



# NORTH WAGGA WAGGA LEVEE OPTIONS AND THIRD PARTY IMPACTS

## North Wagga Wagga Structural Assessment

Report number H15/01

Date 23 June 2015

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## North Wagga Wagga Structural Assessment

Report number H15/01

Date 4<sup>th</sup> March 2015

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## Executive Summary

NSW Public Works has been engaged by Wagga Wagga City Council to assess a number of options for North Wagga Wagga levee and assess the Third Party impacts of those options. Third Party Impacts being those impacts occurring outside the North Wagga Wagga levee system.

This assessment was based on a “desktop” review of those options based on information that could be readily obtained from using both Google Maps, a drive-by assessment of the structures in North Wagga Wagga and information from the previous flood modelling studies and assessed damages. There were no building inspections or similar activities involved.

The purpose of this type of assessment is to determine which options may be considered further in more detail and which options are not worthwhile pursuing further.

The options assessed are as per Council's Motion. The following table summarises the economic appraisal of all the options and shows that the most cost effective option is to raise the North Wagga Wagga levees to the 1 in 100 year flood level followed by the option of raising it to the 1 in 20 year flood level.

OPTIONS	Estimated capital cost (\$)	Present Value of Total Costs @ Discount Rates		
		7%	4%	10%
Option 1 - 1 in 20 year level of protection	\$4,800,000	\$23,533,535	\$29,921,657	\$19,517,931
Option 2 - 1 in 100 year level of protection	\$6,810,000	\$18,144,638	\$21,656,739	\$15,837,618
Option 3 - Remove the existing levees	\$395,000	\$30,310,571	\$41,204,526	\$23,657,446
Option 4 - Relocation of village	\$93,500,000	\$103,234,964	\$106,780,016	\$101,069,940
Option 5 - Raising houses in North Wagga and Mill and East St	\$16,850,000 <sup>#</sup>	\$26,732,463	\$30,331,229	\$24,534,636
Option 6 - Voluntary purchase of properties	\$37,200,000 <sup>#</sup>	\$46,934,964	\$50,480,016	\$44,769,940
*Option 7 - Raising Dwellings in Mill and East St	\$1,650,000 <sup>#</sup>	\$11,532,463	\$15,131,229	\$9,334,636
Option 8 - Maintain current (1 in 12 year) level of protection	\$ -	\$26,026,949	\$35,504,837	\$20,238,641

+ - Option 7 is a subset of Option 5 and has been presented for information purpose only.

# Middle level capital expenditure estimate; \* - Does not include AAD costs

However, it should be noted that the PV of costs for the 1 in 100 year level of protection option has not considered the costs of a number of dis-amenities identified for this option, whereas the option 1 (1 in 20 year level of protection) appears not to have as much of dis-amenities as for option 1.

The Third Party Impacts of these options was also assessed with an analysis of the “worst-case” scenario of having a 1 in 100 year flood event and the North Wagga Wagga levees raised to the 1 in 100 year flood level. The analysis found that there were increases in the flood heights up to 5km upstream of North Wagga Wagga in the floodplain, however this increase was small as follows:

- 0km – 2km between 100mm – 200mm;
- 2km – 3km between 50mm – 100mm;
- 3km – 5km between 20mm – 50mm.

Most of the development affected, which is in East Wagga Wagga, only has a change in depth of 20mm – 50mm, with the majority only having a change around 20mm.

The additional Average Annual Damages associated with all these increased flood depths would not alter the relativity of the options examined previously.

For lesser flood heights (i.e. 1 in 50 year flood events) the effect is less than the above. The analysis found that there were increases in the flood heights up to 4km upstream of North Wagga Wagga in the floodplain, and the increases were less as follows

- 0km – 3km between 50mm – 100mm;
- 3km – 4km between 20mm – 50mm;

Only half of the development in East Wagga Wagga is affected by flooding and those that are affected only have a change in depth of 20mm – 50mm.

In view of the above observations, it is recommended that the options 1 and 2 be shortlisted for further detailed evaluation.

## North Wagga Wagga Option Assessment

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NSW Public Works has been engaged by Wagga Wagga City Council to assess a number of options for North Wagga Wagga.

Options for floodplain management are conventionally grouped into two (2) categories, being non-structural and structural options. Examples in the non-structural category are such measures as town planning, flood warning and flood insurance; while examples in the structural category are flood mitigation dams, levees and channel improvements.

In this section various options that may be relevant to the situation in North Wagga Wagga will be discussed by undertaking a desktop assessment.

The desktop assessment consisted of obtaining the necessary information on house/dwelling numbers, locations, building types etc. etc. using both Google Maps and a drive-by assessment of the structures in North Wagga Wagga. There were no building inspections or similar activities involved.

These options assessed, as specified by Council, are as per Council's Motion:-.

*"Receive a further report on other options for providing flood protection for North Wagga residents and commercial operators in response to feedback from the community including:*

- i. *raising the North Wagga levee to a 1 in 20 year level of protection*
- ii. *raising the North Wagga levee higher than a 1 in 20 year level of protection*
- iii. *removing the existing North Wagga levees*
- iv. *relocation of the village from the floodplain*
- v. *raising residences in North Wagga*
- vi. *voluntary purchase for properties in North Wagga*
- vii. *raising houses in Mill and East Street that are protected by North Wagga levee two*
- viii. *maintain the levees at their current level of protection and take no further action"*

All assessments below assume that the main Wagga Wagga levee is raised to the 1 in 100 year flood level.

### OBJECTIVE

This report summarises the results of cost effectiveness analysis of these alternative options.

The primary objective of this analysis is to evaluate the proposed alternative options and recommend the most cost effective option in terms of the least Net Present Value.

### METHODOLOGY

Economic appraisal is a way of systematically analysing all the costs and benefits associated with various management strategies that meet the project objectives to assess their relative desirability.

NSW Treasury Guidelines for Economic Appraisal recommends the following two techniques:

- Cost Benefit Analysis (CBA)
- Cost Effectiveness Analysis (CEA)

CBA is usually adopted where the major costs and benefits of the alternative strategies can be valued in monetary terms.

CEA is adopted when the major costs and/or benefits of a project are not readily measured in monetary terms and the outputs of options are same or similar.

In the current context, as the alternative options are expected to offer same (or similar outcomes), CEA has been adopted for the analysis.



### **i) Raising the North Wagga Levee to a 1 in 20 year level of protection**

This option involves assessment of raising the North Wagga levee from the current approximate 1 in 12 years to the 1 in 20 year level of protection.

This option is currently being designed.

The cost estimates are:-

- a) Cost of raising the North Wagga Wagga levee is approximately \$3.35M.
- b) Cost of raising Levee Two is approximately \$1.45M.

These cost estimates are based on extracted quantities from the current design and unit rates from similar previous levee projects in the region.

#### **Average Annual Damages**

The estimated average annual cost of flooding in Australia is some \$400 million per year, of which New South Wales incurs some \$140 to \$150 million.

Actual and potential flood damage data can be presented as stage-damage curves for different property types. Such curves relate contents damage to depth of flooding above floor level. These curves are generally derived on the basis of numerous damage studies undertaken throughout Australia.

