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Townsville City Council received funding under the Natural Disaster Risk Management Studies Program to undertake a Disaster Risk Management Study specific to flooding including a preliminary assessment of storm surge. Primary objectives of the Study included:

- quantifying flood and storm surge inundation in Townsville, Magnetic Island and Cungulla,
- determining the flood hazards and the vulnerability of community and infrastructure, and
- identifying possible risk mitigation measures and strategies to allow proper and effective management of the identified risks.

The Project Plan identified three distinct yet inter-related phases to the Study. This report addresses Phase 3, which required a Vulnerability Assessment, Risk Analysis and Mitigation Strategies, based on the results of Phase 2 modelling and investigation. Phase 3 of the Study was carried out in accordance with the principles contained in the Risk Management Standard (AS/NZS 4360:1999), the Queensland Department of Emergency Services (DES) Guidelines for Disaster Risk Management, and the guiding principles contained in the Consultancy Brief.

The following sections provide a brief overview of the investigations undertaken in Phase 3:

Establishing the Context

The primary aim of the Study was to determine those areas within the urban areas of Townsville that may be affected by the 50 Year and 100 Year ARI flood events, and use this information to:

- assess the vulnerability of the community, expressed in terms of people, properties, businesses, public assets and essential services,
- review town planning controls over infill development in flood prone areas to ensure long-term sustainable growth,
- implement an improved flood warning network and refined evacuation procedures that target areas most at risk,
- enhance the Counter Disaster Plan,
- determine flood damage estimates,
- assess flood mitigation program currently under review, and
- assess potential structural and non-structural treatment options to mitigate the impacts of flooding and develop a prioritised action plan.

A risk management team (Study Advisory Group) was established at the onset of the Study, to administer, guide and review the risk management process. The Project Plan was reviewed and proposed methodology adapted during the course of the investigation.

Identifying Risks and Hazard

The Study was mainly restricted to the analysis of the risks associated with the hazard of flooding of existing properties in the Townsville Floodplain and Magnetic Island areas. In addition, due to budgetary constraints, preliminary assessment of storm surge and tidal inundation of coastal areas including the communities of Pallarenda and Cungulla was also completed in lieu of a full flood investigation of these areas. Various events (10 Year ARI, 50

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Year ARI and extreme flood event of January 1998) were assessed for flooding, and storm surge and tidal inundation mapping was reviewed for 50 Year ARI and the synthetic extreme storm surge scenario of Cyclone Althea coincident with a high tide.

Due to the limited extent of the flood hazard study area, the study has not investigated the issue of future development in flood prone areas in any great detail. A separate investigation will be required to consider this issue.

The risk evaluation process is used to establish whether a risk can be deemed acceptable or unacceptable. Preliminary risk evaluation criteria were developed in consultation with the Study Advisory Group and used to compare the likelihood and consequence of a hazard against a set of criteria, to assign a level of seriousness to the risk. Hazard maps were produced using MIKE21 model outputs of depth and velocity for the same range of flood events detailed in Volume 2 of the Phase 2 Report. Flood hazard mapping identifies flood hazard zones and other areas that are susceptible to unacceptable levels or frequency of inundation.

Community Vulnerability Assessment

Vulnerability relates to a community's susceptibility to a hazard, and its resilience in coping with the hazard. A vulnerability profile for the community was developed and critical facilities and engineering lifelines were mapped. A detailed access route analysis was also undertaken to access the risk of isolation of communities and loss of evacuation routes.

Table 1 shows an example of the risk register for the 50 Year ARI event detailing the communities susceptibility to flood damage.

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Table 1
Risk Description – Townsville – 1 in 50 Year ARI Event

