EXECUTIVE SUMMARY

The primary aim of the Hamilton Flood Investigation was to undertake definitive flood investigations for Hamilton and to undertake a comprehensive analysis with all available data to determine a robust 1% Annual Exceedence Probability (AEP) flood extent for the flood plains of the Grange Burn and other minor tributaries in and around Hamilton. The study area for this project is shown in Figure 1.1.

Key Deliverables

The primary outcomes from the Flood investigation included:

- Report summarising the Hamilton Flood Investigation;
- Digital floodplain maps showing both floodplain and floodway areas;
- Economic damage assessment;
- Mitigation option assessment and risk assessment;
- Victoria Flood Data (VFD) compliant datasets;
- Draft Planning Scheme Amendment documentation; and
- Municipal Emergency Management Plan Appendices.

Hydrology

For the study area is was evident from the rainfall and streamflow analysis that antecedent conditions within the catchment play an important role in the translation of rainfall to runoff with significant differences in loss rates for rainfall events between the wet and dry periods. The hydrological assessment for the Hamilton catchment was restricted by the limited availability of streamflow data with only four years of streamflow record upstream of hamilton. The gauges within the system are summarised in Table i.

Table I Available streamflow gauges

Gauge No.	Gauge Name	Area	Start Date	End Date
238239	Grange Burn at Hamilton	222 km^2	May -1981	Apr-1985
238219	Grange Burn at Morgiana	964 km^2	Jul -1963	Present

Flood frequency assessment was undertaken on both gauges to determine the peak flow rates associated with the design Annual Exceedence Probabilities (AEP). The design events were simulated using the method specified in Australian Rainfall and runoff (AR&R, 1987) and using the rainfall runoff program RORB. The Probable Maximum Flood (PMF) was developed using the Generalised Southeast Australia Method (GSAM) in accordance with the Bureau of Meteorology (BoM, 2003). The peak design events are summarised in Table ii.

Table ii Design peak flow rates for the Hamilton Investigation

AEP (%)	Design Flow Rates			
	Grange Burn at Hamilton	Petschels Lane Tributary[1]	Marshalls Road Tributary[1]	Kennys Road Tributary[1]
20%	35.7	4.9	2.8	1.8
10%	57.1	7.8	4.0	2.5
5%	96.8	10.8	5.7	3.4
2%	153.2	15.8	8.0	5.0
1%	200.5	20.7	10.1	6.3
0.5%	241.0	25.9	12.4	7.7
0.2%	314.7	33.5	15.8	9.8
PMF	2,266	215.7	91.8	61.6

[1] Flows derived at RORB model outlets, these will be distributed within the hydraulic model.

Climate change was assessed with a 10%, 20% and 32% increase in rainfall intensity explored. Under the 32% increase scenario for the Grange Burn, the 1% AEP flood event increased to be greater than the 0.2% AEP event (an increase of 89%). It was observed that the percentage increase of peak flow rates for the smaller, more frequent events was greater than for the rarer more extreme events. For example, for the Grange Burn catchment the 20% AEP event is expected to increase by 229%, whereas the 0.2% AEP event is expected to increase by 81%.

Hydraulic Modelling

The hydraulic modelling for the project was undertaken using the WL|Delft 1D2D modelling system, SOBEK. Three models were developed to represent the study area (see Section 5 for details). Structures within the model are represented using 1D model elements and the topography was represented using a 5m x 5m grid. Within the Grange Burn system there is one major active storage, Lake Hamilton. This acts as a control structure upstream of the township of Lake Hamilton. Lake Hamilton was previously assessed in the *Report on the Lake Hamilton Spillway / Grange Burn Flooding Investigations* (GHD, 1987) which identified that the Lake Hamilton spillway was undersized.

One difference between the GHD (1987) report and the current topography was the height of the Lake Hamilton embankment. The embankment in the GHD report was assumed to be 180 mAHD, whereas the embankment within the current model was found to be within 179.5 and 179.75 mAHD. It should be noted that the maximum elevations for the embankment were extracted from 1 m LiDAR elevation data sets to ensure the top of the embankment was accurately captured. This difference of between 300 and 500 mm between the GHD report and the current LiDAR implies that the dam wall may be overtopped in the current design runs sooner than GHD predicted in the 1987 report. It is recommended that the dam wall of Lake Hamilton be surveyed in detail and an assessment completed on the appropriate sizing of the spillway to meet large storage requirements.

The hydraulic model was calibrated to the 1983 and 2010 flood events. Overall the model was well calibrated and validated to these events. The hydraulic model was used to assess the 20%, 10%, 5%, 2%, 1%, 0.5% AEP and PMF flood events. The results of these model runs are summarised in Section 5.6.

