Appendix A. Analysis of Historic Rainfall Event Data

The five highest rainfall totals for the 1, 2, 3, 4 and 5 day durations are summarised for the selected rainfall gauges in and around the study area. For the multi-day durations, only the dates from unique rainfall events are shown. For example, 21/04/2015 and 20/04/2015 may occur as rank #1 and #2 at a gauge for 3-day totals, however, since both dates occur during the same storm event, the rank #2 date (20/04/2015) is excluded from the table. Rainfall values are based on daily rainfall recorded to 9am as per BOM convention.

Station No.	061054
Name	Nelson Bay (Nelson Head)
Start Date	19/5/1881
End Date	7/04/2016
Length (days)	49267

Rank	1 day		2 day		3 day		4 day		5 day	
	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm
1	9/2/1889	258	21/04/2015	308	21/04/2015	331	16/04/1946	362	15/04/1946	393
2	22/05/1949	225	25/03/1946	290	17/06/1949	329	20/04/2015	347	15/06/1949	359
3	26/03/1946	218	17/06/1949	276	24/03/1946	297	17/06/1949	337	19/04/2015	351
4	15/02/2009	211	6/5/1898	268	17/04/1946	287	1/08/1990	299	6/05/2001	334
5	24/9/1892	208	8/2/1889	258	13/3/1886	287	23/03/1946	297	13/3/1886	319

Station No.	061411
Name	Fingal Bay (Fingal Haven)
Start Date	1/09/2007
End Date	31/03/2016
Length (days)	3135

Rank	1 day		2 day		3 day		4 day		5 day	
	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm
1	22/04/2015	145	21/04/2015	284	20/04/2015	301	19/04/2015	307	19/04/2015	313
2	15/02/2009	142	28/01/2013	183	27/01/2013	219	4/01/2016	238	11/02/2009	247
3	2/04/2009	139	1/04/2009	168	4/01/2016	206	27/01/2013	221	4/01/2016	239
4	21/04/2015	139	15/02/2009	156	31/03/2009	202	12/02/2009	218	20/07/2011	233
5	6/01/2016	118	5/01/2016	154	17/04/2012	172	21/07/2011	202	25/01/2013	221

Station No.	061303
Name	Salamander Bay (Randall Drive)
Start Date	21/05/1971
End Date	31/07/2007
Length (days)	13221

Rank	1 day		2 day		3 day		4 day		5 day	
	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm
1	6/02/1981	236	5/02/1981	265	2/02/1990	297	1/02/1990	302	6/05/2001	328
2	27/11/2001	204	3/02/1990	263	5/02/1981	284	5/02/1981	288	3/02/1990	324
3	3/02/1990	185	19/10/1976	222	3/06/1998	256	6/05/2001	276	4/02/1981	289
4	19/10/1976	157	3/06/1998	207	19/10/1976	224	3/06/1998	264	2/05/1998	271
5	4/03/1977	152	26/11/2001	204	7/06/2007	223	2/05/1998	260	2/06/1998	264

Station No.	061395
Name	Tanilba Bay WWTP
Start Date	1/01/2002
End Date	13/01/2016
Length (days)	5126

Rank	1 day		2 day		3 day		4 day		5 day	
	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm
1	21/04/2015	209	21/04/2015	345	20/04/2015	379	19/04/2015	379	18/04/2015	379
2	6/01/2016	209	5/01/2016	245	4/01/2016	283	4/01/2016	309	3/01/2016	309
3	15/02/2009	183	15/02/2009	199	7/06/2007	227	12/02/2009	259	11/02/2009	289
4	29/01/2013	170	8/06/2007	181	13/02/2009	210	7/06/2007	230	6/06/2007	230
5	18/11/2013	142	28/01/2013	170	17/04/2012	195	17/04/2012	200	22/04/2008	213

JACOBS

Station No.	061078
Name	Williamtown RAAF
Start Date	1/09/1942
End Date	7/04/2016
Length (days)	26883

Rank	1 day		2 day		3 day		4 day		5 day	
	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm	Date	Depth mm
1	3/02/1990	276	3/02/1990	451	2/02/1990	474	2/02/1990	485	1/02/1990	488
2	6/01/2016	225	21/04/2015	270	4/01/2016	291	4/01/2016	328	3/01/2016	328
3	4/02/1990	175	6/01/2016	262	20/04/2015	283	20/04/2015	292	19/04/2015	292
4	18/11/2013	167	4/01/1978	209	8/06/2007	227	7/06/2007	252	7/06/2007	253
5	3/03/2013	158	8/06/2007	196	27/04/1963	224	6/05/2001	243	6/05/2001	248

Appendix B. Community Consultation

B.1 Community Questionnaire and Analysis of Responses

Anna Bay and Tilligerry Creek Flood Study
Local Resident and Land Owner Questionnaire

We need your help!

Port Stephens Council has engaged Jacobs to carry out the **Anna Bay and Tilligerry Creek Flood Study**. We would like feedback from the community on a number of issues related to flooding in your area. The results of the survey will help inform the overall flood study which will be placed on public exhibition in 2016.

Community engagement is an integral part of the study. The aim of this survey is to gather resident's intelligence and feedback on their experiences with flooding in the area. Significant flooding has occurred in the area in 1955 and 1990, and may have occurred during recent major storms such as in 2007, 2015 and 2016.The information that you provide will improve the flood model being developed.

If you cannot answer any question, or do not wish to answer a question, then leave it unanswered and proceed to the next question. **Your input to this important study will be greatly appreciated. Any information that you provide will be treated as confidential. Specific information on the respondents or their responses will not be made available or reported on.** There is a page at the back for additional comments. If you need additional space, please add sheets.

Your contact details would be appreciated in case we need to follow up on some details or seek additional comment, and will be treated with confidentiality. Can you please also mark the location of your residence/business with a clear dot on the attached plan, as best as you can. Please note that providing these details is **optional**.

Name: ……..

Email: ……..

Telephone: ……..

Address: ……..

If you would prefer to provide a letter with your comments or respond to this questionnaire by speaking to Council by telephone, this would also be welcomed. To discuss any aspects of this questionnaire, please call

Port Stephens Council
Phone 02 4980 0250
or
Email FloodRequests@portstephens.nsw.gov.au

An online version of this survey is also available. For links to the online survey and more information on floodplain risk management, visit http://www.portstephens.nsw.gov.au/annabayflood.

Please complete the Questionnaire within three weeks of receiving it and post the responses to:

Anna Bay and Tilligerry Creek Flood Study
116 Adelaide Street (old Pacific Highway)
Raymond Terrace NSW 2324

OR scan and email to FloodRequests@portstephens.nsw.gov.au

Place a tick in the relevant box or write answers.

