URS

Report

Constraints Management Strategy Prefeasibility

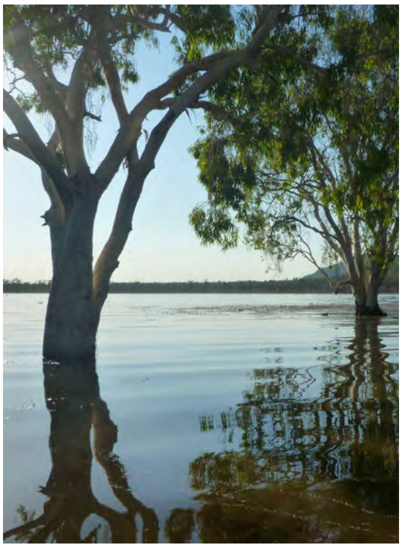
AUSTRALIA

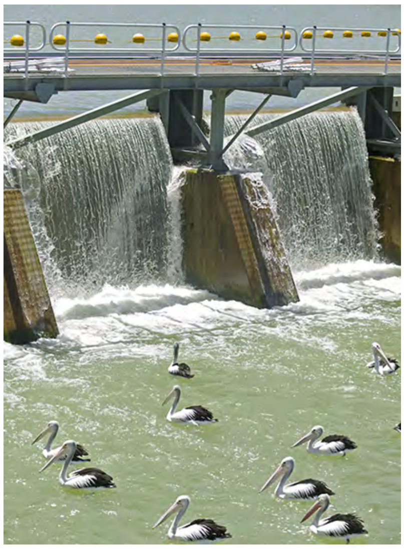
Regional Infrastructure Costing

3 December 2014
43157204/07/3

Prepared for:
Murray-Darling Basin Authority

Prepared by URS Australia Pty Ltd





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EXECUTIVE SUMMARY

URS Australia Pty Ltd (URS) was engaged by the Murray Darling Basin Authority (MDBA) to assist in the development of pre-feasibility cost estimates of infrastructure works that may be required to mitigate the impacts of higher managed environmental flows. These estimates are informing Phase 1 (pre-feasibility) of the Constraints Management Strategy.

This is the final project report and presents the outcomes of the costing exercise. It should be read in conjunction with separate reports which estimate the costs associated with easements or other land management arrangements, and selected other infrastructure items not considered by URS in this report.

Costings were undertaken on a regional basis in six areas of the Basin:

- Hume to Yarrawonga
- Goulburn River
- Yarrawonga to Wakool Junction
- Murrumbidgee
- Lower Darling River
- River Murray in South Australia.

The cost estimates were developed through a desktop exercise based on readily available information. Given limitations on the state of knowledge and the data available, it has not been possible to identify the works required across these regions with any certainty. Therefore the project has pragmatically envisioned what works may generally be required, and then used broad unit rates to calculate a cost. This provides a starting point for the MDBA, Basin Governments and other stakeholders to undertake further work to better identify the works required, and the associated costs.

For each region, the MDBA requested that analysis be undertaken for a range of specific flow rates. These flow rates are presented in Table ES-1.

Table ES 1 Regional Summary

REGION (Gauge Point)	FLOW RATES (ML/day)
Hume to Yarrawonga (Doctor's Point)	40,000
Mid Goulburn (d/s Eildon)	12,000 15,000 20,000
Lower Goulburn (d/s Goulburn Weir)	25,000 30,000 40,000

REGION (Gauge Point)	FLOW RATES (ML/day)
Yarrawonga to Wakool Junction (Tocumwal) [1]	20,000 35,000 50,000 77,000
Mid and Lower Murrumbidgee (Wagga Wagga)	30,000 40,000 48,500
Lower Darling(Weir 32)	14,000 17,000
River Murray in South Australia (South Australian Border)	60,000 80,000

A summary of the costs determined through the regional costing exercise is provided in Table ES 2 below. The table presents the costs related to the lowest flow rate within each region, and then each subsequent column provides the additional costs related to the nominated increase in the flow rate. As an example, in the Goulburn Reaches E to H the moderate cost estimate for roads at the "25,000k" flow rate is $290,000. An additional $2,800,000 is estimated for the flow rate increase to "25k to 30k", and an additional $4,100,000 on top of that is estimated when moving to the flow rate "30k to 40k". The table also includes total costs for the highest flow rates considered in each region, and for the 50K flow rate in the Yarrawonga-Wakool.