Sensitivity analysis was undertaken to assess the variability in flood extent and depth due to a number of parameters. The purpose of the sensitivity was to demonstrate the variability of the model results to critical input parameters and to provide some guidance to the importance of each parameter. The sensitivity assessment examined:

- Hydrology sensitivity – tested through varying the hygrologic loss rates.
- 'Low' and 'High' roughness – this was achieved through decreasing and increasing the manning's roughness by +/- 20% respectively.
- Individual buildings included in the roughness – this assessment modified the approach to roughness from a lumped roughness approach for properties and buildings to a method which delineated the buildings and reduced the property roughness accordingly.
- Climate change assessment for the 32% increase in rainfall intensity.

Planning

The recommended flood controls to be put in place are a FO and LSIO. The method of deriving the FO was to use the 10% AEP extent. The LSIO included all areas inside the 1% AEP flood extent that are not covered by the final FO shape. It is recommended that the area within Model C covered by the PPRZ (Public Park and Recreation Zone) be excluded from the FO and included in the LSIO as this area already has planning restrictions and is not intended for development. This section of the model is also impacted by the man-made channel to the old Reservoir which has not been accurately surveyed and included within the model in detail. Planning Amendment documentation has been prepared in conjunction with this investigation.

Economic Damage Assessment

An economic damage assessment was undertaken which included an assessment of the 20%, 10%, 5%, 2%, 1%, 0.5% AEP and PMF flood events. Buildings within the 1% AEP had their floor levels surveyed in order to assess the damages. Rating curves were developed using the Department of Culture and heritage (DECCW) damage curves adapted to Hamilton. Damages were estimated based on building, property and road damage.

The calculated Annual Average Damage (AAD) for Hamilton was $ 208,912 per annum. Details of the number of properties inundated and buildings with overfloor flooding is summarised in Section 7.3.

Mitigation Option Assessment

High risk flood areas were highlighted at the area of Holden Street and Apex park for the Grange Burn and on King Street near Coleraine Road on Marshalls Road Tributary. The mitigation options were proposed and assessed included:

- Option A1 - Levees within King Street park
- Option A2 - Additional culverts under Coleraine Road at King Street Park
- Option B1 - Levee upstream of Ballarat Road (west side of the Grange Burn).
- Option B2 - Upgrading Apex Park Road to act as a raised road levee bank.
- Option B3 - Extending a levee from the Apex Park Road upgrade to Mt Napier Road (west side of Grange Burn)
- Option B4 - Removing the existing pedestrian bridge (at Apex Park)

The cost / benefit assessment indicated the payback periods as specified in Table iii.

Table iii Cost / Benefit analysis results

Model Run	Mitigation option applied	AAD (restricted to 0.5% AEP)	Reduction in AAD ($)	Option Estimated Cost ($ 2012)	Payback Period (years)
Existing	*Existing*	*$ 183,772*			
1	A1, A2	$ 107,753	$ 76,019	$ 928,000	12
2	B1, B2, B3, B4	$ 141,195	$ 42,577	$ 1,152,000	27
All	A1, A2, B1, B2, B3, B4	$ 65,100	$ 118,672	$ 2,080,000	18

Recommendations

Following this study the following actions are recommended:

- Implement a stream flow monitoring upstream of Lake Hamilton at the old Robsons Road gauge location for the purpose of additional flood warning and for use in future flood studies.
- Possibly develop a temporary (or permanent) gauge location that could be used for periods where large rainfall events are expected at Tarrington-Strathkellar Road to give additional warning times.
- Develop a gauge within Hamilton, possible location includes at Portland Road. This would allow verification of the peak flows during large events within Hamilton excluding the influence of Lake Hamilton.
- Undertake Community awareness programs to highlight the information generated within this study to the community to improve flood awareness within the community.
- Consider undertaking a dam break assessment on Lake Hamilton as this was identified as being undersized compared to the original design specification based on the revised hydrology.
- Implement the flood overlays as suggested in this study for future planning control within the catchment. Incorporate the flood overlays into the Council's future development plans.
- Consider implementing detailed assessments of the mitigation options for development (if these are to be developed in the future via funding).
- Flood maps as generated by this project should be made available to emergency response agencies to assist with the response within Hamilton.
- Ensuring that flood information such as inundated properties, peak flood heights, timing of flood events, flood depths etc are captured post each event for future studies.
- Implementing a plviograph station within the Hamilton catchment would assist future flood investigations as this would aid the calibration of hydrologic models within the catchment. This gauge could be located within Hamilton or upstream within the catchment.