Question	Question and Answer
1.	**Do you live in the study area?** o Y o N **If no, are you a frequently visitor in the area? (Please elaborate on your answer)**
2.	**Do you own or rent your property in the study area?** o Own o Rent How long have you occupied your property in the study area? ……years.
3.	**Do you own or manage a business in the study area?** o Yes. How long has it operated in the study area? ……years. o No (go to Question 5)
4.	**What kind of business?** o Home based business o Shop/commercial premises o Others, please write type of business ……
5.	**Are you aware of flooding in the study area?** (Please tick one) o Aware o Some knowledge o Not aware Information such as photographs of flooding and comments on your experiences would be invaluable to the study. Comments can be written in the space at the end of this questionnaire. If you wish to send in photos, we will make copies and return them to you.
6.	**Do you know of any locations that flood frequently? Please describe or mark on the map provided.**
7.	**When have you experienced significant flooding in the area? Can you provide dates of these events?**
8.	**Was vehicle access to/ from your property via local roads disrupted due to floodwaters during the worst flooding? Can you describe the depths, durations and locations of flooding? Further detail can be added to the sheet at the back.** o Not affected o Minor disruption (roads flooded but still driveable) o Access cut off o Property flooded o House or business flooded

Question	Question and Answer
9.	**During flood events have you seen floodwater pooling or flowing in any areas? Please comment or identify on the map provided.**
10.	**Have you ever noticed debris blocking the flow of water during flood events? Please identify on the map provided.** o Yes (If yes please identify on map provided) o No
11.	**Do you wish to share any information on flooding on your property?** (You can tick more than one box). Please write any descriptions at the end of the questionnaire o (a) No information o (b) Own experience o (c) Information from Council o (d) Photographs o (e) Other ……..
12.	**Do you wish to comment on any other issues associated with the development of the Flood Study? Please add comments at the back of the questionnaire.**
13.	**Do you wish to remain on the mailing list to receive further details, such as Newsletters or Community Bulletins on the Flood Study?** o Yes (please provide contact details in the space provided on page 1.) o No
Space for additional comments	

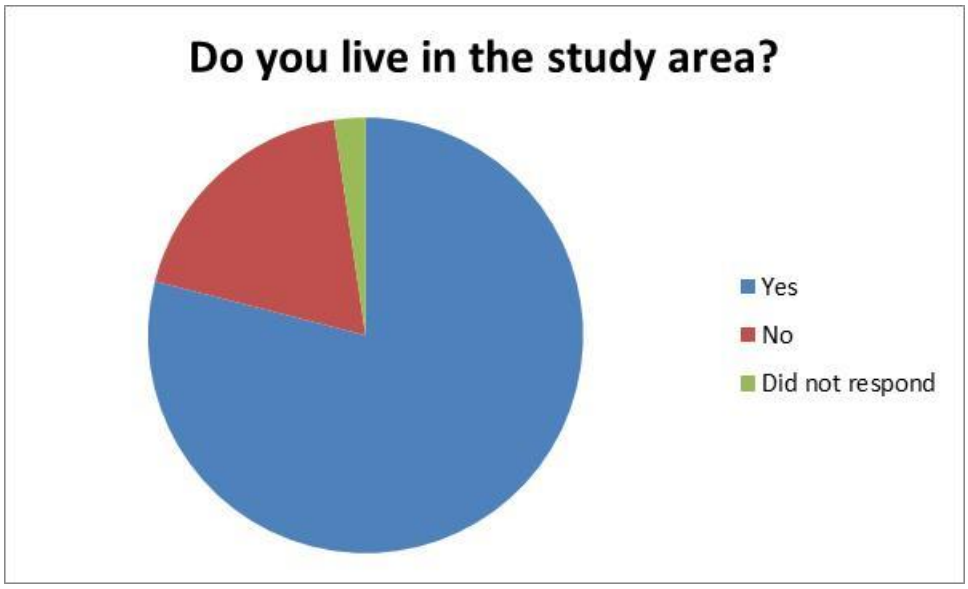
Study Area Map

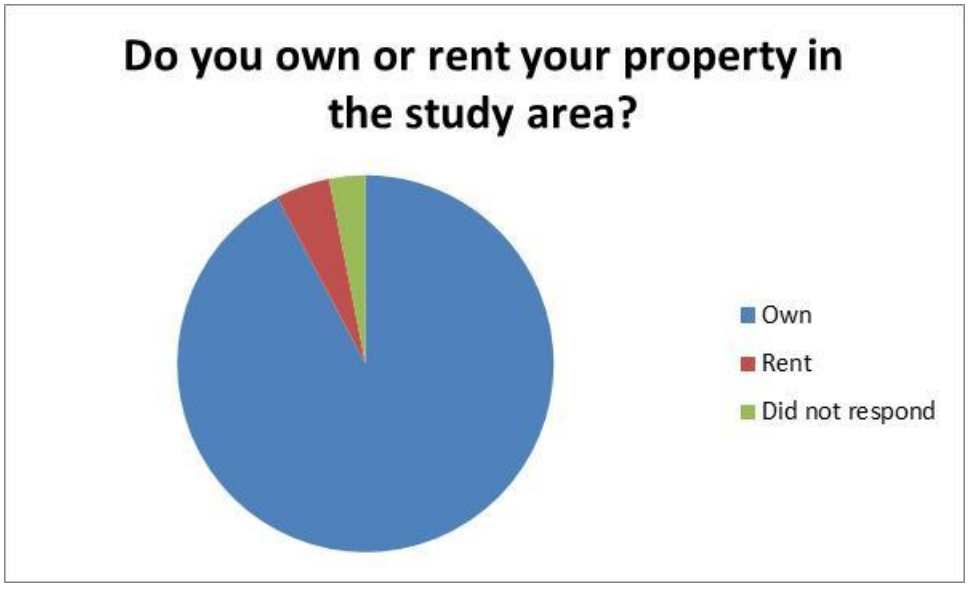
Please indicate the location of your previous flood observations as best as you can. This will greatly assist in improving the quality of our flood study.

Summary of Key Questionnaire Responses

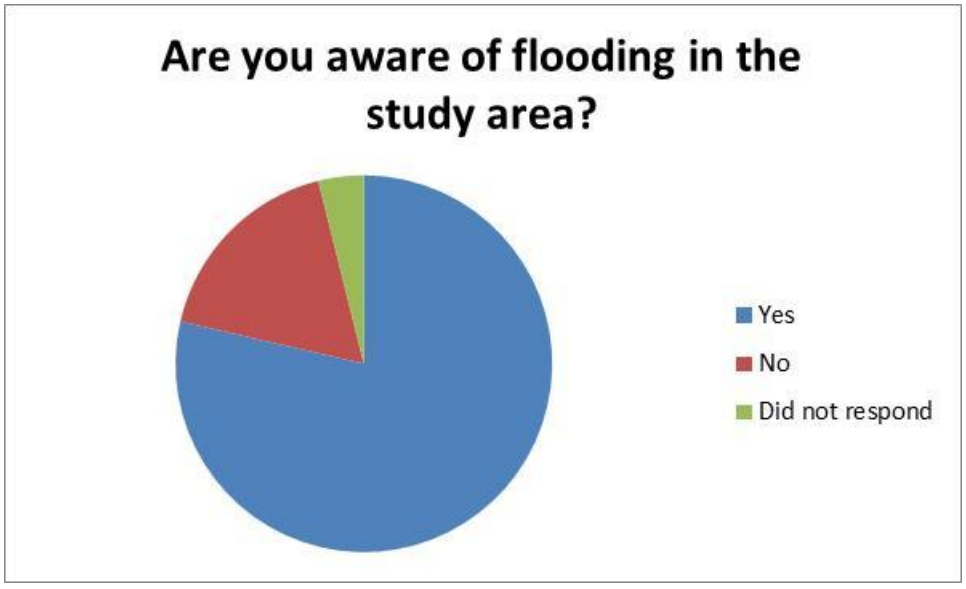
Number of questionnaires distributed: 6000