[1] CMS prefeasibility work in the Yarrawonga-Wakool drew on information which was generated with reference to both the Tocumwal gauge and downstream of Yarrawonga Weir. Inundation maps (i.e. the areas modelled as inundated at specified flow rates, which informed the assessment of effects and/or impacts of higher flows) were generated with reference to the Tocumwal gauge, while hydrological data (i.e. frequency, timing and duration of flows) were generated with reference to downstream of Yarrawonga Weir. Flow rates at the two sites are similar, but not identical—in general, a given flow rate at Yarrawonga Weir equates to a slightly lower flow rate at Tocumwal. For practical purposes the discrepancy is not material to the prefeasibility cost estimates described in this report.

Table ES 2 Cost Overview for Regional Estimates

CMS REGION	CATEGORY								
Goulburn (Reaches A to D)	**Flow rate (ML/day)**	Up to 12K		12K to 15K		15K to 20K		**Total up to 20k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$ -	$85,000	$ -	$17,000	$9,000	$100,000	**$9,000**	**$202,000**
	High Estimate	$ -	$93,000	$ -	$19,000	$15,000	$110,000	**$15,000**	**$222,000**
Goulburn (Reaches E to H)	**Flow rate (ML/day)**	Up to 25K		25K to 30K		30K to 40K		**Total up to 40k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$290,000	$140,000	$2,800,000	$440,000	$4,100,000	$190,000	**$7,190,000**	**$770,000**
	High Estimate	$430,000	$150,000	$4,100,000	$480,000	$6,400,000	$200,000	**$10,930,000**	**$830,000**
Goulburn (Reaches E to H – Inside Levees)	**Flow rate (ML/day)**	Up to 25K		25K to 30K		30K to 40K		**Total up to 40k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$20,000	$140,000	$2,570,000	$400,000	$3,720,000	$140,000	**$6,310,000**	**$680,000**
	High Estimate	$30,000	$150,000	$3,800,000	$450,000	$5,790,000	$145,000	**$9,620,000**	**$745,000**

CMS REGION	CATEGORY								
Hume-Yarrawonga	**Flow rate (ML/day)**	Up to 40K						**Total up to 40k**	
	Infrastructure type	Roads	Bridges and crossings					**Roads**	**Bridges and crossings**
	Moderate Estimate	$16,000	$5,900,000					**$16,000**	**$5,900,000**
	High Estimate	$25,000	$7,400,000					**$25,000**	**$7,400,000**
Lower Darling	**Flow rate (ML/day)**	Up to 14K		14K to 17K				**Total up to 17k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$27,000	$2,000,000	$2,000	$ -			**$29,000**	**$2,000,000**
	High Estimate	$41,000	$2,400,000	$3,000	$ -			**$44,000**	**$2,400,000**
Murrumbidgee (Mid and Lower)	**Flow rate (ML/day)**	Up to 30K		30K to 40K		40K to 48.5K		**Total up to 48.5k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$8,100,000	$11,250,000	$3,200,000	$1,830,000	$1,120,000	$1,730,000	**$12,420,000**	**$14,810,000**
	High Estimate	$13,500,000	$13,760,000	$4,900,000	$2,340,000	$1,410,000	$2,240,000	**$19,810,000**	**$18,340,000**

CMS REGION	CATEGORY								
South Australia	**Flow rate (ML/day)**	Up to 60K		60K to 80K				**Total up to 80k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$700,000	$ -	$1,900,000	$ -			**$2,600,000**	**$ -**
	High Estimate	$900,000	$ -	$2,400,000	$ -			**$3,300,000**	**$ -**
Yarrawonga-Wakool	**Flow rate (ML/day)**	Up to 20K		20K to 35K				**Total up to 35k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$500,000	$50,240,000	$10,800,000	$38,160,000			**$11,300,000**	**$88,400,000**
	High Estimate	$500,000	$62,050,000	$17,600,000	$47,070,000			**$18,100,000**	**$109,120,000**

Note: All cost estimates presented in this table are for the flow regime as defined by the MDBA's "BP2800RC" model run as explained in section 2.2.2 of this report.[2]

As discussed in the body of this report, URS also developed cost estimates for two alternative sets of hydrological assumptions. The outputs from these alternative hydrological assumptions also informed the MDBA's assessment of costs. In particular, the MDBA considers that the flow regime as defined by the "BP2800RC" model run should not be relied on to estimate costs associated with higher flow rates in the Yarrawonga-Wakool. Cost estimates for the Yarrawonga-Wakool associated with these alternative assumptions are presented below.

