Port Stephens COUNCIL

MEDOWIE

FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FINAL

wma water

APRIL 2016

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MEDOWIE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

FINAL REPORT

APRIL 2016

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ACRONYMS

AAD	Average Annual Damages
ABCB	Australian Building Codes Board
ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Airborne Laser Survey (LiDAR)
ARI	Average Recurrence Interval
AWE	Average Weekly Earnings
B/C	Benefit Cost Ratio
BoM	Bureau of Meteorology
CDIA	Campvale Drain Inundation Area
DA	Development Application
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change and Water (now OEH)
DEM	Digital Elevation Model (A grid of terrain elevations usually obtained from ALS)
DIPNR	Department of Infrastructure Planning and Natural Resources (now OEH and DoPI)
DoPI	Department of Planning and Infrastructure
DRAINS	Program for modelling urban stormwater drainage systems and catchments
DRM	Direct Rainfall Method
DSC	Dam Safety Committee
EP&A Act	Environmental Planning and Assessment Act
ERP	Emergency Response Planning
EY	Exceedances per Year
FPA	Flood Planning Area
FPL	Flood Planning Level
FMC	Flood Management Committee
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
HWC	Hunter Water Corporation
IPCC	Intergovernmental Panel for Climate Change
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging (also see ALS)

mAHD	Meters above Australian High Datum
MHL	Manly Hydraulics Laboratory
NMRA	North Medowie Residential Area
NPV	Net Present Value
OEH	Office of Environment and Heritage
OSD	On-site Detention
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PWD	Public Works Department
SEE	Statement of Environmental Effects
SEPP	State Environmental Planning Policy
SES	State Emergency Services
TSC Act	Threatened Species and Conservation Act 1995
TUFLOW	A one-dimensional (1D) and two-dimensional (2D) hydraulic computer model
VP	Voluntary Purchase
WBNM	Watershed Bounded Network Model (hydrologic computer model)
WPS	Water Pumping Station
WSUD	Water Sensitive Urban Design

FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. Flood Study
- Determine the nature and extent of the flood problem.

2. Floodplain Risk Management Study
- Evaluates management options for the floodplain in respect of both existing and proposed development.

3. Floodplain Risk Management Plan
- Involves formal adoption by Council of a plan of management for the floodplain.

4. Implementation of the Plan
- Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The Medowie Floodplain Risk Management Study and Plan (FRMS&P) constitutes the second and third stages of this management process. This study has been prepared by WMAwater for Port Stephens Council (Council) and provides the basis for the future management of flood prone lands in the Campvale and Moffats Swamp catchments. This report is relevant to flooding from major overland flow and mainstream flooding. To inform this FRMS&P the hydraulic modelling undertaken for the Flood Study was reviewed to ensure that model outputs are fit for purpose and to take into account any newly available data since the Flood Study modelling was undertaken.

This report has been prepared with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

1. INTRODUCTION

This report comprises the Floodplain Risk Management Study and Plan for Medowie which has been prepared by WMAwater on behalf of Port Stephens Council. Recommendations are in accordance with best practice and NSW flood policy as per the Floodplain Development Manual (Reference 1).

The NSW Floodplain Management Program places an emphasis on extreme rainfall events (for example, the 1% AEP design event) and protecting residential dwellings from inundation. However, due to the catchment characteristics and local resident concerns, this study also considers management of ponding which occurs as a result of typical seasonal rainfall.

1.1 Study Area

The Medowie study area is located 5km's to the north east of Raymond Terrace and lies within Port Stephen Councils Local Government Area (LGA). It covers an area of approximately 25km^2 and consists of two catchments relatively equal in area; Campvale Swamp to the west and Moffats Swamp in the east as shown in Figure 1. The Campvale and Moffats Swamps are generally separate catchments with respect to flooding except during extreme events (greater than 1% AEP) where Moffats Swamp can flow into the Campvale catchment over Medowie Road near the southern limit of the catchments.

The catchment is affected by two types of flooding, discussed in detail in Section 4;

- Design Event Flooding – flooding due to design rainfall events. It causes overland flows in the upper catchment and filling of the Campvale Drain Inundation Area (CDIA) in the lower catchment; and
- CDIA Ponding – ponding in the CDIA as a result of typical seasonal rainfall patterns and impaired drainage.

1.2 The Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the floodplain risk management process is formed of sequential stages:

- Data Collection;
- Flood Study;
- Floodplain Risk Management Study;
- Draft Floodplain Risk Management Plan; and
- Plan Implementation.

The first key stage of the process has been undertaken with the completion of the Data Collection and Medowie Drainage and Flood Study (Reference 2). Following this, the Draft Floodplain Risk Management Study and Plan (FRMS&P) are undertaken for the catchment in two phases:

Phase I –Floodplain Risk Management Study in which the floodplain management issues confronting the study area are assessed, management options investigated and recommendations made.

Phase II – Draft Floodplain Risk Management Plan which is developed from the Floodplain Risk Management Study and details how flood prone land within the study areas is to be managed moving forward. The primary aim of the Plan is to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with flood hazard now and in the future. The Plan consists of prioritised and costed measures for implementation.

1.3 Previous Studies

This FRMS&P follows on from the Flood Study (Reference 2) and Medowie Hydrological and Hydraulic Model Review (Reference 3). The Flood Study (Reference 2) summarises a number of previous studies in the Medowie area, including:

- Medowie Structure Plan: Preliminary Flooding, Drainage and WSUD Analysis, WBM Pty Ltd, 2006 (Reference 4);
- Medowie Drainage Study: Part 1 - Campvale Catchment, Port Stephens Council, 1995 (Reference 5);
- Medowie Drainage Study: Part 2 - Moffats Swamp Catchment, Port Stephens Council, 2000 (Reference 6); and
- Boundary Road / Federation Drive Flooding Investigations, GHD, 2008 (Reference 7).

1.3.1 Flood Study Review and Update

Before undertaking this FRMS&P there was a need to update the hydraulic model built as part of the Flood Study (Reference 2). A separate report was issued (Reference 3) detailing the update to the modelling including development of a separate hydrological model using the Watershed Bounded Network Model (WBNM) to replace the previous Direct Rainfall Method (DRM) approach as well as re-calibration and verification of the revised model. Details of the model revision comprising the initial report and further information on updating flood levels for the full range of design flood events can be found in Appendix B.

The revised modelling determines flood liable land for a range of design events and identifies four dwellings susceptible to above floor flooding in the 1% AEP event. This FRMS&P is based on the conclusions of the Flood Study (Reference 2) and utilises the revised hydrological and hydraulic modelling (Reference 3) in assessing potential mitigation and management options.

1.4 Available Data

In addition to the hydraulic modelling and previous reports noted in Section 1.3, a floor level survey was provided by Council. This survey comprised a total number of 371 residential properties, commercial properties and one school, with details provided on floor levels and ground level at each property. A number of other properties were identified as car parks or vacant and therefore no floor level or ground level details were provided. The floor level survey was used in identifying potential flood damages for Medowie (see Section 5 and Appendix F).

Council also provided detailed survey of the Campvale Drain and some localised survey at isolated areas throughout the study area which was used in the hydraulic model. Towards the end of the project, additional survey data of the Campvale Drain was undertaken to provide a better resolution of data input into the ponding assessments.

2. CATCHMENT CHARACTERISTICS

2.1 Land Use

The land zones as identified in the Medowie Local Environmental Plan 2013 are shown in Figure 2. The Campvale catchment contains a diverse group of landholders; the upper areas generally comprise E1 National Parks and Nature Reserves, while the middle catchment contain rural, rural/residential, residential, commercial and industrial areas made up of mainly R5 Large Lot Residential, but also B2 Local Centre and IN2 Light Industrial uses. The more downstream reaches, especially those bordering the Campvale Drain, comprise land uses that are substantially agricultural (cattle, horticulture, orchards, etc.). The CDIA is largely zoned RU2 Rural Landscape.

The upper reaches of Moffats Swamp comprise largely forested areas (land use zone E1 National Parks and Nature Reserves and RU2 Rural Landscape) transitioning to residential areas comprising R2 Low Density and R5 Large Lot Residential land use zones. The downstream portion of the catchment contrasts with the Campvale catchment in that this area is largely undeveloped. Moffats Swamp catchment is heavily vegetated below approximately 9 mAHD in the area zoned as E1 Nature Reserves.

2.2 Social Characteristics

Understanding the social characteristics of the area can help in ensuring that the floodplain risk management practices adopted are aligned with the communities at risk. For example, 'stable' communities (characterised by a high proportion of homeownership and low frequency of residents moving into or out-of the area) are more like to have a better understanding of the flood risks within the area. Social characteristic data were obtained from the 2011 census (http://www.abs.gov.au/) for the study area.

The suburb of Medowie has a population of 8,843 living in 3,109 private dwellings. Within the last five years 30% of the population has moved into the Medowie area, which indicates a relatively high portion of residents who may be unfamiliar with the history of flooding.

It is also useful to consider the tenure of housing. Those living in properties which they own are more likely to be aware of the flood risks and have measure in place to reduce them. They are also more likely to adopt property modification measures as the benefit is to their own assets. Rental properties are likely to have a higher turnover of people living in them compared to privately owned properties and therefore those people in rental properties may be less aware of the flood risks unless they have been there for enough time to have experienced flooding or have been sufficiently informed by their landlords. In Medowie 76% of dwellings being privately owned, higher than the NSW average of 66% .

The language spoken by the population is also useful to consider as it can have implication on providing flood information to the public. However, in Medowie, 95% of the population are speak English at home as their primary language.

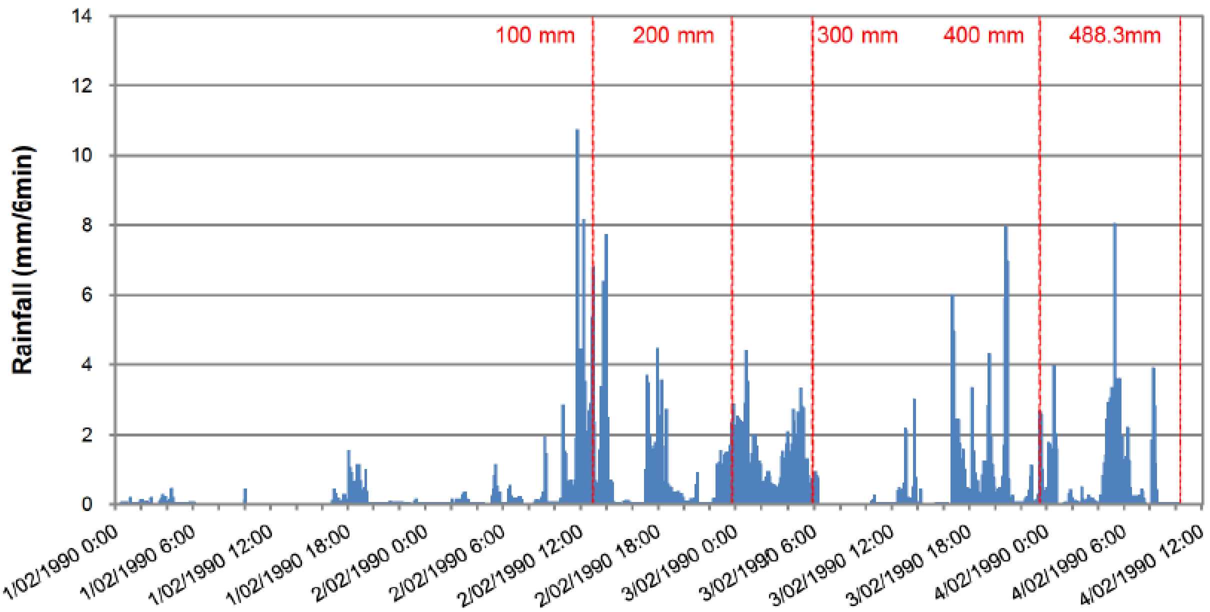
2.3 Historical Flood Issues

Community consultation undertaken as part of the Flood Study (Reference 2) identified that February 2009, June 2007 and February 1990 are well remembered events with 62 of the 88 respondents (from 508 mail outs) experiencing some flooding. Other events were noted in 2008, 2006 and 2013.

2.3.1 February 1990

The 1990 event occurred between the 1st and 5th of February. The January preceding had experienced below average rainfall. Prior to the deluge that occurred on February 2nd, 5 mm fell on the last day of January and then 25 mm on the 1st of February. No gauged data exists to establish to what degree runoff had or had not begun to occur prior to the 2nd, which is when the first of the three or four major bursts of the storm fell. Peak runoff was caused by rainfalls in excess of 270 mm observed at Williamtown daily gauge to 9 am on the 3rd February and 175 mm to 9 am on the 4th February (refer to Diagram 1).

Diagram 1: February 1990 rainfall hyetograph



Flood levels in the CDIA are assumed not to have exceeded 7.5 - 7.8 mAHD as otherwise dwellings in Abundance Road would have had flood waters near or over floor level and it is likely this would have been reported.

2.3.2 June 2007

The 2007 event occurred between the 8th and 10th of June. Rainfall in May had been below average with only 69 mm of rainfall falling (relative to the mean figure of approximately 115 mm). Immediately prior to the event, 29 mm was recorded as falling between 9 am on June 6th and 9 am on June 7th and a further 91.5 mm fell between 9 am June 7th and 9 am June 8th. Based on the Campvale Water Pumping Station (WPS) gauging data it appears that runoff began to arrive at the Campvale WPS from the morning of June 8th and so it is quite likely that at least 30 to 50 mm of rainfall was absorbed into the catchment prior to runoff occurring. It is also likely that the drainage capacity of the Campvale Drain might have been restricted by blockage or debris in its bank.

The June 2007 event was chosen as the calibration event for the hydraulic modelling as it was a large event with the most observations available. Community consultation undertaken as part of the Flood Study (Reference 2) indicated that some severe flooding occurred including three properties experiencing over floor flooding (8 Ballat Close, 31 Lewis Drive and 9 Kirrang Drive) . Some roads became dangerous to pass (Photograph 1).

Photograph 1: Intersection of Kula Road and Kirrang Drive – June 2007 event

Source: D. Fairless

2.3.3 February 2009

The 2009 event occurred between 14th and 16th of February. Daily rainfall records indicate that January rainfall was well below average. However, prior to the actual event which occurred on February 15th, a total of 49 mm of rainfall had fallen over the preceding four days. As such it would be reasonable to suggest that the catchment was relatively wet prior to the occurrence of the main rainfall burst on February 15th.

This event caused flooding for residents in locations including Lisadell Road, Kirrang Drive, Kula Road (Photograph 2) and Ballat Close in the Campvale catchment. In the Moffats Swamp catchment properties on County Close and Federation Drive amongst others were affected. In the Campvale catchment, one resident on Kirrang Drive reported flood water entering their house while others reported shallow flooding in garages and yards. However, the main impact of flooding was inundation of roads and sheds.

The flood partially filled the CDIA starting a period of continuous inundation that, according to comments from local residents, extended into March. Despite the extensive flooding in the CDIA residents reported that the Campvale Drain was unable to deliver sufficient flow in order for the Campvale WPS to operate at peak capacity throughout the period of continuous inundation. Smaller rainfall events after to the main event replenished the inundation in the CDIA and prolonged the period of ponding.

Photograph 2: Drain on Kula Road – February 2009 event

Photograph taken on 15 February around 9am.
Source: J. Banville

2.3.4 March 2013

Minor flooding occurred in Medowie between the 1st and the 3rd March 2013 (Photograph 3). Heavy rainfall caused several culverts to be exceeded on 2nd March. Flood waters spilled over the road at the culverts at the south end of Kirrang Drive, and at other locations minor flooding was observed as drains neared capacity.

Photograph 3: Drain on Kula Road a) March 2013 event, b) dry in February 2014

Source: J. Garry

2.4 Water Quality Considerations

Water from the CDIA is eventually pumped into Grahamstown Reservoir which is owned and managed by Hunter Water Corporation (HWC) for the supply of drinking water to more than 300,000 people during summer months. Approximately 7% to 10% of the long-term average inflows to the reservoir are sourced from the Campvale catchment (Reference 8).

HWC are a stakeholder in the FMC. Their primary concern however, is not with the flooding or ponding issues, but rather the quality of water reaching Grahamstown Reservoir. HWC have consistently stated they do not support any option that may result in a reduction of water quality entering the reservoir (Reference 8) or that could potentially increase peak flows beyond the current capacity of the pumping station of the Campvale WPS (attachment to Reference 8). Nonetheless HWC are obliged, under their Licences and Approvals (Reference 9), "*to maintain and operate the Campvale WPS at Grahamstown Storage to minimise local flooding.*".

It is acknowledged that water quality is a major concern to HWC due to the status of Grahamstown Reservoir. HWC would ideally like to see longer detention times in the CDIA to provide water quality benefits, however this is contrary to the desires of the residents who wish for a reduction in the duration of ponding of water on their land. As such, water quality issues are likely to constrain most recommendations within this FRMS&P which address detention times, however none of the options recommended will increase peak flows beyond the capacity of the Campvale WPS.

A water quality assessment will be a requirement before any of the preferred options can be implemented. Details will be needed on the minimum detention times required to prevent a decrease in water quality in the reservoir. The assessment should include water quality samples from the upstream catchment, in the CDIA, at the Campvale WPS and in the reservoir to see how water quality varies with time, flow and location. It is also recommended that any proposals HWC may have for increasing detention times to improve water quality are assessed for ponding and flooding implications, and Council should not support any recommendations for increased detention time at the disbenefit to CDIA residents.

3. STAKEHOLDER CONSULTATION

3.1 Community Consultation

One of the central objectives of the Floodplain Risk Management Study is to actively liaise with the community throughout the process, keep them informed and address their needs. The following activities were undertaken throughout the study.

3.1.1 Questionnaires

As part of the Flood Study (Reference 2) WMAwater undertook a comprehensive community consultation program in conjunction with Council. This program involved:

- A media release advising Medowie residents the Flood Study was being carried out and its aims as well as inviting those with any interest or information to contact WMAwater and/or Council;
- A questionnaire issued to residences that, based on Council experience, were likely to be impacted by drainage issues; and
- Information provided on Council's website.

A copy of the media release and questionnaire is included in Appendix B of the Flood Study (Reference 2) as well as photographs received from residents showing flood affectation.

A total of 508 questionnaires were mailed out of which approximately 17% were returned; a total of 88 responses. The high return rate indicates that residents feel strongly about flooding and drainage issues in their area although it could equally be a function of targeting relevant residents. From the returned questionnaires a database was compiled of information to be used in reporting and calibration and validation of the hydraulic models.

The awareness of historical flood events was high with more than half of respondents recalling the 2007 and 2009 events. Based on information gained from the consultation six peak flood level marks were able to be surveyed for the June 2007:

- Yulong Oval
- 59 Kula Road
- 8 Ballat Close (three flood marks)
- 31 Lewis Drive

And nine peak flood level marks for the February 2009 event:

- 3 Kirrang Drive
- 5 Kirrang Drive
- 7 Kirrang Drive
- 8 Kirrang Drive
- 9 Kirrang Drive (two flood marks)
- 13 Kirrang Drive
- 31 County Close
- 35 Ferodale Road

Major findings of the community consultation campaign include:

- The February 2009, April 2008, June 2007 and February 1990 are well remembered events with 62 of the respondents experiencing some flooding;
- Inundation of properties (not necessarily buildings) and roads in Medowie is a major issue for approximately 40 households;
- Approximately 10% of the residents who had reported to have experienced flooding suffered from over floor flooding (inclusive of garages and other non-habitable rooms);
- Rainfall events which cause ponding and drainage issues occur relatively frequently, roughly once every two years at least;
- Residents in upper areas experience relatively brief and shallow inundation of their properties and access roads (including inundation of garages which are at ground level in many cases); and
- Residents in lower southern areas, extensively in the CDIA, are impacted by the duration of the flood event along with high water levels reducing ability to use their land.
- Some residents believe Council is failing to meet its planning and infrastructure provision obligations with regard to drainage issues in Medowie;
- Some residents are concerned that expansion of urban areas and further sub-division of existing land holdings will lead to more flooding;
- Some residents believe that the operating capacity of Campvale WPS should be improved to solve the flood problem; and
- The capacity of Campvale Drain to deliver water to the Campvale WPS was also queried.

3.2 Other Stakeholder Consultation

A Floodplain Management Committee (FMC) was been formed to raise and discuss issues related to the floodplain risk management process. It also allows community input throughout the process from start to finish. The committee includes Councillors, Council engineers and Planners, HWC representatives, members of the SES, OEH, local residents and other community representatives. During preparation of the draft report, WMAwater held meetings with the committee on:

- 26 February 2013 at Council Offices, Raymond Terrace; and
- 27 November 2013 at Council Offices, Raymond Terrace.

The committee was provided a draft version of the report in February 2014 and an opportunity to provide comment.

A Technical Committee was also formed of Council Engineers, representatives from OEH and HWC, and WMAwater. The purpose of this committee was to oversee the technical aspects of the Study and share information between the key stakeholders with regards to flood management in the study area. Meetings were held on:

- 26 February 2013 at Council Offices, Raymond Terrace;
- 23 May 2013 at OEH Offices in Newcastle; and
- 15 August 2014 at Council Offices, Raymond Terrace.

3.2.1 Site Visits

Several site visits were undertaken by WMAwater and Council staff throughout the project, including some visits with residents to better understand their concerns regarding flooding in Medowie. A photomontage is included as Figure 1.

3.2.2 Planned Consultation

The draft Public Exhibition Report is first agreed with Council and the FMC before being made available for the community during a public exhibition period. This will be the opportunity for the community to examine the report and make any comments or suggestions. Formal submissions from the community will be considered by Council and the FMC before finalisation of the FRMS&P.

4. EXISTING FLOOD BEHAVIOUR

The revised hydrological and hydraulic modelling in Appendix B established the flooding patterns in Medowie for a range of design events. Mapping of flood depths, levels and velocities for design events is included in the figures in Appendix C.

4.1 Flood Mechanisms

Within Medowie, there are two types of flooding mechanisms. Design Event Flooding (see Section 4.1.1) of developed areas occurs when flows exceed the drainage system capacity. This mainly occurs in the upper catchment although a few properties in the CDIA are also affected by flooding from Campvale Drain (however the majority of dwellings are not impacted until extreme (greater than 1% AEP) design events)

Ponding in the CDIA (see Section 4.1.2) occurs during periods of heavy seasonal rainfall, most prevalent during February through to June. This issue does not affect any dwellings but causes loss of amenity for land holders, sometimes for significant periods of time (30 days or more). This type of flooding is not typically considered in the Floodplain Management Process, which is more concerned with extreme (1% AEP) events and their impacts of properties, however it has been assessed in this study due to its importance to local residents.

4.1.1 Design Event Flooding

Within the Campvale catchment runoff will make its way into the Campvale Drain via a variety of upstream tributaries, many of which flow through urban residential areas, and is then detained in the CDIA. The CDIA is a terminal basin. Water leaves it via the Campvale WPS (Photograph 4), infiltration or evaporation, but the basin does not naturally drain. The pumps are responsible for conveying the majority of all stormwater runoff from the catchment into Grahamstown Reservoir.

Flood behaviour within the CDIA is influenced by a topographical feature called the pinch. The pinch is a ridgeline approximately 2 km upstream of the Campvale WPS where invert levels in the Drain increase going downstream and therefore can hydraulically separate the CDIA from the pumping station (see Figure 1).

Photograph 4: Campvale Water Pumping Station

Runoff from the Moffats Swamp catchment flows via a series of tributaries, some of which traverse relatively dense urban development, into Moffats Swamp which is in a relatively natural state and is densely vegetated. Flooding in design events generally occurs when the catchment drainage systems upstream of the swamp is exceeded. Four mechanisms exist for flow to leave Moffats Swamp. Three of the Moffats Swamp outlets move flow out of the Medowie area entirely towards Salt Ash and Swan Bay, whilst the fourth outlet is to the Campvale catchment and into the CDIA over a natural ridge between the two catchments and only occurring when the swamp level rises above approximately 9.5 mAHD. Each of the outlets operates at different water levels and has varying stage-discharge characteristics.

Design flood event mapping is presented in Appendix C. The modelling undertaken for this study (Appendix B), indicates that only four dwellings will incur over-floor inundation in the 1% AEP event. Most flooding of dwellings will occur in upstream areas where flows moving downstream are not able to be contained in overland flow paths and drains. Mainstream flooding, which is flooding from exceedance of the main drain channel, affects more properties in the lower catchment such as those on Abundance Road. This is compounded by the terminal basin nature of the CDIA. A number of properties suffer from flooding in the yard but above flood level flooding is limited.

The critical duration of flooding, that is the duration of the flood event which caused the highest peak flood levels varies across the catchments. In the lower catchment areas, the volume of rainfall is most influential. As such the 72-hour event was shown to be critical. In the mid catchment it is the 9-hour event, while in the upper catchment, where flooding occurs from small local catchments, the 2-hour even is critical (see Figure B8).

Throughout the overall study area, flood levels and flood extents do not vary significantly between design events. This lack of “scaling”, i.e. significant increases between design flood events of varying probability, is due to the expansive capacity of overbank areas throughout the study area. That is, once overbank, flow is not constrained but instead can spread out.

4.1.2 CDIA Ponding

A primary issue raised by the community has been the extended period of inundation that occurs in the CDIA on a near annual basis. Typically between February and June the Campvale catchment will receive rainfalls of at least 100 mm per month. A heavy rainfall event within this interval can lead to extended periods of ponding within the CIDA. In some areas this is compounded by blocked or poor connectivity in the lateral open drainage running through lots and into the Campvale Drain. Although ponding does not affect any dwellings, many land holders in the CDIA use their land for grazing. Ponding in the CDIA significantly reduces land holder amenity as their land may not be useable for an extended period of time.