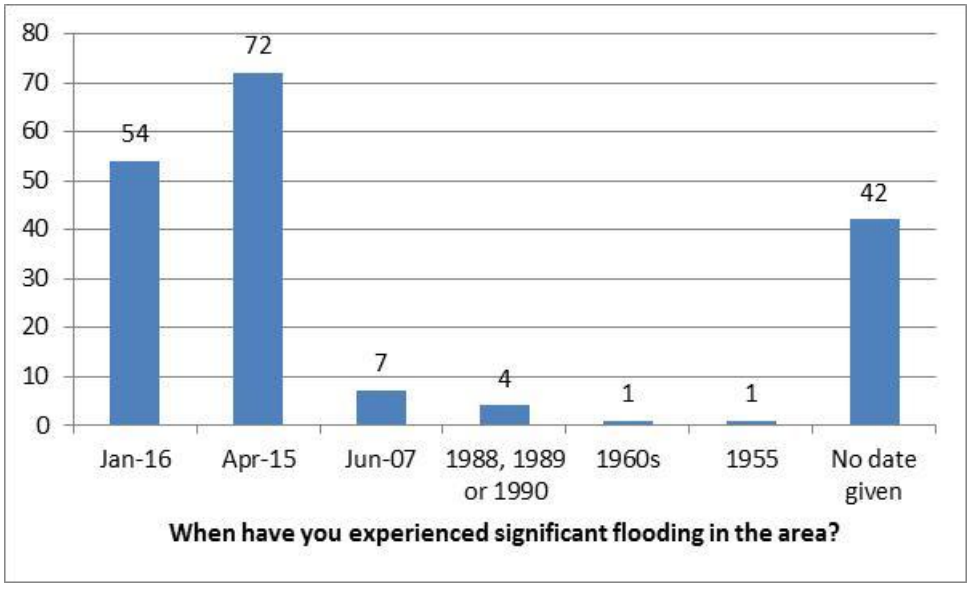
Number of responses: 257






120
100
80
60
40
20
0
40
25
46
26
24
96
<5 yrs
5-10 yrs
11-20 yrs
21-30 yrs
>30 yrs
Did not respond
How long have you occupied your property in the study area?


Are you aware of flooding in the study area?
Yes
No
Did not respond


80
70
60
50
40
30
20
10
0
54
72
7
4
1
1
42
Jan-16
Apr-15
Jun-07
1988, 1989 or 1990
1960s
1955
No date given
When have you experienced significant flooding in the area?

B.2 Public Submissions on Draft Report

18/11/2017

The General Manager
Port Stephens Council
council@portstephens.nsw.gov.au

Anna Bay and Tilligerry Creek Flood Study – Draft Report: Submission

Introduction

TRRA welcomes the Draft Anna Bay and Tilligerry Creek Flood Study as the first and second stages in a five stage process under the New South Wales Government's Flood Prone Land Policy. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

1. Data Collection Involves compilation of existing data and collection of additional data
2. Flood Study Determines the nature and extent of the flood problem
3. Floodplain Risk Management Study
4. Floodplain Risk Management Plan
5. Implementation of the Plan

The Flood Study is a complex scientific process which was undertaken in accordance with the NSW Government's Floodplain Development Manual. As a result TRRA are not in a position to question the actual content of the study but would like to make the following comments which may also be of use in the preparation of the remaining three steps in the process.

Connection with Anna Bay Strategy and Town Plan December 2008

In the Introduction of the draft flood study it is reported

> "A number of main flood problem areas have been identified in the study area. Two flood problem areas located in the Anna Bay township area are subject to significant development pressures as outlined in Council's Anna Bay Strategy and Town Plan. Potential mitigation options have been

identified for each area, including structural and non-structural options for each area, as summarised in Table 2."

The 2008 Anna Bay Strategy and Town Plan is overdue for an update. TRRA submits that the Flood study, once approved, should be a major driver in a revision of that Strategy/Plan rather than the flood Study being unduly influenced by the outdated Strategy. (The development of the Birubi Aboriginal Place Masterplan and Plan of Management is a significant initiative in the area that also supports the need for a Strategy update.)

Within the 2008 Strategy there are a number of references to large areas of land in Anna Bay that are mapped as flood prone and this represents a significant constraint to the expansion of the town, particularly to the north of the sand ridge and in proximity to the town centre.

Of particular note are the following:

- Within the section of the Strategy on *Drainage - Anna Bay North*, it states "Any rezoning and filling of the floodplain area will require the developer to further develop the flooding and drainage study and implement works as required."
- Within *Strategic Directions - Anna Bay East*, the Strategy states "Limited number of environmental living lots are proposed on the northern side of the sand ridge. Their inclusion reflects a resolution made by Council to support development on this site and the rezoning request received the support of the DECC at the time. These lots provide public benefit by funding the up-front provision of necessary drainage works. In the event of rezoning occurring, landowners in the Anna Bay East sub-catchment will be required to contribute towards recouping the cost of these drainage works based upon the amount of developable land."
- Under *Implementation – Anna Bay East*, the Strategy states: "In Anna Bay East it is essential that drainage infrastructure be in place prior to, or concurrent with development occurring. …..Rezoning and development in this location must provide arrangements for the funding and construction of this infrastructure at the first stage of development."

Clearly from the 2008 Strategy it was envisaged that Developers would be expected to meet the expense of providing much of the mitigation works needed. Work to safeguard public infrastructure such as roads to ensure a safe exit route during widespread flooding would need to be met by Local or State Government.

As part of the final three steps of the floodplain management system, a comprehensive analysis of the priority of future mitigation works and potential new development sites (through rezoning) will need careful consideration in regard to need and cost. The cost-benefit analysis may now show that some potential development areas could be no longer viable.

Climate Change

We note that a range of model runs have been undertaken, using current climatic conditions and a range of possible climate range conditions with increases in sea level and/or rainfall intensity.

At times it is a little confusing with statements such as

> "Design flood conditions are defined based on the full level of permissible development under Council's LEP 2013 and for existing climate conditions."

contrasting with:

> "The flood planning area has been defined based on Council's Floodplain Risk Management Policy, by the area below the 1% AEP flood level under the climate change scenario (0.9m sea level rise and 20% increase in rainfall intensity) plus a 0.5m freeboard."

We note that Council's Sea level Rise Policy (May 2009), incorporates the State-wide sea level rise planning benchmarks from the NSW Floodplain Development Manual (DIPNR, 2005) requires consideration of climate change in the preparation of Floodplain Risk Management Studies.

Port Stephens Council has adopted the 1% AEP flood in climate change scenario of the year 2100 (+0.9m sea level) and 20% increase in rainfall intensity for the flood planning level design flood.

TRRA supports the recommendations (points one and three) made at the conclusion of the study in section 11.2 and encourage all further studies and discussions to always consider the effects of climate change. We submit that a 'precautionary' approach be adopted that errs on the side of not allowing development on low lying land that might be flood prone in the event of climate change scenarios.