Average Annual Damages (AAD): Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.

Average Annual Damages can be thought of as a Self-Insurance Policy. That is, it is the amount of money that would have to be set aside each and every year to be drawn upon as needed to pay for flood damages when they occur in the future.

The Average Annual Damages for North Wagga Wagga and Levee Two for this option is \$689,000/year. Additionally, the AAD for the 233 residential properties on the Murrumbidgee flood plain at Wagga Wagga that are situated outside both the Main City and North Wagga Levees has been assessed as \$730,000/year. The total AAD for this option is \$1,419,000/year.

PROS	CONS
Provides additional level of protection over current level.	Does not provide full protection against flooding.
Provides the same level of protection that was designed for previously.	

### **ii) Raising the North Wagga levee higher than a 1 in 100 year level of protection**

This option involves assessment of raising the North Wagga levee to the 1 in 100 year level of protection.

The costings for this option allows for additional sheet piling work along Hampden Avenue where space is currently limited and where an earth levee would not be able to be constructed.

The cost estimates are:-

- a) Cost of raising the North Wagga Wagga levee is approximately \$4.13M.
- b) Cost of raising Levee Two is approximately \$1.62M.

These cost estimates are based on extrapolated quantities from option 1 and unit rates from similar previous levee projects in the region.

In addition, this option also impacts on the Main Wagga Wagga levee design as it causes an Aflux in the water levels immediately behind the North Wagga Wagga levee. This Aflux necessitates a height increase of a 5.1km length of the Main Wagga Wagga levee of between 100-200mm.

The additional cost to raise the Main Wagga Wagga levee to accommodate this is as follows:

- Length of levee raised = 5.1 km;
- % of levee sheet pile currently = 52%;
- Assume that this will increase to 75% for roughly 0.15m average raising;
- Total additional sheet pile becomes 5,100m x 0.5m wide @ \$250/m<sup>2</sup> = \$637,500;
- Concrete volume increase = 50 cub meter = \$100,000;
- Including CPI 10% from concept and 30% contingency gives \$1,054,625

Say \$1.06M.

Therefore the total Capital Cost of this option is \$6.81M.

### Average Annual Damages

The Average Annual Damages for North Wagga Wagga and Levee Two is reduced to \$149,000/year. The additional AAD for the 233 residential properties on the Murrumbidgee flood plain has been assessed as \$732,000/year. Hence, the total AAD for this option is \$881,000/year.

PROS	CONS
Provides similar level of protection as the Main Levee.	Loss of amenity with the levee being 0.9m – 1.0m higher than it currently is.
Has one of the least Average Annual Damages.	<p>There will be growing pressure to allow the construction of new houses on vacant blocks which will lead to an increase in the number of houses (say 200%) which will:-</p> <ul style="list-style-type: none"> <li>• Create a huge responsibility for rescue organisations when floods larger than the 1 in 100 flood eventuates and there is no high ground to evacuate to;</li> <li>• Lead to more damages costs due to there being more infrastructure.</li> </ul>
	Existing road access is currently very congested when there is a flood event and if there were 3 times the volume of traffic it would be unworkable requiring extra costs (e.g. for road widening, more bridging) to improve access.
	Causes the height of the Main Wagga Wagga levee to increase for 5.1km.

### iii) Removing the existing North Wagga levees

As a comparison to the other options, the removal of the North Wagga Wagga levee system would involve the removal and disposal offsite of some 50,000m<sup>3</sup> of fill from the North Wagga Wagga Levee and some 20,000m<sup>3</sup> of fill from Levee Two.

Where to dispose of these quantities of material would be a problem. Options to consider would be to dispose of them back into the Borrow Pit being used for the construction of the Main Levee Bank, at the Tip Site or to be used as needed by residents.

It is unlikely that the material would be needed at once by the Tip but would only be able to be disposed of over many years (minimum 10 – 15 years). A similar time period is envisaged for the disposal of material to resident's as well.

Therefore, for comparison, the costs are prepared on the basis of disposal at the Borrow Pit.

The cost estimates are:-

- a) Removal of North Wagga Wagga levee is approximately \$320K.
- b) Removal of Levee Two is approximately \$75K.

These cost estimates are based on the cartage of material 2-3km from site and using unit rates from similar previous levee projects in the region.

### Average Annual Damages

The Average Annual Damages for North Wagga Wagga and Levee Two increase to \$1,515,000/year. Including the AAD for the additional 233 residential properties that are situated outside both the Main City and North Wagga Levees (\$716,000/year), the total AAD for this option is \$2,231,000/year.

PROS	CONS
Has the cheapest capital cost.	Provides NO flood protection.
	Has the highest Average Annual Damages.
	Will result in property damage (and potentially loss of life).

### Planning

Planning measures which seek to attain Council's objectives are a basic and common-sense option. Techniques such as development controls and land use zoning can be used to positively identify flood hazards, to deter unwise development in flood prone areas and to prevent further obstruction of floodways. As implied by the name, planning measures are most powerful and useful in a situation where they precede development. However, this is not the case for North Wagga Wagga.

In situations like North Wagga Wagga where there is already a large degree of development on the floodplain, town planning measures addressing the flood problem must be realistic and applied with sensitivity. Questions arise as to the rights of landholders, compensation, economic hardship and social disruption. There are many examples where inappropriate, or inappropriately applied, town planning measures have generated considerable opposition from those whom the planners sought to benefit; opposition which lead to the eventual abandonment of the measures.

#### iv) Relocation of the village from the floodplain

Relocation of the dwellings and other forms of development is a measure that can be implemented through the planning process. This option also has a structural component. In the end it comes down to the physical removal of structures and resiting outside the floodplain (for example "New North Wagga Wagga" suburb).

Except for brick clad buildings and buildings with slab-on-ground, transportation of dwellings to another site can usually be accomplished at moderate cost and minimal disruption. In other cases extensive demolition is usually required. The relocation of steel tanks and silos, and stockpiles of building materials can also be readily achieved.

There are also a number of commercial premises that would not be readily relocatable as follows:-

**Table 1 – Number of dwellings**

	Number of dwellings probably relocatable	Number of dwellings unlikely to be relocatable	Total
North Wagga Wagga	96	52	148
(Non-residential properties)	7	12	19

In consideration of the social and economic well-being of residents, assessment of this option is on the basis of providing “like-for-like”. That is, on the basis of the equivalent amount of land, infrastructure and amenities as well as keeping the sense of neighbourhood. In effect this option is based on the creation of a new Suburb in Wagga Wagga and relocating

The cost of the infrastructure works (i.e. the new development) is expected to be in the order of \$107/m<sup>2</sup>. The size of the current North Wagga Wagga area (i.e. the area inside the levee bank) is 816,000m<sup>2</sup> and Mill and East Street Levee is 58,000m<sup>2</sup>.

This unit rate is based on general industry advice for developments within the region.

Therefore, the cost to prepare the new Suburb is:-

**Table 2 – Development costs of new suburb**

	Area (m <sup>2</sup> )	Cost of infrastructure (\$107/m <sup>2</sup> )
North Wagga Wagga	816,000	\$87.3M
Mill and East Street Levee	58,000	\$6.2M

This does not include the cost of the purchase of land nor the relocation of all the dwellings and other the facilities (e.g. garages, sheds, gardens, fences, parks, sporting facilities, school etc.) currently in these areas.

