.4 Modelling Assumptions

Computer models require certain assumptions when used to simulate real events. These assumptions are either implicit within the mathematical formulations or explicit in the modelling technique when used to imitate difficult flow situations.

Some assumptions are used if the model becomes unstable because high flows or low water depths can be generated. The following is a list of assumptions that were used within the model.

2.4.1 MOUSE - hydrology

1. Rainfalls were modelled at 60 second time increments.
2. Synthetic design rainfalls were used.
3. The subcatchment shapes are rectangular and all flows merge to one point at the subcatchment outlet. Flows are either via a trunk pipe system and/or by overland flow.

2.4.2 MIKE11 - hydraulics

1. Channel roughness was set to a Manning's n of 0.033 throughout the model. This is a standard value for these types of channels. Some channel reaches may be smoother than this because of their construction but since the system

is “storage controlled” this would have little impact on final water levels.

2. Stormwater was put into off-channel storage at a given height based on whether the channel banks were overtopped and/or based on the contours. Initial tests indicated whether storage was applicable at any given point based on overtopping of the banks.
3. Flows are one-dimensional and no allowance for eddy flows or lateral flows was given. This is typical for these types of narrow channels.
4. All channels are connected at right angles to each other. In reality tributaries connect at acute or obtuse angles which may improve or hinder flows. However the errors involved are quite small (10mm to 20mm) due to low velocity differences of less than 0.5m/s.
5. The tailwater level at the outlets was set to RL1.8m (MHWS). In Phase 4 a tide level of RL2.3m was considered to assess the effect of a high tide coupled with a storm and expected sea level rise.

3 MODEL CALIBRATION

3.1 Introduction

Flow and rain data was collected from April to May 2004 in order to calibrate the model. The flow locations were the 2 culverts into Vipond Stream at D'Oyly Drive (mainly urban), the culverts under Whangapararua Road in Brightside drain and Stanmore stream (less urbanised). The rain gauge was stationed at the latter flow gauge.

Initially the model was calibrated using Model A in MOUSE. However, at a late stage in the project Model A was not the method used in the final analysis in preference to the TP108 method. Thus the early calibration work is a moot point. However some discussion will be presented.

3.2 Model A Calibration

Figures A2 and A3 in the Appendix show the rain events measured. These are from 29 April to 5 May and 17 June to 20 June. These are estimated to have 4%AEP (1 in 25 year) and 60%AEP (less than 2 year) return periods respectively. Using the Model A methodology it was found that the C factor for the pervious areas ranged from 0 for the D'Oyly drive location up to 0.55 for the Stanmore stream location. These were inconclusive. However running a C factor of 0.55 for the pervious component, the peak flows compared favourably with the OIC results.

3.3 TP108 Calibration

Examining the rainfall-runoff relationship allows one to develop a CN for the catchment. Figure A4 plots the measured rain against the measured runoff depth and compares them to a range of curve numbers. Table 3.1 gives the numbers. A 10% error band has been applied.

Table 3.1 – Measured Rainfall Runoff

Date	Rain (mm)	Runoff (mm)	Location
29/04/2004	36	9.42	D'Oyly
1/05/2004	67	23.43	D'Oyly culverts
17/06/2004	48	31.04	D'Oyly culverts
17/06/2004	48	12.64	Brightside Drain
29/04/2004	36	5.80	Stanmore Stream
1/05/2004	67	28.08	Stanmore Stream
17/06/2004	48	23.47	Stanmore Stream

It can be seen that 4 of the points are above the CN=70 line. Using the TP108 manual the recommended CN value of 74 should be used for the lithology present and this comes close to 5 of the 7 points. The other 2 point suggests a CN of 85 or 90 should be used.

After consultation it was decided that CN=74 would be used for the pervious component except were the lithology was alluvial. The CN would be 61 in these areas and complies with Table 3.3 of TP108.