There is a perception that this issue has become worse over time due to upstream development and lack of maintenance of the drain. Insofar as a lack of maintenance will tend to lend to silting and blockage of drains this perception is likely valid.

As the CDIA is a terminal basin, drainage of the CDIA is dependent on infiltration, evaporation and pumping to Grahamstown Reservoir, with the latter mechanism being the main element of drainage. The Campvale WPS is maintained by HWC and operation is automatic, based on the water level in the take-off pool area immediately upstream of the pumping station. At peak capacity approximately 5.4 m^3/s can be pumped from the CDIA into the reservoir; around 1.35 m^3/s (120 ML/day) for each of the pumps. However, in reality the Campvale Drain fails to deliver a flow equivalent to pumping station peak capacity when the water levels in the CDIA are less than around 6.5 mAHD. This is largely due to a lack of drain capacity caused by an uphill slope on the drain (refer to Section 7.3.2 for further details). As such the pumping station tends to alternate between no pumps and one pump being operational when CDIA ponding occurs. Further rainfalls then lead to additional runoff and top up the ponding in the CDIA. Gradients in the CDIA are very flat and therefore some degree of ponding is always likely, however improving connectivity could assist in reducing the duration of ponding.

Landholders in the CDIA are keen to see improvements in drainage of the CDIA for water levels below 6.5 mAHD with general enhancement of the Campvale Drain being a priority for them. Council are continuing to acquire drainage easements along the Campvale Drain however a continuous easement has not yet been established. General works to improve Campvale Drain appear to be hindered by this as well as environmental regulations of any such works due to the presence of protected vegetative species. That said, some drain clearance and maintenance works have recently been carried out in upstream areas.

HWC has stated that any water arriving at the pumps will be pumped as per the previously described automatic settings. However, given the importance of the Grahamstown Reservoir to water supply in the region, they would prefer that water is detained in the CDIA prior to being pumped into the reservoir as increased detention time can enhance the water quality. No absolute time period for detention is targeted, rather this is a preference for a relatively longer time of detention rather than a relatively shorter period of detention.

It is clear that HWC's preference for increased detention is in opposition with the desires of those land holders subject to CDIA ponding, and therefore any options recommended to reduce ponding will also need to be assessed for their impact on water quality. Furthermore, residents and HWC are both concerned that further development in the catchment (i.e. the creation of further impervious area) will increase runoff volumes as well as reduce water quality, exacerbating existing issues in the CDIA.

Photograph 5: Ponding in the CDIA Caused by Non-Drainage Issues

4.2 Modelling CDIA ponding

In order to better understand the issues that cause CDIA ponding and the opportunities for mitigation, a water balance modelling exercise has been undertaken. This involved developing a model for the CDIA, verifying its performance as far as possible, and then utilising the model to describe the specific works required to eliminate the issue.

Ponding occurs as not enough flow moves out of the CDIA. In some cases residents have focused their concerns on the pumping station as being the cause of this issue. During the course of the Medowie Flood Study (Reference 2) it was identified that the actual issue is the capacity of the drain to deliver water to the pumping station rather than limited operating capacity of the pumps themselves. Essentially if the Campvale Drain could convey enough flow to allow even one pump to run 24 hours a day, no ponding in the CDIA would occur except for in the larger and rarer of rainfall sequences. At present, for water levels below 6.0 mAHD, the drain capacity does not allow one pump to run continuously. HWC are obliged to maintain and operate the Campvale WPS to minimise local flooding under their Licenses and Approvals (Reference 9).

Water balance modelling typically looks at inputs to runoff volume (rainfall minus losses) versus other losses such as evaporation, infiltration and outflow. The CDIA is modelled as a basin over a significant time period (72 years for which rainfall data was available). The water balance modelling only takes into account the area upstream of the pinch.

4.2.1 Methodology

The water balance model has been built in Microsoft Excel. The overall structure of the model is as follows:

- The CDIA is modelled as a basin described by stage-volume and stage-surface area relationships calculated using ALS data ;
- Inputs to the basin are runoff. Runoff only enters the basin when it rains. A runoff coefficient is used to calculate how much runoff volume results from a given rainfall;
- An impervious factor is included in defining runoff which can be modified to represent changes in developed areas within the catchment;
- Basin outputs are evaporation, infiltration and outflow to the downstream pumping station;
- The model time step is daily;
- A stage-discharge curve is used to calculate the level in the CDIA on the basis of the modelled volume in the CDIA. However, on-going calculations use volume rather than stage; and finally
- Threshold for a day of “ponding” is when the CDIA is equal or above 6.0 mAHD.

Features of the water balance model were based on known data where readily available and were calibrated using both the TUFLOW model and the 1D MIKE model developed to assess drain improvements. Key parameters and assumptions are detailed in Table 4.1.

Table 4.1: Key Parameters of the Water Balance Model

Parameter	Value	Comment
Rainfall	-	Informed by actual gauge data obtained from the daily gauge at Williamtown RAAF (#061078). The gauge has 72 years of recorded data (commenced in 1942) and therefore provides a reasonable range of data.
Runoff co-efficient	0.32	Used in most scenarios

	0.69	Used where the preceding day had been wet or where daily rainfall exceeded 25 mm.
Stage-Surface Area relationship	-	Derived from the DEM. Used to determine infiltration and evaporation volumes on a daily time step.
Evaporation	5 mm per day	Evaporation is estimated. Overall evaporation volumes are very low, at around 3% of overall rainfall volume, and therefore unlike to have significant bearing on the water balance.
Infiltration	0.5 mm per day	Overall infiltration volumes are very low* at around 0.3% of overall rainfall volume, and therefore unlike to have significant bearing on the water balance.
Impervious factor	16	Represents the % imperviousness in the catchment draining to the CDIA. Is based on aerial data and uses the same values as the WBNM hydrologic model developed for this FRMS&P.

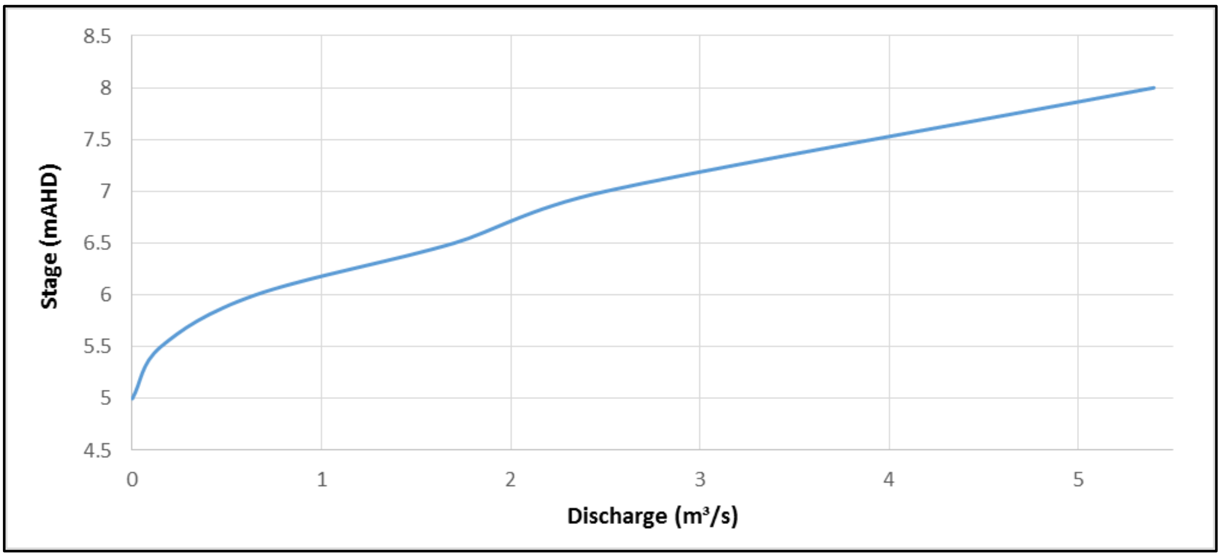
*Note that the 2007 rainfall event referred to in this report had unusually high infiltration at 30-50mm

Observations of historical ponding behaviour were obtained from several residents in the CDIA. An extended period of inundation was observed in the CDIA in 2013, estimated at being around 30 days. Based on observations, the height of the detained water is estimated at above 6.0 mAHD.

Initially the CDIA outflow stage-discharge relationship was estimated based on cross-sections surveyed in 2005 for WBM's 2006 report (Reference 4), however, it was quickly found that the stage-discharge relationship derived from these cross-sections overestimated discharge. As such it was presumed that the 2005 cross-section set did not capture subsequent sedimentation of the channel, limiting section in the channel and/or in-bank vegetation. As a result, Council provided additional survey undertaken in October 2014 at a more frequent cross section interval.

The new survey was used to establish a 1D model of the Campvale Drain. From this model a stage-discharge relationship was calculated as shown in Diagram 2.

Diagram 2: Rating Curve for Campvale Drain (upstream of Pinch)



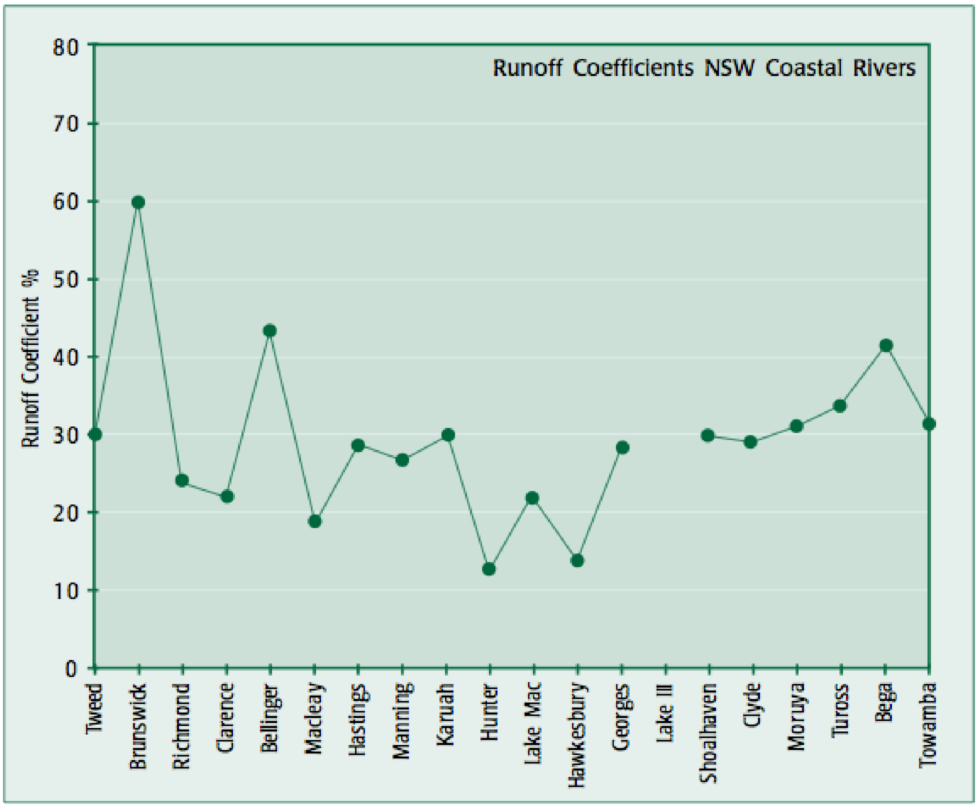
The water balance model was adjusted to achieve an approximate 30 day ponding event in 2013 and then secondly to achieve a result where roughly 50% of years exhibit one month ponding sequences. This second criterion was however given far less weight than the 2013 result.

In looking at how mitigation works might improve the ponding problem the stage-discharge relationship was iteratively altered to assess how much additional flow is required through the drain to reduce the duration of ponding in the CDIA. Discharge values for CDIA stages of 6.0 mAHD and less were altered as it is the reduced levels of flow occurring at low water levels that is the main driver in CDIA ponding.

4.2.2 Results

Over the simulation period of 72 years, the water balance model gave a runoff co-efficient of 0.32. This result seems reasonable in the context of other gauged catchments and when compared to the runoff coefficient results for NSW coastal rivers provided in Diagram 3 below. Variation in NSW runoff coefficients varies from 0.60 to 0.15 and given the smaller size of the Campvale catchment, urbanisation and its terminal basin nature, the 0.32 result in this case seems reasonable.

Diagram 3: Annual Runoff Coefficients for NSW Coastal Catchments (Source NSW DLWC)[1]



The water balance model was considered to be a reasonable representation of existing CDIA ponding behaviour on the basis of the following:

1 http://www.em.gov.au/Documents/Ecological_impact_flood_mitigation_drainage_in_coastal_lowlands.pdf

- Runoff co-efficient of 0.53 over a period of 72 years;
- Model estimated ponding above 6 mAHD for 26 days in 2013 occurring between January 28th 2013 and February 22th 2013; and
- Ponding lasting for more than 30 days occurred a total of 24 times over the 72 year data period thus slightly less than one in every two years. This seems to align with community observations.

4.3 Hydraulic Categories

The 2005 NSW Government's Floodplain Development Manual (Reference 1) defines three hydraulic categories which can be applied to define different areas of the floodplain;

- Floodways;
- Flood Storage; and
- Flood Fringe.

Floodways are areas of the floodplain where a significant discharge of water occurs during flood events and by definition if blocked would have a significant effect on flood flows, velocities or depths. Flood storage are areas of importance for the temporary storage of floodwaters and if filled would significantly increase flood levels due to the loss of flood attenuation. The remainder of the floodplain is usually defined as flood fringe.

There is no quantitative definition of these three categories or accepted approach to differentiate between the various classifications. The delineation of these areas is somewhat subjective based on previous experience and knowledge of an area, hydraulic modelling and literature review (Reference 15).

The process for defining the provisional floodway in Medowie was as follows, using the 1% AEP design event only (due to the lack of scaling between events). Initially, the floodway was delineated based on the frequently used criteria of velocity multiplied by depth is greater than 2.25 m^2/s AND velocity is greater than 2.25 m/s (Reference 15). However, this did not result in a continuous floodway area which is required for planning purposes (to prevent new development from blocking flow paths and increasing flood risk to other properties). The criteria was then simplified to any area with velocities greater than 1 m/s and/or depths greater than 0.5m as this generally follows the flow paths. In addition, the low natural valley depression through the catchment was delineated using ALS data and the floodway was extended to include a 10m buffer either side of this natural flow line, to create a consistent floodway of a minimum 20 m wide.

Within the swamp areas of Moffats Swamp and the CDIA, defining a floodway is difficult due to the extremely slow velocities in the swamps; less than 1 m/s. In these areas the floodway was defined by identifying the main drainage paths for normal low flows and buffering to create a 20 m wide floodway.

In the developed upper catchment area, the use of the 1 m/s criteria to define the floodway results in many isolated and patchy areas identified as floodways. In reality these areas are unlikely to be floodway by definition of the Floodplain Development Manual (Reference 1), merely areas where localised higher velocities may occur due to local drainage features and as such these areas were removed from a floodway classification. Open areas of drain were considered floodway. A number of dwellings were identified as being within areas classified as floodways based on this definition.

Flood storage areas were based on flood depths greater than 0.5 m and/or those locations identified as being within swamp areas or detention basins. Much of the flood prone areas are considered flood storage with the exception of natural drainage paths. In the upper catchment, flood fringe occurs on the periphery of natural floodways.

4.4 Flood Hazard Classification

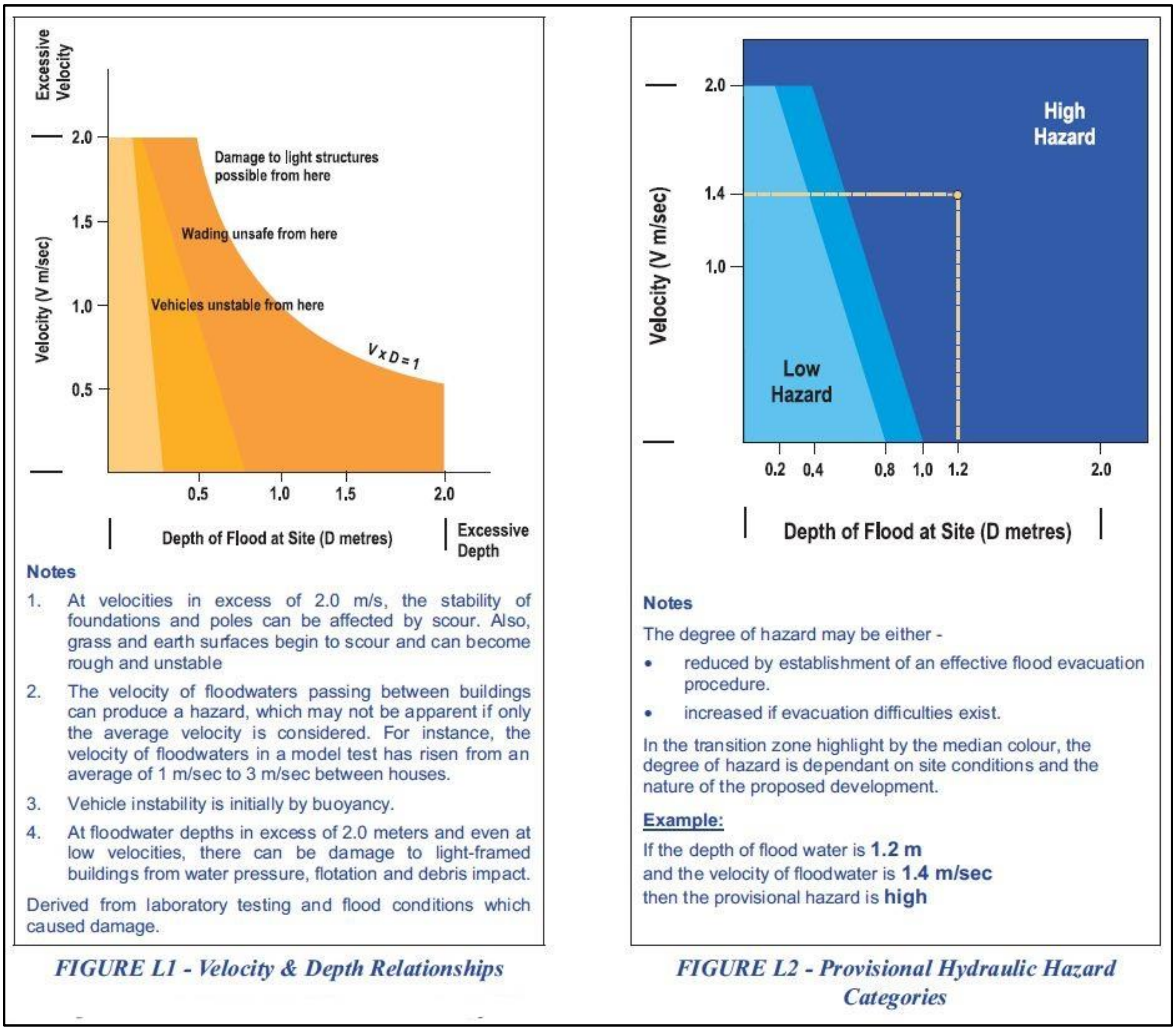
Flood hazard is a measure of the overall adverse effects of flooding and the risks they pose. The 2005 NSW Government's Floodplain Development Manual (Reference 1) describes two provisional flood hazard categories; High and Low, based on the product of the depth and velocity of floodwaters:

High Hazard - *an area or situation where there is possible danger to personal safety, evacuation by trucks is difficult and able-bodied adults would have difficulty in wading to safety. There could also be potential for significant structural damage to buildings.*

Low Hazard - *people and possessions can still be evacuated by trucks if necessary and able-bodied adults would have little difficulty wading to safety.*

The provisional hazard categories are only based on depth and velocity (see Diagram 4) and do not take into account any other factors which may influence the flood hazard. True flood hazard takes into account number of additional flood related criteria, and the provisional hazard is modified accordingly.

Diagram 4: Provisional Flood Hazard Categories



Source: Extracted from the Floodplain Development Manual (Reference 1).

To assess the true flood hazard, a number of other criteria are considered alongside the provisional (hydraulic) hazard. Table 4.2 assesses true hazard for Medowie.

Table 4.2: True Hazard Classification

Criteria	Weight [1]	Comment
Size of the flood	Medium	The size or magnitude of the flood can affect depths and velocities. Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation. However, as flood extents in Medowie do not scale significantly with event magnitude there is not a significant difference in flood levels. Hazard is unlikely to be affected by this criteria.
Depth and velocity of floodwaters	Medium	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event. Generally in Medowie, velocities and depths are not significant in developed areas. However in the swamp depths can reach several meters in the 1% AEP event although there are unlikely to be any people in this location. At depths of 0.3 m wading should be possible for most mobile adults. This obviously could be more of an issue for children, elderly or disabled people. The majority of flood prone dwellings in Medowie (those outside of the swamp areas) have access with flood depths of 0.3 m or less and velocities are generally quite slow (less than 1 m/s). Larger vehicles can easily travel through water at this depth and aid evacuation.
Rate of rise of floodwaters	Low	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events. The faster the onset of flooding the more difficult warning becomes and the quicker evacuation may need to occur. In upper areas of Medowie little to no flood warning is available. In areas near Kirrang Drive and Ferodale Road the time difference between peak rainfall and peak flood level can range between 35 to 90 minutes. The flow's rate of rise at these locations ranges between 0.4 to 0.8 m/h. In the lower areas, such as the CDIA for example, waters will rise over days for longer duration (critical) events.
Duration of flooding	High	The greater the duration of flooding the more disruption to the community and potential flood damages. A short period of inundation may allow some materials to dry and recover whereas a long duration may cause damages beyond repair. A number of residents have commented that water levels in the swamp will stay elevated for several weeks following a flood event, such as that which occurred in February 2009. In this is a key concern for residents.
Effective warning and evacuation time	Medium	This is dependent on the rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act. There are no gauges for warning in Medowie as the nature of flooding does not lend itself to effective warning. There is no flood warning system in Medowie although the BoM do issue severe weather warnings for the area when necessary.

Criteria	Weight [1]	Comment
Flood awareness and readiness of the community	High	The community of Medowie has a degree of flood awareness but it is likely to be limited to those people subject to ponding issues in the CDIA, or those on Kirrang Drive and other local areas where Council has already provided flood mitigation measures, rather than awareness of design events as large as the 1% AEP event. Recent flooding events and community consultation undertaken as part of the current flood risk management process (of which this report forms part) has raised awareness of the flood problem. The awareness of the community has a high weight in considering flood hazard as a more aware community will be able to better prepare and therefore potentially evacuate before hazards become high. General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent, event. In areas where flood warning is limited it is more important for a community to be flood aware so that individual can notice the signs of the onset of flooding and prepare for themselves. In Medowie it is considered that the flood awareness of the community to larger flood events is low.
Effective flood access	High	As floodplain extents are not vast and largely contained within the swamp areas, there should be easily available vehicular access to dry higher ground for the majority of residents. Most of Medowie is considered to have rising road access (see Section 4.5). The vehicular and pedestrian access routes are all along sealed roads and should not present any unexpected hazards if the roads have been adequately maintained. A number of main routes do become inundated during flooding although for most alternative routes are available (see Section 5.3). Flooded roads could be hazardous to pedestrian and vehicles traversing through faster flowing flood water as it spills over the road.
Evacuation problems	Low	In addition to affected flood access, evacuation problems could also be exacerbated by the time of day during which flooding occurs. The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. As there are few significantly flood affected dwellings in Medowie, evacuation of streets conducted by the SES is unlikely to occur. Those subject to above floor flooding may choose to locate elsewhere in a flood event.
Type of development	Low	The type of flood prone development is useful to understand the likely level of occupant awareness, mobility of people as well as population density. Longer term home owners would likely have a better level of flood awareness than a guest at a hotel while residents from an residential care home are likely to be less mobile than average. Generally in Medowie the most flood prone properties are residential. In addition, the construction type can affect hazard. Older timber structures area more likely to be susceptible to flood damages.

Criteria	Weight [1]	Comment
Additional Concerns	Low	Floating debris, vehicles or other items can increase hazard. The impact of debris is unlikely to be a significant factor due to the low flood depths and/or velocities. However, there is always concern over floating debris causing injury to wading pedestrians or structural damages to property. Generally velocities during flooding in Medowie are not significant to carry large debris, however depths could still cause large objects to float. In a large flood it is likely that services will be cut (sewer and possibly others). There is also the likelihood that the storm may affect power and telephones. Sewerage overflows can occur when flood levels are high preventing effective discharge of the sewerage system.

[1] Relative weighting in assessing the hazard for Medowie

Figure C 13, Figure C 14 and Figure C 15 present the true flood hazard for the 5% AEP, 1% AEP and PMF events, based on the discussions in Table 4.2. Within Medowie, true flood hazards make little difference to the provisional flood hazard within the CDIA and Moffats Swamp. In events up to the 1% AEP design event, the provisional hazard for flood prone areas outside of the swamp is generally low apart from those areas defined as flow paths or detention basins. There may be some very localised areas subject to higher hazard where flood velocities are high, such as near obstructions to flow or culverts and drains that would not be identified at the current scale of the result mapping. In the PMF event, depths in excess of several meters make most of the flood prone area high hazard.

4.5 Flood Emergency Response Planning Classifications

To assist in the planning and implementation of response strategies, the SES in conjunction with OEH has developed guidelines to classify communities according to the impact that flooding has upon them. These Emergency Response Planning (ERP) classifications (Reference 16) consider flood affected communities as those in which the normal functioning of services is altered, either directly or indirectly, because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, resupply and rescue. The ERP classification can identify the type and scale of information needed by the SES to assist in emergency response planning (refer to Table 4.3). They are based on modelling of design event flooding.