[2] Refer to MDBA (October 2012) *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results.*

Table ES-3 Cost overview of Alternative Scenarios for Yarrawonga-Wakool

CMS REGION	CATEGORY										
Yarrawonga-Wakool (Scenario 2 hydrological assumptions – assume 5 additional events / 25 years)	**Flow rate (ML/day)**	Up to 20K		20K to 35K		35K to 50K		50K to 77K		**Total up to 77k flow rate**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$3,500,000	$50,240,000	$3,100,000	$38,160,000	$4,800,000	$25,360,000	$14,700,000	$64,590,000	$26,100,000	$178,350,000
	High Estimate	$4,800,000	$62,050,000	$4,800,000	$47,070,000	$7,400,000	$32,470,000	$22,300,000	$78,600,000	$39,300,000	$220,190,000
Yarrawonga-Wakool (Scenario 3 hydrological assumptions – assume 10 additional events / 25 years)	**Flow rate (ML/day)**	Up to 20K		20K to 35K		35K to 50K		50K to 77K		**Total up to 77k flow rate**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$6,500,000	$50,240,000	$5,600,000	$38,160,000	$9,000,000	$25,360,000	$26,600,000	$64,590,000	$47,700,000	$178,350,000
	High Estimate	$9,300,000	$62,050,000	$9,100,000	$47,070,000	$14,400,000	$32,470,000	$41,800,000	$78,600,000	$74,600,000	$220,190,000

As well as the regional costings, URS also estimated the costs associated with specific items of infrastructure that were known to potentially require upgrading. These are presented in Table ES-4.

Table ES-4 Cost Overview – Specific Items of Infrastructure

REGION	ITEM	MODERATE ESTIMATED COST	HIGH ESTIMATED COST
Goulburn	Lower Goulburn Regulators	$4 million	$8 million
Mid-Murrumbidgee	Wagga Wagga stormwater control	$5.5 million	$8 million
Lower Murrumbidgee	Yanco Creek Regulator	$8 million	$10 million
Lower Darling	Regulators	$2.5 million	$4 million

A number of significant assumptions have been made to enable this pre-feasibility costing exercise. A more detailed feasibility assessment would be required to provide a robust cost estimate. This feasibility assessment needs to:

- Use the best available knowledge to identify actual impacts of the proposed flows. This would include:
  - Engagement with government agencies who manage the infrastructure potentially impacted by the flows. This includes local government and water authorities
  - Engagement with local communities and other stakeholders to ascertain the impacts at a local scale.
- Develop new knowledge as needed to fill current information gaps. This could include:
  - Specific hydraulic and hydrological modelling to identify the extent of the inundation, flow velocities and heights across the regions, at all flow rates
  - Site specific engineering and technical studies to identify infrastructure needs and design solutions
  - Environmental and social studies to identify and manage impacts.

1 INTRODUCTION

1.1 Purpose of report

The purpose of this report is to present the outputs from a regional costing exercise undertaken for the Murray-Darling Basin Authority (MDBA). This work has specifically been undertaken to assist in the development of pre-feasibility estimates of the costs of infrastructure works that may be required to mitigate the impacts of higher managed environmental flows. These estimates are informing Phase 1 (pre-feasibility) of the Constraints Management Strategy.

As well as the regional costings outputs, this report incorporates cost estimates undertaken by URS for specific infrastructure items. Full details of these costs have been provided in separate reports, which have been included as appendices to this report.

1.2 Background

Constraints are river management practices and structures that govern the volume and timing of regulated water delivery through the river system. Constraints to delivering water to environmental assets within the Basin include:

- Physical constraints - such as structures along or near the river, like bridges or roads, or activities by landholders, which may be affected by higher environmental flows
- Operational and management constraints - relating to the river management practices which have been developed over the past century, mostly to support navigation and irrigation. Some practices, or the absence of them, mean that environmental water may not be managed as effectively as it could be.

Through the Constraints Management Strategy, Basin Governments and the MDBA are investigating the potential to relax or remove key constraints in the Murray-Darling Basin. This could allow for more flexibility in water delivery, and improve outcomes of environmental watering. However, higher managed environmental flows could also result in negative impacts as a result of more frequent inundation of land or infrastructure.