Land Use

We note that models have been run for flooding conditions associated with fully permissible development under Council's LEP 2013. We suggest an element of caution in regard to land zoned Rural as there have been three "caravan parks" approved under the LEP 2000 within the study area on rural zoned land which are in effect high density housing for approximately 500 permanent manufactured homes. Our assessment is that these would not have been allowed under the LEP 2013 – this means that planning will have to cope with the legacy of these approvals, at least one of which appears to be on low-lying land.

Value of Rural Land

In the Anna Bay Strategy 2008 it states "… outside of the town the majority of land is zoned for agriculture. This is despite limited agricultural activity, pressure for development and the presence of areas of significant vegetation."

In the section on mitigation there are a number of possible works that may have a negative result of potential flood levels increasing in other areas (e.g. increases of up to 0.3m in trapped points on the Fern Tree Drain floodplain). The report states that the affected areas are currently rural and pasture areas with no impact to existing dwellings or structures. We submit that this is an important example of the value of maintaining the rural nature of the surrounding area and that the pressure to develop on rural zoned land on a piece meal basis needs to be resisted.

Further Mitigation Work - Consultation

With the complex nature of the water flows we support the recommendation to undertake land owner consultation to clarify impacts and confirm acceptable mitigation options as being essential. It is important that this also involve comment from the general community and the RMS. From the modelling it is clear that mitigation for one area may come at a cost to another area.

John James
TRRA Vice President
vicepresident@trra.com.au
0447 158 810

Anna Bay Flood Study.

The Anna Bay Drainage Union has had the opportunity to review the draft flood study. We make the following submissions.

We would like consideration given to upgrading the anna bay main drain flood gates. The significant issue with the current flood gates is the ability to allow flood water to escape when tides are high. From our experience, there is usually 3 hrs of draining when tides are turning, this occurs twice a day. Whilst this is adequate in every day operation, it is not enough to cope when there is a flood event. This was experienced in the 2015 and 2016 floods, when the main drain burst its banks. See attached photo of main drain in January 2016, this is reflections drive end of drain.

A pump station in combination with flood gates would allow the removal of flood waters through the entire time of the flood event, being independent of tidal impacts, drastically reducing the impact of the flood and improve the recovery time.

A second option would be to increase the number of flood gates, however the tidal flows still present an issue.

The draft plan has proposed upgrades to several drains that feed into the main drain, in flood events this would contribute to the pressure on the main drain and affect local properties. We question the finding at J.5 ‘Discussion on Flood Impacts to Downstream Areas’, at J.5.2 it is stated that, “although the increases in flows are generally contained in the drains”. As you can see from the attached photos, there is no containment of flood water in the main drain.

We ask that the improvements of the flood gates is prioritised prior to increasing flow into the main drain.

Thank you for your consideration

Anna Bay Drainage Union

Received 14/11/17

To whom it may concern,

The flood mitigations options 2 to 5 described in Appendix J of the Draft document all result in larger peak flows and volumes of water being directed onto the rural properties north of Old Main Road. This will result in increased flood and groundwater levels in that area as noted in the description for option 6a.

Our concern is that if options 2 to 5 are implemented, our property will be negatively impacted by these increased flows and water levels. We consider it essential that options 6a & 6b be implemented as well and the drains increased in capacity right through to the outlet into Tilligerry Creek. Not doing so has the potential to create downstream drainage and flooding impacts on private property.

Regards

[redacted]

Received 24/10/17

I refer to:

Section 10.3 Page 99 of the Draft Study as appear s on your web site.

Title: Trapped water in low point at Gan Gan Road bottom of Blanch Street (see map supplied in report)

To whom it may concern:

You will note that this catchment area represents a reasonable size (coloured red) at the bottom of the only steep topography in the area. You will note that the red area DOES NOT include any existing residential development. The red area indicates a high depth at peak floods and also describes how this area tends (because of its clay soil) to hold in the area and discharge slowly. Inspection will reveal that this is a traditional and natural wet zone with dense undergrowth and has flooded (without impact) in this fashion since prior to urban development.

The plan, states that the drainage pipe is inadequate to drain the area. Why should it be drained anyway? Let time absorb the flash flood of sudden downpour, and not transfer these huge trapped volumes to create a problem somewhere else? It could be argued that this natural storm water detention actual replenishes the ground water table, thus mitigating the effects of acid -sulphate soils and provides valuable bore water irrigation for gardens in summer. In modern terminology this is what is called "Storm water detention" holding back sudden volumes so they do not overwhelm down stream situations' The Very successful artificial catchment opposite Anna Bay Public school, preventing localised flooding by retaining volumes for slow discharge gradually later, shows how efficient this system is.

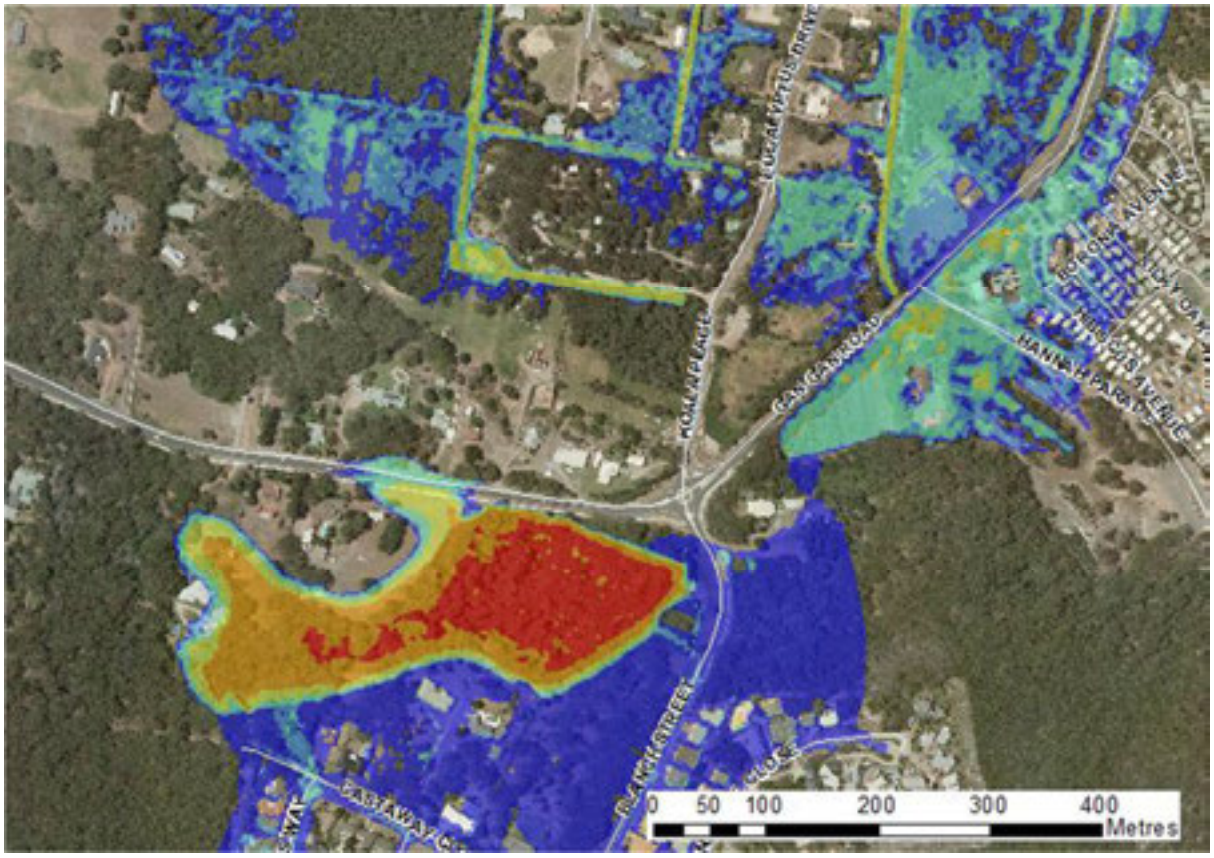
My address is: [redacted] and my property is surrounded by minor drainage channels, which although are adequate, coupled with permeable soils allowing for fast absorption, and buildings above current flood levels, will be placed under stress, by the discharge of this catchment area onto the flat lands immediately adjoining my property and others.