A table was created to calculate the various parameters to be used in the UHM module of MOUSE. Tables A1 and A2 in Appendix A gives all the details for existing and MPD scenarios.

Catchment 5B was spilt into 3 components to distribute the flows better. Its real area is 65.43ha. The unconnected impervious area was assumed to be 25% of the actual impervious area.

Seven scenarios were run. These are tabulated below with the associated 24 hour rain depth according to the TP108 manual.

Table 3.2 – Storm Scenarios and Rain Depths

Scenario	24 Hour Rain Depth (mm)
Water Quality	28
50% AEP	85
20% AEP	115
10% AEP	150
5% AEP	170
2% AEP	200
1% AEP	230

The flow hydrographs were imported into the MIKE11 model.

Table A3 in Appendix A gives the peak flows and discharges for all subcatchments for the MPD scenario.

4 FLOODING ISSUES IDENTIFIED

From modelling the 10 year and 100 year scenarios the following areas have been identified as having flooding problems in terms of houses at risk. For all problems the default reason for flooding problems is that the houses were built too low in natural (historical) floodplain zone.

1. Vipond Stream from the diversion structure overflow to Kauri Road. In essence this reach is part of the historical tidal flat floodplain with a nominal watercourse with little capacity. Further urban development will exacerbates the problem. There are 3 other reasons for the flooding. The diversion structure outfall does not convey greater than 50%-20% AEP and thus the extra water from catchment 1CDEF is stored in D'Oyly reserve and ultimately directed (in-line) into the channel. The channel can not convey local runoff and the backwater effect of the tidal coupled with Stanmore Stream having a higher head level creates a fixed downstream water level with very little opportunity for water to escape Vipond Stream.
2. Brightside Road from Holiday Road to Kauri Road. Like Vipond Stream this is an artificial channel with little capacity in an historical floodplain area. The hydraulic grade is very poor with a restrictive downstream control. Again local runoff causes problem even without upstream inflows from catchment 3BC which are directed to the diversion structure. The diversion pipe also can not convey greater than 2-5 year flows.
3. Stanmore Stream at the back of properties in Rimu and Rata Streets. This is the upstream end of the floodplain where large flows enter the system.

These issues are supported by public consultations via flood questionnaires.

Items 1 to 3 will be examined in the following sections.

5 RESULTS

5.1 Introduction

The hydraulic analysis was done in 3 phases.

Phase 1 was examining broad brush options to eliminate opportunities that by themselves or in combination with others would not provide reasonable mitigation. Phase 2 looked further into the outcomes of phase 1 and included other ideas that will reduce flooding. Phase 3 was the final examination of options that were deemed feasible.

The reduction in flows at critical locations and the reduction in the number of houses at risk were the criteria for taking an option further.

5.2 Phase 1

Table 5.1 describes the options examined in phase 1. These options were examined for the existing land-use for a 100 year rainfall using the MOUSE Model A approach.

Option 1 was tested because water from Stanmore Stream enters Vipond Stream due to the hydraulic head. By using a pump station this inflow would be prevented and the Vipond Stream flows could be “kept moving” so a pond does not form behind the restriction. The results indicated this option has minimal benefit.

Option 2 considered a diversion channel at the Stanmore Bay park culverts out to the sea with similar dimensions to Vipond Stream at this point. The number of houses flooded is not reduced. The flood level in Vipond Stream in Brightside Road has reduced by about 30mm which clearly is not significant.

Option 3 is to raise the stage I diversion weir by 0.7m to create more storage. It reduces the peak flow over the weir from 20m³/s to 16m³/s and thus the Langton Road overflow is reduced by 25%. However when examining the

flood levels in Brightside (even numbers houses only) the flood level only drops by 30mm.