As part of the Constraints Management Strategy, the potential for these impacts to be mitigated is being considered.

URS was engaged by the MDBA to undertake a 'pre-feasibility' investigation of the costs that might be associated with infrastructure works that could be required to mitigate these impacts.

The aim of the project was to provide a consistent but preliminary and indicative set of cost estimates for infrastructure works required to mitigate the impacts of higher flows in six priority regions: Hume to Yarrawonga, Goulburn River, Yarrawonga to Wakool Junction, Murrumbidgee, Lower Darling River, and the River Murray in South Australia. The Gwydir Wetlands have also been identified as a priority region for further consideration under the Constraints Management Strategy. However, there was insufficient information on which to undertake a similar analysis in the Gwydir so it has not been included in this assessment.

For each region, the MDBA requested that analysis be undertaken for a range of specific flow rates. These flow rates are presented in Table 1-1.

Table 1-1 Regional summary

REGION (Gauge Point)	FLOW RATES (ML/day)
Hume to Yarrawonga (Doctor's Point)	40,000
Mid Goulburn (d/s Eildon)	12,000 15,000 20,000
Lower Goulburn (d/s Goulburn Weir)	25,000 30,000 40,000
Yarrawonga to Wakool Junction (Tocumwal) [3]	20,000 35,000 50,000 77,000
Mid and Lower Murrumbidgee (Wagga Wagga)	30,000 40,000 48,500
Lower Darling (Weir 32)	14,000 17,000
River Murray in South Australia (South Australian Border)	60,000 80,000

The flow rates that are being explored are generally below or up to minor flood level. By definition these flow rates 'cause inconvenience' and would typically lead to low-lying areas next to watercourses being inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged[4]. While some of the highest flows being considered (e.g. in the Goulburn and Yarrawonga-Wakool) are in the minor flood level category, it is assumed that these represent flows far lower than the 1 in 100 year flood events that major infrastructure is typically built to.

[3] CMS prefeasibility work in the Yarrawonga-Wakool drew on information which was generated with reference to both the Tocumwal gauge and downstream of Yarrawonga Weir. Inundation maps (i.e. the areas modelled as inundated at specified flow rates, which informed the assessment of effects and/or impacts of higher flows) were generated with reference to the Tocumwal gauge, while hydrological data (i.e. frequency, timing and duration of flows) were generated with reference to downstream of Yarrawonga Weir. Flow rates at the two sites are similar, but not identical—in general, a given flow rate at Yarrawonga Weir equates to a slightly lower flow rate at Tocumwal. For practical purposes the discrepancy is not material to the prefeasibility cost estimates described in this report.
[4] For the full definition of minor flooding, see http://www.bom.gov.au/water/awid/id-333.shtml

This informed many of the decisions and assumptions that were made during the costing exercise. For example, it was assumed that impacts on buildings would not be significant as it was considered unlikely that buildings in the floodplain would be impacted by the flow rates being considered. Where buildings do exist within the inundation areas associated with these flow rates, they are likely to be minor structures that have a history of flooding so that significant costs will be minimised by current practice, such as the relocation of expensive equipment above flood level, or via the use of relocatable equipment. It was also assumed that the focus of infrastructure works on roads would be on additional maintenance due to increased wear and tear rather than reconstruction, and that major roads like highways would not be impacted.

The other basis for the project was to be conservative in the costing to increase the probability that the costs presented were at the higher end of what may actually apply.

1.3 Scope

The regional cost estimates have been derived from GIS-based data provided by the MDBA and drawn from sources as summarised in section 2.2.2. This has been combined with URS developed unit rates to provide a 'pre-feasibility' level estimate of costs related to infrastructure. URS did not undertake any data analysis or hydraulic, hydrologic, or flood modelling. No community or stakeholder engagement was undertaken by URS to validate this data, or to ascertain whether it reflected what was really happening at the sites.

The results should be taken as an indication of the level of costs that may be associated with relieving constraints through the system based on a number of key assumptions. They form the starting point for further detailed analysis to provide a robust cost estimate on which to make budgeting decisions.

None of the works presented in this report are to be taken as recommendations from URS as to what works are required across the Basin. A long-term detailed technical analysis supported by strong community input and stakeholder engagement is required before confidence around the actual works required will be obtained.