I have no other option to make this submission as a matter of record, because your proposal to artificially drain the catchment in question, can only be considered a man made alteration and intervention to existing circumstances that have provided flood free status of my property for the previous 20 years (the life time of the subdivision.) Having that flood free status influenced, or placed in jeopardy by Council intervention, to repair an upstream problem of zero impact, puts Council in a situation of liability and cause. To place many established properties at risk, to solve an issue of minor point is greatly irresponsible and places the actions of Council at great risk of liability by a change in our existing risk factors.

Topographical maps of our immediate area show we do not receive any surface run off from any other area higher than us, that is, we are not on the receiving end, no run of from elsewhere reaches us. And you wish to dump an entire catchment into our existing barely adequate drains.

A copy of this email has been forwarded to my insurance company to inform them that proposed actions by council may well change the existing risk status of my property at [redacted]

[redacted]


0 50 100 200 300 400
Metres

Anna Bay and Tilligerry Creek Flood Study – Draft Report public submissions – Jacobs response 23 November 2017		
Issue	**Raised By**	**Response**
Relation with Anna Bay Town Strategy 2008 The 2008 Anna Bay Strategy and Town Plan is overdue for an update. The Flood study, once approved, should be a major driver in a revision of that Strategy/Plan rather than the flood Study being unduly influenced by the outdated strategy. Clearly from the 2008 Strategy it was envisaged that Developers would be expected to meet the expense of providing much of the mitigation works needed. Work to safeguard public infrastructure such as roads to ensure a safe exit route during widespread flooding would need to be met by Local or State Government. As part of the final three steps of the floodplain management system, a comprehensive analysis of the priority of future mitigation works and potential new development sites (through rezoning) will need careful consideration in regard to need and cost. The cost-benefit analysis may now show that some potential development areas could be no longer viable.	Submission 1	The Anna Bay Strategy 2008 was used as an indication of the potential level of development within the study area and its impacts on flooding. This development scenario also guided the assessment of potentially required mitigation works. The assessment findings will inform further considerations of future development in Anna Bay, including appropriate levels and patterns of development given that the extent of flood prone land has now been confirmed. It is expected that further comprehensive analysis of flooding conditions and drainage works associated with development of the area will be conducted as a part of a development Master Plan of Anna Bay. It is also expected that the subsequent floodplain risk management study and plan (FRMSP) following this flood study will prioritise mitigation works with consideration of benefits to the existing community and future development, and equitable sharing of costs between council/community and stakeholders in future development.
Consideration of Climate Change Sometimes confusing in the study report, stating design flooding conditions based on existing climate. Contrasting with flood planning area based on climate change scenario TRRA supports the recommendations (points one and three) made at the conclusion of the study in section 11.2 and encourage all further studies and discussions to always consider the effects of climate change. We submit that a 'precautionary' approach be adopted that errs on the side of not	Submission 1	The report does state that design flooding estimates are based on existing climate, while for the purposes of flood planning the climate change scenario is taken into account to allow for some conservatism. The respondent's concurrence on the consideration and adoption of climate change scenario flooding conditions in land use planning is acknowledged.

allowing development on low lying land that might be flood prone in the event of climate change scenarios.		
Land use in the flood assessment suggest an element of caution in regard to land zoned Rural as there have been three "caravan parks" approved under the LEP 2000 within the study area on rural zoned land which are in effect high density housing for approximately 500 permanent manufactured homes. Our assessment is that these would not have been allowed under the LEP 2013 – this means that planning will have to cope with the legacy of these approvals, at least one of which appears to be on low-lying land.	Submission 1	The flood study has accounted for the existing caravan park developments in the hydrologic response and flood modelling. It is not in the scope of this flood study to consider or make recommendations for change in current land use in relation to existing and future flood risk. The FRMS is expected to make appropriate assessment on this issue.
Value of rural land In the section on mitigation there are a number of possible works that may have a negative result of potential flood levels increasing in other areas (e.g. increases of up to 0.3m in trapped points on the Fern Tree Drain floodplain). The report states that the affected areas are currently rural and pasture areas with no impact to existing dwellings or structures. We submit that this is an important example of the value of maintaining the rural nature of the surrounding area and that the pressure to develop on rural zoned land on a piece meal basis needs to be resisted.	Submission 1	The resident makes the point that existing rural zoned land has value in remaining rural. Among other benefits, it allows for floodplain functioning and flood management with no impact to existing or future development. It is expected that Council will make appropriate assessment of development applications with guidance from the findings of this flood study on flood prone land and key flood hydraulic zones (e.g. flood storage areas).
Consultation on further mitigation work and assessment		
With the complex nature of the water flows we support the recommendation to undertake land owner consultation to clarify impacts and confirm acceptable mitigation options as being essential. It is important that this also involve	Submission 1	The flood study makes the recommendation for comprehensive stakeholder consultation and to quantify the downstream impacts of the potential mitigation options during the FRMS to determine the feasibility of the options. It is expected that

comment from the general community and the RMS. From the modelling it is clear that mitigation for one area may come at a cost to another area.		optimisation of proposed mitigation works will be done at the FRMSP stage with the objective of preventing any resultant flood impacts to adjacent properties. Prioritisation of mitigation measures in the FRMSP should consider the presence and degree of any resultant impacts from the measures.
The draft plan has proposed upgrades to several drains that feed into the main drain, in flood events this would contribute to the pressure on the main drain and affect local properties. We question the finding at J.5 'Discussion on Flood Impacts to Downstream Areas', at J.5.2 it is stated that, "although the increases in flows are generally contained in the drains". As you can see from the attached photos, there is no containment of flood water in the main drain.	Submission 2	The flood study statement "although the increases in flows are generally contained in the drains" relates to the mapping of the increase in flood levels, which indicates that the increases are mainly contained in the drains This is separate to the issue that there is already existing flooding and ponding of water on the paddocks out of the drains. Nevertheless, Jacobs acknowledges the respondent's concerns that the potential mitigation options will add more floodwater to the main drain system and affect its capacity to service the drainage of existing properties. It is expected that the overall feasibility of the mitigation options will be further investigated in the FRMSP, taking into account the wider constraints on their effectiveness and their impacts.
The flood mitigations options 2 to 5 described in Appendix J of the Draft document all result in larger peak flows and volumes of water being directed onto the rural properties north of Old Main Road. This will result in increased flood and groundwater levels in that area as noted in the description for option 6a. Our concern is that if options 2 to 5 are implemented, our property will be negatively impacted by these increased flows and water	Submission 3	It is expected that optimisation of potential mitigation options will be done at the FRMSP stage with the objective of preventing any resultant flood impacts to adjacent properties. This may include amplifying existing drain capacity. Prioritisation of mitigation measures in the FRMS will consider whether they result in impacts to existing properties.