Nor does it include the cost of demolition of buildings that cannot be relocated.

### Average Annual Damages

The Average Annual Damages including the AAD for the 233 residential properties on the Murrumbidgee flood plain at Wagga Wagga that are situated outside both the Main City and North Wagga Levees would be \$726,000/year.

PROS	CONS
Has the dearest capital cost.	Would be a <u>major</u> disruption.

### v) Raising residences in North Wagga

Raising of the dwellings is a measure that can also be implemented through the planning process. While this option is a structural option it also has a planning component (i.e. any future development to only have raised dwellings).

This option is a flood proofing measure which involves the raising of dwellings so that floor heights are above the flood levels. This would also involve sealing off the ingress of floodwaters through sewers underneath the dwellings and in the streets.

The following assumptions have been made when assessing this option:-

1. Only the houses are raised;
2. There will be no raising of sheds, garages or other structures;
3. There are some houses that cannot be raised (determined from drive-by assessment only i.e. no internal inspections);
4. Cost of all plumbing, sewer etc. to be included;
5. Assume an open steel frame support structure;
6. Assume underneath area not to be enclosed.

For a weatherboard house, an indicative cost may be:-

a. Jacking the house and providing steel frame support	\$30K
b. Plumbing	\$ 3K
c. Electrical	\$ 3K
d. Structural certification	<u>\$ 5K</u>
	\$41K

For a brick house an additional \$10K has been allowed \$51K

However, the costs will vary depending on a number of factors including, but not limited to, the size of the house, the condition of the flooring, complexity of services etc. As well, the volume of work (i.e. raising multiple houses) can influence the above unit costs.

As such, for this desktop assessment, it has been decided to use a range of unit costs as follows:-

Lower value \$40K

Middle value \$50K

Higher value \$60K

These unit rates are based on general industry advice for raising house within the region.

In the 2009 the Floodplain Management Study (prepared by consultants WMA Water) identified the following properties that would be inundated:-



From "Wagga Wagga Floodplain Management Study" – WMA Water 2009

**Table 3 – Number of dwellings**

	Number of dwellings probably raised	Number of dwellings unlikely to be raised	Total
North Wagga Wagga	96	52	148
(Non-residential properties)	7	12	19

**Table 4 – Cost of raising dwellings that probably can be raised**

	Number of dwellings probably raised	Lower value (\$40K/unit)	Middle value (\$50K/unit)	Higher value (\$60K/unit)
North Wagga Wagga	96	\$3,840,000	\$4,800,000	\$5,760,000
(Non-residential properties)	7	\$280,000	\$350,000	\$420,000
<b>Total</b>	<b>103</b>	<b>\$4,120,000</b>	<b>\$5,150,000</b>	<b>\$6,180,000</b>

However, the above costs do NOT include the cost of raising the other dwellings that are considered unlikely to be raised. The dwellings and non-residential premises that cannot be raised are a major disadvantage of this option as they would still incur flood damage.

However, for the purposes of comparison with other options, the cost of construction of a new raised dwelling needs to be allowed. For comparative purposes, assume the cost of a new house ranges from \$150K - \$250K with the cost of non-residential dwellings being double that.

These costs are based on typical costs for various standards of new construction.

Indicative costs are as follows:-

**Table 5 – Cost of construction of additional dwellings**

	Number of dwellings probably constructed	Lower value (\$150K/unit)	Middle value (\$200K/unit)	Higher value (\$250K/unit)
North Wagga Wagga	52	\$7,800,000	\$10,400,000	\$13,000,000
(Non-residential properties) – assume double the	12	\$3,600,000	\$4,800,000	\$6,000,000
<b>Total</b>	<b>64</b>	<b>\$11,400,000</b>	<b>\$15,200,000</b>	<b>\$19,000,000</b>

For comparison purposes, the total costs are:-

**Table 6 – Comparative cost of all dwellings**

	Number of dwellings	Lower value	Middle value	Higher value
North Wagga Wagga	148	\$11,640,000	\$15,200,000	\$18,760,000
(Non-residential properties)	19	\$3,880,000	\$5,130,000	\$6,420,000
<b>Total</b>	<b>167</b>	<b>\$15,520,000</b>	<b>\$20,350,000</b>	<b>\$25,180,000</b>

For the Mill and East Street Levee:-

**Table 7 – Number of dwellings that probably can be raised**

	Number of Houses probably raised	Number of Houses unlikely to be raised	Total
Mill and East Street	17	4	21

**Table 8 – Cost of house raising**

	Number of dwellings probably raised	Lower value (\$40K/unit)	Middle value (\$50K/unit)	Higher value (\$60K/unit)
Mill and East Street	17	\$680,000	\$850,000	\$1,020,000

For the purposes of comparison with other options, the cost of construction of a new raised dwelling needs to be allowed. For comparative purposes, assume the cost of a new house ranges from \$150K - \$250K with the cost of non-residential dwellings being double that.

These costs are based on typical costs for various standards of new construction.

Indicative costs are as follows:-

**Table 9 – Cost of construction of additional dwellings**

	Number of dwellings constructed	Lower value (\$150K/unit)	Middle value (\$200K/unit)	Higher value (\$250K/unit)
Mill and East Street	4	\$600,000	\$800,000	\$1,000,000

For comparison purposes only, the total costs are:-

**Table 10 – Comparative cost of all dwellings**

	Number of dwellings	Lower value	Middle value	Higher value
Mill and East Street	21	\$1,280,000	\$1,650,000	\$2,020,000

The cost for both North Wagga Wagga and the Mill and East Street combined are:-

**Table 11 – Comparative cost of all dwellings (North Wagga Wagga and the Mill and East Street combined)**

	Number of dwellings	Lower value	Middle value	Higher value
All	188	\$16,800,000	\$22,000,000	\$27,200,000

### Average Annual Damages

The order of magnitude of the Average Annual Damages for the properties within the levee protected area cannot be calculated as it is unknown how many dwellings will be raised, how many home owners will take up the offer for this to be done etc. Hence, the AAD considered for this option comprises only the AAD for the residential properties on the Murrumbidgee flood plain at Wagga Wagga that are situated outside both the Main City and North Wagga Levees and has been assessed as \$726,000/year.

PROS	CONS
Dwellings are out of the floodwaters.	Some dwellings cannot be raised.
	Those dwellings that cannot be raised would require the construction of new raised dwellings.
	Damage to other property (i.e. sheds, garages, stables etc. etc.) would still occur.
	Damage to facilities (e.g. water, sewerage, parks and gardens etc.) would still occur.
	More difficult for elderly or disabled people to access dwellings.
	Cost greater than cost of levee raising.



## vi) Voluntary purchase for properties in North Wagga

The Voluntary Purchase of properties may be done as follows:-

- If and when a property is put on the market, Council buys the property;
- Council not allow the sale of the property to anyone else;
- Property value determined by independent Valuer;
- No new development to be allowed.

Consideration may also give consideration to imposing a time limit for this scheme (e.g. 15 years).