Table 4.3: Emergency Response Planning Classifications of Communities

	Response Required		
Classification	**Resupply**	**Rescue/Medivac**	**Evacuation**
High flood island	Yes	Possibly	Possibly
Low flood island	No	Yes	Yes
Area with rising road access	No	Possibly	Yes
Area with overland escape routes	No	Possibly	Yes
Low trapped perimeter	No	Yes	Yes
High trapped perimeter	Yes	Possibly	Possibly
Indirectly affected areas	Possibly	Possibly	Possibly

Key considerations for flood emergency response planning in these areas include;

- Cutting of external access isolating an area;
- Key internal roads being cut;
- Transport infrastructure being shut down or unable to operate at maximum efficiency;
- Flooding of any key response infrastructure such as hospitals, evacuation centres, emergency services sites;
- Risk of flooding to key public utilities such as gas, power, sewerage; and
- The extent of the area flooded.

Flood liable areas of Medowie have been classified according to the ERP classification above considering the 1% AEP and PMF events (see Figure 3). As the classifications take account of flood extents and do not necessarily regard flood depths, it was seen as unsuitable to use the full flood extent for Medowie where, using the above classification, areas surrounded by less than only 0.1 m of water could be classified as flood islands when in reality most people could move through this water without problem. As such, before assessing the ERP classifications flood depths less than 0.1 m were removed from the flood extents. The ERP classifications therefore exclude areas of local drainage flooding which would have little impact on SES response.

Most of Medowie is considered as being indirectly affected or unaffected. Those flood prone areas of Medowie typically have Rising Road Access or Overland Escape Route. Generally there are no locations where evacuation would be necessary as over floor flood affectation is minor and flood depths are generally shallow. Flood depths are deepest in the CDIA and Moffats Swamp and these areas are considered as low flood island areas, however there are few dwellings within this area and it is unlikely people will be here in large design rainfall events.

The ERP classifications for all other design events, up to and including the PMF are similar to those presented in Figure 3 due to the lack of scaling between events.

5. IMPACTS OF FLOODING

5.1 Residential Flood Damages Assessment

Flood damages provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation works. By quantifying flood damage for a range of design events, management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation.

The estimation of flood damages focuses on the physical impact of damages on the human environment but there is also a need to consider the social and ecological cost and benefits associated with flooding which is more subjective. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. A flood damages assessment is typically undertaken based on the tangible damages.

Council provided a floor level survey of 371 residential dwellings and 12 commercial buildings identified as potentially being within the PMF flood extents. Of the 12 commercial buildings included in the survey only four were identified as having potential to be flood affected above floor level and not until events of greater magnitude than the 0.2% AEP event. As there is such little over floor flood affectation, and commercial properties were excluded from the damages assessment.

Appendix F provides full details of the flood damages assessment, the results of which are summarised in Table 4 below.

Table 5.1: Potential Residential Flood Damages – Existing Design Event Scenarios

Event	No. Dwellings Affected Below Floor	Number of Dwellings Flooded Above Floor Level	Total Potential Damages for Design Event	Contribution to AAD
0.5 EY	43	1	$ 334,000	26%
0.2 EY	53	1	$ 384,300	34%
10% AEP	57	1	$ 412,000	13%
5% AEP	61	4	$ 625,100	8%
2% AEP	65	4	$ 727,500	6%
1% AEP	73	4	$ 806,000	2%
0.5% AEP	80	7	$ 898,000	1%
PMF	183	96	$10,838,700	9%
	Average Annual Damages (AAD)		**$ 318,500**	**100%**

Four dwellings have been identified as flooded above floor level in the 1% AEP event with one of these likely to be first flooded above floor level in the 0.5 EY event. In the 1% AEP event, the affected dwellings have between 100 mm and 400 mm of flooding above floor levels. Of concern is the likelihood of above floor flooding for the four dwellings during small magnitude flood events less than the 1% AEP event, even though depths are generally minor (< 50 mm) in these events.

The hydraulic floodway is associated with an area critical to the conveyance of floodwaters and is therefore often classified as a high hazard area (see Sections 4.3 and 4.4). Three dwellings were identified as being affected by the hydraulic floodway in the 1% AEP event and of these one is also flooded above floor level. One further dwelling was not classified as being within floodway but has a significant area of the floodway within the property boundary. Details of the flood affectation of these properties is included in Appendix G (not for public distribution).

5.2 Other Assets Affected

The following properties, infrastructure and assets were shown to be flood affected based on the design events determined in the Flood Study (Reference 2) and survey undertaken as part of this study.

5.2.1 Sewer Pumping Stations

Three HWC owned sewer pumping stations were identified in the floor level survey as being flood affected, as summarised in Table 5 below.

Table 5.2: Flood Liability of Sewerage Pumping Stations

Locations	Sump or Floor Level (mAHD)	Ground Level (mAHD)	Event First Flooded Above Ground	Event First Flooded Above Sump or Floor Level	1% AEP Flood Level (mAHD)	PMF Flood Level (mAHD)
36b Ferodale Road	7.53	7.42	10% AEP	10% AEP	7.80	9.50
697 Medowie Road	11.65	11.42	PMF	Not Flooded Above Floor	-	11.50
4 Kingfisher Close	8.30	8.10	PMF	PMF	-	9.50

Inundation of sewer pumping stations can cause pump failure leading to backing up of sewerage and even mixing of sewerage and flood waters, with potential health consequences.

Photograph 6: Ferodale Road Sewerage Pumping Station

During the site inspection in February 2014 it was noted that a small bund had been constructed to the east and south sides of the pumping station and around the area of trees to the east of the pumping station (Photograph 7). In a design flood event which exceeds the main channel capacity, water spilling from the channel immediately downstream of the Ferodale Road Culverts could enter the bunded area from the north east and cause exacerbated flooding in the area behind the bund. If HWC were to consider bunding the pumping station a full ring bund would be necessary to avoid trapping water within the area.

Photograph 7: Bund Near Ferodale Road Sewerage Pumping Station

5.2.2 Educational Facilities

The floor level survey included one school located at Kindlebark Drive. Although the grounds of the school are likely to become partially inundated in the 1% AEP event, the school buildings themselves are not inundated until the PMF event when flooding would be approximately 0.15 m above floor level.

Table 5.3: Flood Liability of Kindlebark School

Locations	Floor Level (mAHD)	Ground Level (at buildings) (mAHD)	Event First Flooded Above Ground	Event First Flooded Above Floor Level	1% AEP Flood Level (mAHD)	PMF Flood Level (mAHD)
42 Kindlebark Drive	21.14	21.13	PMF	PMF	21.05	21.18

In addition to Kindlebark School, the school at Ferodale and Brocklesby Road is affected by shallow depths in the PMF event although it is not likely to be subject to major flooding.

5.3 Flood Access

Flooding in Medowie causes a number of main routes to become inundated. In most cases alternative safe routes can be taken, however, unless residents are guided to or aware of them some may attempt to cross through flooded areas putting themselves at risk. Main crossings and predicted peak flood levels for a range of design events are presented in Table 5.4 below.

Table 5.4: Inundation of Main Access Routes

ID	Road Location	Event first flooded over road	Depth road flooded in first flooded event (m)	Velocity over road in first flooded event (m/s)	Depth in 1% AEP event over road (m)	Velocity over road (m/s)	Comment – Alternative Access Available?
1	**Ferodale Road over Campvale Drain***	2% AEP	0.13	0.71	0.15	0.78	Other areas of Ferodale road are still accessible as well as Abundance Road and Medowie Road.
2	**Kirang Drive over Campvale Drain**	0.5 EY	0.13	0.36	0.55	0.34	High flood depths to the north along Kirrang Drive and to the east along Ferodale Road. Best alternative access route is to the west along Ferodale Road or to the east along Wilga Road.
3	**Kirrang Drive over Campvale Drain near Kula Road intersection**	5% AEP	0.11	0.93	0.16	0.94	High flood depths to the south of Kirrang Drive. Access is possible to the north along Kirrang Drive to Medowie Road.
4	**Kula Road downstream of Kirrang Drive**	0.5 EY	0.16	0.66	0.26	1.03	Possible access via Court Road-Ryan Road-Lewis Drive-Kirrang Road.
5	**Intersection of Kula Road and Karwin Road.**	0.5% AEP	0.12	1.71	0.09	1.31	The best alternative access route is along Waropara Road.
6	**Campvale drain inlet, between intersections of Karwin Road and Kula Road and Kula Road and Court Road**	0.5 EY	0.12	0.15	0.34	0.64	High flood depths to the west of Kula Road, possible alternative access routes via Court Road – Ryan Road – Lewis Drive – Kirrang Drive or alternatively to the east along Waropara Road.
7	**Intersection of Evans Road and Kula Road**	5% AEP	0.11	0.56	0.16	0.61	Possible alternative access via Evans Road and to the south along Waropara Road.
8	**Ryan Road west of the intersection with Court Road.**	1% AEP	0.11	1.90	0.11	1.90	Portion of Ryan Road over stormwater channel inundated from the 0.5 EY event, but most of the road is still clear until 1% AEP event. Best alternative access route is via Ryan Road North
9	**Lewis Drive downstream of Cole Close (Campvale drain)**	0.2 EY	0.16	0.16	0.25	0.47	Lewis Drive is inundated to the south with low flow depths. Best alternative access is to the north towards Fishers Road.
10	**Lisadell Road near drain, west of intersection with Fairland Road**	0.5 EY	0.22	0.66	0.34	0.95	Alternative access is possible to the east along Fairlands Road and Grahamstown Road.
11	**Medowie Road, North of Intersection with Brocklesby Road**	PMF	0.16	4.64	0.03	0.88	In the event that the road is inundated to the north and south, possible alternative access via Brocklesby Road.
12	**Medowie Road, south of intersection with Blueberry Road intersection, north of intersection with South Street.**	PMF	0.13	2.95	0.07	1.24	In the event that the road is inundated to the north and south, possible alternative access via Brocklesby Road.

Note: Roads are considered inundated when depths exceed 100 mm. Locations are mapped on Figure 3.

** Although the road is first flooded from the drain in the 2% AEP event, there is flooding on the road from local catchment areas in events less than this.*

5.4 Implications of Future Development

Further development in a catchment can cause increased runoff due to increased area of impermeable land cover as well as potential diversion of flow by blocking floodways or displacement of water in flood storage areas. Appropriate land zoning, planning and development controls can reduce these impacts. Good planning controls will mean that as areas regenerate they may become more flood compatible as developers are required to consider runoff and impacts on overland flow paths and flood storage areas.

As Medowie has been identified as an urban growth area in the Port Stephens LGA, consideration of flooding should be a key concern. The Medowie Strategy 2013 (Reference 14) sets out planned growth areas within Medowie however Council have advised that the strategy is currently under review and planned development is likely to change from what is currently presented.

Although increased impervious areas could cause increased runoff and increased local flooding in the upper catchment area, it is unlikely that there will be significant increases in flood levels in the CDIA as the storage volume of the CDIA is so large compared to the increased volume of runoff due to reduced infiltration. Furthermore, the upper catchment has clayey soils and infiltration rates are not high even in undeveloped areas so the effects of future development are likely to be minimal. However, there could be increases in localised flooding in upstream areas due to higher volumes and faster rates of runoff.

The Flood Study (Reference 2) assessed the peak flood level impacts of future development as envisaged in the Medowie Strategy 2013 (Reference 14). Results showed that in the 1% AEP event flood levels are slightly higher in downstream locations; up to 0.03 m in the CDIA and 0.01 m in Moffats Swamp, however no dwellings are affected by the increases. Impacts are slightly greater in the Campvale catchment than Moffats catchment, due to more envisaged future development in the Campvale catchment and the terminal nature of the CDIA.

New development could modify or block major overland flow routes thus increasing flooding upstream of the development and a diversion in flows which would affect previously unaffected areas. For this reason development should not be allowed to occur in floodways

Filling in the CDIA could increase flood levels by reducing flood storage volume available. Although it can be argued that the filling volume of one single lot development would be minor compared to the total volume of the CDIA, the cumulative effects of multiple developments needs to be considered.

An assessment of filling in the CDIA was undertaken using the hydraulic model to identify a level at which it was reasonable to allow development to occur without any significant disbenefit to properties within the CDIA. Initially all areas above 7 mAHD in the Campvale catchment south of Ferodale Road were filled, with the exception of areas critical to flow. The resultant impacts on peak flood levels in the 1% AEP event are shown in Figure 5 and show increases in peak flood levels in the CDIA of up to 0.25 m. Although assuming that areas above 7 mAHD are entirely filled above the flood level is a conservative assessment, an increase in peak water levels of 0.25 m is not considered to be acceptable. Furthermore this would cause a further three dwellings to become flooded over floor in the 1% AEP event. Therefore it is recommended that a higher threshold be identified for filling within the CDIA area.

As such, the assessment of filling was undertaken assuming fill only in areas above 7.7 mAHD. Assessed for the 1% AEP event, peak water levels in the CDIA increased by no more than 0.05 m (Figure 5). Although an increase in peak flood levels occurs, it is not a significant increase and in reality the increase would be less than the assessment shows as the entire area above 7.7 mAHD is unlikely to be filled.

If filling is required for construction, for a house pad for example, it is required that the fill be balanced by local cut (at a Cut/Fill Ratio of at least 1) so as to not reduce the volume of storage available in CDIA below 7.7 mAHD

In the Moffats catchment there is little development in the downstream swamp area and it is unlikely to be a problem in the future. Land use zoning in this area is appropriately zoned E1 Nature Reserves which would restrict most development. Levels in the swamp are generally above 8 mAHD.

5.4.1 Future Development Effect on Ponding

Residents within the CDIA are concerned increasing development in Medowie is leading to increased ponding durations. The water balance model was used to assess the impact an increase in imperviousness has on ponding duration.

Under the Medowie Strategy (Reference 14) the impervious percentage of the Campvale catchment area increases from 16% to nearer 24% (see Section 2.5.1.1. By revising the impervious factor in the water balance model to represent this increase the effect on the duration of ponding can indicatively be assessed.

For the future scenario an increase of 50% is assumed. This increases the number of ponding periods occurring over the 72 years from 26 to 29 (Table 5.5).

Table 5.5: Catchment Impervious versus Number of Ponding Periods

Change in Catchment Imperviousness	Total Catchment Imperviousness	Number of Periods of Ponding (more than 14 days)	Number of Periods of Ponding (more than 30 days)
0 %	16.0 %	168	24
10 %	17.6 %	172	26
20 %	19.2 %	172	26
50 %	24.0 %	181	29
75 %	28.0 %	185	30
100 %	32.0 %	192	35

5.5 Implications of Future Climate Change

As well as considering increases in development in the future, the potential impacts of climate change need to be considered. It is expected climate change will increase flood risk as a result increases in sea levels and increases to rainfall intensity.

Council uses the best available information when undertaking flood studies and is required to consider the potential impacts of climate change, in accordance to Reference 1.

Council has adopted the State's sea level rise planning benchmarks in May 2009 of 0.4 m by 2050 and 0.9 m by 2100. While the State Government changed this policy in 2014 to remove the compulsory application of the sea level rise planning benchmarks, these represent the current best available information with regard to sea level rise and are used in flood studies. It is unlikely that sea level rise would impact on the study area which has outfalls at heights of over 8 mAHD.

The State Government released the "Floodplain Risk Management Guideline: Practical Consideration of Climate Change" in 2007. The Guideline highlighted that:

> *"In addition until more work is completed in relation to the climate change impacts on rainfall intensities the following sensitivity analyses are recommended:*
>
> *Rainfall intensities. Increases of:*
>
> - *10% in peak rainfall and storm volume*
> - *20% in peak rainfall and storm volume*
> - *30% in peak rainfall and storm volume"*

The State Government released the "NSW Climate Impact Profile: The impacts of climate change on the biophysical environment of New South Wales" in 2010. The report noted that for the Hunter region:

> *"Flooding behaviour is likely to change.*
>
> *The combination of rising sea levels and catchment-driven flooding is likely to increase flood frequency, height and extent in lower portions of coastal floodplains. Increases in the intensity of flood-producing rainfall events are likely to change flood behaviour everywhere, but catchment conditions at the time of each rainfall event (soil moisture conditions and levels in major water storages) will affect the degree of change."*

CSIRO and the Bureau of Meteorology released their Federal Government-funded report in 2015 on projections of future climate for the East Coast based on our current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and aerosol emissions.

The CSIRO/BoM work used up to 40 global climate models with the full range of emission scenarios, as defined by the Representative Concentration Pathways used by the IPCC, with a particular focus on RCP4.5 (low emissions pathway) and RCP8.5 (high emissions/business as usual pathway).

For the East Coast cluster of NRM regions, it is noted that:

> *"… there is high confidence that the intensity of heavy rainfall extremes will increase in the cluster, but the magnitude of change cannot be reliably projected."*

This report also found that for the East Coast South (Northern Rivers to the Hawkesbury-Nepean), the relative change in the 20-year return level of maximum 1-day rainfall is approximately 18% for the low-emissions pathway and 25% for the business-as-usual pathway. As such, Council uses the mid-range change in peak rainfall and storm volume (20%) as the most appropriate increase to incorporate climate change into the 2100 Flood Planning Level.

Medowie may however see increases in flooding due to potential increases in rainfall intensity. The effect of increased rainfall intensity was assessed in the Flood Study (Reference 2) which found that a 10% increase for the 1% AEP flood event would cause increased flood levels up to 0.2 m and a 30 % increase in rainfall would increase levels in the CDIA up to 0.4 m. Increases in peak flood levels due to rainfall increase are greater in the CDIA. This is due to the fact that it is, for all intents and purposes when it comes to peak flood levels, a terminal basin.

6. POLICIES AND PLANNING

6.1 Legislative and Planning Context

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Under the Policy, the management of flood liable land remains the responsibility of local government. Furthermore, Section 117(2) of the 1979 Environmental Planning and Assessment Act Direction 15 states that Council must ensure development is appropriate in regard to flood risk and that it does not cause impacts on adjoining property.

Councils have a number of planning tools available to them in order to fulfil this role, including the Local Environment Plan (LEP) and Development Control Plans (DCPs). A high level summary of the specific planning documents relevant to Medowie are provided below.

6.1.1 NSW Flood Prone Land Policy

The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property and reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual (Reference 1) relates to the development of flood liable land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy.

The Manual outlines a merits based approach to floodplain management. At the strategic level this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk.

6.2 Existing Council Policy

Updated and relevant planning controls are important in flood risk management. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. Councils use Local Environmental Plans (LEPs) and Development Control Plans (DCPs) to govern control on development with regards to flooding. Existing Council Policy is discussed below and later reviewed in regards to flood risk management to identify where improvements might be made (see Section 7.4.11)

6.2.1 Port Stephens Local Environmental Plan 2013

The Port Stephens LEP 2013 came into force in February 2014 and replaces the former LEP 2000. Council's LEP 2013 covers the whole Port Stephens area including Medowie. Two clauses are particularly relevant to this FRMS&P.

Clause 7.3 of the Port Stephens LEP 2013 applies to "*all land identified as being within the "Flood Planning Area" on the Flood Planning Map and other land at or below the Flood Planning Level"* (FPL). The FPL is defined as *"the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*". The clause seeks to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property to enable safe occupation of flood prone land, reduce public and private losses resulting from floods utilising ecologically positive methods and to avoid significant adverse impact on flood behaviour and avoid significant impacts upon the floodplain environment.

Clause 7.8 refers to drinking water catchments and applied to all land identified on the LEP's drinking water catchment map. Much of Medowie, including the area to the west of Medowie Road and the CDIA is defined as being within the drinking water catchment. The objective of the clause is to *"protect drinking water catchments by minimising the adverse impacts of development on the quality and quantity of water entering drinking water storages."*.

6.2.2 Port Stephens Draft Development Control Plan - November 2014

Council has prepared a Draft DCP 2014 which makes some changes to the current Port Stephens DCP 2013. In terms of flooding, this includes addition of two chapters; Drainage and Water Quality, and Flooding. The Draft DCP will be subject to a period of public exhibition before becoming effective. The DCP applies to all land to which the Port Stephen LEP 2013 applies and is designed to supplement to provisions of the LEP.

6.2.2.1 Draft Chapter B5 - Flooding

Draft Chapter B5 refers to flooding. It applies to all development within the Flood Planning Area (FPA) or below the Flood Planning Levels (FPL) and aims to satisfy the flood provisions of the LEP 2013.

The Draft DCP sets out a number of development controls to achieve its objectives and sets the Flood Planning Level (FPL) as the 1% AEP design flood level plus 0.5 m freeboard. The Draft DCP chapter stipulates that no building or structure is to be erected and there is to be no filling in any area identified as floodway. Again this in is keeping with the principles of the Floodplain Development Manual (Reference 1). Council recognises, that in terms of existing development this can be an issue and a number of exceptions are therefore allowed;

- Minor alterations to ground levels for roads, parking, below ground structures and landscaping, provided that the fundamental flow patterns are not significantly altered; and
- Where dividing fences across floodways cannot be avoided they are to be constructed to not restrict the flow of floodwaters.
- Filling within the 7.7 mAHD line is permitted if it is balanced by local cut so as to not reduce the overall storage capacity of the CDIA.

Within flood storage areas the Draft DCP chapter requires that development does not impede flow from ancillary drainage including overland flow and the cumulative impacts of filling do not significantly impact on flood levels or behaviour on the site.

The Draft DCP chapter requires that risk to life is considered and necessitates that a Flood Evacuation Management Plan is provided and implemented where flood flows have the potential to present risk to life and/or required flood refuge and/or evacuation during flooding. Within Medowie, there is little risk to life from flooding however each development should be assessed on its own merits.

Floor level requirements are stipulated for all residential, industrial and commercial development to be at least at the 1% AEP flood level plus 0.5 m freeboard (the FPL criteria). The Draft DCP chapter also notes that Council may consider reductions in minimum floor levels for commercial and industrial development subject to consideration of appropriate flood proofing, use of flood compatible material, suitable structural design and construction, and provision of a flood storage area of at least 10% of the floor space to be provide above the FPL. Further discussion on setting Flood Planning Levels (FPLs) is given in Section 7.4.8 and 7.4.9 of this report including compliance with NSW Flood Prone Land Policy and relevant controls for different development types.

6.2.2.2 Draft Chapter B4 – Drainage and Water Quality

This part of the Draft DCP applies to development that increases non-permeable surfaces, requires connection to public drainage and/or is in a riparian corridor. It includes considerations for storm water drainage plans, a Statement of Environmental Effects (SEE), On-Site Detention (OSD), water quality, Water Sensitive Urban Design (WSUD), and riparian corridors.

Where development increases impermeable surfaces and will place additional flows into public drainage, a storm water drainage plan is required to ensure that a legal and physical point of discharge is in place to minimise impacts on water balance and surface water flow regimes and flooding.

The Draft DCP chapter sets out a number of criteria for when OSD is required including identifying specific areas (Part D Specific Areas) and where the maximum impervious area in a lot reaches a given percentage depending on land use zone.

With regards to water quality, WSUD features are encouraged and water quality modelling may be required.

Section 51 of the Hunter Water Act imposes an obligation on consent authorities (Council) that Development Applications that are likely to have a significant impact on water quality should be referred to HWC for comment. HWC is obliged to protect source drinking water from all tributaries draining into Grahamstown Dam. Campvale Drain catchment is one such tributary (gazetted Catchment Area 'Special Area' under the Hunter Water Act 1991 and the Hunter Water Regulation 2010). Council in this case, is required to consider Hunter Water's comment into consideration along with other relevant stakeholders.

6.2.2.3 Draft Section D – Specific Areas

A local control for the Pacific Dunes Estate area in Medowie is included in Part D9 of the draft

DCP. This area is a residential development area set around the golf-course and includes new dwellings in the Hillside and Fairway Lots, additions and alterations to other areas and tourist and/or serviced apartment in a Village Centre precinct. This area was identified in the Flood Study (Reference 2) as being the connection point between the two catchments in Medowie; Campvale and Moffats, particularly in the larger flood events. The controls for this area, in terms of flood risk management, include a Flood Planning Level (FPL) of 10 mAHD (1% AEP flood level of 9.5 mAHD plus 0.5 m freeboard) at which the habitable floor level of any dwelling or serviced apartment must be constructed at or above. Flooding should be considered in accordance with Part B of the Draft DCP.

Part D8 of the Draft DCP is specific to the North Medowie area which is the Urban release Area off Boundary Road. The controls for this area, in terms of flooding and water management, aim to effectively manage stormwater within the North Medowie area and ensure downstream impacts are minimised. This includes provision for a detention basin to be constructed prior to the first occupation certificate.

6.2.3 Port Stephens Sea Level Rise Policy

In October 2009 the NSW Government issued a Sea Level Rise Policy Statement with the best international projection of sea level rise along the NSW coast being an increase of 0.4 m between 1990 and 2050 and an increase of 0.9 m by 2100. Since this, NSW Government have now issued a statement that Councils are responsible for adopting their own estimates of sea level rise. Council has adopted the sea level rise benchmarks of 0.4 m increase by 2050 and 0.9 m increase by 2100. These are based on Intergovernmental Panel on Climate Change (IPCC) findings.

Development controls for sea level rise are set out in Council's Draft DCP. Neither Campvale nor Moffats Swamp catchments are exposed to the potential of impacts from sea level rise. The Moffats Swamp easterly outlet discharges to Swan Bay at an invert level of 8.35 mAHD and is therefore unlikely to be impacted by the adopted levels of sea level rise. Sea level rise is therefore not considered further in this FRMS&P.