Table 5.1 – First Phase Options

Option	Description	Proceed	No Houses Flooded
	Base Case		56
1	Major pump at Stanmore Bay	No	56
2	Diversion channel (3m bottom, 2m deep, 5 top) to the sea starting just upstream of Stanmore Bay park culverts	No	56
3	Raising diversion weir to RL6.5m (is RL5.8m)	Yes	56
4	Upgrade Kauri Road drain A culvert to 5mW x 1.5mH	No	54
5	Option 4 plus pipe from Brightside Rd to Kauri upgrade to 2 x 1.2m square box culverts	No	54
6	Combine options 3 and 4	Yes	49
7	Raising diversion weir to RL7.0m (is RL5.8m)	Yes	53
8	Raising diversion weir to RL8.3m (is RL5.8m)	Yes	41
9	Parallel diversion pipe for Stage II to outfall using a 3mW x 2mH culvert	No	53
10	Diversion channel (3m bottom, 2m deep, 5 top) to the sea starting just upstream of Kauri Road in drain A plus Brightside Rd to Kauri Rd upgrade to 2 x 1.2m square box culverts.	No	39

The Kauri Road culvert in Vipond Stream clearly causes an obstruction to flow and therefore option 4 was created to examine its upgrade. The size finally used was a 5m wide by 1.5m deep box culvert. The impact in terms of houses flooded was minimal even though the flood level dropped by 200mm.

Option 4 was enhanced for option 5 by upgrading the “minor diversion” along Kauri Road connecting Brightside Drain to Vipond Stream. No great

improvement was found and thus all flood levels are controlled by downstream conditions as opposed to the conveyance of any infrastructure.

Option 6 is a combination of options 3 and 4 with the objective of restricting upstream inflows and allowing downstream flows to escape quickly. With this option only 7 houses are prevented from flooding even with a flood level drop in Vipond Stream of 250mm.

Option 7 looked at building on option 3 by raising the weir to RL7.0m, that is, to the present maximum embankment height. The results are effectively the same as option 3. The so-called storage area is not actually acting as storage with the incoming flows bifurcating between the outfall and weir with no attenuation obvious. On close examination of the storage area it is basically a typical expanding cross-section with a weir cut-off. There is no discernable storage of any significance for the 1%AEP storm event. A close check on the volumes show the storage available is about 4% of the total volume which has no effect on the incoming discharge hydrograph.

Based on option 7, option 8 was developed with the weir raised to RL10m. The results are quite significant. Only 41 of the original 56 houses are at risk. The overflow is reduced to zero and the pond level is RL8.10m (meaning that a weir at RL8.30m would work). Houses adjacent to Knott Road would then need to be protected. Ongoing performance of the diversion structure becomes very critical for this option. The flow in Vipond Stream behind Brightside Road and between Langton Road and Kauri Road has reduced from $22\text{m}^3/\text{s}$ to $4\text{m}^3/\text{s}$ with a corresponding flood level drop of 330mm. Therefore from an initial hydraulic perspective this option would appear simple with a widespread benefit.

Brightside Road is clearly a physical barrier between Vipond Stream and properties adjacent to Brightside Drain. Odd number houses do not benefit from work in Vipond Stream. Option 9 looked at enhancing the diversion of inflows from the stage II diversion to the outfall. Initially a pumped system was considered. However a gravity pipe would work because the ground slopes in the south-north direction. Initially a pipe was modelled in parallel to the existing 1600mm diameter pipe was tried. Eventually a 3m wide by 2m

high box culvert was modelled. This new pipe diverts a peak flow of $8\text{m}^3/\text{s}$. The number of houses flooded has reduced by 3 with a 100mm flood level drop in Brightside Drain. Option 9 has a marginal benefit of protecting 1 extra house not protected by option 8. Thus option 8 should be considered for its overall effect widespread effect.

Option 10 is a variant of option 2 with the diversion to the sea starting upstream of the Kauri Road culvert in Vipond Stream. The flood level in Vipond Stream has reduced by approximately 500mm which is significant but the number of houses flooded is still 39 and is the best option based on the criteria. The total volumes entering the sea during the middle 12 hours of the storm increases by 50%. However this option was not considered further due to environmental impacts of a new outlet, velocities generated and the very high construction cost.