levels. We consider it essential that options 6a & 6b be implemented as well and the drains increased in capacity right through to the outlet into Tilligerry Creek. Not doing so has the potential to create downstream drainage and flooding impacts on private property.		
The plan, states that the drainage pipe is inadequate to drain the area. Why should it be drained anyway? There is currently no development in this area affected by the flooding at Blanch St low point in the 1% AEP. Let time absorb the flash flood of sudden downpour, and not transfer these huge trapped volumes to create a problem somewhere else? It could be argued that this natural storm water detention actual replenishes the ground water table, thus mitigating the effects of acid -sulphate soils and provides valuable bore water irrigation for gardens in summer. In modern terminology this is what is called "Storm water detention" holding back sudden volumes so they do not overwhelm down stream situations' The Very successful artificial catchment opposite Anna Bay Public school, preventing localised flooding by retaining volumes for slow discharge gradually later, shows how efficient this system is. My property is surrounded by minor drainage channels, which although are adequate, coupled with permeable soils allowing for fast absorption, and buildings above current flood levels, will be placed under stress, by the discharge of this catchment area onto the flat lands immediately adjoining my property and others. I have no other option to make this submission as a matter of record, because your proposal to	Submission 4	The resident's concern that the Blanch Street low point drainage modifications will result in increased runoff and flooding to their downstream property is acknowledged. The resident makes the point that this option is not worthwhile, as there is currently no development affected by the low point flooding, and that this potential option is likely to worsen flooding and drainage conditions to downstream properties. Further modelling and prioritisation of mitigation measures in the FRMS will consider whether they result in impacts to existing properties. The options are expected to be optimised with the objective of eliminating these impacts if possible. Furthermore, the need for this and other potential mitigation options will be determined during the FRMSP by weighing up its benefits against its costs, impacts and dis-benefits. Priority ratings will be placed on these options based on the outcomes of the assessment.

artificially drain the catchment in question, can only be considered a man made alteration and intervention to existing circumstances that have provided flood free status of my property for the previous 20 years (the life time of the subdivision.) Having that flood free status influenced, or placed in jeopardy by Council intervention, to repair an upstream problem of zero impact, puts Council in a situation of liability and cause. To place many established properties at risk, to solve an issue of minor point is greatly irresponsible and places the actions of Council at great risk of liability by a change in our existing risk factors. Topographical maps of our immediate area show we do not receive any surface run off from any other area higher than us, that is, we are not on the receiving end, no run of from elsewhere reaches us. And you wish to dump an entire catchment into our existing barely adequate drains. A copy of this email has been forwarded to my insurance company to inform them that proposed actions by council may well change the existing risk status of my property		

Upgrade of Main Drain Flood Gates We would like consideration given to upgrading the anna bay main drain flood gates. The significant issue with the current flood gates is the ability to allow flood water to escape when tides are high. From our experience, there is usually 3 hrs of draining when tides are turning, this occurs twice a day. Whilst this is adequate in every day operation, it is not enough to cope when there is a flood event. This was experienced in the 2015 and 2016 floods, when the main drain burst its banks. A pump station in combination with flood gates would allow the removal of flood waters through the entire time of the flood event, being independent of tidal impacts, drastically reducing the impact of the flood and improve the recovery time. A second option would be to increase the number of flood gates, however the tidal flows still present an issue.	Submission 2	A wide range of options for improving flooding conditions in the study area will be investigated in the FRMS, and this is likely to include the suggested improvements to Main Drain floodgates and a pump station, among others. Issues which will be considered in evaluating options include hydraulic performance and constraints, costs, sources of funding, engineering constraints and environmental impacts, and these will affect the options' feasibility and priority.

Appendix C. Model Calibration and Verification Data and Results

All daily rainfall data below is for rainfall depths recorded to 9am as per BOM convention.

Table C-1 Daily rainfall data April 2015 storm event

Date	Williamtown RAAF 061078	Fingal Bay (Fingal Haven) 061411	Tanilba Bay WWTP 061395
18/04/2015	0.1	0.2	2.9
19/04/2015	3.3	6	6.7
20/04/2015	9.6	17.2	23.2
21/04/2015	156	138.6	209
22/04/2015	114.4	145.4	136*
23/04/2015	8.8	5.4	-
Total	**292.2**	**312.8**	**377.8**

* Rainfall depth of 136mm was reported at Tanilba Bay gauge on 23/04/2015, but has been shifted to 22/04/2016 in this flood study based on the rainfall recorded at adjacent gauges on this date and from analysis of archived BOM rainfall radar images.

Table C-2 Daily rainfall data January 2016 storm event

Date	Williamtown RAAF 061078	Fingal Bay (Fingal Haven) 061411	Tanilba Bay WWTP 061395
3/01/2016	0	0	0
4/01/2016	40.6	52.4	38
5/01/2016	25.2	36	36
6/01/2016	225	117.8	209
7/01/2016	37.4	31.4	26
8/01/2016	0	1	0
Total	**328.2**	**238.6**	**309**

Figure C-1 Cumulative rainfall adopted for modelling of April 2015 calibration storm event