The costs presented do not include any costs related to the potential need for flood easements over private property as these are being analysed in a parallel project.

2 COSTING METHOD SUMMARY

2.1 Overall project approach

This final report is the culmination of a series of tasks undertaken by URS together with the MDBA. The project evolved from its starting point, as information came to hand, and as the project team became more aware of the gaps and limitations of the base data, and indeed as the MDBA learnt more about specific issues for each region.

The overall method employed was:

1. Develop a best guess of the potential infrastructure items that may require costing
2. Develop unit rates for each item, listing main assumptions and data gaps/limitations
3. Refine costings and assumptions. To inform this refinement, a preliminary set of assumptions was run as a "pilot" exercise in the Goulburn, using preliminary data in that region
4. Apply the refined costings and assumptions to derive regional costings
5. Undertake specific infrastructure costings as directed by the MDBA.

2.2 Outline of approach to regional costings

The detailed explanation of the assumptions and unit rates that were used in this costing exercise are contained in Appendix A *Infrastructure Costing Assumptions - Common Baseline Assessment*. Some of the key points related to the regional costing exercise are provided below:

- The MDBA defined the regions and the flow rates that would be investigated. Within each region, the MDBA provided URS with a modelled inundation map for each flow rate. This inundation map was used to identify the infrastructure potentially impacted by each flow.
- A standardised and consistent approach was applied across all regions. To the extent possible, the regional costings made use of comparable and consistent datasets. Furthermore, URS was directed not to utilise additional information that may aid the assessment (such as the outputs of flood modelling) where this was available in some regions but not others, as this would have meant some areas would have had costings based on a different method and a different information base.
- The MDBA and URS together adopted a suite of standardised infrastructure solutions, for which URS then developed unit rates. These unit rates were created as a 'lower bound' and 'upper bound' figures to enable cost to be presented as a range. These were adopted as the 10th and 90th percentile figures within the costing analysis, which were then used to calculate the corresponding 50th percentile figure.
- Probabilistic costing was then used to provide further analysis, which is then presented as the moderate and high estimates in this report. These estimates were based on the 50th and 90th percentile cost estimates respectively from the analysis. However, they have not been presented as specific percentiles in this report in order to not give a false sense of the accuracy attached to the costs. At this pre-feasibility stage, the actual package of works required is unknown, and this costing exercise is only providing a 'first step' costing output to inform Basin Governments and the MDBA.

2.2.1 Development of infrastructure solutions and standardise unit rates

The full detail around the infrastructure solutions proposed, and their associated unit rates, is provided in Appendix A *Infrastructure Costing Assumptions - Common Baseline Assessment*. A description is provided below and an overall summary presented in Table 2-1 at the end of this section, which also details which infrastructure estimates have been applied to which region.

Roads

With regards to roads, for this regional desktop costing exercise there was no way to specifically identify what works may be required where. As such it was pragmatically decided to adopt a regime that seemed suitable for flows below or up to minor flood levels. It was assumed that the vast majority of the roads required additional maintenance to cater for possible damages related to the flows, and that a very small minority of the roads required some form of replacement/upgrade. It was further assumed that no works were required on major roads such as highways, as these would be designed to be above the minor flood levels, and that 2WD and 4WD tracks could be excluded from the analysis as for the flow regimes being considered, they would require at most only a period of closure, and not require any works.

As the GIS data was unable to discriminate levels of flooding over roads, estimates of the proportion of inundated roads requiring maintenance, raising and culverts were made:

- 95% of inundated roads assumed to require maintenance only
- 4.5% of inundated roads assumed to require raising by 500 mm
- 0.5% of inundated roads assumed to require a row of 450 mm high culverts.

For the cost estimates related to maintenance, a Net Present Value (NPV) analysis was undertaken to present the cost as a lump sum figure in today's dollars. The NPV analysis was undertaken over a 25 year period, at a 7% discount rate and accounted for the hypothetical increases in the frequency of inundation events as advised by the MDBA.