Finally option 11 was done to determine what size culvert would be required on the south side of Brightside Road for the 5 year standard. The maximum height of culvert available is about 1.5m. The new culvert would at the very minimum mimic the existing conditions. Initially a 2m wide box culvert was used but the flood levels were raised by 50mm. A 3m box culvert was used and the flood levels were the same as existing.

A throttle on Brightside Drain just downstream of the stage II diversion pipe was used with the 2m wide box culvert. The throttle pipe was reduced from 1600mm to 900mm. It gave similar results to the 3m wide box culvert. It must be noted that constructing this culvert increases Kauri Road flood levels by 130mm so this must be mitigated with other works but essentially a 3m x 1m box culvert should work.

The options of creating a new sea outfall, Options 2 and 10, are the clear winners at the confluence of Vipond Stream and Stanmore Stream. Option 8 brings the 100 year flood level down to the existing 5 year level at 8 Langton Road with all the others seeing no real change. Options 8 and 10 are clearly the best for properties along Vipond Stream between Kauri Road and Langton Road and also reach the target level at 118 Brightside Road (north side).

Finally, for 125 Brightside Road and odd number houses along the south side of Brightside Road there is no clear better option with all in a 100mm band.

5.3 Phase 2

Phase 2 consisted of examining phase 1 further. There are also new options to test the sensitivity of the Brightside Road floodplain for the 1%AEP storm event. Table 5.2 gives the details of the options for the MPD land-use, 1%AEP storm and 500mm freeboard.

Option 1 was further work on the previous options. There was some consideration that more storage could be created behind the Vipond bund. This gave some further protection but it would be extremely difficult to build for geotechnical reasons and it was decided to abandon this option.

Option 3 was a middle ground option for options 7 and 8 from phase 1 and it was felt this was the greatest height the weir could be built and be feasible. It is very close to the no overflow allowed option.

Option 4 was undertaken to determine whether diverting the whole of the upper Brightside catchment (3BC) would have a benefit in the Brightside Road area. It was slightly worse than the raising the weir and improved storage options. This option shows that the weir and storage option has great merits than diverting the catchment above Brightside Road alone would not provide significant protection.

There is the possibility that flows could be diverted to Stanmore stream from catchment 4A. By it self there is a small improvement and could be considered with other options.

Options 7 to 15 were all combinations of the others. Only options 13 and 15 could be considered further with good reductions. Option 13 gives the best reduction in flooded houses from 56 to 30 (although the houses adjacent to the storage area in D'Oyly reserve become at risk).

Table 5.2 – Phase 2 Options Examined

Option	Description	Proceed	No Flooded
	Base Case		56
1	Weir raised to RL8.5, no overflows for 100 year event	Yes	41
2	Weir raised to RL6.8m, 11,000m ³ of excavation	No	36
3	Weir raised to RL7.6m (mid-way between phase 1 options 7 and 8)	Yes	42
4	Catchment 3BC completely stored, no flow through Whangapararoa culvert	No	45
5	Parallel diversion pipe for Stage II (use a 3mx2m high gravity culvert)	No	50
6	Catchment 4A diverted to Stanmore Stream	Yes	51
7	Options 1 and 4	No	23
8	Options 2 and 4	No	22
9	Options 3 and 4	No	24
10	Options 1 and 5	No	27
11	Options 2 and 5	No	26
12	Options 3 and 5	No	35
13	Options 1 and 6	Yes	30
14	Options 2 and 6	No	28
15	Options 3 and 6	Yes	35
16	20,000m ² of ponding upstream Whangapararoa Rd Brightside drain	Yes	51
17	Options 1 and 16	Yes	30
18	Options 2 and 16	No	28
19	Options 3 and 16	Yes	41

Option 16 was introduced as this is a sensible storage solution for the undeveloped catchment 3BC. This option is the “hydrological neutrality” option for the development of the catchment and should be part of a “base case” solution. Based on the expected changes in land-use the extra volume

generated in the 10 year event is 12,000m³ and that in the 100 year storm is 14,000m³. Therefore storage of 20,000m³ is sufficient to examine impacts.