Hazard – Flooding (1 in 50 Year ARI Event)		
Vulnerable Elements	Risk	Consequence
People	<ul style="list-style-type: none"> ▪ A population of 573 is at risk of inundation by flooding, in the following additional areas: ▪ City: Garbutt, West End, Hyde Park, Hermit Park, Mysterton, Currajong, Aitkenvale, Heatley. ▪ South Townsville: Railway Estate. ▪ Annandale: Annandale. 	<ul style="list-style-type: none"> ▪ People may be injured and require medical treatment. ▪ People may be displaced from their homes for short period (eg 24hrs). ▪ People may require local services. ▪ People may be able to work with some inconvenience.
Buildings	<ul style="list-style-type: none"> ▪ Approximately 177 residential buildings are at risk of inundation by flooding, in the following additional areas: ▪ City: Garbutt, West End, Hyde Park, Hermit Park, Mysterton, Currajong, Aitkenvale, Heatley. ▪ South Townsville: Railway Estate. ▪ Annandale: Annandale. 	<ul style="list-style-type: none"> ▪ Buildings may suffer some damage (contents). ▪ Temporary loss of power, telecommunications and sewerage. ▪ Property owners may incur some clean-up costs.
Business	<ul style="list-style-type: none"> ▪ 12 businesses are at risk of being affected by flooding, in the following additional areas: ▪ City: Garbutt, Hyde Park, Hermit Park, Aitkenvale. ▪ Mt Louisa: Mt Louisa. ▪ Fairfield: Stuart. 	<ul style="list-style-type: none"> ▪ Businesses operate with some inconvenience. ▪ Temporary loss of power, telecommunications and sewerage. ▪ Some clean-up costs. ▪ Damage to caravan parks.
Engineering Lifelines	<ul style="list-style-type: none"> ▪ Engineering lifelines (water, sewerage, power and communications) may suffer damage by flooding within the following additional areas (>300mm): <p><u>Pump Stations</u></p> <ul style="list-style-type: none"> ▪ City: Hugh Street, Douglas Street/Lancaster Street, Sussex Street, Hugh Street/Chandler Street, Mariners Drive. ▪ Annandale: Marabou Drive. 	<ul style="list-style-type: none"> ▪ Sewerage, power and telecommunications may fail temporarily.
Critical Facilities	<p>Some critical facilities in the following additional areas are at risk from flooding (>300mm):</p> <p><u>Evacuation Areas</u></p> <ul style="list-style-type: none"> ▪ Fairfield: Area at Mervyn Crossman Drive flooded. ▪ City: Access to area at the showgrounds restricted at Kings Road and portion of area inundated. ▪ City: Access restricted to area at Fulham Road/Swanson Street intersection. ▪ Annandale: Access restricted to area on Yolanda Drive/Oleander Street and area inundated. 	<ul style="list-style-type: none"> ▪ Inconvenience to local goods distribution. ▪ Local clinics operate with some inconvenience. ▪ Hospital may operate with some inconvenience. ▪ Some delay in the response of emergency services (fire, police, ambulance) due to road access restrictions.

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Flood Damages

A comprehensive flood damage assessment was undertaken for the Townsville urban area using MIKE FA, a GIS based add-on for the MIKE suite of programs developed to allow economic assessment of flood losses and mitigation options. This process utilised flood level data (outputs from Phase 2), stage-damage curves (developed following detailed investigations to provide supplementary information) and GIS databases of floor levels and building type. A detailed GIS property database existed with zoning information and property type/size however additional investigations were required to assess building floor levels.

Although the flood damage assessment applied industry standard guidelines, a number of shortcomings became evident during the course of the study. These include no existing information on building floor levels and no information on damages curves for different property types. Consequently, it was difficult to make an accurate assessment of flood damages.

Such inaccuracies are not unusual. For example, the direct residential losses estimated for North Queensland by the Department of Emergency Services following the 1998 event ranged from \$26 million to in excess of \$152 million, a factor greater than 5.

To improve the estimation of flood damages in the study, direct damages from flood inundation were calibrated against actual damages recorded for the 1998 event. This process required some manual manipulation of the input data sets to achieve a reasonable damage estimate. The GIS based flood damages estimates for the January 1998 event are shown below in **Table 2**.

Table 2
Estimate of 1998 Flood Damages

Property Zoning	Damages (1998 Flood Event)
R1	\$9.91m
RH100	\$0.35m
RH80	\$5.28m
RH60	\$8.49m
RH40	\$9.54m
RH20	\$1.14m
COM	\$9.63m
IND	\$9.37m
OS	\$0.27m
PD	\$0.04m
SP	\$0.51m
TOTAL	\$54.53m
Total Residential	\$34.72m

Damage estimates were prepared for the full range of flood events (2 year ARI up to PMF) and two storm surge events (Cyclone Althea and the extreme event of Cyclone Althea coincidental with a high tide). The results are shown below in **Table 3**.