For the assessment of this option, no attempt was made to obtain actual property values. The cost estimates given below are illustrative only. If it is required to investigate this option further, then more accurate estimates of property values would need to be obtained.

However, as can be seen below, the cost of this option is considered prohibitive.

**Table 12 – Comparative cost of voluntary purchasing**

	Number of dwellings probably raised	Lower value (\$150K/unit)	Middle value (\$200K/unit)	Higher value (\$250K/unit)
North Wagga Wagga	167	\$25,050,000	\$33,400,000	\$41,750,000
Mill and East Street	19	\$2,850,000	\$3,800,000	\$4,750,000
<b>Total</b>	<b>186</b>	<b>\$27,900,000</b>	<b>\$37,200,000</b>	<b>\$46,500,000</b>

### Average Annual Damages

Average Annual Damages cannot be calculated as it is unknown how many dwellings within the North Wagga levee protected area will be purchased, how many home owners will take up the offer for this to be done etc. Hence, for this option also, an AAD of \$726,000/year has been considered to account for the damages to the residential properties that are situated outside both the Main City and North Wagga Levees.

PROS	CONS
	<u>Very</u> expensive.
	Damages can occur while waiting for properties to be voluntarily sold.

## vii) Raising houses in Mill and East Streets only

An option that is to be considered is to raise only the houses in Mill and East Streets that are currently protected by the North Wagga levee two to above the flood level (similar to Option v).

**Table 13 – Number of dwellings**

	Number of Houses probably raised	Number of Houses unlikely to be raised	Total
Mill and East Street	17	4	21

**Table 14 – Cost of house raising**

	Number of dwellings probably raised	Lower value (\$40K/unit)	Middle value (\$50K/unit)	Higher value (\$60K/unit)
Mill and East Street	17	\$680,000	\$850,000	\$1,020,000

Like Option v, this does NOT include the cost of raising the other dwellings that are considered unlikely to be raised. The dwellings that cannot be raised are a major disadvantage of this option as they would still incur flood damage.

However, for the purposes of comparison with other options, the cost of construction of a new raised dwelling needs to be allowed. For comparative purposes, assume the cost of a new house ranges from \$150K - \$250K with the cost of non-residential dwellings being double that. Indicative costs are as follows:-

**Table 15 – Cost of construction of additional dwellings**

	Number of dwellings probably raised	Lower value (\$150K/unit)	Middle value (\$200K/unit)	Higher value (\$250K/unit)
Mill and East Street	4	\$600,000	\$800,000	\$1,000,000

For comparison purposes only, the total costs are:-

**Table 16 – Comparative cost of raising all dwellings**

	Number of dwellings probably raised	Lower value	Middle value	Higher value
Mill and East Street	21	\$1,280,000	\$1,650,000	\$2,020,000

The pros and cons are the same as for option vi). Also, the Average Annual Damages for this option has been considered as the same as for option vi).

### **viii) Maintain the levees at their current level of protection and take no further action**

This is the “status-quo” option.

At present, the current level of protection of the levee system is approximately 1 in 12 years only. Prior to the 2009 Flood Study, the levee system was considered to offer a 1 in 20 year level of protection.

It is likely development decisions have been made over the years based on their being a 1 in 20 year level of protection and the current 1 in 12 year protection negates those decisions.

There is no cost associated with this option.

### Average Annual Damages

The Average Annual Damages for the properties within the levee protected areas estimated as \$1,204,000/year. Including the AAD for the additional 233 residential properties that are situated outside both the Main City and North Wagga Levees (\$726,000/year), the total AAD for this option is \$1,930,000/year.

### SUMMARY

Options	North Wagga Wagga	Levee Two	AAD	
			Levee Protected Areas	Murrumbidgee Floodplains
<i>i) raising the North Wagga levee to a 1 in 20 year level of protection</i>	\$3.35M	\$1.45M	\$689,000	\$730,000
<i>ii) raising the North Wagga levee higher than a 1 in 20 year level of protection</i>	Raise to 1 in 100 year level of protection \$4.13M + Main Levee works \$1.06M	\$1.62M	\$149,000	\$732,000
<i>iii) removing the existing North Wagga levees</i>	\$320K	\$75K	\$1,515,000	\$716,000
<i>iv) relocation of the village from the floodplain</i>	greater than \$87.3M*	greater than \$6.2M*	\$0	\$726,000
<i>v) raising residences in North Wagga and Mill and East Streets</i>	\$15.5M to \$25.18M	\$1.28M to \$2.02M	-	\$726,000
<i>vi) voluntary purchase for properties in North Wagga</i>	\$25M to \$41.7M	\$2.85M to \$4.75M	-	\$726,000
<i>vii) raising houses in Mill and East Street that are protected by North Wagga levee two</i>	-	\$1.28M to \$2.02M	-	\$726,000
<i>viii) maintain the levees at their current level of protection and take no further action</i>	\$0	\$0	\$1,204,000	\$726,000

## Economic Appraisal of Options

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### Objective

This section summarises the results of cost effectiveness analysis of the alternative options for flood security in the areas protected by the North Wagga Levees. The primary objective of this analysis is to evaluate and recommend the most cost effective option from among the proposed alternative options.

### Methodology

Economic appraisal is a way of systematically analysing all the costs and benefits associated with various management strategies that meet the project objectives to assess their relative desirability.

NSW Treasury Guidelines for Economic Appraisal recommends the following two techniques:

- Cost Benefit Analysis (CBA)
- Cost Effectiveness Analysis (CEA)

CBA is usually adopted where the major costs and benefits of the alternative strategies can be valued in monetary terms.

CEA is adopted when the major costs and/or benefits of a project are not readily measured in monetary terms and the outputs of options are same or similar.

In the current context, as the alternative options are expected to offer similar outcomes and not all the major benefits are quantified and valued in monetary terms, CEA has been adopted for the analysis.

### Cost Effectiveness Analysis

Following assumptions have been made for the cost effectiveness analysis:

- All estimated capital costs are in current (2014/15) dollars and all the capital expenditure will be incurred by June 2015
- The evaluation period is 30 years
- The useful economic life of the assets constructed under the project is 100 years
- The residual value of the assets at the end of the evaluation period will be at a level pro-rata to the remaining useful economic life
- Maintenance of the levee system is deemed to include the costs of
  - i. Yearly inspections;
  - ii. 5-yearly Audits;
  - iii. 5-yearly crest level surveys

As well as the normal yearly maintenance activities (e.g. tree/shrub removal, erosion repair, pest eradication/repair e.g. rabbit holes, grass mowing, weed eradication etc.).

While a newly constructed levee may not need maintenance, the annual growth of saplings and shrubs means that maintenance needs to commence soon afterwards. As well, if there are levees through high visibility areas (e.g. parks and gardens, town centre) there can be also a cost in maintain them in pristine condition.

As levees age, the deterioration also accelerates thus requiring more maintenance. If maintenance is neglected for a few years, the cost of maintenance actually increases as problems just magnify in size (e.g. removal of a small sapling one year is significantly less than the removal of a tree a few years later).

In addition, there is the cost of maintaining the stormwater structures (i.e. pipes, gate valves and pumps).