Option 16 was then combined with 1, 2 and 3.

With all options there are still a substantial number of properties at risk under the 1%AEP storm event.

5.4 Phase 3

This phase uses the TP108 methodology. It builds on the previous phases with slight alterations and focuses on the 10 year standard before testing the preferred option for the 100 year standard. Options regarded as unfeasible or ineffective were not considered further.

The options for the mitigation along Brightside Road are

- Raise the Vipond Stream diversion structure bund to RL6.8m. (provides a 10 year standard for zero overflow) or RL7.6m.
- Allow for 20,000m³ of storage upstream of Whangapararua Road in catchment 3BC. This would provide mitigation for full development of the previously undeveloped catchment.
- Install a culvert in Brightside Drain in the existing open drain,
- Divert parts of catchments 4A and 4B into Stanmore Stream. This modelling assumes 4.3ha and 5.0ha could be diverted from catchments 4A and 4B respectively.

Table 5.3 – Phase 3 Option Combinations

Option	Elements Examined			
	Diversion Structure Crest at RL6.8m	20,000m ³ storage Upper Brightside	New Brightside culvert	Diversion catchment 4A
F1	Yes			
F2		Yes		
F3				Diversion catchment 4A
F4			3 x 1m box	
F5	Yes	Yes		
F6	Yes	Yes		Diversion catchment 4A
F7			Open box 3m wide	
F8			Twin 1.8m culvert	
F9	Yes	Yes	Twin 1.8m culvert	
F10	Yes	Yes	Twin 1.8m culvert	Diversion catchment 4A
F11	Impact of 10 year solution for 100 year flood Best of F1 to F10 (F10 Used)			
F12	Raise weir to RL7.6			
F13	Widen Vipond Stream by 5m minimum from Langton Road culvert			
F14	Install rain tanks throughout catchment			

Table 5.3 shows the options numbering system and the combinations. Table A4 in the Appendix also summarises the number of houses at risk for the zero and 200mm freeboards. Tables A5 to A6 in the Appendix gives the flood levels for all properties identified at risk for freeboards of 0mm and 200mm respectively. The cells shaded yellow show the houses at risk for the various scenarios. Table A7 in the Appendix creates a summary of flows and water levels.

It is clear option F1 compared to all the other individual options (F2, F3, F7 and F8) gives the greatest benefit in terms of houses at risk.

In terms of installing a culvert along Brightside drain three options were examined. The options were as close as comparable as possible in terms of inverts and size. The 3 sub-options were:

- 3m wide x 1m high culvert,
- 3m wide rectangular concrete channel,
- Twin 1.8m culverts.

The average grade was 1 in 500.

A 5m wide box culvert was tested but had minimal benefit in terms of the 3m wide box. The downstream water level control at the confluence of the Brightside drain into Vipond Stream is RL2.25m. If a zero HGL was created then 1 house would still flood with zero freeboard. Any structure would create a HGL and there are limitations to how close to zero HGL can be achieved.

The results in Table A4 show that the 3m x 1m culvert (option F4) or the twin 1.8m culverts (option F8) achieve the same outcomes that are 10 houses flooded with a 200mm freeboard allowance. The 3m wide open concrete channel (option F7) fairs slightly better with 9 houses at risk with the 200mm freeboard.

In Table A7 the rectangular channel option creates a water level 0.09m below the twin culverts at 123 Brightside Road. This implies the open box potential creates a reduced risk to housing. However in consideration of the environmental and social impact of a 3m open concrete channel it has been decided that the twin culverts would be considered hereon in. This choice also implies that if a rectangular concrete channel was preferred then the following results of the combinations would be conservative.