6.2.4 Medowie Strategy 2013

It is understood that the development areas set out in the Medowie Strategy are currently under review. Nonetheless, the following sections provide a summary of the document with reference to flood risk.

The Medowie Strategy 2013 (Reference 14) was adopted by Council in April 2013, revising the Medowie Strategy 2009 (Reference 13) which is now superseded. Medowie has been identified as one of two significant release areas for urban development within the Port Stephens LGA for the next 25 years. The Medowie Strategy aims to identify how to manage urban growth and build communities in Medowie. It defines the general location and density of future development that Council will use to undertake additional infrastructure studies such as drainage and flooding, intersection analysis, streetscape and a commercial centre master plan.

Mapping shows where flood prone land, from mainstream flooding, has been identified based on the WBM report 2006 (Reference 4); this will need updating with the most recent mapping from this current study.

Within the Medowie Strategy a number of existing overland flow paths are identified. These are based on natural stormwater paths that are predominantly vegetated. The Strategy goes on to state that the actual widths of flow paths will be determined by developers through undertaking necessary flood and drainage studies. It then goes on to state that Council ownership of these paths will be necessary to ensure that vegetation and stormwater elements are maintained and that it is recommended that the overland flow path areas identified in the Medowie Strategy are reviewed as the strategy is reviewed.

The Strategy identifies potential for a town park and lake south of Ferodale Road in the swampy area through which the Campvale Drain currently flows which it suggests *"would serve the purposes of stormwater detention basin, water quality and amenity in the town centre."* A similar option has been reviewed in this report as Option J (see Section 7.3.4) but was not recommended on the grounds of a poor B/C ratio resulting from very little benefit in terms of reduction in peak flood levels.

As part of the implementation strategy Council resolved to undertake a Flooding and Drainage Study for the Medowie Catchments to add detail to the WBM report 2006 (Reference 4). The Flood Study (Reference 2) undertaken by WMAwater and the subsequent review (Reference 3) as well as this FRMS&P report should be used to inform this work.

6.3 Existing Structural Flood Management Measures

A number of works to the floodplain have occurred over time as shown in Table 6.1 in order to attempt to relieve localised flooding issues.

Table 6.1: Existing Structural Floodplain Management Works (from 1990)

Date	Works on the floodplain
After 1990	Western end of Richardson Road raised 0.5 m after 1990 flood.
Approximately 1993	Moffats Swamp outlet to weapons range. Invert of 8.35 mAHD. Outlet to Salt Ash blocked to 8.7 mAHD.
1994/1995	Ballat Close levee constructed.
1995	Changes to Medowie Road started due to construction of the Pacific Dunes Golf Course.
1996	Retarding basin levee upstream of Boundary Road.
1996/1997	Retarding basin in Medowie Road near Kindlebark Drive.
1997	Kirrang Drive culvert upgraded.
1998	Two retarding basins constructed. The first one on Evans Road near Kula Road at 1 and 3A Evans Road (Photograph 16), and the second one upstream of Evans Road.
2002/2003	Changes to South Street in the proximity of the Pacific Dunes Golf Course.
2002/2005	Construction of Pacific Dunes Golf Course.
2007	Ballat Close levee raised after June 2007 floods.
2009	Levee on County Close (Photograph 9). Construction started after the February 2009 flood event. Completed between May and July 2009.
2012	Levee completed on Kirrang Drive (Photograph 19) to protect from flooding from Campvale Drain. Not to protect properties from overland flows from road at the front of the properties.

A stormwater basin is also present in Coolabah Reserve (Photograph 8) although date of construction is not known.

Since the Flood Study (Reference 2) was adopted a new levee has been constructed to the rear of properties on Kirrang Drive which provides protection to residents at 3 to 9 Kirrang Drive from 1% AEP flooding resulting from the Campvale Drain. Construction works also included drainage pipes through the levee to allow any overland flows coming from the front of the properties to still drain to the Campvale Drain. These pipes have flap-gates installed to prevent back flow from the drain into the property (Photograph 19). The Kirrang Drive levee was therefore added to the hydraulic model for all the design events used within this FRMS&P. This is discussed further in Appendix B.

Photograph 8: Existing Detention Basin at Coolabah Reserve

Photograph 9: Levee at County Close

An SES requirement of a FRMS&P is to consider failure of levees. Failure of levees refers to structural collapse, or overtopping in a flood event smaller than the design height but does not constitute overtopping in events greater than the design height. The levees within the Medowie are small low earth embankments which are unlikely to fail in non-overtopping scenarios. Should the levees fail, the few properties at risk of inundation could become flooded, however, velocities due levee failure are unlikely to be significant enough to cause any sudden hazardous conditions.

6.4 Flood Awareness and Flood Warning

The flood awareness of the community and the available flood warning time are important factors in reducing the likely flood damages. From the responses received during community consultation it initially appears that the flood awareness of the Medowie community is relatively high. However, this is generally an awareness of the ponding issue which occurs on a nearly annual basis. Awareness of the effects of flooding in larger events such as the 1% AEP would still be low. People become aware of certain types of flooding and flood behaviour and are therefore less likely to be prepared for the impacts of a different magnitude flood.

There is no specific flood warning system for the Medowie area and no gauges existing in the catchment to allow for warning. Furthermore, the nature of flooding does not allow sufficient time for warning. Fortunately, the overall low hazard category of the flooding means ultimately that flood risk is low despite this. However, the lack of warning time means a strong emphasis should be put on community flood awareness as a risk management measure particularly in regard to road crossings.

7. FLOODPLAIN RISK MANAGEMENT MEASURES

7.1 General

The NSW Government's Floodplain Development Manual (2005) separates floodplain management measures into three broad categories:

Flood modification measures modify the flood's physical behaviour (depth, velocity) and include flood mitigation dams, retarding basins and levees.

Property modification measures modify land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (zoning) or voluntary purchase.

Response modification measures modify the community's response to flood hazard by educating flood affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

7.2 Relative Assessment of Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. The B/C is the ratio of the net present worth of the reduction in flood damages (benefit) compared to the cost of the works. Generally, the ratio only expresses the reduction in tangible damages as it is difficult to accurately include intangibles (such as anxiety, risk to life, ill health, etc.).

The FRMS&P aims to identify and assess risk management measures which could be put in place to mitigate flooding risk and reduce flood damages. As well as the hydraulic impacts, flood risk management measures should be assessed against the legal, structural, environmental, social and economic conditions or constraints of the local area. In the following sections a range of options have been considered to manage existing, future and continuing flood risks at Medowie and assessed for their feasibility.

Mitigation options have been prescribed by the project Brief and in some cases measures aimed at improving the ponding situation are being evaluated for benefit in large floods. Due to the lack of flood liability across the study area and insensitivity in flood levels between design events, benefit is often only marginal. The calculated B/C ratios presented in this FRMS are strictly based on flooding and do not include the value of land impacted by ponding. Measures such as cleaning out the drain and improving drainage time would have significantly better B/C ratios if assessed against criteria more appropriate to the CDIA as opposed to damages related to flooding of dwellings.

Given HWC's important role as a stakeholder in Campvale Catchment outcomes, a report by HWC might investigate and then specify their preference in managing water quality and volumes that move from the CDIA into Grahamstown Reservoir. Continuing to develop and communicate HWC's water quality preferences with the community is important. A study examining the issues and including consultation may be an edifying process for both HWC and local residents.

7.3 Flood Modification Measures

The purpose of flood modification measures is to change the behaviour of the flood itself by reducing flood levels or velocities through excluding water from areas under threat. These measures usually involve structural works.

7.3.1 Optimising Pumping from the CDIA

Other than by infiltration or evaporation, the Campvale WPS is the primary means by which water can leave the CDIA. The current pumping capacity of the four pumps is up to 5.4 m^3/s combined and each has a different cut-in level.

Option B1 – Increasing Pump Capacity

This option doubles the maximum capacity of the four pumps to 10.8 m^3/s. Impacts on peak flood levels for the 0.2 EY and 1% AEP events are shown in Figure E 1 and Figure E 2. Although peak flood levels are reduced by up to 0.08 m in the 0.2 EY event and 0.15 m in the 1% AEP event, there is no change to property flood affectation. As a result, there would be little decrease in flood damages and resultant AAD.

The costs associated with doubling pumping capacity will be significant; initially for construction as the existing pumping station (Photograph 4) would need to be doubled, but also for on-going maintenance and operation. It is considered that the B/C ratio of this option would not exceed 1.

Option B2 – Lowering Cut-In Levels

The four existing pumps each have different cut-in levels at which they start to operate based on the water level in the take-off pond - 5.5 mAHD, 5.6 mAHD, 6.1 mAHD and 6.5 mAHD. Lowering the cut-in levels of the pumps would mean that they function sooner and for longer, provided enough flow is reaching the take-off pond.

Option B2 lowered the cut-in level of each of the four pumps by 1 m to assess the impact and was run for the 0.2 EY and 1% AEP design events. Peak flood level impacts are shown in Figure E 3 and Figure E 4. There are minimal reductions in peak flood levels in the 0.2 EY event (no more than 0.04 m). In the 1% AEP design event there is no change to peak flood levels as the pumps are already operating at maximum capacity. As a result, there would be negligible reduction in damages/AAD and the B/C ratio would not exceed 1.

SUMMARY

Neither option B1 or B2 would provide sufficient benefits in terms of peak flood level reduction and reduction in flood damages and therefore have not been considered further. It must be emphasised that the CDIA ponding issue is about water failing to get to the pumps, not about a lack of pumping capacity.

7.3.2 Channel Modifications and Drain Maintenance for the CDIA

Channel modification includes a range of measures from straightening, concrete lining, removal of structures, dredging and vegetation clearing. In some instances 'naturalising' the channel upstream can reduce peak levels downstream by slowing flows and making better use of flood storage. This section considers the Campvale Drain from downstream of Ferodale Road and through the CDIA. Upstream of Ferodale Road the drain is referred to as a drainage channel rather than mainstream watercourse, and modifications and maintenance to this, and other drainage infrastructure are discussed in Section 7.3.3.

The CDIA is hydraulically separated from the Campvale WPS by the pinch and also a rising bed level. Modifying ground levels around the pinch and removing the uphill slope from the channel could reduce this restriction and allow more flow to pass forward towards the Campvale WPS.

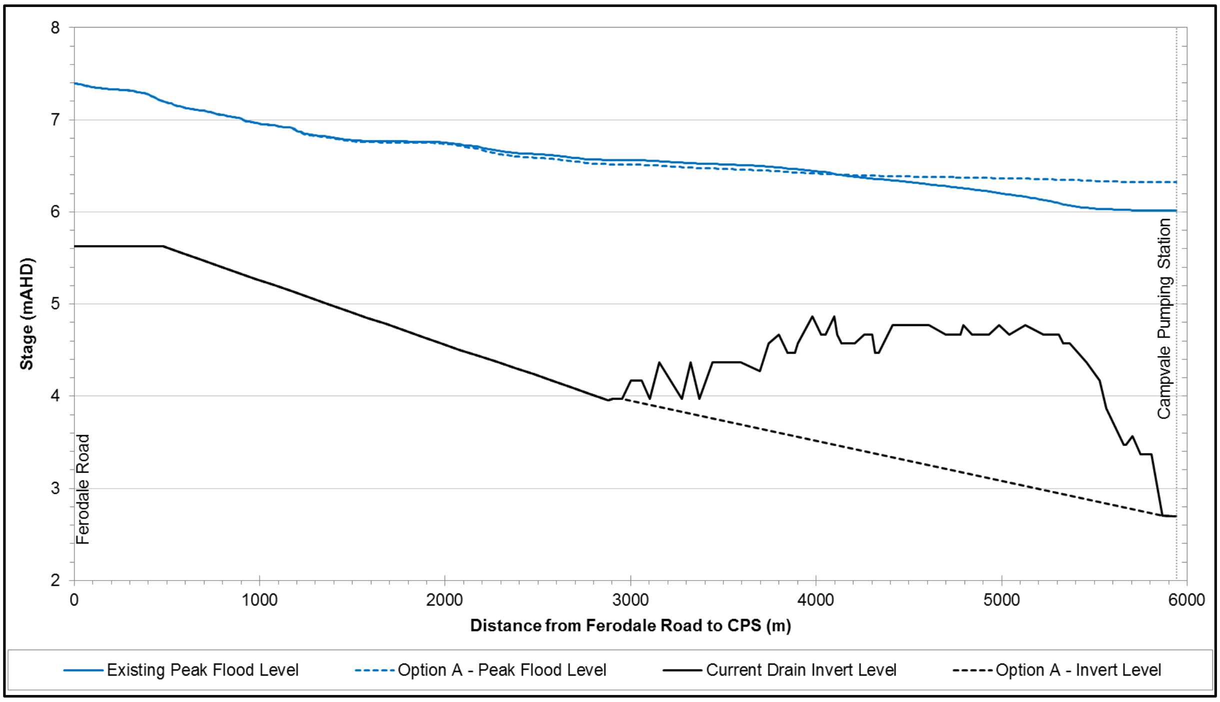
Option A1 – Removal of the Pinch, Earth Bunds and Drain Upgrades to Reduce Flooding

This option considered removal of earth bunds and modification of the drain for some 3 km (Diagram 5). The option was run through the hydraulic model for the full range of design events, with peak flood level impacts for the 0.5 EY, 10% AEP and 1% AEP events shown in Figure E 1 to Figure E 7. Greater benefits in terms of peak flood level reduction are seen in the shorter duration and smaller magnitude events where the drain has more influence (Diagram 5). Nonetheless peak flood levels are reduced by no more than 0.08 m in the 0.5 EY event[2] (Figure E 1). In the 10% AEP event, maximum reduction in peak flood levels is 0.02 m (Figure E 6). These changes do not result in a reduction in flood damages/AAD as there is no change to the number of dwellings flood affected.

Peak flood levels increase in the area downstream of the pinch but do not affect any dwellings as changes are generally contained locally to the channel and within land designated for E1 Nature Reserves use in the LEP 2013.

[2] This is assuming the critical duration in the CDIA of 72 hours. For events of shorter duration, but same ARI or AEP, the benefits will appear larger.

Diagram 5: Peak Flood Level Profile and Drain Invert – Option A1 - 2 hour 10% AEP event



As there is no improvement in flood levels at any dwellings, the B/C ratio of the option would be less than one, and therefore considered uneconomic.

Option A2 – Campvale Drain Improvements to Reduce Ponding Duration

The removal of the pinch was shown in Option A1 to have only a small benefit in terms of reduction in peak flood levels. A similar option could, however, be more beneficial in terms of reducing the duration of low level ponding in the CDIA.

The water balance model was used to assess an increase in outflow and the impact this would have on the longest sequence of ponding as well as the number of times water ponded over 6 mAHD for over 30 days. Results are summarised in Table 7.1 and show that increased flows can significantly reduce the number of times ponding occurs and the duration of ponding events.

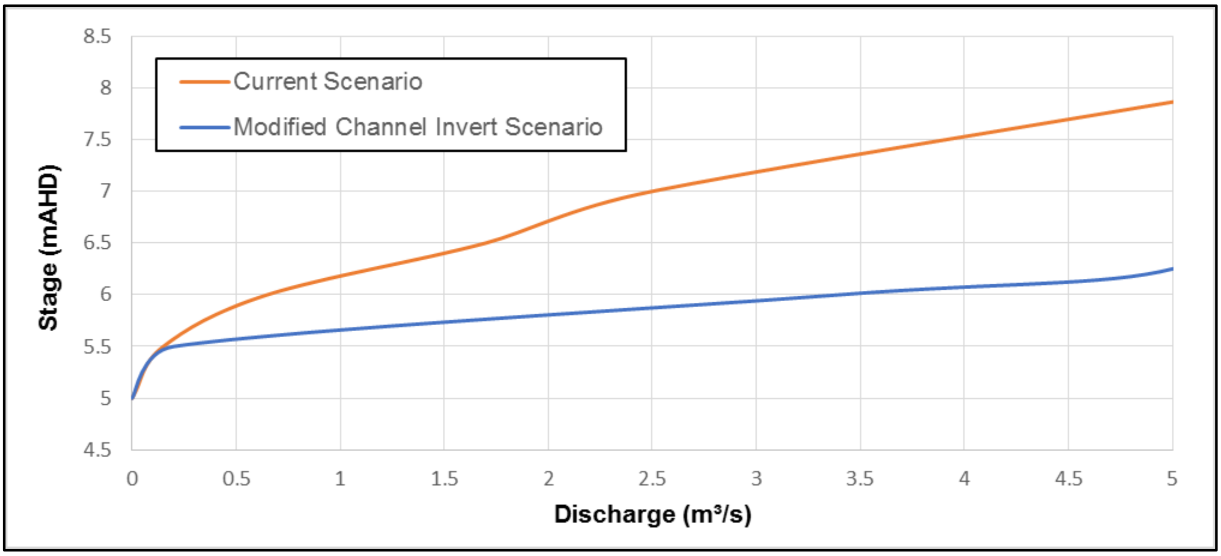
Table 7.1: Effect of Increased Flow in Campvale Drain on Ponding Duration

Increase in Flow	Number or Periods of Ponding (of over 30 days)	Longest Consecutive streak of ponding (days)	2013 event – number of ponding days
existing scenario	24	81	26
50% increase	0	29	20
75 % increase	0	13	8
100 % increase	0	12	5

A 1D model of the Campvale Drain was then built using MIKE11 software covering approximately 2.2 km - from upstream in the CDIA (approximately 800 m south of Abundance Road) to approximately 600 m downstream of the pinch.

A long profile of the drain shows that there is an uphill gradient within the channel around the vicinity of the pinch. It is this feature that is clearly restricting downstream flows. The cross sections within the MIKE11 model were modified by decreasing the invert level to remove this uphill gradient and create a gradual slope of 0.1 %. The change in gradient and cross sections is presented in Figure D 1. A new rating curve was extracted from the modified MIKE11 model (Diagram 6). From this it is easy to see that the modified channel situation would allow a larger flow at lower levels of stage within the CDIA.

Diagram 6: Rating Curves for Campvale Drain (upstream of Pinch) – Existing and Modified



The new rating curve was input into the water balance model to assess the effect on ponding duration. As a result of the channel modification, flows increase by approximately five times at 6 mAHD. This has the effect of reducing the number of periods where the water level in the CDIA exceeds 6.0 mAHD for 30 days or more from 24 to none. At this increased flow the capacity of the Campvale WPS would still not be exceeded. It should be noted that although ponding for 30 day or more periods has been reduced, ponding of the CDIA may still occur for shorter durations. Furthermore, this assessment assumes that lateral drains have good connectivity to the Campvale Drain. In reality, assessment has shown that some ponding is likely due to the lack of lateral drain connectivity (refer Option G below).

A volume of approximately 14,100 m^3 of material would need to be removed to lower the invert levels of the channel bed as required. The uphill gradient which currently exists slows flows and encourages deposition of material which over time will only exacerbate the current situation. Therefore, it is important to improve the situation to reduce the risk of Council having to undertake more significant works on the drain in the future.

A reduced ponding duration of water in the CDIA may potentially have a negative effect on the quality of water eventually reaching Grahamstown Reservoir. Outside of the scope of this FRMS&P, Council will need to undertake discussions with HWC to gain their support for such a scheme with regards to water quality concerns. HWC have indicated that any water quality impacts would need to be fully addressed as part of the option (including impacts of the construction activity and acid sulphate soils). The operation of the reduced-level drain with respect to impact on water quality should also be addressed.

Option C – Drain Improvements in Conjunction with Improved Pump Capacity

This option essentially combines Option A and Option B1, with Option B1 reducing the increases in peak water levels downstream of the pinch which occur as a result of Option A. Overall, there is some minor benefit in terms of peak flood level reductions upstream of the pinch, however, reductions in peak flood levels are not significant enough to change dwelling flood affectation. Flood damages would not reduce significantly enough for the B/C ratio to be above 1.

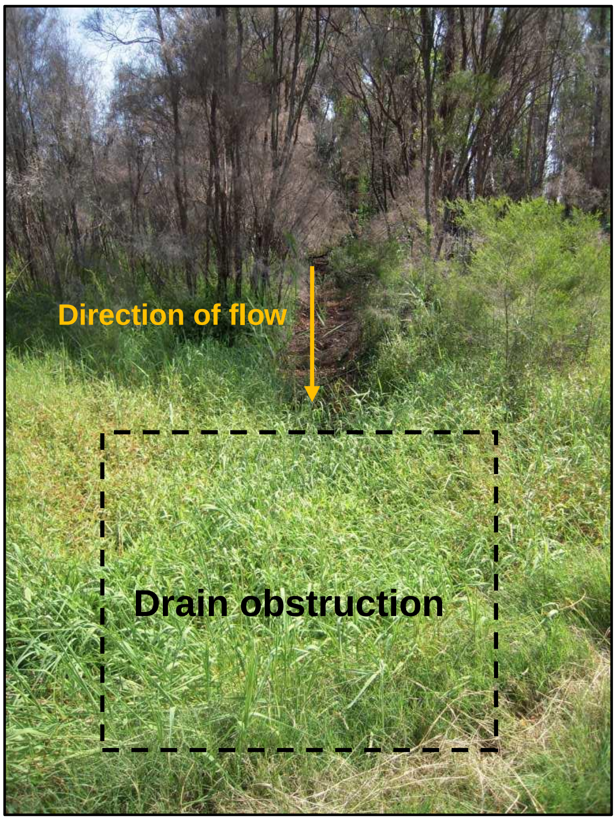
Option G – Improved Lateral Drain Connectivity in the CDIA

The drainage capacity of the CDIA has little influence on the design event flooding for events greater than the 10% AEP event, as the swamp has already begun to fill and drainage capacity has been exceeded. However, lateral drains do have a bearing on ponding events (see Section 4.2).

Site visits to the CDIA and Campvale Drain area highlighted that many of the local drains within the CDIA were blocked with debris or silted (Photograph 10). Furthermore in some cases, connectivity between drains did not exist, entirely negating their purpose (Photograph 11). This is confirmed by ALS data of the area which clearly shows that there is poor connectivity between the lateral drains within the CDIA (Figure D 2).

Photograph 10: Blocked drainage in the CDIA

Photograph 11: Vegetated Local Drain in CDIA



Option G assessed improving connectivity of the lateral drainage channels to each other and to the Campvale Drain. This option was tested in the TUFLOW model for the 0.2 EY and 1% AEP design events to assess benefit in terms of reductions in peak flood levels. The changes were

negligible as this option does little to improve the volume of the CDIA and was not considered further for design event flooding.
However, it was considered likely that improving drain connectivity in the CDIA will provide benefit to the ponding issue. Lateral drains in the CDIA are small and the heavily vegetated nature of the surrounding area makes them particularly prone to blockage. Some ponding in the CDIA may result from the lack of connectivity between some low lying areas and the Campvale Drain. Figure D 2 shows areas of land in the CDIA below 6.0 mAHD.

To assess the effect of improved drainage connectivity, the TUFLOW model was run under existing conditions and also with the Option G improved drains and connectivity scenario. The drain-down time was compared when the water level in the CDIA is at 6.5 mAHD to 5.4 mAHD (the cut-in level of the pumps). Under Option G, the total time to drain is approximately 70 hours (Figure D 3), compared to existing conditions where ponding at above 6.4 mAHD can last for more than three days alone. Therefore, improvement of the connectivity of the lateral drains within the CDIA could be a beneficial option in terms of reducing the ponding occurring in the CDIA.

Council is currently acquiring easements along the Campvale Drain to allow continuous access for maintenance (see Section 7.4.6). Generally maintenance of watercourses on private property is the responsibility of the property owner however where Council have legally acquired easements, they are responsible for maintaining the drain. It is unlikely that the lateral drains within the CDIA are within the official easements and therefore the responsibility ultimately falls on the property owner for maintenance. Property owners are bound by various legislation with regards to drain maintenance, for example taking care not to move native vegetation or to alter the bed and banks of the drains. There is also often a lack of understanding of who is responsible for maintenance, and where owners know that the various legislation is in place, this can deter them from undertaking drain maintenance themselves.

It is recommended that to improve the lateral drainage within the CDIA, Council first undertake works to clear and improve the connectivity of the lateral drains, regardless of whether within the official easement or not. To do so, Council would need consent from property owners however, given the current ponding situation within the CDIA, property owners may welcome attempts for improvement. Following this Council could either acquire additional easements along the lateral drains to allow access for future maintenance, or provide education to the property owners on their maintenance responsibility and rights, and any legislation they would need to comply with, including helping residents understand the legislation.

Clearance of Campvale Drain

A number of residents have commented on the build-up of vegetation and siltation in Campvale Drain from the pinch into the upper catchment, which they believe is exacerbating flooding. Council are in the process of obtaining drainage easements to improve their access to the drain for clearing and maintenance. Clearing is likely to reduce flooding in the smaller short duration design events but would have no benefit in the larger and longer duration design events.

The drain is heavily vegetated with Alligator Weed, however *Maundia Triglochinoides* (Maundia) is also present which is listed as vulnerable under the Threatened Species and Conservation Act 1995 (TSC Act). Council have therefore had to apply to OEH for permission to undertake drain maintenance and clearing for an area of 14,400 m^2 covering the drain downstream of Ferodale Road to the Campvale WPS. Council prepared a Species Impact Statement (SIS) which described removing 50% of the Maundia and its habitat in the affected area of the drain and offsetting this by creating a new habitat in a diversion drain off the side of Campvale Drain (Photograph 12). OEH have subsequently granted a licence to conduct drain maintenance activities and weed spraying activities and Council commenced works towards the end of 2013.

Council should liaise with HWC prior to removing vegetation or spraying around the Campvale Drain, so that they are aware of the extent of the work.