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Table 3
GIS Damage Estimates for All Events*

Property Zoning	Flooding						PMF	Surge	
	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI		Cyclone Althea	Cyclone Althea + MHWS
R1	\$0.55m	\$1.79m	\$1.81m	\$2.88m	\$3.86m	\$4.61m	\$5.57m	\$0.00m	\$0.00m
RH100	\$0.00m	\$0.03m	\$0.04m	\$0.11m	\$0.14m	\$0.16m	\$1.06m	\$0.00m	\$0.00m
RH80	\$0.08m	\$0.15m	\$0.23m	\$1.18m	\$1.58m	\$2.05m	\$5.96m	\$0.81m	\$19.52m
RH60	\$0.14m	\$0.33m	\$0.47m	\$3.56m	\$4.05m	\$4.61m	\$36.03m	\$0.00m	\$1.01m
RH40	\$0.24m	\$0.38m	\$1.18m	\$1.62m	\$2.41m	\$3.34m	\$90.76m	\$0.18m	\$14.00m
RH20	\$0.00m	\$0.00m	\$0.01m	\$0.15m	\$0.23m	\$0.34m	\$18.06m	\$0.00m	\$0.00m
COM	\$0.03m	\$0.05m	\$0.06m	\$1.37m	\$2.12m	\$3.26m	\$54.96m	\$0.00m	\$6.44m
IND	\$0.08m	\$0.09m	\$0.7m	\$2.62m	\$2.86m	\$3.19m	\$74.58m	\$0.00m	\$1.65m
OS	\$0.04m	\$0.04m	\$0.05m	\$0.12m	\$0.15m	\$0.17m	\$1.13m	\$0.04m	\$0.26m
PD	\$0.01m	\$0.02m	\$0.03m	\$0.07m	\$0.08m	\$0.10m	\$0.54m	\$0.00m	\$0.00m
SP	\$0.04m	\$0.06m	\$0.09m	\$0.15m	\$0.19m	\$0.23m	\$3.25m	\$0.05m	\$0.48m
TOTAL	\$1.22m	\$2.94m	\$4.04m	\$13.77	\$17.59m	\$21.98m	\$395.72m	\$1.09m	\$43.38m
Total Residential	\$1.02m	\$2.67m	\$3.75	\$9.51	\$12.26m	\$15.12m	\$261.26m	\$1.00m	\$34.54m

*(for legend, see Section 5.3.1)

These estimates are based on a number of assumptions which may result in the estimates varying by a factor of five. See page 49 **Section 5 – Flood Damages**.

The damage estimates indicate that Townsville generally has a less than 20 year ARI channel capacity at which the overland flow component becomes more significant and causes significant damage.

Risk Analysis, Evaluation and Treatment Options

Using the assigned likelihood and consequence levels, the level of risk was estimated, ranging from Low (managed by routine procedures) to High (works identified and included in forward works program). No immediate action is required to address a perceived Extreme Risk). Hazards were further evaluated from greatest to least risk so that a priority of treatment can be assigned. Risks are generally described as acceptable, unavoidable, undesirable or unacceptable, and have been evaluated for a range of recurrence interval flood events and storm surge levels (where appropriate). A register of prioritised unacceptable risks was developed.

The final step in the risk management process involved the selection of appropriate strategies that will minimise the potential for harm to the community. The process involved the identification, evaluation and selection of treatment options to deal with unacceptable risks, using the following framework for the selection of risk treatment options:

- Prevention/mitigation measures: seek to reduce the consequences of the event, and can be structural and non-structural.
- Preparedness measures: seek to reduce the harm caused by a hazard by reducing community vulnerability (eg. community awareness programs)

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- Response measures: seek to reduce the harm to the community by ensuring that well trained resources are available to respond to a hazard situation.
- Recovery measures: seek to minimise the medium to long-term harm to a community.

Disaster Mitigation Plan

An endorsed treatment strategy was developed for the Study Area, further details of which are provided in **Section 7** and **Tables 35, 36** and **37** in **Appendix A**. The strategy includes general recommendations like town planning measures and updates to the Counter Disaster Plan, as well as detailed recommendations with respect to flood warning and structural improvements to achieve at least 20 Year ARI immunity. Where appropriate, schematic drawings have been provided showing the location of key mitigation strategies proposed. Preliminary cost estimates have been prepared for most options, with discussion provided on other factors that affect the benefit to the community of undertaking the works. **Table 4**, **Legend: H** – High Priority, M – Medium Priority, L – Low Priority

Table 5 and **Table 6** show some of the mitigation works proposed for Townsville, Magnetic Island and Pallarenda and Cungulla respectively.