Table 2-1 Summary of roads unit rates

		LOWER BOUND ($/m)	UPPER BOUND ($/m)
Maintenance	Unsealed Road	30	190
	Sealed Road	180	380
Raise road by 500mm	Unsealed Road	330	1,040
	Sealed Road	370	1,130
Row of 450mm culverts	Unsealed Road	3,470	11,760
	Sealed Road	3,510	11,850

Bridges

Due to the lack of inundation depth GIS data available, an assumption that 5% of bridges would need replacement was made. Therefore the total length of single/dual lane bridges was multiplied by 5% to give an estimate of the length of bridge replacement needed.

Unit costs for bridge works based on a unit area (length multiplied by width) with the following adopted:

- Estimated minimum cost for road bridge of $2,500/m^2$
- Estimated maximum cost for road bridge of $3,000/m^2$

These rule of thumb cost estimates were based on advice from experienced URS bridge design engineers and align with those currently being adopted by the construction industry for bridge construction tender submissions. Minimum and maximum unit costs represent possible variations in construction complexity/bridge type (e.g. clear span vs. crown units) and site conditions. Rule of thumb estimates are based on bridges designed and constructed to the AS 5100 standard.

Crossings

The MDBA identified four regions that had a significant number of waterway crossings through the floodplain. These may be a mix of private and public crossings that predominately enable landowners/farmers to access different parts of the floodplain, and/or their properties.

The MDBA identified which crossings were affected by each flow regime, and provided data on the type of crossing, its length, and height.

The type and height of the existing crossing and the associated flow scenario was then used to determine the replacement crossing type assumed to be constructed. This was done according to the decision matrix presented in Table 2-2.

Table 2-2 Decision Matrix for Crossing Replacement Solution

EXISTING CROSSING TYPE	ASSUMED REPLACEMENT CROSSING TYPE BY FLOW RATE		
	0 to 20 GL/d	**20 to 50 GL/d**	**>50 GL/d**
Low Level Causeway/Ford	Do Nothing	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)
Culvert (height ≤ 1.2m)	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)
Culvert (1.2 ≤ height ≤ 2.1)	Moderate Culvert (height 2.1m)	Moderate Culvert (height 2.1m)	Moderate Culvert (height 2.1m)
Culvert (height > 2.1m)	Major Culvert (height 3.6m)	Major Culvert (height 3.6m)	Major Culvert (height 3.6m)

The following assumptions were made:

- All culverts are square (same width and height)
- Culverts are required for the entire length of crossing as given in the GIS data supplied by MDBA
- Single lane crossings assumed to be 7.4m wide to allow passage of agricultural machinery and other large vehicles.
- Dual lane crossings assumed to be 8m wide

Other items

A number of other infrastructure items were identified at the preliminary stages of the project, and included in Appendix A *Infrastructure Costing Assumptions - Common Baseline Assessment* in case costings analysis was required. These were:

- Levee's
- Pump pads and sheds
- Block banks
- Regulators.

These items were not included in this regional costing exercise due to a lack of consistent and standardised data across all regions on which costings could be based. It should also be noted that the potential upgrade of existing levees or the creation of new levees is a complicated hydrologic/hydraulic modelling exercise which was beyond the scope of this regionally focused, desktop exercise.

Table 2-3 Infrastructure assumptions summary

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Specified major infrastructure items	Infrastructure works which cannot be costed through application of unit rates	These items are costed separately through more detailed individual assessments.	Not applicable	Infrastructure being considered in this way are: • Regulators on Lower Darling • Regulators on Goulburn • Regulator on Yanco Creek • Stormwater management at Wagga Wagga
Roads (Maintenance)	Assume 95% of roads require maintenance rather than capital works	Does not apply to major roads as it is assumed they are designed to above the minor flood level For unsealed roads, assume the following works: • Grade and reshape road surface to profile • Scarify and recompact <=150mm of road surface • Grade and reshape table drains including cleaning out existing drains (both sides of road) • Place a new 150mm thick layer of granular material (gravel). Similar to above for sealed roads, but includes: • Provide a new 7-14mm two-coat spray seal • Provide line marking.	• The lower bound cost for an unsealed road is $30/m and the upper is $190/m • The lower bound cost for an sealed road is $180/m and the upper is $380/m • Based on Rawlinsons, Australian Construction Handbook, 2014, and cross checking with costs to do similar works	A net present value (NPV) assessment is undertaken to capitalise the costs. NPV analysis based on 25 year period at 7% discount rate. Frequency of inundation provided by MDBA. Estimates calculated for road maintenance in the following CMS regions: • Goulburn • Murrumbidgee • Hume-Yarrawonga • Yarrawonga-Wakool • Lower Darling • South Australia