Photograph 12: Diversion Channel Downstream of Ferodale Road – February 2014

SUMMARY

Channel clearance and maintenance could be beneficial, particularly in the Campvale catchment, in terms of reducing ponding issues and to avoid the build-up of vegetation. The following measures are recommended:

► **Option A2** – Campvale Drain improvements; modifying invert levels within the channel to maintain a downhill slope to reduce periods of ponding, which amounts to removal of some 14,000 m^3 of material..

► **Option G –** Improved lateral drain connectivity in the CDIA to reduce ponding duration. Council will need to acquire permission from property owners before undertaking the works. To continue maintenance in the future, Council will need to acquire additional easements or provide education and advice to property owners on maintaining drains within their property.

► Continued program for drain maintenance and clearance of debris of the main Campvale Drain.

7.3.3 Drainage Network Modifications and Maintenance

Upper areas of both the Campvale and Moffats catchments have flooding issues where pipe systems lack capacity to convey extreme flows. The existing drainage network could be modified to increase capacity by installing larger or more pipes within the network or by providing areas for attenuation to hold back volumes of flood water and release at a slower rate such as detention basins (see Section 7.3.4). Maintenance of the drainage network is important to ensure that it is operating with maximum efficiency and reduce risk of blockage or failure.

This section considered the drainage infrastructure and the Campvale Drain upstream of Ferodale Road culverts.

Drainage systems are typically designed for events up to the 10% AEP event, and therefore modifications to the system cannot radically change peak flood levels for the 1% AEP event and thus can be difficult to support on an economic basis. However, drainage network modifications could aid in managing the ponding issue, as well as improving flood access during events by reducing flooding of roads.

Increased Drain Capacity near Ballat Close

WMAwater was previously asked by Council to assess potential drainage upgrades in the vicinity of Ballat Close to alleviate flooding to a dwelling which has reported over floor flooding on several occasions (Reference 22) (Photograph 13). The assessment considered a number of drainage options - upgrading the existing drainage system between 8 and 10 Ballat Close as well as across Ballat Close, and widening the existing drainage channel between 7 and 9 Ballat Close. A levee around the property was also considered.

It was found that whilst the drainage upgrades did reduce peak flood levels at the flooded dwelling, the options also resulted in increases in flood levels in the surrounding areas, worsening the situation for other dwellings and also making flood access on the street more dangerous. The report suggested that Council should cease to seek engineered solutions to flooding of the dwelling on Ballat Close as although solutions may be found for the smaller design events, larger flood events will continue to pose a flood risk to the property due to its location in the defined floodway. The report concluded the dwelling would benefit from voluntary purchase (see Appendix G).

Photograph 13: Flooding at Ballat Close

Source: M. McCaig

Option I1 – Increased Capacity of Ferodale Road Culvert

The three existing culverts at Ferodale Road measure approximately 2.4 m by 1.35 m (see Photograph 14) and have limited capacity which causes flooding of the road. Upgrading the culverts could reduce flooding of the road as well as reduce upstream flood levels and potentially provide benefit to dwellings on Kirrang Drive. However, the hydraulic performance of the culverts is downstream controlled and therefore without improvements in the downstream channel also, any improvement to the culverts are likely to be minor.

Option I1 investigated the benefits of increasing the number of culverts beneath Ferodale Road from three to five assuming an additional culvert would be placed either side of the existing culverts. At the same time the channel would be marginally widened immediately upstream and downstream to allow for flow to enter and exit the culverts. The changes allow more flow through the culverts themselves and less over the road (Table 7.2: Peak Flow at Ferodale Road and Kirrang Drive (9 hour duration event)), although flooding of the road is not eliminated entirely. In smaller events, although the capacity of the culverts may not be exceeded, flows move over the road from a local catchment causing shallow depths of flooding.

Table 7.2: Peak Flow at Ferodale Road and Kirrang Drive (9 hour duration event)

	FERODALE ROAD				KIRRANG DRIVE			
	EXISTING		OPTION I1		EXISTING		OPTION I1	
Design Event	Culverts	Over Road	Culverts	Over Road	Culverts	Over Road	Culverts	Over Road
0.5 EY	14.1	0.8	16.6	0.0	14.6	0.5	15.8	0.2
0.2 EY	15.1	5.5	19.9	1.1	17.1	3.7	19.1	2.1
10% AEP	15.5	8.2	20.1	3.2	17.8	6.1	20.1	5.6
5% AEP	16.3	12.6	21.6	7.7	19.3	9.9	20.9	8.8
2% AEP	16.3	18.9	21.6	13.6	21.6	15.3	21.9	14.2
1% AEP	16.3	25.1	21.7	19.5	22.8	20.7	23.7	19.3
0.5% AEP	16.3	31.3	21.7	25.9	23.5	27.7	24.3	26.4
PMF	17.1	263	22.8	259	32.2	216	32.7	216

NOTE: All values in (m^3/s). Flows over Ferodale Road in events smaller than the 2% AEP event are of a result of flows from local catchments, not as a result of limited capacity of the culverts.

The impacts on peak flood levels for the 0.5 EY, 0.2 EY, 10% AEP, and 1% AEP events are shown in Figure E 8 and Figure E 9. Impacts generally propagate upstream as far as Kula Road and reductions in peak flood levels to the rear of dwellings on Kirrang Drive are in the order of 0.01 to 0.04 m in most design flood events. Greater reductions in peak flood levels occur in the smaller flood events.

Downstream of Ferodale Road there are increases in peak flood levels up to 0.04 m but this does not affect any dwellings and the increase is only notable in the 0.5 EY event. While the option does not reduce the number of dwellings suffering from over floor flooding, it does reduce flood levels at three dwellings although the average reduction per property is only 0.03 m. One property on Wilga Road previously subject to below floor flooding (with depths of less than 0.1 m) is no longer flooded in the 0.2 EY and 10% AEP events.

Table 7.3: Option I1 – Change in Flood Damages

Design Event	Change in Total Event Damages
0.5 EY	-$ 200
0.2 EY	-$ 1,100
10% AEP	-$ 3,000
5% AEP	-$ 2,000
2% AEP	-$ 2,000
1% AEP	-$ 1,800
0.5% AEP	-$ 1,900
PMF	no change
Reduction in AAD	***-$ 700***

A flood damages assessment shows that the reduction in AAD is only $ 700. Assuming two new culverts, the road and associated works costs are in the order of $ 55,000, the B/C ratio for a 50-year timespan would be 0.2 making the option economically unfeasible. It should be noted that the work may be economically feasible if undertaken as part of road reconstruction, or if partly funded by developer contributions. For this reason, the option is recommended for further investigation in the Medowie Drainage Strategy.

Option I2 – Increased Capacity of Ferodale Road Culvert plus Concrete Lining of Upstream Channel

This option assumed the upgrade of the Ferodale Road culverts as per Option I1 and in addition concrete lining the channel upstream between Ferodale Road and Kirrang Drive. The current channel is formed of earth and over time a build-up of vegetation occurs. Conveyance is improved by lining the channel, represented in the model by reducing the manning's *n* value from 0.035 to 0.018.

The option was tested for the nine hour duration (the critical duration at this location) 10% AEP and 1% AEP events, and peak flood level impacts are presented in Figure E 10. The resulting flows for the range of design events are presented in Table 7.4 below.

Table 7.4: Peak Flow at Ferodale Road and Kirrang Drive (9 hour duration event) – Option I2

	FERODALE ROAD				KIRRANG DRIVE			
	EXISTING		OPTION I2		EXISTING		OPTION I2	
Design Event	Culverts	Over Road	Culverts	Over Road	Culverts	Over Road	Culverts	Over Road
0.5 EY	14.1	0.8	17.5	0.0	14.6	0.5	16.5	0.0
0.2 EY	15.1	5.5	21.7	0.7	17.1	3.7	21.1	0.8
10% AEP	15.5	8.2	22.9	2.5	17.8	6.1	22.5	2.7
5% AEP	16.3	12.6	23.8	6.5	19.3	9.9	23.6	6.4
2% AEP	16.3	18.9	24.0	11.8	21.6	15.3	24.7	12.5
1% AEP	16.3	25.1	24.3	18.3	22.8	20.7	26.9	16.6
0.5% AEP	16.3	31.3	24.4	24.9	23.5	27.7	27.9	22.3
PMF	17.1	263	26.9	259	32.2	216	34.2	216

NOTE: All values in (m^3/s). Flows over Ferodale Road in events smaller than the 5% AEP event are of a result of flows *from local catchments, not as a result of limited capacity of the culverts.*

In the 10% AEP event, the increased flows through the culverts causes some minor increases in peak flood levels downstream in the CDIA by up to 0.016 m. Although no dwellings are newly flooded above floor as a result, this increase does affect four dwellings. Upstream of Ferodale Road there are reductions in peak flood level of up to 0.013 m however, these are mainly limited to the Yulong Oval and does not affect any dwellings. In the 1% AEP event, peak flood levels upstream of the culverts are reduced less than 0.01 m, and again, no impacts on dwellings. As a result the B/C ratio of this option would be very low, and lower than Option I1 due to the higher construction costs. As with Option I1, the work is not economically feasible, but may be further investigated as part of the Medowie Drainage Strategy.

Benefit is provided however in terms of reduced flow over Ferodale Road and also Kirrang Drive (Table 7.4) thereby improving safety on the road during periods of flooding. As flows thorough the culverts are increased, flow over the road is reduced although not mitigated entirely. At Ferodale Road, although the water level in the drain does not exceed the crest level of the road above the culvert until the 1% AEP event, there is some flooding of the road in slightly lower areas to the west and east of the culverts caused by local catchment flows.

Option N1 – Upgrade Culverts around Wellard Close and Wilga Road and Open Drain Improvements

This option considered doubling the capacity of the culverts around Wellard Close and Wilga Road by installing an additional culvert at each location. The option was run for the full range of design events. Peak flood level impacts for the 0.2 EY and 1% AEP events are presented as Figure E 11 and Figure E 12. Generally the option decreases peak flood levels in the vicinity of the drain for all design events assessed however, peak flood levels increased downstream of the drain in events up to and including the 10% AEP event (although increases were no more than 0.02 m and affected no dwellings).

Most of the benefit occurs in open land at properties in the vicinity of the open drains around Wilga Road, Wellard Close and Kirrang Drive. Three dwellings previously flooded below floor level are no longer flooded in the 1% AEP design event, and one further dwelling which was previously flooded above floor level in the 5% AEP event is now no longer flooded above floor until the PMF event (Table 7.5).

Table 7.5: Option N – Change in Flood Damages

Design Event	Change in No. of Dwellings Flooded Below Floor	Change in No. of Dwellings Flooded Above Floor Level	Reduction in Total Event Damages
0.5 EY	0	0	-$ 7,900
0.2 EY	0	0	-$ 3,300
10% AEP	0	0	-$ 1,200
5% AEP	-1	-1	-$ 2,500
2% AEP	-2	-1	-$ 65,400
1% AEP	-3	-1	-$ 69,600
0.5% AEP	-4	-1	-$ 73,300
PMF	-1	0	-$ 3,700
		Reduction in AAD	***-$ 6,300***

Although a number of dwellings benefit from this option, the reduction in AAD is small as peak flood levels are reduced by a maximum of 0.15 m.

An assumed cost for these works is $ 170,500 based on $ 2,500 per culvert and additional costs for removal of existing culverts and associated construction works such as resurfacing the roads. Assuming a 50-year lifetime, a B/C ratio of 0.5 is achieved. As such, the option is not considered economically feasible. It should be noted that the work may be economically feasible if undertaken as part of road reconstruction, or if partly funded by developer contributions. For this reason, the option is recommended for further investigation in the Medowie Drainage Strategy.

Option N2 – Open Drain Improvements and Culvert Upgrade near Kirrang Drive / Kula Road intersection

Option N2 is a variation of Option N1 which upgrades the lower reach of open drain and culvert beneath Kirrang Drive. This option was run for both the two hour and nine hour durations as the critical duration varies for the main drain and local catchment drainage. The impacts of peak flood levels are presented in Figure G 4 for the 10% AEP and 1% AEP events respectively.

The option is shown to have considerable benefit in both the 10% AEP and 1% AEP events reducing levels near the Kirrang Drive / Kula Road intersection by up to 0.5 m in the 10% AEP event and 0.2 m in the 1% AEP event. Not only does this improve the flooding situation for dwellings near to the intersection with one property no longer flooded above floor level, it also reduces flood depths thus improving access during flooding. This location has been known to flood in the past (e.g. the 2007 rainfall event) (Photograph 1). In the 10% AEP event the intersection is shown as no longer flooded. Some minor increases in peak flood levels occur downstream in the 10% AEP event but are no greater than 0.01 m and affect no dwellings.

Based on the significant reduction in peak flood levels as a result of Option N2 for the two design events tested, it is likely that similar results will be achieved for all design events. Therefore this option could provide considerable benefit at this location and is therefore recommended for further consideration.

Option P – Drainage Upgrade at County Close

This option doubled the number of culverts at County Close from two 0.55 m by 1.2 m box culverts to four, as well as made some improvements to the open drain. Impacts on peak flood levels for the 0.2 EY and 1% AEP events are shown in Figure E 13 and Figure E 14 respectively.

In the 1% AEP event, the flood extent is significantly reduced as the flow area of the culverts and capacity of the open drain is increased. In the 0.2 EY one dwelling is shown as benefitting, however, under the current scenario flood depths at the property are only minor being only 0.05 m in the 1% AEP event. The option provides more benefit to gardens and yards than it does actual dwelling buildings and therefore would result in little reduction in the AAD. Combined with significant construction costs, this option was not considered economically feasible.

Option S – Improvements to James Road Drainage to Moffats Swamp

The drainage at James Road was improved by replacing the existing two 0.9 m diameter pipes with two 1.2 m by 0.8 m box culverts.

In the 1% AEP event peak flood levels in the retarding basin on James Street are reduced by up to 0.2 m, with a similar decrease in the 0.2 EY event (Figure E 15). However, as more flow is now able to pass forward through the culverts, peak flood levels downstream of James Road are increased by up to 0.04 m in both design events.

Flooding is reduced for one property each on Windeyer Close and James Road. However, under the existing scenario neither dwelling was flooded above floor, and flood depths above ground level are shallow (in the order of 0.04 m). Therefore the reduction in AAD would not be sufficient to warrant the costs of the option.

Drainage Infrastructure Maintenance

Section 7.3.2 considered clearance activities for the main drain within the CDIA. Build-up of vegetation has also occurred in the open drainage channels upstream of the CDIA. Earlier site visits noted vegetation upstream of the culverts at Ferodale Road (Photograph 14) which would prevent the culverts from acting at maximum capacity, although clearance works subsequently began in late 2013. Likewise the culverts at Kirrang Drive are heavily vegetated, as is the immediate upstream channel (Photograph 15). The channel downstream of the Kirrang Drive culverts to Ferodale Road has been cleared as part of the recent clearing works. Areas upstream of Kula Road were also noted to be cleared on a site visit in February 2014.

Photograph 14: a) Vegetation Upstream Of Ferodale Road Culverts in November 2009, b) Cleared in February 2014

Photograph 15: a) Vegetation Upstream Of Kirrang Drive Culverts (still to be cleared as of Febraury 2014), b) Cleared in February 2014

Sensitivity analysis of blockage of the culverts was tested in the hydraulic model in the Flood Study (Reference 2). The current hydraulic model assumes that all drainage infrastructure is 25% blocked which is a reasonable assumption to make to allow for siltation and vegetation growth. The Flood Study (Reference 2) found that in the 1% AEP event, full blockage of the culvert only caused nominal increases in peak flood levels in the area as in the 1% AEP event the majority of flow moves over the road rather than via the limited culvert capacity. However, in smaller events such as the 0.2 EY, blockage is likely to have a larger impact on peak flood levels and therefore it is important for Council to undertake clearance of the culverts.

A more detailed investigation of the effect of blockage may be carried out as part of the Medowie Drainage Strategy. Individual culverts may be assessed for their effect on flooding, as per the latest AR&R Guidelines for Blockage of Hydraulic Structures. Council has identified the following drainage features for investigation:

- Inlet upstream of Boundary Road (near Ryan Road)
- Evans Road detention basin outlet
- Inlet upstream of Ballat Close
- Inlet upstream of Ryan Road (near Court Close)
- Inlet upstream of Kirrang Road (near Kula Road)

- Upstream of Kirrang Road culvert

In addition to a more detailed investigation, the introduction of maintenance protocols or policies would ensure that drainage assets are effectively managed and regularly maintained such that they will perform as required when needed. Australian Rainfall and Runoff Blockage Guidelines for Culverts and Small Bridges – Project 11: Blockage of Hydraulic Structures (February 2015) suggests the following to minimise the effects of debris blockage:

- *"Take all reasonable and practicable measures to maximise the clear height of the culvert*
- *In the case of floodplain culverts, spacing individual culvert cells such that they effectively operate as single-cell culverts without a common wall*
- *Managing sedimentation using, for example,*
    - *a multi-cell vulert with variable invert levels such that the profile of the base slab simulates the natural cross section of the channel, or*
    - *sediment training walls that reduce the risk of sedimentation of the outer cells by restricting minor flows to just one or two cells."*

Road Flooding – Level of Service

The Medowie Drainage Strategy should include investigation of the degree of works required to improve roads in the area to a common standard. Council has defined a level of service for eight categories of road, with each having a required capacity of the roads' drainage assets, as shown in Table 7.6. The level of service will ensure road affectation is managed, and that evacuation routes can be improved over time.

Table 7.6: Council Level of Service for Existing Roads

Road Category	Desirable Design for Drainage Assets	Maximum Design for Drainage Assets
Arterial Roads	2100 1% AEP +0.3m obvert freeboard	PMF+0.5m road freeboard
Sub-arterial Roads	2100 1% AEP +0.3m obvert freeboard	PMF+0.5m road freeboard
Industrial Roads	2100 1% AEP +0.3m obvert freeboard	PMF+0.5m road freeboard
Main Streets	2100 2% AEP +0.3m obvert freeboard	2100 1% AEP +0.5m road freeboard
Major collectors (distributor)	2100 2% AEP +0.3m obvert freeboard	2100 1% AEP +0.5m road freeboard
Neighbourhood collectors	2100 5% AEP +0.3m obvert freeboard	2100 1% AEP +0.5m road freeboard
Local streets	2100 5% AEP +0.3m obvert freeboard	2100 1% AEP +0.5m road freeboard
Cul-de-sacs	2100 5% AEP +0.3m obvert freeboard	2100 1% AEP +0.5m road freeboard

SUMMARY

By increasing drainage capacity larger volumes of surface water can be drained away more quickly. Enhancing the capacity of trunk drainage systems may achieve a degree of flood relief for properties exposed to flooding on a regular basis. However, few options were shown to be beneficial and/or the reduction in peak flood levels was not significant enough to warrant implementation of the option, with the exception of the following measures which are recommended for further consideration:

► **Option N2** - Open drain improvements and culvert upgrade near Kirrang Drive / Kula Road intersection. Significantly reduces flooding at the intersection and several dwellings including one previously flooded over floor.

► **Drainage Infrastructure maintenance -** Identify policies for maintenance of drains and channels and determination of protocols for ownership maintenance and development / upgrade of infrastructure.

7.3.4 Detention or Retarding Basins

Retarding basins are often used to manage flooding in small catchments or to mitigate the effects of increased runoff caused by development. Retarding basins store runoff temporarily and then release it at a slower rate, thereby reducing the rate at which runoff occurs and downstream peak flood levels.

There are already several detention basins in the Medowie catchments including;

- Evans Road (Photograph 16);
- Boundary Road;
- James Road; and
- Coolabah Reserve (Photograph 8).

These systems can be convenient to implement in large scale new development, like that anticipated under the Medowie Strategy (Reference 14). Council can place the responsibility on the developer to provide appropriate drainage systems through their DCP which may require some form of onsite detention. Often the 1% AEP event is used as the design event for new development however flows also need to be restricted back to the pre-development rates for smaller events for the basin to be effective. Hydraulic structures can be used to restrict the outlet discharge rate to a required rate. Within an urban catchment, basins may need to be used to reduce downstream peak flows.

Retention basins can also have benefits for the community other than flood control. For example, some basins when dry are used as sports fields and recreation grounds, others can be designed to be permanently wet creating scenic and wildlife areas. There are also pollution control benefits associated with retention basins allowing settlement of particulates.

Like all drainage systems, retarding basins have maintenance requirements. Regular checks and maintenance will be required by Council or agreements put in place with the developer and land holder. If Council is not to be responsible for the maintenance, they should still maintain regular checks to ensure that appropriate maintenance is being undertaken.

Large retarding basins can also be a safety hazard particularly when full. Appropriate safety controls such as fencing and signage should be included as part of the overall asset and should also be subject to routine checks and maintenance. In NSW, large basins may be prescribed by the Dam Safety Committee (DSC) which means that the DSC will maintain a continuing oversight of their safety. This is particularly applicable to basins identified as threatening communities downstream in case of failure. It is not believed any of the existing basins in the Medowie area are prescribed.

Option K – Further Improvements to the Basin at 1 and 3A Evans Road

The current capacity of the basin located on land at 1 Evans Road (Photograph 16) is approximately 5,400 m^3. The upstream catchment of approximately 47 ha, has a runoff volume in the order of 69,000 m^3 in the 72 hour 1% AEP event. Council own the land at 3A Evans Road which could potentially be used for increasing the size of the basin.

Photograph 16: Detention Basin at Evans Road

WMAwater previously assessed the impacts of extending the basin into the land at 3A Evans Road to increase the volume by nearly three times to 14,200 m^3 and concluded there would be little benefit in these works in the 1% AEP flood event (Reference 23), in terms of reducing peak flood levels and property flood affectation. The assessment used the hydraulic model to increase the basin volume by lowering land on 3A Evans Road to 12.3 mAHD. The embankment levee was raised to 14.5 mAHD from 13.5 mAHD. Resultant peak flood level impacts for the 1% AEP event are shown in Figure E 17. The same basin design was run for the 0.2 EY design event. The reduction in peak flood levels propagates downstream as far as Yulong Park (Figure E 16) however the maximum reduction is 0.02 m and therefore not considered to be cost-beneficial given the likely high costs of basin improvement works.

The Medowie Strategy may include further investigation for minor works at the Evans Road Retarding Basin around inlet improvements and minor earth works.

Option J – Retarding Basin at Area Bounded by Kirrang Drive and Kula Road

The area to the west of Kirrang Drive, to the rear of properties and on the west bank of the Campvale Drain, is currently designated E2 Environmental Conservation land use in the Port Stephens LEP 2013. West of this, land on the higher ground is designated R5 Residential (Figure 2). Part of this area is noted in the Medowie Strategy 2013 (Reference 14) as having potential for providing a stormwater attenuation feature.

The current storage capacity in this area is approximately 5,900 m^3 at 7.8 mAHD. A catchment of approximately 470 ha drains to the area with a runoff volume of some 700,000 m^3 in the 1% AEP event. Option J assessed increasing the storage in the area to approximately 452,900 m^3 at a level of 7.8 mAHD to attenuate flows in the 1% AEP event. To create a basin with this volume it would be necessary to remove some 447,000 m^3 of earth over a surface area of 26 ha which would result in a large wetland lake feature. The option was run for the full range of design events, and peak flood level impacts for the 0.2 EY and 1% AEP event are presented as Figure E 18 and Figure E 19.

For all design events, except for the PMF, peak flood levels are reduced as far as the pinch. In the 0.2 EY event, peak flood levels in the Campvale Drain at the rear of properties on Kirrang Drive and Kula Road are reduced by around 0.4 m. South of Ferodale Road peak flood levels reduce by up to 0.18 m but no dwellings benefit. In the 1% AEP event, the benefits are less, with reduction in peak flood levels of 0.26 m at Kirrang Drive and Kula Road and of only up to 0.04 m downstream of Ferodale Road.

The flood damages assessment shows that the option would reduce potential AAD by $ 1,300 (Table 7.7). There is no change to the number of dwellings affected by above floor flooding. Two dwellings benefit most from the option. One dwelling on Kula Road, previously first flooded below floor level in the 2% AEP design event is now not flooded until the 1% AEP event and one dwelling on Wilga Road first flooded below floor level in the 0.2 EY event is now not flooded until the 2% AEP design event.

Table 7.7: Option J – Change in Flood Damages

Design Event	Change in No. of Dwellings Flooded Below Floor Level	Change in No. of Dwellings Flooded Above Floor Level	Reduction in Total Event Damages
0.5 EY	0	0	-$ 800
0.2 EY	-1	0	-$ 2,500
10% AEP	-2	0	-$ 4,600
5% AEP	-1	0	-$ 7,000
2% AEP	-1	0	-$ 11,800
1% AEP	0	0	-$ 14,800
0.5% AEP	-1	0	-$ 20,300
PMF	0	0	-$ 69,500
		Reduction in AAD	***-$ 2,100***

Assuming a cost of only $ 20 per cubic metre of fill to be removed, and not taking into account any other costs, the works would come in at a cost of nearly $ 9 million. This is a high cost for a flood mitigation option which benefits few properties. In addition, there could be issues with relocating the waste material, acid sulphate soils and ecological concerns with works over such a large area. Assuming a life-time of 50-years, the B/C ratio of this option would be less than 0.1. This exceptionally low B/C ratio suggests that even a smaller basin in the area, where costs may be achievable, would have little to no benefit in terms of reducing flood damages for Medowie.

A basin of such scale would potentially have greater environmental benefit in terms of water quality by allowing for settlement of particulates thus possibly reducing HWC's desire for extended inundation times in the CDIA, or by creating an environmental area for wildlife and vegetation species.