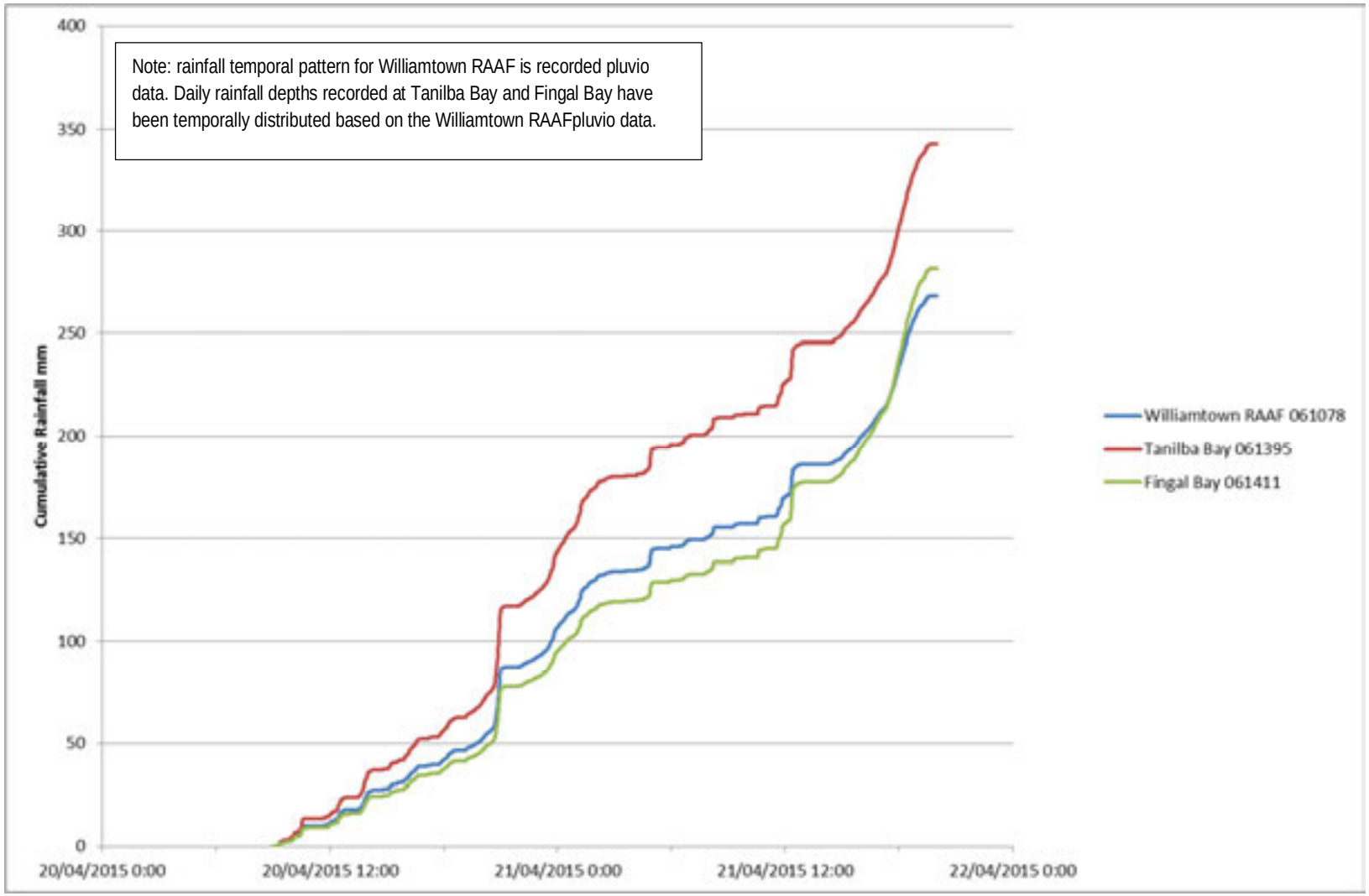
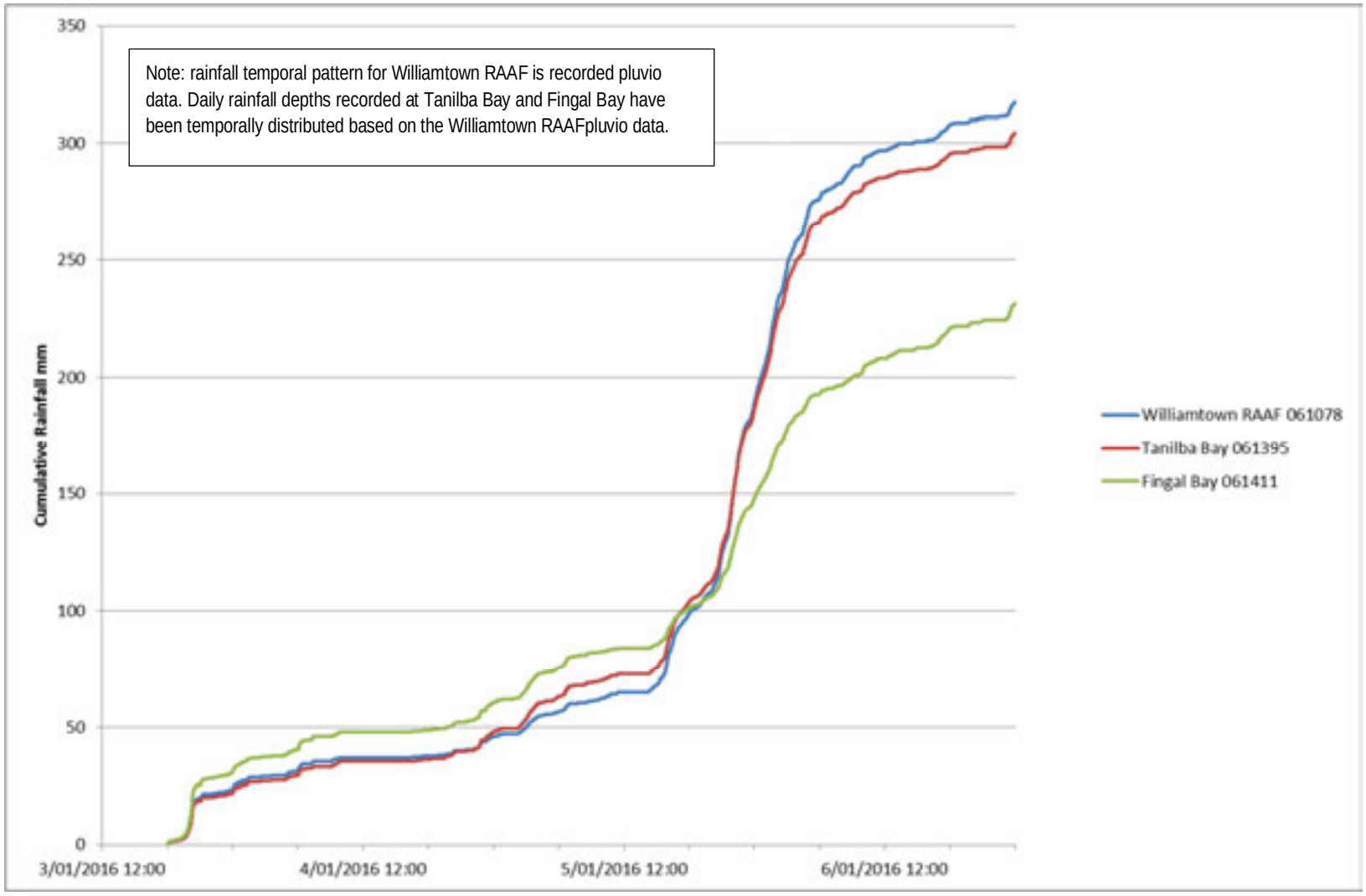


Figure C-2 Cumulative rainfall adopted for modelling of January 2016 Verification storm event



Legend

- Historic Flooding Observation
- Study Area

0 1 2 3 4 5 Kilometres

N

1:75,000@ A3

Figure C-3 Model Calibration and Verification Locations

JACOBS

Table C-3 Questionnaire responses and verification of modelled flood behaviour – April 2015 Storm Event

Refer to Figure C-1 for locations.