Taking all the above into consideration, the average cost can be related to a per metre rate of approximately \$2.00/m/year. For the main Wagga levee this equates to approximately \$18K/year and North Wagga Wagga \$11K/year.

The present values (PV) of the total costs comprising the capital cost, O&M cost and the estimated average annual damage (AAD) cost of options have been determined for a discount rate of 7% p.a. The sensitivities of the PVs of options at higher and lower discount rates of 10% p.a. and 4% p.a. also have been analysed. The results of cost effectiveness analysis are presented in the Table below.

The primary objective of this analysis is to evaluate the proposed alternative options and recommend the most cost effective option in terms of the least Present Value.

OPTIONS	Estimated capital cost (\$)	Present Value of Total Costs @ Discount Rates		
		7%	4%	10%
Option 1 - 1 in 20 year level of protection	\$4,800,000	\$23,533,535	\$29,921,657	\$19,517,931
Option 2 - 1 in 100 year level of protection	\$6,810,000	\$18,144,638	\$21,656,739	\$15,837,618
Option 3 - Remove the existing levees	\$395,000	\$30,310,571	\$41,204,526	\$23,657,446
Option 4 - Relocation of village	\$93,500,000	\$103,234,964	\$106,780,016	\$101,069,940
Option 5 - Raising houses in North Wagga and Mill and East St	\$16,850,000 <sup>#</sup>	\$26,732,463	\$30,331,229	\$24,534,636
Option 6 - Voluntary purchase of properties	\$37,200,000 <sup>#</sup>	\$46,934,964	\$50,480,016	\$44,769,940
*Option 7 - Raising Dwellings in Mill and East St	\$1,650,000 <sup>#</sup>	\$11,532,463	\$15,131,229	\$9,334,636
Option 8 - Maintain current (1 in 12 year) level of protection	\$ -	\$26,026,949	\$35,504,837	\$20,238,641

+ - Option 7 is a subset of Option 5 and has been presented for information purpose only.

# Middle level capital expenditure estimate; \* - Does not include AAD costs

## Conclusions and Recommendations

The PVs of costs considered for the analysis present the long term aggregated value of all the current and future costs for each of the alternative options over the next 30 year period in today's dollar values. Hence, the most preferable option will be the one with the least PV of costs and the least preferable option with the highest PVs of costs.

A comparison of the PVs of alternative options for the improving the flood protection level by North Wagga Levees clearly establishes that the options 3, 4 and 6 are least cost effective and would not require any further consideration. It should be noted that option 3 does not offer any flood protection.

Options 5 and option 8 have about the same PV of costs. However, it should be noted that option 5 does not considered any costs towards annual damages in the current levee protected areas. Hence, the PV of costs for option 5 is less reliable and is not preferable.

Option 8 is the 'status quo' option offering no further improvements towards flood protection while incurring damage costs due to flood risks, hence can be disregarded.

Among the remaining options, the North Wagga levy upgrade 'Option 2 – 1 in 100 year level of flood protection' has the lowest PV of total costs at the benchmark discount rate of 7% p.a. The PV of option 2 remains the lowest at both the sensitivity discount rates of 4% p.a. and 10% p.a. Therefore, in terms of cost effectiveness, option 2 is preferable. However, it should be noted that the PV of costs for this option has not considered the costs of a number of dis-amenities identified for this option.

Option 1 – 1 in 20 year level of protection is the second best among the proposed alternative options in terms of cost effectiveness and appears not to have as much of dis-amenities as for option 1.

In view of the above observations, it is recommended that the options 1 and 2 be shortlisted for further detailed evaluation.

## Third Party Impact Assessment

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NSW Public Works has been engaged by Wagga Wagga City Council to determine what impact the proposed of the levee will have on properties in the floodplain and to propose feasible mitigative measures. The assessment is carried out based on concept and detailed design drawings.

NSW Public Works engaged WMA Water to re-run the hydraulic model to explore the impacts of various alternatives at North Wagga Wagga.

Where a property is impacted, an assessment was made for the change in water depth which is the primary indicator of any additional damages. The assessment then formed part of a database on each structure in relation to its intrinsic characteristics and floodplain changes.

Where the upgrade of the levees will result in an unreasonable impact upon a residential or commercial property, feasible mitigative measures were to be suggested to remove or reduce the risk to an acceptable level. The mitigative measures would be costed appropriately so that Council has a clear understanding of the possible economic and social ramifications.

### Third Party Impact Assessment

NSW Public Works through discussions with WMA Water understands the current flood model has been used to assess the following design scenarios:

- 1% AEP flood with current levee conditions;
- 1% AEP flood with Main levee raised to 1%AEP with 0.9m freeboard and North Wagga raised to a 5% AEP with 0.7m freeboard;
- 5% AEP flood with current levee conditions; and
- 5% AEP flood with current Main levee conditions and North Wagga raised to a 5% AEP with freeboard

Two additional model runs were required:

- 1% AEP flood with Main levee raised to 1% AEP with 0.9m freeboard and North Wagga with current conditions; and
- 1% AEP flood with Main levee raised to 1% AEP with 0.9m freeboard and North Wagga levee removed.

### Flood Modelling

Flood Modelling has been undertaken for Wagga over a number of years. Firstly by Webb, McKeon & Associates Pty Ltd. in 2004 then WMA Water in 2009 and WMA Water in 2014. This last flood modelling was commissioned to ensure Council had the latest flood modelling information in light of the 2010 and 2012 flood events. Further analysis by WMA Water was also undertaken in January 2015 for the two additional model runs.

The assessment of the North Wagga Wagga Levee Options and the Third Party Impacts are based on these modelling results.

The following graphical information has been extracted from these previous reports for the scenarios shown on the next page.

SCENARIO	FIGURE	MODELLED FLOOD EVENT
1. Leave at existing level.	1	1 in 100 year
2. Remove levee entirely.	1	1 in 100 year
3. Increase levee design height to 1 in 20 year event. Change in depth.	2 3	1 in 20 year 1 in 20 year
4. Increase levee design height to 1 in 100 year event. Change in depth.	4	1 in 50 year
5. Increase levee design height to 1 in 100 year event. Change in depth.	5	1 in 100 year

## Discussion

The following observations are made:-

1. From Figure 1 - The flood extent and water depth in a 1 in 100 year flood event are the same for both removing the North Wagga Wagga levee completely and leaving it at its current height (i.e. scenarios 1 and 2);
2. From Figure 2 – The flood extent and water depth in a 1 in 20 year flood event is less than that of a 1 in 100 year flood event. Primarily the areas in the south east of Wagga Wagga (along the Sturt Highway) start to become affected;
3. From Figures 3, 4 & 5 – For the scenario that the North Wagga Wagga levee is raised to the 1 in 100 flood level, there is a change in flood levels upstream but very little additional land is inundated.

## Assessment and conclusion

Figure 5 shows the worst case scenario of the 1 in 100 year flood level with the North Wagga Wagga levee also raised to the 1 in 100 year level.

Floodwaters have to now go around the North Wagga Wagga levee (rather than overtopping it) on the northern and southern sides. This results in there being some 20mm – 100mm of additional depth of water at these locations.