Option H – Increase Storage in CDIA

HWC have expressed an interest in additional storage in the CDIA albeit mainly in regard to water quality benefits which is outside the scope of the current assessment. With respect to flooding, a simple volumetric assessment shows that to reduce peak flood levels in the CDIA by 0.2 m, over 1 million cubic metres of material would need to be removed from the swamp. Significant issues with this are that costs are likely to be in excess of $20 million, the presence of acid sulphate soils in the CDIA, a location needed for placing removed material and the additional detention times (due to enhanced volume stored) being against the desires of the land holders in the CDIA to reduce the period of inundation on their land. The B/C ratio of such a measure would be low and the option would not be economically feasible under the program. Nevertheless other benefits (e.g. water quality) may be such that a differently focused study may find greater support for it.

HWC could consider this option for water quality benefits outside the scope of this FRMS&P, however, any increased attenuation option which reduces the amenity of private land holders within the CDIA is discouraged. Furthermore, HWC's Licences and Approvals (Reference 9) require them to maintain and operate the Campvale WPS to minimise local flooding.

SUMMARY

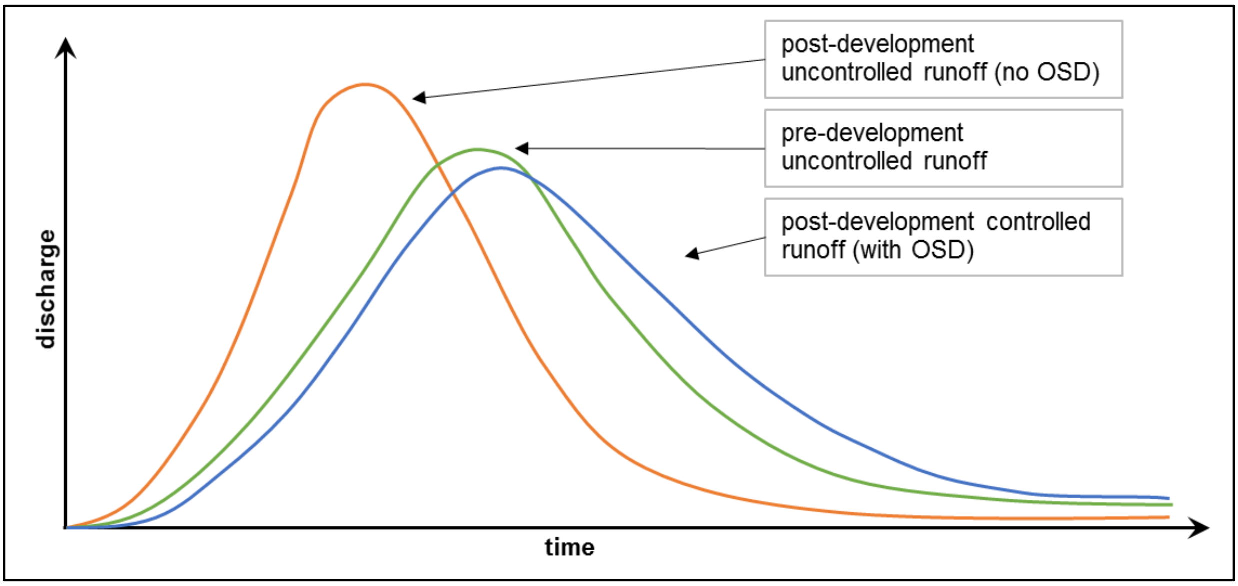
Several basins already exist in the catchment as flood management measures. Increasing capacity of these was shown not to provide a sufficient benefit to warrant the likely costs and therefore have not been considered further.

The use of retention basins in the upper catchment could however have water quality benefits that may reduce HWC's desire to maximise the detention time of water in the CDIA. This issue requires consideration by HWC and, if it was to be investigated further, the effect on flooding of any proposed feature would also need detailed consideration.

7.3.5 On-Site Detention (OSD)

On-site detention (OSD) restricts runoff from development and can be used to ensure that the rates of flow discharged from a site do not exceed the rates pre-development, thus preventing increases in peak flows downstream. OSD releases the attenuated runoff at a controlled rate over a longer period of time (see Diagram 7). Council require OSD for some new developments and set out minimum requirements in their Draft DCP (see section 6.2.2.2)

Diagram 7: Effect of Development and Use of OSD on Site Hydrograph



Runoff does not necessarily need to be attenuated in a basin. On a small scale, storage areas can include flooding above ground to shallow depths such as in parking areas or garden features. Storage can also be provided in underground systems which can reduce above ground nuisance flooding to land owners. On a larger scale, basins are often used for communal provision of OSD.

OSD must be designed to ensure that peak rates are restricted for the full range of design events, not just to the 1% AEP event. OSD is often designed for the critical duration with reference to the site area and location, although in some cases Councils stipulate that OSD is required to restrict flows based on the downstream catchment critical duration. Many councils are now adopting OSD policies to require that runoff from new developments is restricted back to the pre-development (or greenfield rate) rates of discharge. Port Stephens Council currently has drainage requirements for new developments (see Section 6.2.2.2) but recognises that OSD is not appropriate to all areas.

Within the CDIA where flooding is a volume related issue, OSD is unlikely to have much benefit in reducing peak flood levels or the duration of ponding. The potential storage volume of OSD in the upper catchment is minor compared to that in the CDIA and would therefore be unlikely to have any significant measurable effects in regard to peak flood levels in this area. Furthermore the upstream areas of the catchment are more sensitive to shorter duration rainfall events while the CDIA, as a terminal basin, will be subject to greater peak flood levels in the longer duration rainfall events. Nonetheless, the use of OSD on new development could have some localised benefit in the upper catchment areas.

Maintenance of OSD is important to ensure it continues to function as intended. As OSD infrastructure tends to be on private property and falls under the responsibility of the property owner, there is a risk of lack of maintenance. In a shared or multi-dwelling development responsibility of operation, maintenance and replacement of any OSD feature would generally fall to the Body Corporate. Smaller OSD features such as those on single dwelling lots may have little benefit as they can be more difficult to maintain and can be more susceptible to blockage, or be simply forgotten about as new occupants move in. For this reason, Council may want to consider

OSD exemption for single dwelling and other small developments and encourage other drainage features such as WSUD (see Section 7.3.6) where infiltration is possible. Council should also maintain a register of all OSD features within the LGA and undertake regular inspections to ensure they maintain full function over time. This notation of OSD features on a development could be provided on S149(5) certificates to prospective owners.

In areas where OSD would provide little benefit, as an alternative Council could use Section 94 contributions from the developer to assist with improvements and maintenance of the Campvale Drain and other drainage infrastructure (see Section 7.4.12). Essentially all new development could increase runoff volume unless OSD is implemented, and all increased volume, even though it may be minor, would cumulatively affect the CDIA. Therefore, developer contributions in the form of Section 94 agreements could be used for improvements in this downstream area.

ASSESSMENT

Uncontrolled development within Medowie could lead to increases in peak flood levels (see Section 5.4). An assessment was undertaken to consider the benefits should OSD be implemented when new development occurs. As previously discussed, the benefits of OSD would be most pronounced in the upper catchment during shorter duration events. Therefore the two hour duration was assessed which was found to be critical for much of the upper catchment area.

For the future development scenario, the effect of OSD was simulated by altering the losses in the hydrologic model to take account of the storage provided by OSD. Resultant hydrographs were run through the TUFLOW model to assess the impact on peak flood levels and the results compared with the existing scenario to show the effect of future development with OSD. Peak flood level impacts for the 1% AEP event are presented in Figure 6. There are increases in peak flood levels as a result of the intensified development, which could be negated by the implementation of OSD for future development. There are benefits of OSD in areas of the catchment subject to a lower critical duration where volume is not the main driver for peak flood levels and therefore, use of OSD in the upper catchment could reduce the impact future development has on increasing flood risk within this area.

SUMMARY

Where it is appropriate, providing OSD on new developments should be encouraged and can have prevent exacerbation of urban flooding in the future. However, a pragmatic approach should be taken as OSD is not applicable to all sites and alternative drainage solutions may provide greater benefits. To aid development Council should provide advice on appropriate OSD and the long term maintenance requirements.

Council can make requirements for OSD through their DCP. Small developments such as single dwelling houses are unlikely to have a significant effect in increasing runoff and therefore requirements of OSD should be at Council's discretion based on the type and scale of new development. No areas of the catchment are specifically designated as an area requiring OSD, however OSD is not necessary for those areas within the CDIA or draining directly to it or those areas within the 1% AEP flood extent.

Where OSD is not implemented, or would be of little benefit, Council may wish to require developer contributions through Section 94 of the *Environmental Planning & Assessment Act 1979* as a contribution to drainage works and/or maintenance (for Campvale catchment only).

Council should develop a register of all OSD features within the LGA and undertake regular inspections. Council should also consider noting the existence of OSD features on S149(5) certificates.

7.3.6 Catchment Treatment and Water Sensitive Urban Design (WSUD)

While OSD decreases the peak flow rates from a site it does not reduce the total volume. The use of WSUD, which allows for infiltration and transpiration techniques can reduce the total volume of runoff in areas where soils have a high degree of permeability. These measures are most effective in relatively small, more frequent events although large features can be designed to allow infiltration over a wider area. In some instances, for small scale development, WSUD features have been shown to have been better at reducing peak runoff rates than OSD where infiltration is possible.

In terms of reduction in flood levels, the effects of small scale catchment treatment and WSUD features are hard to quantify exactly through hydraulic modelling and depend on a range of factors such as permeability of soil, antecedent conditions, intensity of rainfall, size of the garden etc. WSUD features can have water quality benefits by allowing settlement of sediments from the runoff. Vegetated areas also act as a filter to water, removing various particulates.

In Medowie much of the catchment, particularly in the upper to mid-catchment areas, comprises clayey soils and therefore infiltration techniques are unlikely to provide significant benefit in reducing flooding. Within the lower Campvale and Moffats catchments, WSUD features would have little benefit in terms of reduction in flood levels as the features are simply too small to have any effect of the volume in the downstream areas such as the CDIA. As such, WSUD features would provide little benefit in flood reduction. Nonetheless, these features can have small local benefits in normal heavy rainfall events, and therefore should not be discouraged.

SUMMARY

The use of WSUD in Medowie is unlikely to have wide scale benefits in reduction in peak flood levels and is unlikely to improve drainage times in the CDIA. As a general concept, catchment treatment techniques and WSUD should not be discouraged as they can provide local flood benefits as well as improvements for water quality. However, it is not recommended that Council enforce requirements for WSUD as a measure to reduce flooding.

7.3.7 Levees

Levees are raised embankments situated between the watercourse and flood affected areas, which prevent the ingress of floodwater up to a defined design height. Levees usually take the form of earth embankments but can also be constructed concrete walls where there is limited space or other constraints (Photograph 17). A drainage system is often required to prevent the build-up of local runoff on the protected side of the levee. Pumps are sometimes associated with levee designs. They are installed to remove local runoff behind levees if there is no drainage system in place or in the event of backwatering.

Photograph 17: Example of Levees a) Earth Embankment b) Concrete Wall

Localised levees or bunding can be applied around individual properties. This are considered to be "minor" property adjustments and are discussed in Section 7.4.4.

DISCUSSION

The design height of the levee is the event to which it prevents flooding with a freeboard added (typically 0.5 m to 1 m dependent on the hydraulic conditions in the area) to allow for settlement of the structure over time or variations in flood levels. Unless the levee system is constructed to above the PMF level it will be overtopped. Overtopping of the levee does not constitute levee failure as the flood event may be greater than that to which the levee was designed. Structural failure of the levee may also occur during a flood event prior to overtopping although it is most likely to occur as the levee design height is exceeded. In this scenario the flood damages incurred would be exacerbated. For this reason, levees should only be used to protect existing dwellings and should not be used to facilitate further development on the floodplain.

Although levees can be expensive to construct, and in some cases require land acquisition, maintenance costs are generally low. Nonetheless, the levee system needs to be inspected on a regular basis for erosion or potential failure. The annual cost of inspections are generally small however this amount can vary considerably depending upon the complexity and size of the structure.

Constructing a levee can cause additional flooding behind the levee due to local runoff within the protected area being unable to drain. However, appropriate drainage design can alleviate this issue. In addition, as the levee causes a displacement of water from one area of the floodplain to another they should be carefully designed using hydraulic modelling techniques so as to ensure the construction does not increase flood risk to an adjacent area.

Maintenance of Existing Levees

Within the Medowie catchment levees already exist at:

- Ballat Close (Photograph 18);
- Kirrang Drive (Photograph 19); and
- County Close (Photograph 9).

Photograph 18: Levee and Drainage at Ballat Close

Photograph 19: Levee at Kirrang Drive a) side near local drain b) at rear of properties, local drainage outfalls to Campvale Drain

These current levees will need on-going maintenance and checks to ensure they continue to function as designed. It is understood that there have been some drainage issues at the Kirrang Drive levee and Council is in the process of rectifying this. Regular maintenance of the existing levees and associated drainage infrastructure should be included as a recommendation in the final adopted FRMP.

Option L – Levee at Lower End of Abundance Road

Properties at the lower end of Abundance Road are subject to frequent inundation by small floods which affects access to dwellings. Damages occur in this area for events as small as the 0.2 EY, however no dwellings are flooded above habitable floor level. Option L assumed a levee around the dwellings at the lower end of Abundance Road to provide protection up to and including the 0.5% AEP event peak flood level.

The option was run for the full range of design events. Impacts on peak flood levels for the 0.2 EY event and 1% AEP event are presented as Figure E 20 and Figure E 21, and the changes in damages from the existing scenario presented in Table 7.8.

The levee does not reduce the number of dwellings affected by over floor flooding but does reduce the property land area that is inundated, and provides safer access to some dwellings. Most benefit in terms of flood affectation occurs in the 0.5% AEP event where five dwellings are no longer flooded below floor level. Areas protected by the levee do not become inundated until events greater than the 0.5% AEP design event which result in overtopping, although there may be shallow depth flooding occurring due to local drainage behind the levee in events when the levee is not overtopped. As a result of the levee displacing flood waters in a flood storage area, peak flood levels are increased elsewhere in the CDIA. Generally increases in peak flood levels in the CDIA are no more than 0.02 m although are slightly higher at the upstream point on the levee. Two dwellings are impacted by increased flood levels in the 1% AEP and 0.5% AEP events, although increases in flood levels are no more than 0.02 m compared to existing flood depths of over 0.1 m and flooding at the dwellings is not above floor.

Table 7.8: Option L – Change in Flood Damages

Design Event	Change in No. of Dwellings Flooded Below Floor	Change in No. of Dwellings Flooded Above Floor Level	Reduction in Total Event Damages
0.5 EY	-1	0	-$ 1,900
0.2 EY	-1	0	-$ 3,000
10% AEP	-2	0	-$ 4,400
5% AEP	-2	0	-$ 7,700
2% AEP	-2	0	-$ 11,300
1% AEP	-4	0	-$ 27,900
0.5% AEP	-5	0	-$ 42,200
PMF	0	0	$ 9,500
		Reduction in AAD	***-$ 2,700***

The levee option reduces AAD by $ 2,700 (Table 7.8). At a cost of $ 50 per cubic meter of fill (inclusive of design and construction), the total cost of the works would exceed $ 420,000 assuming a levee with an average height above ground of 1 m, 1 in 4 batters and a 2 m width crest. Over a life-time of 50-years this would give a B/C ratio of 0.1. This B/C ratio is low and is not considered economically feasible.

A levee may also split land within property lots which would have implications for residents ‘use of their property. However, providing a levee at the property boundaries adjacent to the drain is likely to cause increases in peak flood levels elsewhere that would make the alignment unfeasible.

Local runoff within the leveed area would still need to be drained to the CDIA through the levee; in particular the drain from Lisadell Road towards the Campvale Drain. Use of flap-gates on drainage pipes, similar to those used at the existing Kirrang Drive levee, would prevent backing up of floodwater into the leveed area but would mean that local drainage is prevented from leaving the area during a design flood event when water levels in the CDIA are higher. Local drainage is still likely to cause some ponding on the leveed land flooding could not be entirely eliminated from the area. For these reasons, this option has not been considered further.

Option M – Levee at Kirrang Drive and Kula Road

Option M considered levee protection of properties on Kula Road and Kirrang Drive. Although there are shown to be benefits to properties in the 0.2 EY event, in larger events such as the 1% AEP event, the option actually significantly exacerbates flooding of the dwellings on Kula Road as peak flood levels are increased by over 0.25 m due to flood waters becoming trapped behind the levee (Figure E 22). Therefore this option was not considered further.

SUMMARY

With the study area large scale levees are unlikely to mitigate the full impact of flooding. Existing levees function within the catchment to protect dwellings at County Close and Kirrang Drive. However, locations for additional levees are limited.

It is recommended that regular maintenance of existing levee structures is ensured through Council Policy.

7.3.8 Temporary Flood Barriers

Temporary flood barriers include demountable defences, wall systems and sandbagging which are deployed before the onset of flooding.

Demountable defences can be used to protect large areas and are often used as a means to assist mitigation measures rather than as sole protection. For example they are best used to fill in gaps or raising levees as the risk of overtopping develops. The effectiveness of these measures relies on sufficient warning time and the ability of a workforce to install. They are more likely to be used for mainstream fluvial flooding from rivers which have sufficient warning time and are not a suitable technique for overland flooding.

Large temporary barriers would not be an effective solution for Medowie due to the lack of flood warning available. The use of temporary measures in protecting individual dwellings, such as sandbagging, is discussed in Section 7.4.3.

7.3.9 Diversion of Flows and Improvements to Catchment Outlets

As the CDIA is a terminal basin, diverting flows from the upper catchment before they reach the basin or from the CDIA, could reduce peak flood levels and inundation time during design flood events. Schemes would have to involve cross catchment transfers and would require extensive engineering works to be effective.

Option D – Diversion of Upper Catchment Flows

The assessment of this option was requested by Council. It diverts flows from the upper Campvale catchment which covers an area of approximately 150 ha, approximately 7% of the total Campvale catchment. The model simulated the diversion by removing inflows from this area directly to Grahamstown Reservoir.

Peak flood levels are reduced by no more than 0.08 m in the CDIA in the 0.2 EY event (Figure E 23) and by up to 0.1 m in the 1% AEP event (Figure E 24), with no reduction in properties flooded in either event. Therefore the reduction in AAD is minimal. In order to undertake such a scheme, costs are likely to be substantial - in the order of several millions of dollars - for very little flood risk benefit. The B/C ratio would be extremely low. Furthermore, HWC have commented that they would prefer flows not to be directed directly to the Grahamstown Reservoir due to concerns with water quality. This option was not considered further.

Option E, F and U – Diversion of Flows from the CDIA

These options were raised by the FMC including HWC to be considered in the FRMS&P. The model assessed three options:

- Option E – Diversion from the pinch location to Fullerton Cove;
- Option F – Diversion from CDIA under Richardson Road; and
- Option U – Diversion of flows to Windeyers Creek.

Option E assumed the installation of two 2 m by 1 m box culverts from the pinch to Fullerton Cove, approximately 6.6 km long. Option F assumed a diversion beneath Richardson Road, again to Fullerton Cove. Option U would involve a pipe some 7 km long to Windeyers Creek.

All options had minimal benefits in terms of reduction in peak levels during design flood events with peak levels being reduced by a maximum of 0.15 m. Few properties benefited and there are no reductions in flood affection - hence there would be negligible improvement in AAD. Each option would require a major engineering scheme likely to cost millions and possibly have significant ecological concerns. Pumping would likely be required due to the relatively gentle gradient between the CDIA and diversion outfalls making a gravity connection difficult. Other issues would involve land ownership and tidal levels in Fullerton Cove, which could affect the outflows from the diversion scheme. Windeyers Creek also has its own flooding issues which would potentially be worsened by cross catchment flows from the Campvale catchment.

It is therefore considered that any diversion of flows from the CDIA or Campvale catchment, would not be economically feasible.

Option O – Improvement to Moffats Swamp Outlets

Improvements to the outlets at Moffats swamp were investigated to assess if this would provide any benefit to properties on the periphery of the swamp. Unlike the CDIA, the Moffats swamp is not a terminal basin and drains freely at two outlets at Salt Ash and Swan Bay. Option O lowered the outlet at Swan Bay by 0.2 m as well as increased the number of pipes at Salt Ash from 3 to 5 while lowering the invert of the existing culverts by 0.5 m.

Peak flood level impacts are shown in Figure E 25 and Figure E 26 for the 0.2 EY and 1% AEP design events with levels reduced by up to 0.04 m and up to 0.15 m respectively. In the 1% AEP event, peak flood levels in the Campvale catchment are also shown to be reduced slightly as less flow spills into the catchment due to the reduced levels in Moffats Swamp. Despite a reduction in peak flood levels, no dwellings benefit and therefore there would be no reduction in AAD from the existing situation. As such there is no economic justification for the works.

SUMMARY

Diversion of flows from the Campvale catchment, either from the upstream catchment or from the CDIA, would have minimal benefits in terms of flooding while the high costs and other issues involved in such a major scheme would make this an uneconomic and unfeasible option. These options are not considered further.

7.4 Property Modification Measures

Property modification measures refer to changes to existing development and/or development controls on property and community infrastructure for future development. Flood modification measures which apply at the individual property scale have also been included in this section.

New performance requirements for buildings in flood hazard areas were introduced in the National Construction Code (NCC) in 2013 with The Australian Building Codes Board (ABCB)'s 'Construction of Buildings in Flood Hazard Areas' and the accompanying Handbook (Reference 24 and Reference 25). This Standard contains requirements to ensure new buildings and structures located in flood hazard areas do not collapse during a flood when subjected to flood actions and includes consideration of appropriate construction, use of appropriate materials, electrical, plumbing and drainage installation as well as setting floor levels. It applies to residential buildings (Classes 1, 2, 3 and 4) and health care buildings (Classes 9a and 9c). The Standard is not intended to override any land use planning controls imposed by Council or the appropriate authority.

7.4.1 House Raising

House raising has been used throughout NSW to eliminate or significantly reduce flooding of habitable floors particularly in lower hazard areas of the floodplain. However it has limited application as it is not suitable for all building types being more suitable for non-brick single storey buildings. House raising is unlikely to be approved in high hazard areas.

The benefit of house raising is that it eliminates above floor flooding and consequently reduces flood damages. House raising also provides a safe refuge during a flood, assuming that the building is suitably designed for the water and debris loading. However the potential risk to life is still present if residents choose to enter floodwaters or are unable to leave the house during a medical emergency, or when larger floods than the design flood occur.

House raising is not suitable for brick buildings due to the structural difficulties and higher costs. Based on data from the floor level survey, some 80% dwellings in the study area are brick and therefore house raising is unlikely. Furthermore peak flood depths at houses are generally fairly low and over floor flooding is minimal, even in the larger design events. Other simple property modification measures are likely to be a cost effective option.

For new development, floor level requirements and other development controls will negate the need for future raising of properties.

SUMMARY

No houses in Medowie have been identified for raising, and this option has not been considered further.

7.4.2 Voluntary Purchase

Voluntary purchase involves the acquisition of flood affected properties, in particular those subject to high hazard flows and/or within defined floodways. Once purchased, the residence is demolished to remove it from the floodplain.

Voluntary purchase is an effective strategy where it is impractical or uneconomic to mitigate high flood hazard to an existing dwelling. It is often a measure that is used as part of a wider management strategy rather than on its own. Government funding for voluntary purchase schemes can be made available through the Floodplain Management Program as long as a number of complying criteria are met. Voluntary purchase areas are not classified under any specific land use in the Standard Instrument LEP. However, Council can consider creating Voluntary Purchase Zones through their DCP or requiring that voluntary purchase zones apply to all flood prone areas also identified as being high hazard floodway.

Several dwellings in Medowie have been identified as being within the floodway and/or a high hazard area and a number are subject to flooding above floor in events smaller than the 1% AEP event. Although measures such as flood proofing or raising could reduce flood damages for these dwellings during smaller events (if suitable for such works), the high flood hazard means that conditions are unsafe for people and they would still need to be evacuated before the onset of flooding (where possible). Voluntary purchase would allow the areas to be given over to public open space and more importantly, would be the only way of reducing flood risk and hazard for those residents by encouraging them to move to a less flood hazardous area.

Details on the residences that are potentially eligible for voluntary purchase are presented in Appendix G and following assessment, one property was identified for voluntary purchase[3]. This property would not benefit significantly from other schemes, and generally any localised measures to protect the individual property may have significant impacts elsewhere.

All buildings on the purchased property should be demolished and the land rezoned anf appropriate use such as E2 Environmental Conservation or similar in the LEP so that no development may take place. The land can also be defined as floodway in Council's DCP. As part of this study, a series of floodways through the Campvale and Medowie catchments have been defined which can be incorporated into Council's DCP (see Section 4.3 and 7.4.11).

The total AAD of the single property identified as having potential for voluntary purchase makes up for nearly 26% of the total AAD for Medowie. The average AAD per flood affected dwelling in Medowie is around $ 1,700, compared to $ 84,200 for the house identified for voluntary purchase. A damage assessment was undertaken to determine the B/C ratio assuming voluntary purchase of the identified property. Assuming an estimated cost of $550,000 for voluntary purchase of the property (similar to the median price for Medowie from domain.com.au plus an additional allowance for purchase fees, legal costs, demos and other costs to Council), the B/C ratio would be 2.76 over a 50 year timespan. This is a high B/C ratio, showing that voluntary purchase is an economically feasible solution for this property. Further details are given in Appendix G.

The B/C ratio does not include intangible damages to people such as loss of life and stress as a result of floods. Neither does it account for the increased risk to emergency services. These

[3] Specific details of property not given here for privacy reasons.

intangible damages would also be significantly reduced with removal of the property and could be considered to improve the B/C ratio even further.