Option F13 examined the widening, by 5m, of Vipond Stream from the diversion overflow weir to Langton Road. This made no difference to houses being flooded in the 10%AEP event.

Option F14 examined the installation of rain tanks. The number of houses flooding during a 10%AEP event was 6. This is a reasonable outcome

compared to many of the other options considered. However its implementation would be highly risky and perhaps unachievable.

In summary from lowest to highest water levels (best to worst) the Brightside Drain upgrade options are as follows; concrete open channel, natural open channel and then twin culverts.

When the existing system and MPD land-use (X-MPD) are compared to all options the best outcome is 7 houses “saved” for the 200mm for the 10%AEP storm. These are for options F9 and F10. When F10 was used for the 1%AEP storm the benefit was 20 houses (from 36 to 16 houses). This justifies looking at a combination of options.

In terms of 200mm freeboard, the following benefits are realized if the 7 houses at risk for the weir raising are used as the benchmark.

Weir to RL6.8 **PLUS** 20,000m³ storage (Option F5) – no change

Weir to RL6.8 **PLUS** the diversion of catchments 4A and 4B – 2 houses

Weir to RL6.8 **PLUS** the Brightside twin culverts – 3 houses

Weir to RL6.8 **PLUS** the Brightside twin culverts **PLUS** diversion of catchment 4A and 4B – 3 houses.

Therefore as more “construction” occurs the number of houses at risk improves but the diversion of catchments 4A and 4B are of no combined benefit. The storage option in catchment 3BC is redundant in terms Brightside Road protection.

When comparing the “do nothing” option with the full combinations the houses at risk reduces from 11 to 4 and because 4 houses will flood with a zero HGL this results means 7 houses have not received mitigation.

The best option was then run for the 1%AEP storm. This is option F10. The number of houses that are deemed at risk as been reduced from 36 to 16 in terms of the “do-nothing” option. For zero freeboard this has reduced from 19 to 12.

If the diversion structure weir is raised a further 0.8m to RL7.6m (option F12) the houses at risk are 17 and therefore the combination of Weir to RL6.8 **PLUS** the Brightside twin culverts **PLUS** diversion of catchment 4A and 4B is better than increasing the weir height to RL7.6m.

5.5 Phase Four - Further Options

5.5.1 Pressurised Diversion of Subcatchments 4A and 4B

A further option was examined to divert runoff from catchment 4A and 4B directly into Vipond Stream downstream of Kauri Road culvert using a pressurized pipe. It is assumed that the pipe would be sealed. This was called option 30, with the existing system and the reconfigured catchment being option 29. The pressurized pipe had to be a 1.8m culvert due to the low grade available. It was found that along the Brightside Road drain the flood level dropped by 40mm and 30mm in the 50%AEP and 10%AEP storms respectively. Along Vipond the effect was a 20mm and 30mm drop in flood level for the same storms. In essence the pressurized pipe provides insignificant improvement on the potential high frequency flooding along Brightside Road.

5.5.2 Storage above Whangapararoa Road in Stanmore Stream

A check was made on the storage at the top end of Stanmore Stream known as the old tip. A better description of the storage curve was provided and input into the model as shown in Table 5.4 and the overflow level increased to RL17.0m.

Table 5.5 shows the resulting overflow volumes and peak flows. The results in Table 5.5 are based on the assumption that the existing impervious area is 18% and the future impervious area is 55%.

The results indicate that for the status quo that the storage is almost fully utilized but there is no overflow. Future development will cause an overflow although not catastrophic. However if the landfill is filled then the overflow would be substantial and upper catchment storage would need to be utilized.

The numbers indicated that a minimum storage requirement is 16,000m³ but more would be needed for freeboard requirements.