The water also backs up immediately behind the North Wagga Wagga levee resulting in increased water depths for a distance of only some 5km. Beyond this the floodplain widens out and there is no change in the water levels as shown by the areas in grey.

Areas both downstream of North Wagga Wagga levee and greater than 5km upstream means there is NO change in the depth of the floodwaters due to the raising of the North Wagga Wagga levee.

For this approximate 5km section the increased depths are:-

- 0km – 2km between 100mm – 200mm;
- 2km – 3km between 50mm – 100mm;
- 3km – 5km between 20mm – 50mm.

It is also noted that most of the development in East Wagga Wagga only has a change in depth of 20mm – 50mm, with the majority only having a change around 20mm.

The additional Average Annual Damages associated with all these increased flood depths would not alter the relativity of the options examined previously.



For lesser flood heights (i.e. 1 in 50 year flood events) the effect is less than the above. The analysis found that there were increases in the flood heights up to 4km upstream of North Wagga Wagga in the floodplain, and the increases were less as follows

- 0km – 3km between 50mm – 100mm;
- 3km – 4km between 20mm – 50mm;

Only half of the development in East Wagga Wagga is affected by flooding and those that are affected only have a change in depth of 20mm – 50mm.

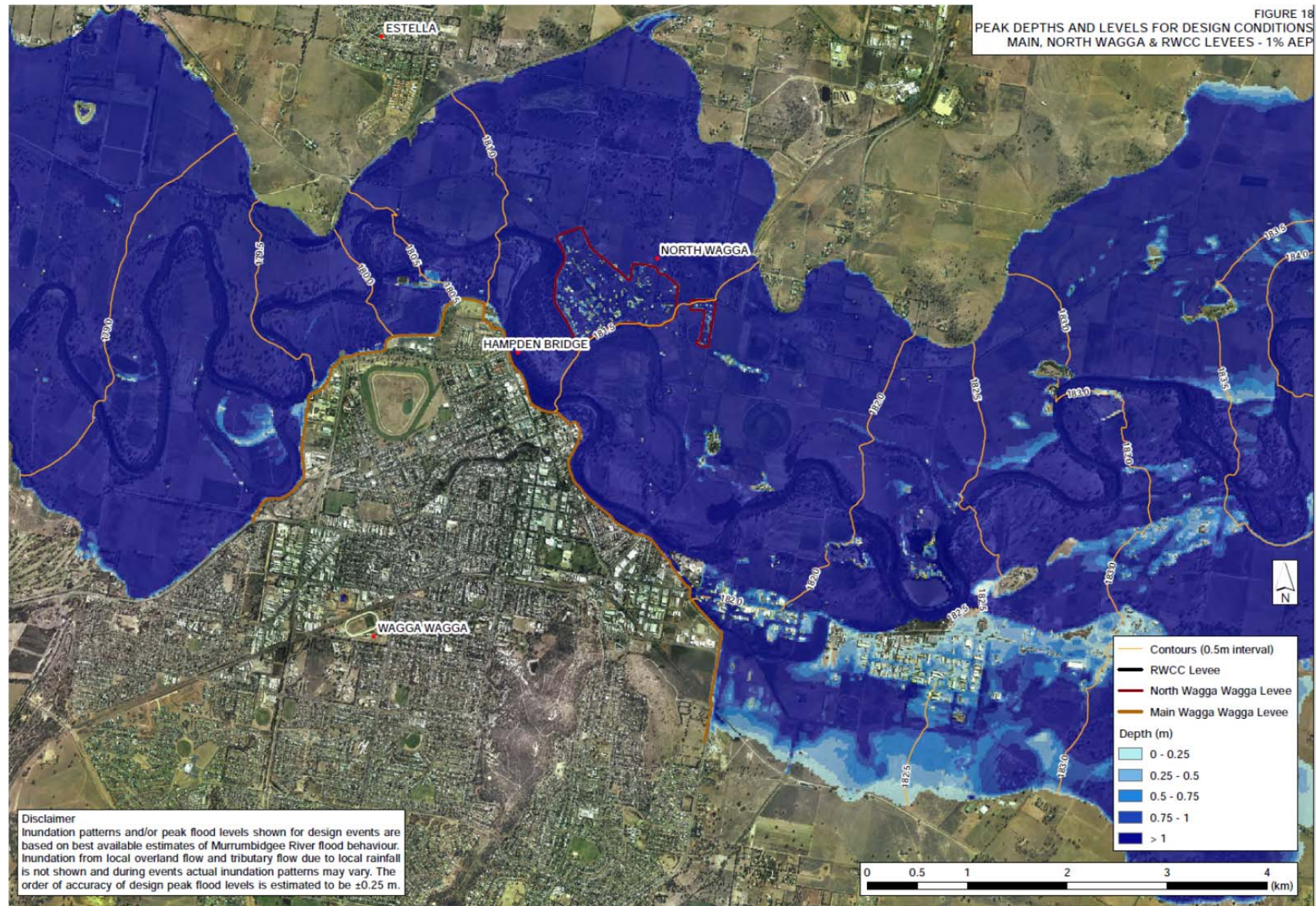


Figure 1 – Current levee level and removal of North Wagga Wagga levee with 1 in 100 year flood extent map