SUMMARY

One property has been identified for potential voluntary purchase. The dwelling on this property is located in a natural floodway and is subject to high hazard flooding and frequent flooding above habitable floor level to significant depths. Other measures to provide flood relief to the property have been tested but proved unsuccessful and therefore voluntary purchase would be the only option for removing the residents of the dwelling from a high flood risk situation. It is therefore recommended that Council undertake a voluntary purchase feasibility study including further investigation and consultation with property owners into voluntary purchase.

7.4.3 Flood Proofing

Flood proofing is divided into two categories; wet proofing and dry proofing. Wet proofing assumes that water will enter a building and aims to minimise damages and/or reduce recovery times by choosing materials which are resistant to flood water and facilitate draining and ventilation after flooding. Fitting non-return valves on plumbing can be useful to prevent back up of sewerage systems and suitable installation of electrical services should prevent service ducts from being inundated and reduce risk of electrocution. Dry proofing aims to totally exclude flood waters from entering a building and is best incorporated into a structure at the construction phase as retrofitting permanent flood proofing measures can be difficult and expensive.

As an alternative to retrofitting permanent flood proofing measures to existing buildings, temporary flood barriers can also be achieved by the use of sandbags in conjunction with plastic sheeting or private flood barriers which fit over doors, windows and vents and are deployed by the occupant before the onset of flooding. During flood events, sandbagging in bathrooms and toilets is beneficial, as although water may be prevented from entering the dwelling through doors and windows, backing up through the plumbing could still occur. Temporary flood proofing can be utilised during flooding although it relies on someone to implement and therefore effective flood warning times and the time of flooding can affect their efficiency. There is little warning time in Medowie (see Section 6.5), and although the use of temporary measures should not be discouraged, they should not be relied on as a solution to flood problems at individual properties.

Whilst it is a requirement of the Floodplain Development Manual (Reference 1) that new residential dwellings have their floor levels above the 1% AEP event plus a freeboard, commercial buildings are not subject to such requirements unless stipulated by Councils. Port Stephens Council requires that all new development in flood prone areas have floor levels at the 1% AEP flood level plus a 0.5 m freeboard regardless of type of development. In exceptional circumstances and subject to a merits based assessment, Council may allow commercial and industrial floor levels to be below the FPL. It is recommended however, that should floor levels be below the FPL, they are not below the 1% AEP flood level at that location and flood proofing of the building and any critical services or infrastructure associated with it is included in the design. Requirements for flood proofing when constructed would include consideration of suitable materials, electrical and other services installation and efficient sealing of any possible entrances for water. Council would implement these requirements through the DCP and planning controls. It is recommended that planning controls allow some flexibility for either dry or wet flood proofing to be used depending on which is most appropriate for the development use, and the risk the owner is willing to take on, and for temporary flood gate options to also be included in building design for low risk non-habitable development.

SUMMARY

Flood proofing is a good solution to reducing flood risk to commercial and industrial properties and should be encouraged for all new development of this type, particularly in the exceptional circumstances where floor levels have been approved that are lower than the FPL. Consideration of appropriate construction materials is still needed for those residential developments where floor levels will be raised above the 1% AEP flood level as the structure can still become inundated below the floor level.

Temporary flood proofing techniques may be deployed although lack of warning time may limit their effectiveness and they should be considered as a secondary option to more permanent measures being implemented.

7.4.4 Minor Property Adjustments

In overland flow areas minor property adjustments can be made to manage flow passing through private property. Such adjustments can include low level bunding (small levees) around individual properties, amendments to fences or construction of fences which act as deflector levees, modifying gardens and ground levels etc,. all of which can affect the local continuity of overland flow paths.

Property adjustments can be used to manage overland flows through private property and minimise impacts on dwellings by helping to divert local overland flows away from dwellings and access points. However, if not designed well, adjustments on one property may have consequential effects on adjoining properties, or require modifications on neighbouring properties to be effective. Therefore any works in flood prone areas which could modify the localised flood behaviour should be shown to have no significant impact on adjoining properties and be subject to approval from Council.

For some isolated properties, bunding of the property may have some benefits allowing the property to remain dry for longer protecting, land as well as the dwelling in smaller design events. The Flood Study (Reference 2) identified the western side of Kirrang Drive as an area where this measure may be beneficial and Council subsequently constructed a levee here.

Four dwellings have been identified as suffering from above floor flooding (in the 1% AEP event) and a fifth regularly has access between the road and the dwelling cut by flooding. For these properties minor property adjustments are recommended to alleviate over floor flooding and to provide safe access and egress to dwellings during flooding. Full details on the measures assessed for each property are provided in Appendix G (not for public distribution). This information has been made available to Council and the individual residents.

SUMMARY
Minor property adjustments can have localised benefits however they should be assessed for their impact on neighbouring properties. For properties within the floodway or subject to above floor flooding, minor property adjustments may not always be sufficient and other management measures may need consideration.

7.4.5 Filling in the Floodplain

Filling in the floodplain can be used to raise areas of land to allow for future flood safe development. However, filling can also reduce floodplain volume and cause increases in peak flood water levels elsewhere. Although the effect of a single dwelling development may be negligible, the cumulative effects over time could increase risk to other residents within the floodplain area.

An assessment showed that uncontrolled filling in the floodplain could increase peak flood levels in the CDIA significantly (see Section 5.4.1) and therefore it is not considered an appropriate flood management measure. Rather it would be more appropriate for Council to limit filling in the floodplain by imposing cut/fill balance requirement, i.e. any filling in the flood plain must be balanced by local cut (also from within the floodplain) so as to not reduce the total storage capacity in the CDIA. For the Campvale catchment, assessment identified that a level of 7.7 mAHD could be an appropriate limiting level for filling for areas south of Ferodale Road. Although there were still increases in peak flood levels these were not major (see Section 5.4.1). For Moffats Swamp, most development at this level is already limited by land use zoning (Figure 2). To control filling in the floodplain Council can use their DCP and/or Flood Policy.

SUMMARY
Filling in the floodplain can increase peak flood levels causing increased flood risk to others and therefore should be limited. Council can do this through development controls and Flood Policy which should include restrictions on filling in the floodplain, namely, ensuring all filling in areas lower than 7.7 mAHD south of Ferodale Road in the Campvale Drain catchment are balanced by local cut so as to maintain the storage capacity of the CDIA.

7.4.6 Drainage Easements

Drainage easements are set distances, usually measured from the centreline of a watercourse, drainage channel or pipe, within which development is restricted. Easements can also be applied where overland flow paths have been identified. For above ground structures drainage easements provide an area for water to spill when the capacity of the channel may be exceeded without immediately affecting properties. Easements also ensure that pipes and channels can be accessed for maintenance.

There can be some social issues related with introducing easements. People can feel that their land is no longer developable and believe this can reduce property values. In reality although no obstructions are allowed in easements, the easements are still allowed to be used as open space areas and can be retained under the ownership of the resident. It can be difficult for Council to enforce easement controls particularly on existing properties. Council could consider purchasing the land within the easement area however, there can be high costs involved with this and in addition, if the easement separates a property into two it is unlikely that the property owners would be co-operative. Community consultation will be key in establishing easements and controls.

Council previously identified that the Campvale Drain runs through 36 properties and are in the process of obtaining easements. A total of 24 easements have reportedly been acquired through discussions with land owners to date. It is intended that once the final easements have been obtained Council will be able to access the drain more regularly for clearing and maintenance. Any means to accelerate the program of acquiring easements to the Campvale Drain should be encouraged.

Drainage easements should be attached to property deeds and details could be included in the S149 certificates (see Section 7.4.13).

7.4.7 Protecting Key Infrastructure

It is important to protect key infrastructure from flooding which could cause failure of systems such as electricity, telecommunication or sewerage supply. Protection can be by relocation to areas outside of the PMF flood extents, or where this is not possible, ensuring that operation will not be affected by flooding by minor property modifications or flood proofing.

The sewerage pumping station at 36b Ferodale Road (Photograph 6) was identified as being flooded above sump level in the 10% AEP design flood event although it is not expected to be flooded above floor level in events smaller than the 1% AEP event (see Section 5.2.1). Flood waters entering the sump could cause contamination of floodwaters and spillage or surcharging of sewerage from the pipe system. HWC, as owners of the pumping station, are responsible for taking appropriate measures to ensure that this does not happen.

SUMMARY

It is recommended that the flood affectation of the sewer pumping station at Ferodale Road is investigated further to ensure than flooding does not cause failure of the pump or contamination of flood waters. If necessary measures such as flood proofing or bunding of the building should be undertaken to prevent failure.

7.4.8 Flood Planning Area

The LEP Standard Instrument for NSW does not include a specific land use zone classification for flood prone land, rather permits a Flood Planning Area (FPA) map to be included as a layer imposed across all land zones.

FPA is used to define an area to which flood related development and planning controls area applied and Councils are required to include a FPA map in their LEP. Like the FPL (see Section 7.4.9), it is usually taken as the 1% AEP flood level plus 0.5 m. Therefore planning controls may be applied to development which is not necessarily within the 1% AEP flood extent but is within in the FPA. It is important to base the FPA on suitable criteria appropriate to the nature of flooding so as not to over or understate the need to control development impacted by floods in some areas.

The purpose of adding a freeboard and extending the FPA past the 1% AEP flood extents is to allow for any future increases in flood extents due to climate change as well as an allowance for differences between flood behaviour during events and local small scale behaviour which cannot be replicated in hydraulic modelling. The recommended FPA, the 1% AEP plus 0.5 m level, is shown in Figure 4. The 1% AEP and PMF flood extents have been also presented for reference.

Council already have a FPA map in their LEP (see Section 6.2.1). This FRMS&P has updated the hydraulic modelling for the Medowie area and it is therefore recommended that the updated FPA should be included in the LEP.

SUMMARY

Defining the FPA is crucial as it is a key concept referred to in Council's LEP and will ensure that flood related development controls only apply to the relevant areas of Medowie. This should be based on the 1% AEP event peak flood level plus 0.5 m and the floodplain extended to reflect this as per the Floodplain Development Manual (Reference 1).

7.4.9 Flood Planning Levels

Flood Planning Levels (FPLs) are an important tool in floodplain risk management. Appendix K of the Floodplain Development Manual, 2005 (Reference 1) provides a comprehensive guide to the purpose and determination of FPLs. The FPL provides a development control measure for managing future flood risk and is derived from a combination of a flood event and a freeboard. It defines the minimum level at which habitable floor levels should be constructed.

The Construction of Buildings in Flood Hazard Areas Standard (Reference 24) states that, unless otherwise specified by the appropriate authority (e.g. Council), the finished floor level of all habitable rooms must be above the Flood Hazard Level[4] and the finished floor level of enclosed non-habitable rooms must be no more than 1 m below the Defined Flood Level[5].

The Floodplain Development Manual (Reference 1) states that in general the FPL for a standard residential development would be the 1% AEP event plus a freeboard, typically 0.5 m. According to the Floodplain Development Manual (Reference 1) the purpose of the freeboard is to provide reasonable certainty that the reduced flood risk exposure provided by selection of a particular flood as the basis of a FPL is actually provided given the following factors;

- Uncertainties in estimates of flood levels;
- Differences in water level because of local factors;
- Increases due to wave action; and
- The cumulative effect of subsequent infill development on existing zoned land.

In determining a suitable FPL, Council must balance the cost to the community by restricting development in flood prone areas with the benefits of the reduction in damage, frequency and danger to life caused by flooding. Generally Councils apply the 1% AEP event flood level plus 0.5 m freeboard criteria in determining the FPL. In areas particularly prone to future climate change

[4] The Standard defines the Flood Hazard Level (FHL) as "the flood level to be used to determine the height of floors in a building and represent the defined flood level (DFL) plus the freeboard.

[5] The DFL is defined in the Standard as "the flood level associated with the defined flood event.". Therefore the FHL is effectively the same as the FPL.

impacts, the FPL can sometimes be defined using the climate change 1% AEP flood level plus freeboard. In Medowie however, climate change will have little impact on increasing flood levels; sea levels rises are unlikely to affect Campvale or Moffats catchments, and increases in rainfall intensities have been shown to have only a minimal impact (See Section 5.5). Such increases would easily be absorbed into the 0.5 m freeboard and therefore it is not recommended that Council include climate change in their FPLs for Medowie.

Depending on the nature of the development and the level of flood risk, individual FPLs can be adopted for a local area within a greater floodplain area. In some instances, the FPL can be varied depending on the use, and the vulnerability of the building/development to flooding. For the less vulnerable commercial and industrial developments, floor levels should be required at the 1% AEP plus 0.5 m FPL but in exceptional circumstances where raising floor levels is not feasible, flood proofing a building to the FPL could be considered as an alternative. Reduced floor levels for commercial or industrial development should only be allowed at Council's discretion subject to a merits based approach assessment and should take into account proximity to major overland flow routes and floodways, flood hazard at the subject site and surrounding area, use of the site, hazardous works or supplies on site etc. Reduced floor levels below the FPL should not be allowed for residential developments or other vulnerable uses. Developments more vulnerable to flooding (hospitals, schools, electricity sub-stations, senior's housing, etc.) should consider rarer events greater than the 1% AEP when determining their FPL and are often required by Council's to consider the PMF; or even better to be situated outside of the floodplain where possible.

Council's current Draft DCP chapter on flooding (see Section 6.2.2.1), requires that floor levels for residential, commercial and industrial development are set at 0.5 m above the 1% AEP flood level, but in exceptional circumstances will allow lower levels for non-residential uses. There is no mention in the Draft DCP chapter on flooding of more vulnerable uses such as critical infrastructure, schools, nursing homes, hospitals etc. council may wish to require more stringent controls for such development such as being out of the 1% AEP extent entirely and with floor levels above the higher of the PMF flood level or FPL.

SUMMARY

The FPL of the 1% AEP flood level plus 0.5 m should be used to set finished floor levels requirements for residential development. Non-residential development considered more vulnerable to flooding should be sited outside of the FPA and PMF extent if possible, and where this is not possible, higher floor level requirements can apply at Council's discretion. Commercial and industrial development should be subject to flood levels at the FPL, however, in exceptional circumstances, and subject to a merits based approach assessment, Council may allow lower floor levels but it is recommended that any buildings or associated critical infrastructure should be subject to flood proofing to the FPL where floor levels are lower. The benefits and consequences of different criteria for setting both the FPA and FLP should be considered together as it is important both are compatible.

A FPL of 1% AEP plus 0.5 m as per Council's Draft Flood Policy is considered appropriate.

7.4.10 Land Use Planning

Appropriate zoning of flood liable land ensures development only occurs in suitable locations compatible with flood risk and hazard. As recognised in the Floodplain Development Manual (Reference 1) land use planning cannot be undertaken effectively without a good understanding of the flood risks and the associated consequences. Council's set out land use zones within their LEP.

The current land use proposal under the Medowie Strategy 2013 (Reference 14) have a tendency to increase development intensity and therefore increase runoff, particularly in the upper catchment areas where short storms cause peak flood levels. As it is understood that the Strategy is subject to change, a number of comments made herein should be taken into account when considering land use planning.

Current residential uses in Medowie mainly comprise R5 Large Lot Residential. Potential in the future to increase density of development can lead to increased flooding (see Section 5.4) although the increase in terms of peak flood levels was not shown to be major. However Council may wish to consider restriction on the density of development within the catchment.

Within flood prone areas such as the CDIA, as well as using land zoning for only low density uses, it is not advised to allow subdivision of flooded lots as this can lead to an increased population living within flood prone areas. Likewise, Council should consider ensuring that residential and other developments where people may be more at risk from flooding such as schools, hospitals and community centres are not located within floodways (see Section 4.3) or high hazard areas (see Section 4.4).

Recommendations have been made for balanced filling in the floodplain below a level of 7.7 mAHD in the Campvale catchment (see Section 7.4.5). The 7.7 mAHD contour line is in presented with the LEP land use zones in Figure 2. While most of the area below 7.7 mAHD is zoned RU2 Rural Landscape, there are some areas zones R5 Large Lot Residential. Council may wish to consider rezoning these as RU2 to restrict future development. A better use may be E1 Nature Reserves as per Moffatts Swamp, however this would have implication for what use current land holders can make of the land. DCP controls regarding filling would also assist regardless of land sue zone classification.

SUMMARY

Land use planning can be an effective measure for reducing the population at risk from flooding. Council should take into account flooding and flood hazard when considering revised land use zoning and information in the FRMS&P should be used in assisting with land use planning in any future Medowie Strategy.

7.4.11 Update Flood Related Planning Policies and Development Controls

Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

A review of Council's existing Draft DCP chapter on flooding has been undertaken (see Section 6.2). As a result of the review and the findings of this FRMS&P, a number of recommendations have been made.

Local Environmental Plan

The LEP should include the Flood Planning Area map. This map is not meant to provide precise depths of overland flow but rather will indicate areas which have been determined to be flood prone and reference that these areas are subject to the controls of the within the DCP. It is recommended the Flood Planning Area map is updated with the results of this current study.

Development Control Plan – Flooding Chapter

A review of the Draft DCP 2014 chapter on Flooding (see Section 6.2.2) shows that most relevant considerations such as floor levels are taken into account. However, a number of additional recommendation have been raised through the process of the FRMS&P. Recommended additions or minor changes to the Draft DCP chapter on flooding and on Drainage are outlined below.

Filling in the Floodplain

Any filling in the floodplain of Campvale catchment south of Ferodale Road or in Moffats Swamp below a level of 7.7 mAHD must be balanced with local cut to ensure there is no reduction in overall storage. This requirement has revised the initial condition that did not permit any filling within the floodplain.

Floor levels

Floor level requirements for residential, commercial and industrial uses are considered appropriate, but Council may wish to include for encouraging more flood sensitive development such as critical infrastructure, schools, nursing homes and hospitals outside of the FPA and/or PMF extents and to have floor levels at or above the FPL or PMF flood level, whichever is greater.

Development Control Plan – Drainage and Water Quality Chapter

Much of this is outside the scope of the FRMS&P so has not been reviewed fully. However OSD has been considered and recommendations are set out below, specific to the Medowie study area.

On-site Detention

Council has stipulated requirements for OSD in the Draft DCP Drainage and Water Quality chapter. However, the policy should recognise that OSD is not beneficial everywhere and areas with the 1% AEP flood extent or those draining directly to the CDIA could be exempt.

Other Development Controls or Policy Recommendations

Other flood related recommendation have been made which would benefit from incorporation into Council policy, either within the DCP or, as it is recognised that some recommendations will be specific only to Medowie, a separate flood policy.

Easements

For all properties subject to drainage easements, Council need to identify limitations on development in, modification to or access to defined drainage easements and protocols for maintenance.

Restrictions on Road Raising

Road raising is not recommended particularly where roads are perpendicular to flow and Council policy will need to identify this. In exceptional circumstances and subject to detailed investigation of a range of design events road raising could be allowed if necessitated for other critical development or service upgrades.

SUMMARY

Up to date planning controls are vital in managing flood risk and Council should ensure that the Draft DCP contains all relevant planning controls. The following measures are recommended;

► Include a Flood Planning Area map in the LEP,

► Minor amendments to the Draft DCP chapters to require any filling in the floodplain to be balanced by local cut, floor levels for development more sensitive to the risks of flooding, and exemptions from providing OSD.

7.4.12 Developer Contributions and Voluntary Planning Agreements

Section 94 contributions, also known as developer contributions, are contributions made under Section 94 of the Environmental Planning and Assessment Act 1979 and Part 4 of the Environmental Planning and Assessment Regulation. Section 94 enables Councils to require a contribution from developers towards to provision, extension or augmentation of public amenities and services that will, or are likely to be required as a consequence of development in the area, or that have been provided in anticipation of or to facilitate such development.

Voluntary Planning Agreements are an agreement entered into by a planning authority (Council) and a developer. They are made under Section 93F of the Environmental Planning and Assessment Act 1979. Under the agreement a developer will agree to either provide or fund public amenities and public services, affordable housing or transport and other infrastructure.

The Medowie Strategy 2013 (Reference 14) suggests that *"funding of drainage and water quality infrastructure will be via conditions of consent, developer contributions, voluntary planning agreements, council's infrastructure funding capacity and possibly grants"*. Council have a Section 94 Development Contributions Plan (Reference 26) which sets out a strategy for assessment, collection and expenditure of contributions. It provides an administrative framework for Council to obtain contributions from developers towards the provision of public amenities, services and infrastructure required as a consequence of future development and ensures an adequate level of public infrastructure is provided as development occurs. Council also have a Section 94A Contribution Plan (Reference 27) which allows Council to levy a maximum of 1% of the total cost of development for commercial, retail and other employment based development or development including mixed us, that would create demand for public amenities and services depending on the cost of the proposed development.

As the requirement for OSD (see Section 7.3.5) has been shown to provide localised flood relief but not to necessary improve the ponding situation it the CDIA, developer contributions could be updated to include for local area contributions for the Campvale and Moffats catchments to allow for maintenance and improvement of the Campvale Drain and upgrading of drainage infrastructure in the catchments. Developers providing OSD on their sites may still be asked for developer contributions. A number of measures to improve the ponding situation have been identified as part of the FRMS&P.

SUMMARY

Developer contributions are a means of ensuring that development does not have disbenefits to the local public. It is recommended that Council requires developed contributions under Section 94 for drainage maintenance and improvement to Campvale Drain.

7.4.13 Modification to the S149 Certificates

Councils issue planning certificates to potential purchasers under Section 149 of the Environmental Planning and Assessment Act of 1979, as amended. The function of these certificates is to inform purchasers of planning controls and policies that apply to the subject land. A certificate issued under Section 149(2) provides information about the zoning of the property, the relevant state, regional and local planning controls and other property affectations such as land contamination and road widening. A certificate issued under 149(5) provides additional information such as advice from other authorities, subdivision history and easements where Council has information available. While the certificate will state all the relevant planning instruments that apply to the property, it does not specify specific development standards or terms of the instruments.

Planning certificates are an important source of information for prospective purchasers on whether there are flood related development controls on the land. They need to rely upon the information under both Section 149(2) and 149(5) in order to make an informed decision about the property. Under Part 2 it is compulsory for Council to advise if they are aware of flood risk or of any other known risks such as bush fire, land slip etc., while Part 5 provides additional details and may not be made known unless it is specifically requested. The Section 149 certificate only relates to the land and not any specific building on the property.

Because of the wide range of different flood conditions across NSW, there is no standard way of conveying flood related information. As such, Councils are encouraged to determine the most appropriate way to convey information for their areas of responsibility. This will depend on the type (whether from major rivers or local overland flooding), and the extent of flooding.

The information provided under Part 2 of the certificate is determined by legislation, and although it must state if flood planning development controls apply, unless specifically included by the Council provides no indication of the extent of flood inundation or whether or not the property is actually flood prone. Under Part 5, which provides further details, there is scope for providing this additional type of information. There can be a general perception from the public that insurance companies, lending authorities or other organisations may disadvantage flood liable properties that have only a very small part of their property inundated by floodwaters. Some Councils have addressed this concern by adding information onto Part 5 to show the percentage of the property inundated as well as floor levels and other flood related information. In addition the hazard category could be provided and also advice regarding climate change increases in flood level. It is recommended that Council provide information under Part 5 where possible.

The compulsory Part (2) should include, in terms of flood risk:

- Whether or not the property is in a FPA;
- Any development control due to siting of the property in the FPA;
- Responsibility for maintenance and compliance for OSD features; and
- Highlight any drainage easements through the property and controls that apply.

Flood related information in Part (5) should include:

- Flood levels / depths at the property;
- Percentage of property flood affected;
- The likelihood of flooding;
- Floor levels (from Council's floor level survey if available); and
- Potential flood hazard.

SUMMARY

As Council information for S149 Certificates and Development Restriction Certificates is obtained mainly from computerised databases and maps, Council should investigate ways to make property-based flooding information more accessible via its web-site.

Data from the hydraulic modelling used in this FRMS&P should be incorporated into Council's Section 149 planning controls. All residents should be advised by personalised mail from Council if their land is affected. Council should determine the appropriate event for advising residents that the same criteria is used as in establishing the FPA.

7.5 Response Modification Measures

Flood response measures encompass various means of modifying the response of the population to the flood threat, and include planning for response.

7.5.1 Local Flood Plan

Good planning for emergency response can reduce losses. Emergency response for flooding is detailed in the Local Flood Plan (LFP). This is prepared and used by the SES on an LGA wide basis and local specific community information is set out in Volume 2 of the Plan. Response measures set out in the LFP are based on flood intelligence from flood studies and FRMS&P

From assessment undertaken in this FRMPS&P it is identified that there are very few dwellings which would benefit from evacuation (see Section 4.5) in a major flood. Evacuation would usually be undertaken under the direction of the lead agency under the EMPLAN, the SES. However, as there are so few flood prone dwellings in Medowie it is unlikely that the SES will call for evacuation. Nonetheless some residents may choose to leave on their own accord, particularly those who know their properties are flood liable.

The SES have a LFP for the Port Stephens LGA. However this does not include details for the Medowie community. Due to the low flood affectation in Medowie and the fact that evacuation is unlikely, it is not considered necessary to include Medowie in the LFP. Doing so would only reduce SES resources available in areas where evacuation and SES emergency response is needed. However, a number of key access routes become inundated and are potentially dangerous for any persons trying to cross them. Therefore, instead of inclusion in the LFP, it is recommended that Council maintain a record of roads which may become inundated during flooding so that suitable precautions can be put in place during a flood event and Council can manage local road closures (see Section 7.5.3).

SUMMARY

Medowie is not included in the Port Stephens LFP and furthermore it is not recommended for inclusion, as SES resources could be better used elsewhere in the LGA during flooding. Low dwelling flood affectation above floor means evacuation is unlikely to be needed. Council can make sure other provisions are in place (see Section 7.5.2).