NOTE:

Since this report only investigates the hazards of flooding and a preliminary assessment of storm surge, it is intended that Council may adapt the information contained herein for inclusion in an all-hazards risk management document (i.e. that includes other hazards to the City of Townsville such as windstorm, bushfire and earthquake). The report also identifies that a more comprehensive assessment of storm surge risk is required.

Table 4 - Treatment Strategy Development - Townsville

Ranking (Priority)	Endorsed Treatment	Responsible Agency	Complete Implementation Timeframe	Estimated Cost	Funding Source(s)
1 (H)	Continue to implement current Townsville West Flood Mitigation Project (Stage 1 and 2).	Townsville City Council	0 – 5 years	\$7.20 million	Council Budget, External Funding Sources
2 (H)	Develop town planning policy on flood and storm surge prone areas.	Townsville City Council	0 – 5 years	\$5000 (Time and Materials)	Council Budget
3 (H)	Upgrade existing flood warning system for Townsville.	Townsville City Council	0 – 5 years	\$25,000	Council Budget, External Funding Sources
4 (H)	Review and Update Counter Disaster Plan	Townsville City Council	0 – 5 years	\$5000 (Time and Materials)	Council Budget
5 (H)	Wandella Crescent/Cranbrook Park Diversion to Ross River	Townsville City Council	0 – 5 years	\$6.0 million	Council Budget, External Funding Sources
6 (H)	Killara Street Diversion to Ross River.	Townsville City Council	0 – 5 years	\$11.80 million	Council Budget, External Funding Sources
7 (M)	Widening of the primary drainage path in the area immediately downstream of Abbott Street.	Townsville City Council	5 - 10 years	\$2.40 million	Council Budget, External Funding Sources

Legend: H – High Priority, M – Medium Priority, L – Low Priority

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Table 4 Continued

Ranking (Priority)	Endorsed Treatment	Responsible Agency	Complete Implementation Timeframe	Estimated Cost	Funding Source(s)
8 (M)	Widening the Woolcock Canal between Kings Road and Parkes Street, and culverts under Kings Road to match.	Townsville City Council	0 – 5 years	\$1.60 million	Council Budget, External Funding Sources
9 (H)	Relocate the exposed section of the western suburb outfall main that crosses the Ross River.	Townsville City Council	0 – 5 years	\$1.00 million	Council Budget, External Funding Sources
10 (H)	Raise section of Bruce Highway (between Abbott St and Stuart Drive).	Department of Main Roads	0 – 5 years	\$0.10 million	State Government

Legend: H – High Priority, M – Medium Priority, L – Low Priority

**Table 5
Treatment Strategy Development – Magnetic Island**

Ranking (Priority)	Endorsed Treatment	Responsible Agency	Complete Implementation Timeframe	Estimated Cost	Funding Source(s)
1 (H)	Establish two rainfall stations on Magnetic Island (Nelly Bay and Horseshoe Bay).	Townsville City Council	0 – 5 years	\$10,000	Council Budget, External Funding Sources
2 (M)	Upgrade culvert and drain along Apjohn Street (Horseshoe Bay).	Townsville City Council	5 – 10 years	\$0.50 million	Council Budget, External Funding Sources

Legend: H – High Priority, M – Medium Priority, L – Low Priority

**Table 6
Treatment Strategy Development – Pallarenda and Cungulla**

Ranking (Priority)	Endorsed Treatment	Responsible Agency	Complete Implementation Timeframe	Estimated Cost	Funding Source(s)
1 (H)	Upgrade Heatley Parade (Evacuation Route from Pallarenda).	Townsville City Council	0 – 5 years	\$0.55 million	Council Budget, External Funding Sources
2 (H)	Install dedicated storm surge sirens at Pallarenda and Cungulla.	Townsville City Council	0 – 5 years	\$10,000	Council Budget, External Funding Sources

Legend: H – High Priority, M – Medium Priority, L – Low Priority

The existing Townsville Thuringowa Counter Disaster Plan is a comprehensive document however some recommendations have been made for upgrading the plan to incorporate the findings of Phase 2 of the this flood study.