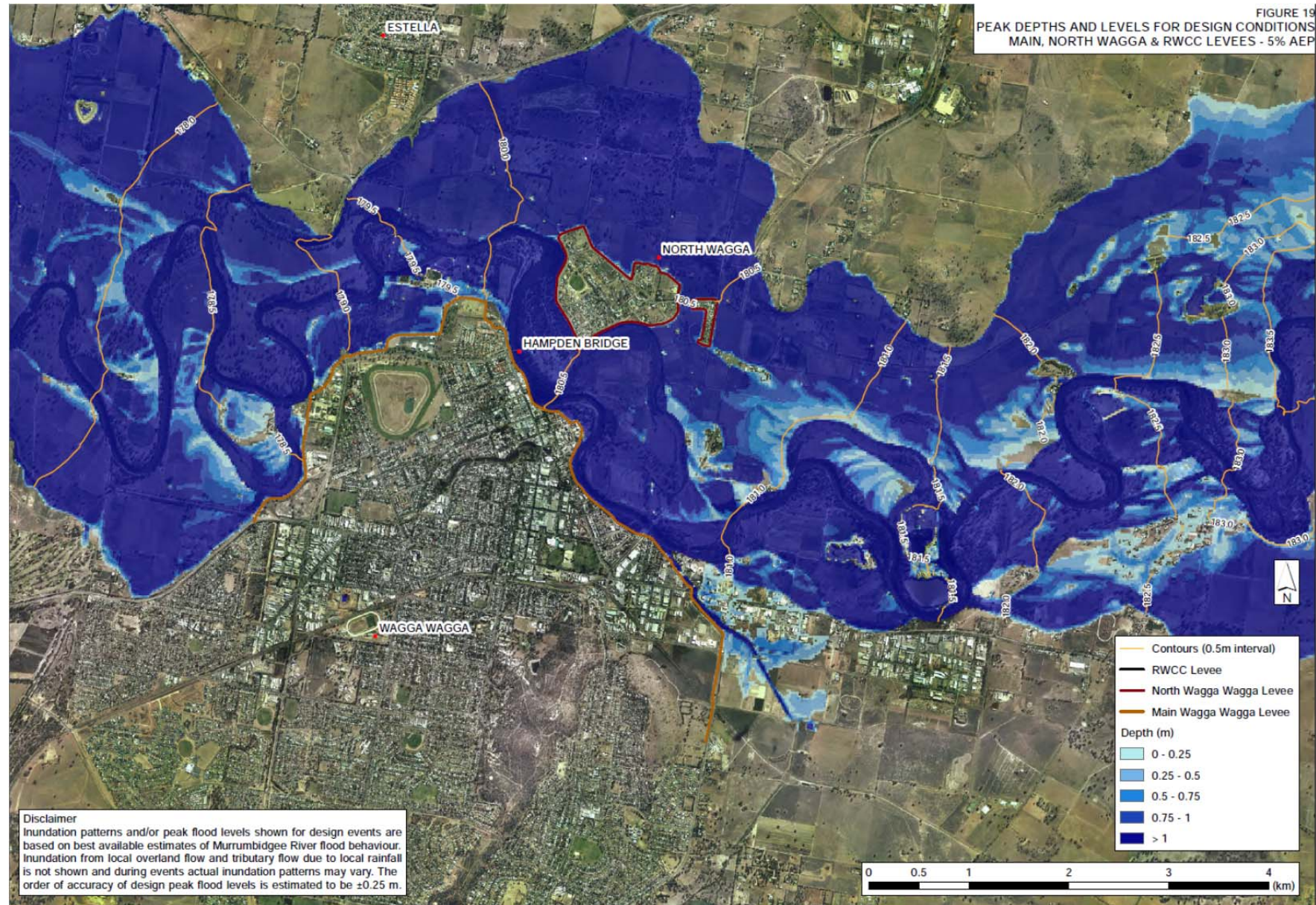


Figure 2 – 1 in 20 year North Wagga Wagga levee with 1 in 20 year flood extent map



## North Wagga Wagga Levee Options and Third Party Impacts

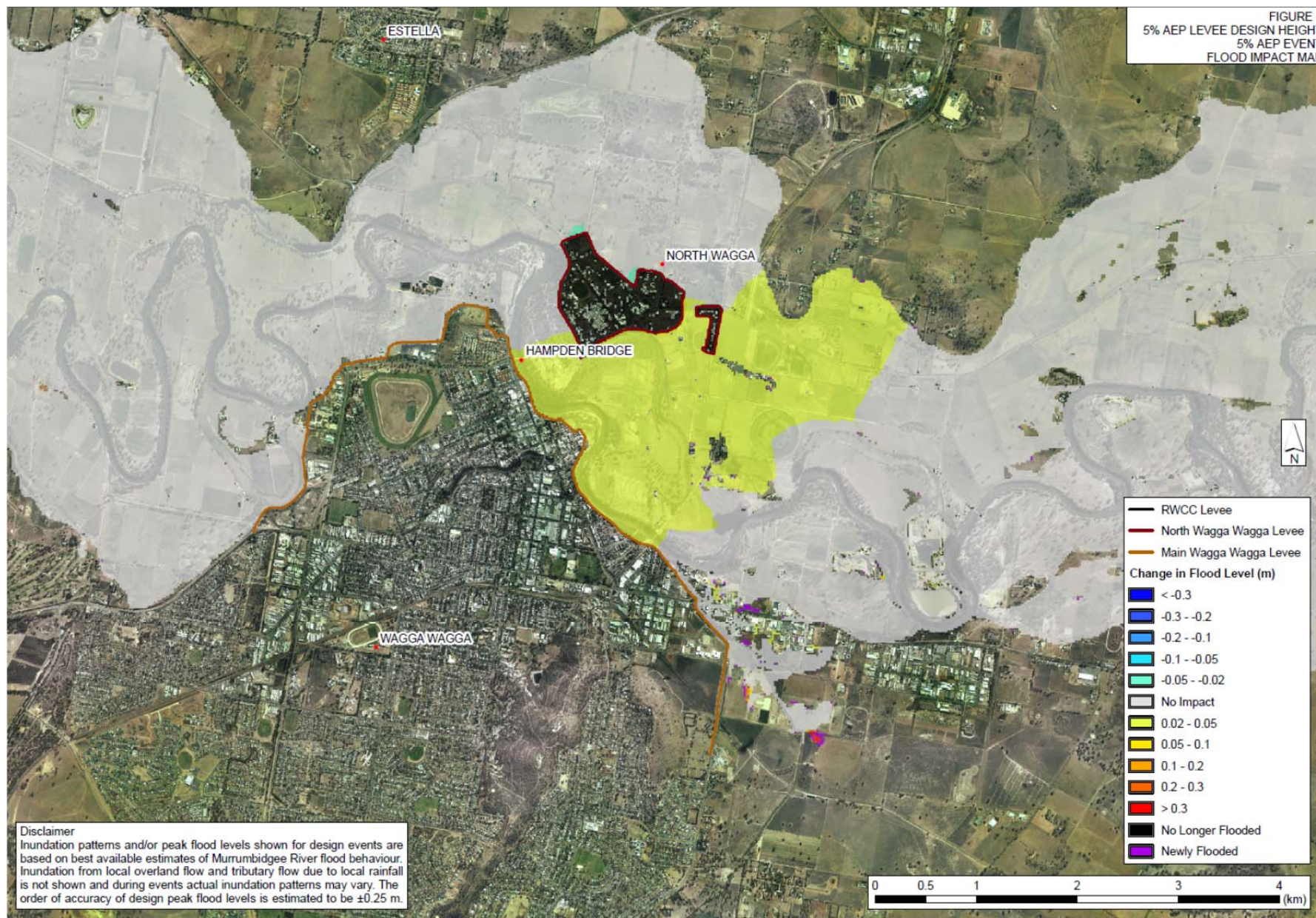
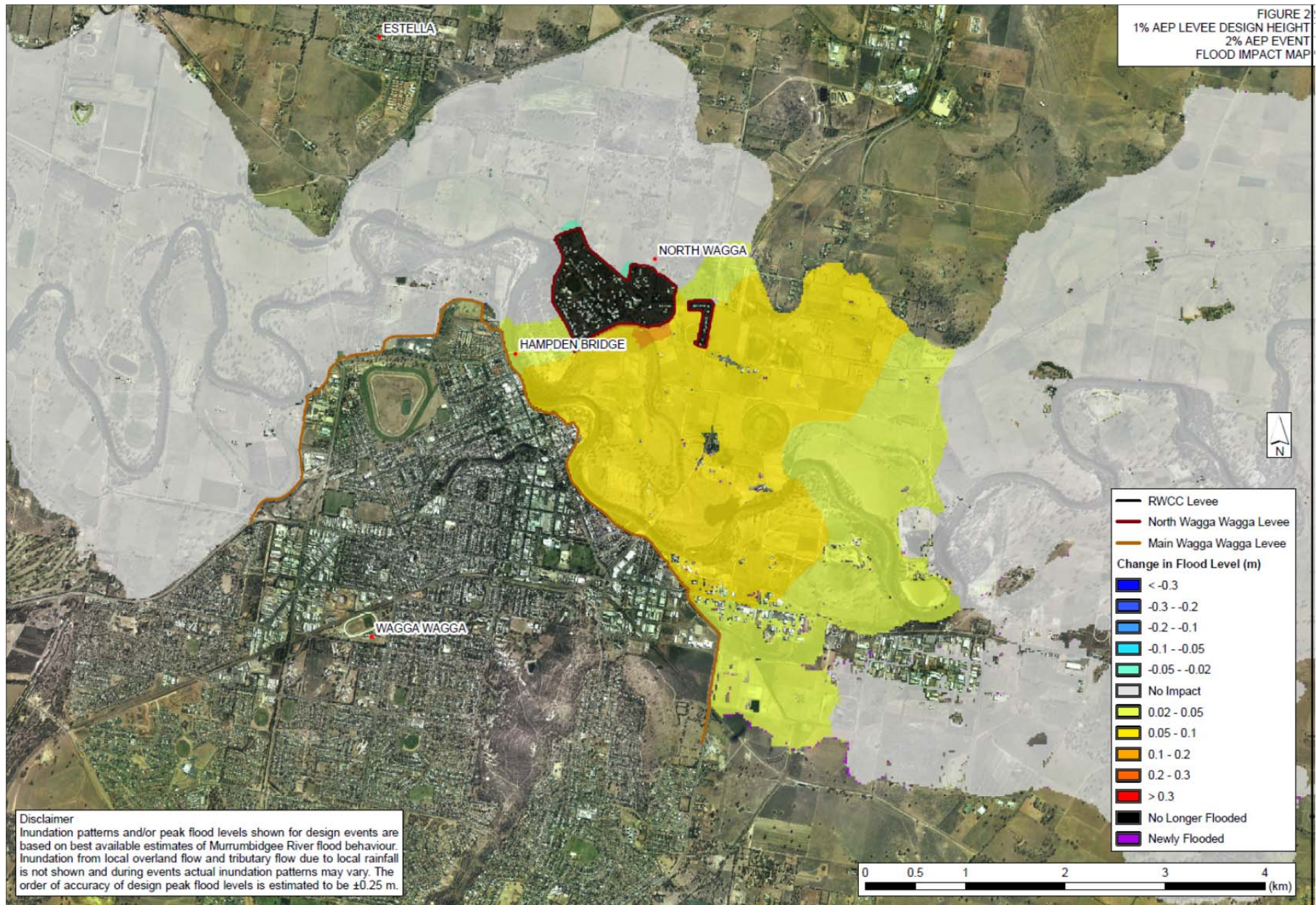