Table 5.4 - Storage at the Whangapararoa Road Council Landfill

Level (RL)	Volume (m ³)
11.5 (base)	0
12.0	7
13.0	71
14.0	317
15.0	2,240
16.0	7,279
16.5	10,872
17.0	15,339
17.5	20,857

Table 5.5 – Landfill Results, 100 year Flood

Scenario	Peak Water Level RL(m)	Peak Overflow (m ³ /s)	Peak Overflow Volume (m ³)
Existing storage, existing land-use	16.86	0.0	0
Existing storage, future land-use	17.19	0.69	1,147
No storage, future land-use	17.67	8.70	15,712

5.5.3 Hydrological Neutrality in Subcatchment 3BC

Hydrological neutrality was considered for catchment 3BC. Based on the expected changes in land-use the extra volume generated in the 10 year event is 12,000m³ and that in the 100 year storm is 14,000m³. Previously a 20,000m³ storage facility was modelled (option 21) just upstream of the Whangapararua Road culvert to mitigate new development. On-site lot by lot mitigation to achieve hydrological neutrality is another approach

5.5.4 Rain Tanks

On-site attenuation was examined using rain tanks. To simulate the effect of rain tanks the rainfall was reduced. This was based on 31% of runoff from each subcatchment being directed into rain tanks. The remaining 69% being non-roof run-off from drive-ways etc which eventuates into the stormwater drainage network. Rain tanks were assumed to be designed for a 2 year storm. Therefore for the 10 year storm the total rain depth simulated was 123.65mm (150mm 10 year minus the 85mm 2 year multiplied by 0.31, 150-85*0.31). The MOUSE to MIKE11 procedure was thus run with this rain depth. This is option F14 and the results in Table A5 shows that 6 houses are at risk of flooding compared to the existing situation of 11 houses for the 10%AEP storm.

5.5.5 Impact of Higher Sea Levels

This was undertaken by increasing the sea level to RL2.3m compared to the RL1.8m used in all the previous analyses. The objective was to test how a rise in sea level combined with a storm surge during extreme high tides would affect flood levels under the preferred mitigation options. The break up of the components is;

MHWS, N2	1.45m
Surge (50% of 50yr)	0.4m
Sea level rise	0.2
Y effects (IPO/ENSO)	0.25

Due to vast array of options considered in the previous sections it was decided to run just one preferred option. This option consists of

- The bund in Vipond Stream is raised to RL6.8m.
- 10,000m³ of storage in Brightside Drain just upstream of Whangapararoa Road.
- Existing storage in Stanmore Stream upstream of Whangapararoa Road.

Appendix B (Tables B1 and B2) gives all the results for the 2, 10 and 100 year return periods. Table B3 gives a summary of the houses flooded for both sea levels considered. Table B4 shows the model chainages where there is a difference in flood level due to the sea level rise consideration.

In summary, for the frequent storms (10%AEP) and assuming sea level will rise as predicted then doing nothing will have 19 houses be flooded while the “preferred option” will mean 12 flooded houses. Therefore in the long term the proposed solution will reduce the risk of flooding to 7 houses.

6 CONCLUSIONS

Hydrological and hydraulic modelling of the Stanmore Bay watercourses has enabled a thorough analysis of the flooding issues and mitigation options.

After 3 phases are identifying various mitigation scenarios the following have been identified as reducing the risk of flooding along the low lying Brightside Road area. These options are based on reducing the risk of houses flooding and not social, environmental or cost reasons.

- Raise the weir of diversion structure to RL7.6m. No change in width. Protection of houses in Knott Road,
- Ensure at least 14,000m³ of storage within catchment 3BC,
- Divert parts of catchments 4A and 4B to Stanmore stream,
- Install twin 1.8m culverts in Brightside Road to replace the open drain,
- Construct a bund/stopbank at the back of the properties in Rimu and Rata Streets to a level of 3.5m plus freeboard.

APPENDIX A

Data and Results

APPENDIX B

Examination of Sea Level Rise Results

APPENDIX C

Peer Review by Geoff Wilson