ID	Comment	Reported depth	Modelled depth	Reported Water Level	Modelled Water Level	Comment
7	Photo shows road flooding ~0.2 - 0.3m	0.2 - 0.3m	0.15 - 0.25m	7.06m AHD	7.02m AHD	Reasonable match
7	Photos show ~0.1m on garage door. water inside garage and alfresco	0.1-0.15m	0.05m	7.1m AHD	7.06m AHD	Shallower than observed. There is some uncertainty about the upgraded drainage network in this area which may affect the flooding conditions.
133	Property partly flooded. To 30cm in road 2015	0.3m	0.3m	5.05m AHD	5.13m AHD	Flooding in road consistent with observed. Backyard and part front yard flooded
149	Property flooded 2015 2016, vehicle access not impacted	-	-	-	-	Property partially flooded
219	2015. 200mm over road	>0.2m	0.15 - 0.2m	>8.41m AHD	8.41m AHD	Consistent with the observations
219	2015. 200mm over road	>0.2m	0.3 - 0.5m	>7.75m AHD	7.86m AHD	Consistent with the observations
226	2015 at door. In 2016, 10mm from coming inside	-	-	1.67m AHD	1.76m AHD	Satisfactory match
244	East end Marsh Road closed - 2015, 2016	-	Up to 0.2 - 0.3m	-	-	The modelled flood levels appear consistent with depths which would cut the road off. Due to elevated tide levels rather than runoff.

Table C-4 Questionnaire responses and verification of modelled flood behaviour – January 2016 Storm Event

Refer to Figure C-1 for locations.

ID	Comment	Reported depth	Modelled depth	Reported Water Level	Modelled Water Level	Comment
10	Sketch indicates road flooding in 2016	-	-	-	-	Model consistent with observation
11	Sketch indicates flooding 2016	-	-	-	-	Model consistent with observation
20	50% of property plus area to west floods	50% of property flooded	40% of property inundated	-	-	Reasonably consistent
37	In 2016 the water came within an inch of the entrance from the front door. The garage floods all the time	0.1m	0.06m	1.51m AHD	1.49m AHD	Satisfactory match
126	Flooding of property in 1990, 2015, 2016 etc. Water pump at rear of house was drowned in 2016, higher than 2015	-	-	1.85m AHD	1.99m AHD	Satisfactory match
126	Driveway flooding 300mm deep	0.3m	0.3 - 0.4m	-	-	Consistent with observation
135	In 2016 flooding to 0.6m in deepest areas. Sheds 0.2m deep	0.6m	0.45m	1.83m AHD	1.80m AHD	Good match
135	0.6m deepest. Sheds 0.2m 2016.	0.2m	Up to 0.2m	1.75m AHD	1.80m AHD	Good match
149	Property flooded 2015 2016, vehicle access not impacted					Property partially flooded
155	Entire lot 0.5m deep 2015 2016. Took 2 weeks to drain.	0.5m	0.2 - 0.5m	2.86m AHD	2.64m AHD	Lower modelled flood level on this property. Adjacent properties up to 0.5m deep
169	2015 drain blocked, overflow through lot. In 2016 0.3m deep under house and into garage.	0.3m	0.15m	7.73m AHD	7.58m AHD	Lower modelled flood level on this property. Actual amount of debris may have been than modelled, causing greater overflows
179	Moores Drain flooding 2015 2016. Under house and all property.	-	-	-	-	Most of property flooded. Flooding under house to shallow depths.
179	Sketch of 2016 flood outline	Flood outline	-	-	-	Modelling is reasonably consistent with sketched flood extent. Note the sketched extent does not exactly follow the ground level contours.
185	Photos of flooding on sheds on next door property.	~0.4m	0.4m	1.76m AHD	1.80m AHD	Model consistent with observation

185	Photos of flooding at rear corner of property	~0.3m	0.15m*	1.79m AHD	1.80m AHD	Model shows shallower depth but the coarse 20m grid is not picking up the actual ground level. When the modelled flood level is compared to LiDAR the flood depth is 0.3m and a good match.
211	20cm over Rookes Rd. 2016	0.2m	-	2.5m AHD	2.38m AHD	Approx. 100mm water over road. Underestimate of the flooding in the model is attributed to assumed higher initial rainfall loss in the upstream catchment, where swampy areas may have contributed to greater runoff in the field.
226	2015 at door. 2016 10mm from coming inside	-	-	1.72m AHD	1.80m AHD	Satisfactory match
244	East end Marsh Road closed - 2015, 2016 (?)	-	-	-	-	Port Stephens tides low compared to road levels and flood levels on high side of Marsh Road, allowing greater outflows through culverts. Tide does not reach road level. Catchment runoff not enough to cause overtopping.

Table C-5 Questionnaire responses and verification of modelled flood behaviour – General Observations

Refer to Figure C-1 for locations.

ID	Comment	Comment
6	Property flooded	Modelling shows this property as flood affected.
12	Previous flooding observed in this location	Modelling shows this area as flood affected.
15	Previous flooding observed in this location	Modelling shows this area as flood affected.
12	Previous flooding observed in this location	Modelling shows this area as flood affected.
12	Previous flooding observed in this location	Modelling shows this area as flood affected.
13	Road cut off (general stretch of Lemon Tree Passage Road near Michael Drive)	Modelled flooding to 0.2m at this location
21	Flooding observed in Anna Bay detention basins	Modelling shows this area as flood affected.
21	Flooding observed in Anna Bay detention basins	Modelling shows this area as flood affected.
23	Previous flooding observed in this location	Flooding shown in low areas of property
25	Flooding through garage once	Flooding of garage indicated for April 2015 simulation
27	Previous flooding observed in this location	Open space/marsh area. Model not configured in detail here, flooding not shown.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
27	Previous flooding observed in this location	Modelling shows this area as flood affected.
28	Previous flooding observed in this location	Modelling shows this area as flood affected.
33	Property does not flood	Rural property located on sand dune area. Required inclusion of runoff infiltration to reduce ponding in model to localised spots.
35	Previous flooding observed in this location	Flooding in swales and low points adjacent to Gan Gan Road, response is a bit vague
58	Previous flooding observed in this location	Modelling shows this area as flood affected.
58	Previous flooding observed in this location	Modelling shows this area as flood affected (tidal).
41	Flooding over road multiple locations	Modelled flooding over Lemon Tree Passage Road consistent with observation
77	Flooding backyard. House 6inch a few years ago	Model indicates shallow flooding of backyard fringe in April 2015 simulation but no flooding of house
105	Runoff from rear property	Model shows property is flood affected with flood behaviour consistent with observation
161	Trapped low point. Previous flooding 1998. Adj properties.	The model only showed very shallow flooding in the April 2015 simulation. Rainfall pattern in 1998 storm may have been different/more intense

165	Everytime we have heavy rain the rear section of our block floods but usually drains away fairly quickly	Depths to 0.7m in April 2015 simulation, drains away quickly after conclusion of rainfall
183	Property flooded, in sheds, 2015 2016	Large majority of property flooded with sheds affected.
203	Corner of Port Stephens Drive & Nelson Bay Road (property) and either side of Nelson Bay Road at various times	Modelling shows this area as flood affected.
232	Floods cnr Pacific Avenue and Fitzroy St and the water then runs through my yard and pools in the bottom of the yard	Appears to be a localised drainage problem being reported? This intersection is near catchment crest with only a small catchment area.
246	Lower level of the house flooded to a depth between 300-500mm approximately 3-4 times in period from 1980 to 2000	Depths to 0.3m in the April 2015 simulation with appears consistent with reports of previous flooding events
247	Water in road sag; also Pacific Ave/Fitzroy St	Model shows water in road sag over 0.3m deep. See comment on 232 for Pacific Ave/Fitzroy St flooding