Figure 3 – 1 in 20 year North Wagga Wagga levee with 1 in 20 year flood extent difference map (i.e. showing difference from current condition)



## North Wagga Wagga Levee Options and Third Party Impacts



**Figure 4 – 1 in 100 year North Wagga Wagga levee with 1 in 50 year flood extent difference map (i.e. showing difference from current condition)**



## North Wagga Wagga Levee Options and Third Party Impacts

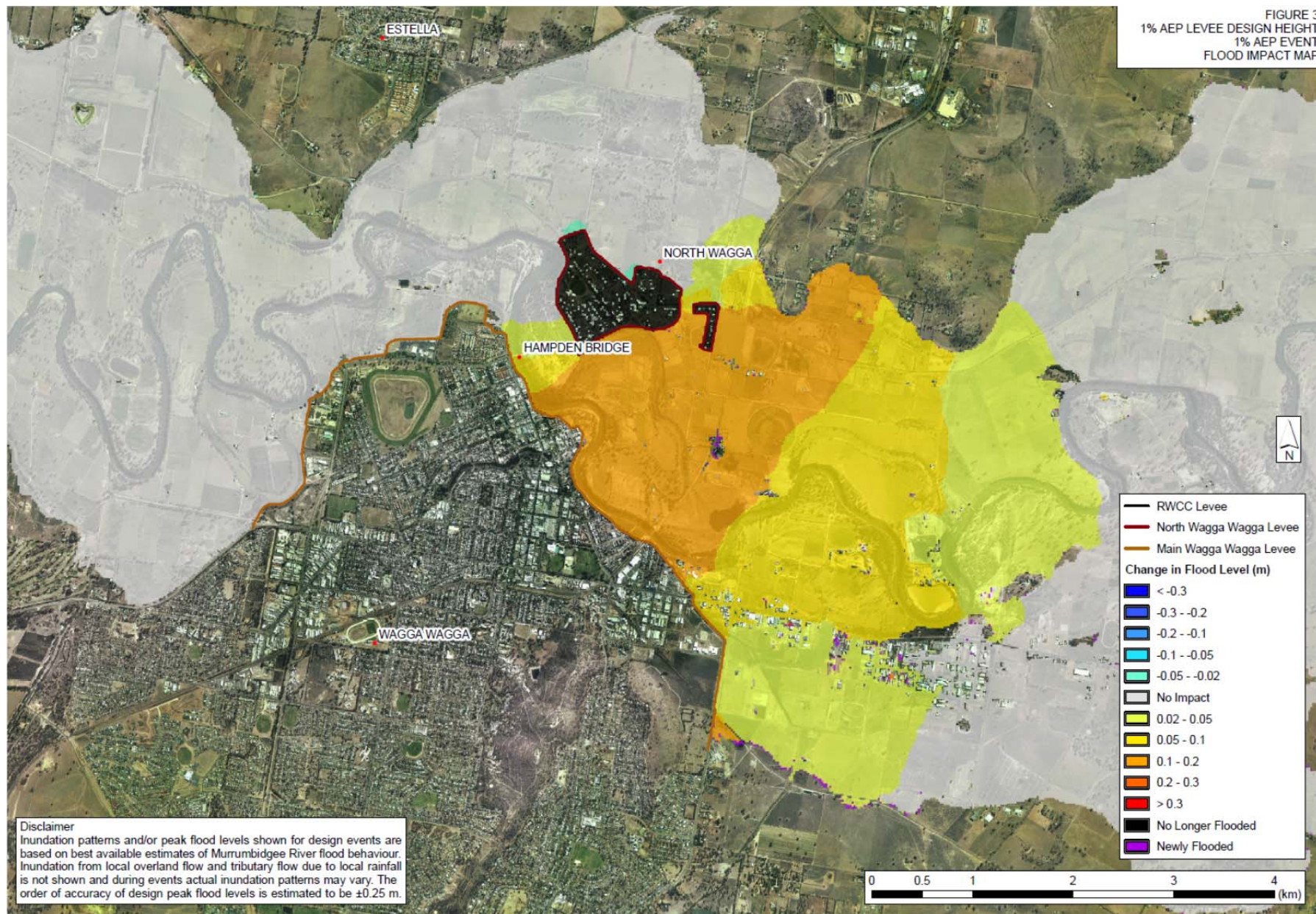


Figure 5 – 1 in 100 year North Wagga Wagga levee with 1 in 100 year flood extent difference map (i.e. showing difference from current condition