7.5.2 Flood Warning and Evacuation

Flood warning and the implementation of evacuation procedures by the SES are widely used throughout NSW to reduce flood damages and protect lives. Severe weather warnings and flood warnings are provided by the Bureau of Meteorology (BoM) and are issued when severe weather or thunderstorms are expected. The warning may also note the hazards associated with the storm including damaging wind gusts, large hail and flash flooding. Evacuation warnings are issued by the SES and advise that people should prepare for the instance that an Evacuation Order is issued. Evacuation Orders require that all people evacuate the area and may be issued through door knock, radio, automated telephone and/or SMS and other forms of media. Once the risk has subsided an All Clear is issued.

Flood warning can significantly reduce damages and risk to life and studies have shown that flood warning systems generally have a high B/C ratio if sufficient warning time is provided.

The success of any flood warning system and the evacuation process depends on the awareness of the community to the flood threat, how prepared the community may be to react to the threat of flooding and whether the community, Council or the SES have damage minimisation strategies (such as sand bags, raising possessions) which can be implemented.

The effective flood warning time depends on the maximum potential warning time before the onset of flooding, the actual warning time provided before the onset of flooding and the flood awareness of the community responding to a warning. In Medowie flood warning time is limited particularly in the upper and mid catchment areas where shorter duration storms are critical. There are no gauges in the catchment that can be used for providing flood warning. Residents can be made aware through community awareness schemes how to act on BoM weather warnings. Within the CDIA, residents are generally aware of the flooding situation and the slow rising water levels give residents time to prepare as necessary. Furthermore, due to the low flood affectation of dwellings in Medowie, the need for evacuation is unlikely.

No recommendations are made for improving flood warning, rather a recommendation for improving flood awareness is considered more appropriate. A flood awareness campaign can make residents aware of how to interpret BOM weather warnings and how to prepare for inundation.

SUMMARY

Due to the nature of flooding in the study area flood warnings are difficult. In addition there would be little time for evacuation. As few dwellings are flooded above floor level a call for evacuation is unlikely. Severe weather warnings should be used as a caution to potential onset of flooding. These are available through BOM and can also be made available on Council's website and through SMS alerts. A flood awareness campaign can assist in providing guidance to residents on how to interpret BOM weather warnings and how to manage flooding.

7.5.3 Flood Access

Evacuation can be improved by ensuring that there are adequate evacuation routes available and appropriate warning as to when the routes will become impassable. Providing safer flood access can also reduce risk to life and assist emergency response. Those key access areas particularly prone to inundation are identified in Section 5.3.

Due to the nature of flooding in Medowie, local changes to ground levels such as raising roads can have significant adverse implications in terms of flooding for local properties. There are a number of roads in the catchments that are perpendicular to flow and act as a barrier, causing backing up of floodwaters and subsequent flooding of properties. Ferodale Road is a good example of this. Therefore it is recommended that road raising in Medowie within flood prone areas should not be allowed. Instead other measures should be investigated such as improving drainage to reduce flood levels (see Section 7.3.3). The hydraulic modelling undertaken for assessment of potential flood management options has shown that this would be a more appropriate solution.

In addition, it is recommended that Council maintain a record of flood prone roads including details of likely inundation and alternative routes. Then, when flooding is likely Council can ensure that appropriate road closures and diversions are put in place to prevent people unnecessarily traversing through flood waters. For roads which may be more frequently inundated, such as Ferodale Road and Kirrang Drive, flood depths indicators and flood signs can be used. A flood depth indicator is already present at the Kirrang Drive crossing of the Campvale Drain and a flood level indicator (to mAHD) is present at Ferodale Road (Section 5.3). It is recommended that a depth indictor be placed at Ferodale Road as the current level indicator does not clearly show depths over the road. Flood signs may also assist in resident awareness as the depths indicators are not prominent from the road.

Flood signs must be installed in accordance with AS 1742.2-2009 *Manual of Uniform Traffic Control Devices Part 2: Traffic Control Devices for General Use*, which stipulates that *"The 'ROAD SUBJECT TO FLOODING, INDICATORS SHOW DEPTH' sign shall be erected on the left side of the road on which Depth Indicators are used, to advise drivers that the road ahead may be covered by floodwaters…the NEXT x km sign may be used in conjunction with this sign when there are two or more floodways ahead, not more than 2km apart." (Clause 4.10.6.9)*

It also specifies that a depth indicator sign *"…shall be used at all fords, floodways and low level bridges. It shall be displayed so as to be clearly visible to drivers before reaching the flooded part of the road. Where necessary, separate indicators should be provided on each approach. The zero mark shall be set at the lowest pavement level on the section of road liable to flooding." (Clause 4.10.6.10)*

Photograph 20: a) Flood Depth Indicator at Kirrang Drive
b) Flood Level Indicator at Ferodale Road

SUMMARY

Raising existing roads within Medowie is not recommended and has potential to actually worsen the current situation. Placement of depths markers and flood signs could assist in preventing drivers from traversing through flood waters at the following liable road crossings:

- Ferodale Road,
- Kirrang Drive,
- Kirrang Drive / Kula Road intersection.

In addition Council should put measures in place to temporarily close flooded roads where possible.

7.5.4 Community Awareness Programme

Public information and the level of public awareness is key in reducing flood damages and losses. A more aware community is likely to be more prepared and will suffer fewer losses than an unprepared community. Raising community awareness can be achieved through a number of means such as leafleting, local posters, media releases, Council and SES attendance at community events and more.

The level of flood awareness within a community is difficult to evaluate. It will vary over time and depends on a number of factors including frequency and impact of previous floods, history of residence, and whether an effective community awareness program has been implemented. Generally community awareness will decline as time since the last flood passes. Community awareness can be raised as a result of community flood or climate change awareness programs. A community with high flood awareness will suffer less damage and disruption during and after a flood because people are aware of the potential of the situation.

Families who have owned properties for a long time will have established a considerable depth of knowledge regarding flooding and a relatively high level of flood awareness whilst a community which consists predominantly of short lease rental homes will have a low level of flood awareness. A difficulty with flood awareness campaigns is often convincing residents that major floods will occur in the future. Many residents hold the false view that once they have experienced a large flood then another will not occur for a long time thereafter. In Medowie, many residents, particularly those in the lower catchment, are so concerned with the ponding issue that they have little consideration for design event flooding.

Following a flood event, it is important to collect available information but to also let the community know that Council is aware of the problems and are managing it. Council staff should meet with affected community members, particularly those properties in the CDIA and in other key areas such as those identified as being prone to over floor flooding or those in floodway and/or high hazard areas. On-going post flood data collection by Council in conjunction with the SES should occur after every flood event to enable improved understanding of the flooding situation and ensure data is always the most recent to allow better decision making for flood management.

For risk management to be effective it must become the responsibility of the whole community. It is difficult to accurately assess the benefits of an awareness program but it is generally considered that the benefits far outweigh the costs. It is important that a high level of awareness is maintained through implementation of a suitable Flood Awareness Program that would include Floodsafe brochures as well as advice provided on Council's and SES's websites. These need to be updated on a regular basis.
Table 7.9 provides examples of further methods to raise community flood awareness that may be developed and supported by Council.

Table 7.9: Community Flood Awareness Methods

Method	Comment
Letter/pamphlet from Council	These may be sent (annually or biannually) with the rate notice or separately. A Council database of flood liable properties/addresses makes this a relatively inexpensive and effective measure. The pamphlet can inform residents of on-going implementation of the Risk Management Plan, changes to flood levels, climate change or any other relevant information. It can also be used to clarify the difference between the ponding and flooding issues in Medowie.
Council website	Council should continue to update and expand their website to provide both technical information on flood levels as well as qualitative information on how residents can make themselves flood aware. This would provide an excellent source of knowledge on flooding as well as on issues such as climate change. It is recommended that Council's website continue to be updated as and when required.

Method	Comment
Community Working Group	Council should initiate a Community Working Group framework which will provide a valuable two way conduit between the local residents and Council. The current FMC includes representatives from Council, OEH, HWC and local residents.
School project or local historical society	This provides an excellent means of informing the younger generation about flooding and climate change. It may involve talks from various authorities and can be combined with topics relating to water quality, estuary management, etc.
Historical flood markers and flood depth markers	Signs or marks can be prominently displayed on telegraph poles or such like to indicate the level reached in previous floods. Depth indicators advise of potential hazards, particularly to drivers. These are inexpensive and effective but in some flood communities not well accepted as it is considered that they affect property values.
Articles in local newspapers	Ongoing articles in the newspapers will ensure that the flood and climate change issues are not forgotten. Historical features and remembrance of the anniversary of past events are interesting for local residents.
Collection of data from future floods	Collection of data (including photographs and recorded flood levels) assists in reinforcing to the residents that Council is aware of the problem and ensures that the design flood levels are as accurate as possible.
Types of information available	A recurring problem is that new owners consider they were not adequately advised that their property was flood affected on the 149 Certificate during the purchase process. Council may wish to advise interested parties, when they inquire during the property purchase process, regarding flood information currently available, how it can be obtained and the cost. This information also needs to be provided to all visitors who may rent for a period. Some Councils have conducted briefing sessions with real estate agents and conveyancers.
Establishment of a flood effects database and post flood data collection program	A database would provide information on a number of issues such as which houses require evacuation, which public structures will be affected (eg. telephone or power cuts). This database should be reviewed after each flood event. This database should be updated following each flood with input from the community.
Flood preparedness program	Providing information to the community regarding flooding helps to inform it of the problem and associated implications. However, it does not necessarily adequately prepare people to react effectively to the problem. A Flood Preparedness Program would ensure that the community is adequately prepared. The SES would take a lead role in this.
Develop approaches to foster community ownership of the problem	Flood damages in future events can be minimised if the community is aware of the problem and takes steps to find solutions. The development of approaches that promote community ownership should therefore be encouraged. For example residents should be advised that they have a responsibility to advise Council if they see a problem such as blockage of drains or such like. This process can be linked to water quality or other water related issues including estuary management. The specific approach can only be developed in consultation with the community.

SUMMARY

The community has a degree of flood awareness. However, many residents are more concerned with ponding as opposed to design event flooding and are therefore less aware of larger events such as the 1% AEP. Council should undertake a regular community awareness program to ensure that there is always a level of awareness in the community and the community can distinguish between the two types of flooding.

The specific flood awareness measures that are implemented will need to be developed by Council taking into account the views of the local community, funding considerations and other awareness programs within the LGA. The details of the exact measures would need to be developed in consultation with affected communities.

8. FLOODPLAIN RISK MANAGEMENT PLAN FOR MEDOWIE

8.1 Introduction

The Floodplain Risk Management Plan (FRMP) for Medowie has been prepared in accordance with the NSW Floodplain Development Manual (Reference 1) and is:

- Based on a comprehensive and detailed evaluation of all factors that affect and are affected by the use of flood prone land; and
- Provide a long-term path for the future development of the community.

The Plan only includes recommended works and does not describe options that have been discarded as part of the floodplain risk management study.

Before the Plan is adopted, it must be accepted by Council and the FMC. Following this it was placed on public exhibition for the community and other stakeholders to comment. Necessary changes were made to revise the Draft Plan to the Final Plan for adoption by Council.

This Plan has been separated out into two separate Plans. The first deals with flood abatement measures or those actionable items that are relevant and likely to be supported under the NSW FRMP. These are measures that pertain to the peak level of flooding in very rare events such as the 1% AEP. The second Plan pertains to the duration of more common flood events and there usability of land within the CDIA that can be affected by sub-standard drainage. The second Plan tends to present works which will require Council implementation only.

8.2 Plan

MEDOWIE FLOODPLAIN RISK MANAGEMENT PLAN

Flood mitigation and management measures are set out below for the Medowie Floodplain Risk Management Plan. These measures have been identified through the floodplain risk management process in accordance with the NSW Government Flood Prone Land Policy and the Floodplain Development Manual (2005). This plan has been finalised following a period of public consultation with approval from Council and the Floodplain Risk Management Committee.

Table 8.1 Floodplain Risk Management Plan (Flooding)

Option	Priority	Details	Benefits	Concerns	Implementation, Costs and Funding
On-site detention (OSD) (Section 7.3.5)	High	Requirement for OSD to be included for new development where appropriate.	In the upper catchment areas OSD will assist in reducing peak flood levels due to new development.	Only reduces effect on increased runoff rates due to new development but does not reduce the increased volumes. OSD is not appropriate in all areas of the catchment such as those within the 1% AEP flood extent or draining directly to the CDIA.	OSD requirements are already included in Council's Draft DCP 2014.
Maintenance of existing levees (Section 7.3.7)	On-going	Existing levees at Kirrang Drive, County Close and elsewhere in the catchment should be regularly checked and maintained.	Reduces risk of failure of levees and ensures they are operating as designed.	None	Council can implement as part of their regular drainage infrastructure checks and maintenance program.
Voluntary Purchase (Section 7.4.2 and Appendix G)	High	One property has been highlighted for potential voluntary purchase. The property is located in high hazard floodway and cannot be protected by other means, or doing so would increase flooding to adjacent properties. In addition, voluntary purchase removes obstructions from the floodway and allows better conveyance of flow.	This is the only means of removing these residents from flood prone areas where there is not only high potential costs of flood damages but also significant risk to people. AAD per property in Medowie averages at $ 1,700 but it is approximately 50 times this for the property identified for voluntary purchase. The B/C ratio is good at 2.76. (Properties identified for potential voluntary purchase are not noted here for privacy reasons).	For this property voluntary purchase is the only way to remove the residents from the high hazard and in some instances, frequent flooding however, residents may not want to move, or may feel that the price for their property should be higher.	Council will be responsible for implementation. Partial funding may be possible from the Floodplain Management Program if a number of criteria are met. Under OEH guidelines, if approved for a voluntary purchase scheme Council would have access to the state-wide Voluntary Purchase / Voluntary House Raising Pool for a three-year period. Council are required to review the scheme every three years.
Flood Proofing (section 7.4.3)	High	Should be required for all non-residential development which has a floor level below the FPL.	Can reduce damages and losses due to flooding.	Appropriate materials and construction techniques must be used.	Council already include requirements for flood proofing in their Draft DCP 2014 where floor levels of commercial and industrial development may be below the FPL.

Option	Priority	Details	Benefits	Concerns	Implementation, Costs and Funding
Minor Property Adjustments (Section 7.4.4 and Appendix G)	High	Can be used to prevent over floor flooding of dwellings or provide safe flood access. Minor modification have been identified for particularly flood prone dwellings. (Dwellings not detailed here due to privacy reasons).	Reduces flood damages and losses and also reduces risk to life. Can reduce localised flooding issues at a number of properties and can improve dwelling access during flooding.	If Council were to undertake works for a single private dwelling then other residents may expect the same to be done for them. Works should only be undertaken by Council where there is a genuine and serious flood risk problem. However, Council should not discourage residents from funding their own works subject to DA approval.	For single dwellings the property owner would usually be responsible although Council can provide funding and support, and in some cases undertake the works if measures are on public land or associated with drainage infrastructure. Council would need to approve minor property modification put forward by individuals to ensure they do not worsen the situation for neighbouring properties. Council can support individual property owners through the DA process, provide advice and flooding information (such as the impact assessments undertaken for selected properties in this FRMS&P).
Restrict filling in the Campvale catchment (Section 7.4.5)	High	Filling below a level of 7.7 mAHD was shown to cause cumulative increases in peak flood levels and should be only undertaken if balanced by local cut.	Would reduce potential cumulative peak level increase effects of future development.	Residents within the balanced-fill zone may feel that their land value is decreased due to reduced development potential.	Council would implement through their DCP.
Protect key infrastructure (Section 7.4.7)	High	HWC should consider the implication of flooding above the sump level at the sewer pumping station on Ferodale Road and perhaps put measures in place to ensure this is not a health concern.	Prevent health concerns and failure of sewer pumping station when inundated.	None.	Hunter Water Corporation
Establish records of road inundation to aid road closures and diversions during flooding (Section 7.5.3)	Medium	Council should maintain records of roads likely to become inundated and prepare protocols for road closures and diversions when flooding occurs.	Road closures during flooding will improve safety by preventing people from traversing flood water unnecessarily.	Need to be developed into a formal plan or protocol to ensure that roads are closed during flooding as needed.	Council would be responsible as most roads in the area are under their jurisdiction.
Install flood depths indicators at Ferodale Road, Kirrang Drive and the Kirrang Drive / Kula Road intersection (Section 7.5.3)	Medium	Flood depth indicators can discourage people traversing through floodwaters.	Safety	None	Generally a low cost measures which can be implemented by Council.
Do not allow road raising on flood prone areas of the catchment (Section 7.5.3)	High	Some roads run perpendicular to flow and therefore raising these roads to reduce their inundation would have adverse impacts on flood levels for upstream areas.	Care must be taken in the catchment so that any development does not increase flood levels elsewhere. Restrictions on raising of roads will prevent backing up of flood waters and increases in peak flood levels in areas upstream.	In some areas works may require road raising otherwise future development could be hindered. In these exceptional circumstances a flood assessment should be undertaken to assess the impacts for all design events to ensure no adverse impacts occur as result of the works.	Council can make provisions for the non-raising of flood prone roads in their DCP and policy documents.

Option	Priority	Details	Benefits	Concerns	Implementation, Costs and Funding
Community Awareness Campaign (Section 7.5.4)	Medium	The community tend to be aware of the ponding issues but less so of design event flooding. An awareness campaign could assist to clarify these issues.	Can give the community a better understanding of both the ponding and flooding issues in Medowie. Can provide information to residents on interpreting the BOM's weather warnings in light of no other formal flood warning system for the Medowie area.	None	To be implemented by Council on a regular basis such as every two years. Awareness campaigns are also undertaken by the SES. It is strongly suggested that HWC are also involved in the process. Funding would likely come from all parties involved.
Define a Flood Planning Area (FPA) for Medowie in the LEP (Section 7.4.8 and 7.4.11)	High	The LEP must contain a Flood Planning Area map identifying areas to which flood planning controls apply.	Both the FPA and FPL make sure that requirements of state legislation are met and ensures that flood related development controls are applied appropriately across the catchment.	None	Council are responsible for implementation. The LEP should include an updated FPA map based on the findings of this FRMS&P.
Make use of the Flood Planning Level to define minimum floor levels and other development requirements (Section 7.4.9)	High	Flood Planning Levels are used to set minimum floor level requirements for development.	For residential properties, the FPL ensures habitable floor levels remain flood free in the 1% AEP event. Commercial and industrial development is also required to have floor levels at the FPL unless in exception circumstances.	New developers may have issues with having to have floor levels higher than neighbouring properties. However, the social benefits of reduced flood damages and risk outweigh this.	Council are responsible for implementation. The Draft DCP 2014 already contains minimum floor level requirements of the 1% AEP flood level plus 0.5 m and this is supported.
Considerations for flooding in land use zoning (Section 7.4.10)	Medium	It is understood that the land use zoning envisaged in the Medowie Strategy will be reviewed. This should be reviewed against the flood extents as well as high hazard and floodway areas and recommendations for not filling in the CDIA.	Will ensure that future development is not at unnecessary flood risk.	Rezoning private land as non-developable land can be objected to by landholders. There is also a need for future development in Medowie and this should be balanced with flood risk.	Council should identify future land zoning and include in their future strategies. Flood data from this FRMS&P is available to assist in this.
Amendments to the DCP regarding flooding and drainage (Section 7.4.11)	High	The DCP is used to control development with regard to flooding and it is important that suitable controls are applied. Recommendations have been made regarding floor levels for more sensitive development, filling in the floodplain, OSD, drainage easement and road raising.	Appropriate development controls ensure that new development does not increase the risk of flooding elsewhere in the catchment and does not increase the population at risk in the catchment.	Changes to the DCP will usually require a period of public exhibition.	Council can implement changes to the DCP while it is in draft format.
Modification to s149 certificates (Section 7.4.13)	Low	Issued to residents to identify any hazards at their property and development controls that apply. Council should offer additional information on Part(5) where it is available. Under Part(2) it is compulsory to note if development controls relating to flooding apply.	Can inform of the flood risk at each property and apply additional information if Part(5) is also included. Ensures residents are aware of development controls, such as minimum floor levels, that affect their property. Can also inform residents of drainage easements through properties and their responsibilities.	Some residents do not like the additional information provided under Part(5) and believe it can affect insurance premiums and value of land.	To be implemented by Council as new s149 certificates are requested.

Table 8.2 Floodplain Risk Management Plan (Drainage)

Option	Priority	Details	Benefits	Concerns	Implementation, Costs and Funding
Option A2 – Campvale drain improvements (Section 7.3.2)	High	Reduces the ponding in the CDIA by increasing flow towards the Campvale WPS. See **Table 8.3** for details.	Increased amenity for landholders within the CDIA.	HWC do not support options which reduce the duration of ponding in the CDIA.	Council would be responsible for implementation and funding. Council would need to undertake discussions with HWC regarding their water quality concerns. It is suggested that HWC should undertake a detailed assessment of water quality in the catchment, to establish the required detention time in relation to the required water quality.
Option G – Improve lateral drain connectivity in the CDIA (Section 7.3.2)	High	Improves drainage times for isolated ponding areas in the CDIA which would otherwise not drain. See **Table 8.3** for details.	Increased amenity for land holders within the CDIA.	Regular maintenance is needed to ensure drains do not become blocked or overgrown. Most lateral drains are in private land, not within Council's acquired easements so Council would need to discuss with landholders regarding maintenance responsibilities.	Council to implement initial improvement and subsequently inform landholders of their maintenance responsibilities. Alternatively Council may need to extend their easements for access.
Clearance of Campvale Drain (Section 7.3.2 and 7.3.3)	High	Highly vegetated and silted channels will convey less flow so clearance will aid conveyance and thus minimise ponding.	Would improve nuisance ponding/flooding but provide little benefit in flood events greater than a 0.2 EY event.	Presence of protected plant species requiring a licence for removal from OEH.	Council would fund and implement on a regular basis.
Drainage infrastructure maintenance (Section 7.3.3)	On-going	To check hydraulic structures and channels for potential causes of blockage or damages which would reduce effectiveness.	Reduce the risk of culvert blockage.	Council need regular access to the drain.	Council would implement this as part of their regular infrastructure checks.
Acquire drainage easements (Section 7.4.6)	On-going	Drainage easements allow Council access through private land to undertake drainage maintenance. Council is currently acquiring drainage easements on the Campvale Drain and this process should be accelerated.	Allows Council access to undertake drain maintenance.	Residents who have given over easements have concerns that the easements are not being used for access and that the drains are not being maintained. Property owners affected are likely to have concerns with loss of developable land.	Council are already in the process of obtaining easements and should continue to do so for the full length of the drain. Consultation is required with each of the individual land owners affected. Easements should be noted on s149(2) certificates.
Developer contribution for drainage maintenance of Campvale Drain and drains within the CDIA (Section 7.4.12)	Medium	Developer contributions can be used by Council to assist in funding for improvements to the Campvale Drain and other drains within the CDIA.	Upstream development can have implications on the ponding in the CDIA due to increased volume. OSD features on site will not eliminate the increased volume of runoff from a developed site and therefore drain improvements are required to reduce the effects of new development on the ponding situation.	None	Council should implement this through their current Developer Contribution Plans.
Improvements upstream of Ferodale Road for Medowie commercial area (Section 7.3.3)	High	Improve drainage hydraulics upstream of Kirrang Drive to downstream of Ferodale Road, including water quality device to stop branches etc upstream of Kirrang Drive bend, channel lining and upgraded Ferodale Road culvert.	Improved flow and reduced levels for small flood events. Reduced risk of culvert blockage and over-topping.	None	Council to implement through the drainage improvement program.

Table 8.3 Campvale Drain Improvement Works

Option: **A2**

Description: **Removal of the Pinch, Earth Bunds and Drain Upgrades to Reduce Ponding Duration**

References: **Section 7.3.2, Fig D1a & D1b**

Item	Description of Works
1	**Preliminary Works**
1.1	Detailed design of proposed drain bed levels b/w Ch 1335.30 - Ch 2750.12 (Including regulatory consultation, Acid Sulphate Soils Management and Environmental Assessment)
1.2	Allocation of a suitable local spoil location(s) (possibly outside of CDIA) If locally unavailable, consider haulage to appropriate spoil site(s)
1.3	Gain access to affected parts of drain - easement permissions, access for machinery
1.4	Prepare Tender Brief with complete scope of works
1.5	Distribute Tender Brief to key earthworks contractors
1.6	Appointment of Contractor
2	**On Site Works**
2.1	Site Establishment - ensure works zone is dry
2.2	Excavation of existing drain bed and spoil removal
2.3	Compaction of new drain bed
2.4	Completion of Works

Option: **G**

Description: **Improved Lateral Drain Connectivity in the CDIA**

References: **Section 7.3.2, Fig D2**

Item	Description of Works
1	**Preliminary Works**
1.1	Council acquisition of easements to allow continuous access
1.2	Development of maintenance schedule locating work zones, outlining and prioritising works
1.3	Council to apply to OEH for permission to undertake clearing
1.4	Council to undertake works to fulfil OEH requirements for flora and fauna listed as vulnerable under the Threatened Species and Conservation Act (1995)
1.5	Liaise with HWC prior to undertaking any works
1.6	Distribute pamphlet to affected residents informing them of proposed works and their role (if any) in providing access or assistance.
2	**Ongoing Connectivity Improvement Works**
2.1	Spraying of weeds
1.4	Removal of debris
1.5	Removal of earth bunds
1.6	Ongoing documentation of works undertaken

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- NSW Office of Environment and Heritage; and
- Hunter Water Corporation.

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