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Road Upgrade (Box culverts)	Assume 0.5% of roads require a full box culvert solution	The following tasks have been allowed for with this option: • Assumes culvert depth of 1200mm • Assumes that the installation of the culverts and road pavement over can be undertaken without modifying the crest height of the road • Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements • Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons) • Install cast in-situ reinforced concrete base slabs and aprons • Install pre-cast concrete box culverts (450mm clear internal height) • Install cast in-situ reinforced concrete headwalls and wingwalls • Backfill culvert ends and wingwalls with granular material • Construct 300mm thick unbound granular base over culverts and approaches • Grade and shape shoulder / batters • Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only) • Provide line marking (applicable to sealed roads only)	• The lower bound cost for an unsealed road is $3,470/m and the upper is $11,760/m • The lower bound cost for a sealed road is $3,510/m and the upper is $11,850/m • Based on Rawlinsons, Australian Construction Handbook, 2014	Estimates calculated in the following CMS regions: • Goulburn • Murrumbidgee • Hume-Yarrawonga • Yarrawonga-Wakool • Lower Darling • South Australia

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
		• Install erosion protection to: – upstream / downstream of culvert (rip rap rock fill) – road batters (soil and grass). The above tasks are applicable for a sealed or unsealed road, with the exception of the two-coat spray and line marking		
Road Upgrade (Raise road)	Assume 4.5% of roads require lifting by 500mm with culverts placed every 1km	The following tasks have been allowed for with this option: • This option assumes that the crest height of the road for the full length (approaches and over the culvert) is increased uniformly by 500mm. It also assumes that the existing road height is sufficient to allow installation of the nominated culverts • The culvert size has been assumed as adequate to pass the required flows • Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements • Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons) • Install cast in-situ reinforced concrete base slabs and aprons • Install pre-cast concrete box culverts (1200mm clear internal height)	• The lower bound cost for an unsealed road is $330/m and the upper is $1,040/m • The lower bound cost for a sealed road is $370/m and the upper is $1,130/m • Based on Rawlinsons, Australian Construction Handbook, 2014	Estimates calculated in the following CMS regions: • Goulburn • Murrumbidgee • Hume-Yarrawonga • Yarrawonga-Wakool • Lower Darling • South Australia

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
		• Install cast in-situ reinforced concrete headwalls and wingwalls • Backfill culvert ends and wingwalls with granular material • Scarify existing remaining road surface for full length between culverts • Construct 500mm thick unbound granular base over full length of road • Grade and shape shoulder / batters • Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only) • Provide line marking (applicable to sealed roads only) • Install erosion protection to: – upstream / downstream of culvert (rip rap rock fill) – road batters (soil and grass). The above tasks are applicable for a sealed or unsealed road, with the exception of the two-coat spray and line marking.	•	

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Bridge	Any bridge identified within the data	It is assumed that bridges on major roads will not require replacement and can cater for minor floods. Of the bridges identified on non-major roads, it is assumed: • 5% of the total length of bridges require replacement • Single lane bridges are 5 m wide. • Double lane bridges are 8 m wide • AS5100 applies	• Estimated minimum cost for a road bridge is $2,500/m^2. (rule-of-thumb) • Estimated maximum cost for a road bridge is $3,000/m^2. (rule-of-thumb) • Unit rates are for bridges designed and built to AS5100	Estimates are calculated in the following CMS regions: • Goulburn • Murrumbidgee • Hume-Yarrawonga • Yarrawonga-Wakool • Lower Darling
Crossings	Crossings other than bridges – including culverts, low-level crossings and fords	The required solution at each crossing is a function of the existing crossing type, length, depth and flow regime. A decision matrix has been created to allocate a solution to each crossing point, and then this is costed based on established unit rates. Key assumptions: • Full replacement cost • Small, medium or large box culverts according to depth and length required • Adopted solution at each crossing point a function of existing crossing type, length, depth, and flow regime • Width of single-lane crossings assumed to be 7.4m based on advice from Wakool council.	• “Unit costs” are a function of the type of crossing, solution, length and depth	Estimates are calculated for the following CMS regions: • Yarrawonga-Wakool • Hume-Yarrawonga • Murrumbidgee • Lower Darling

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Buildings	Sheds, houses, other buildings	Not being considered for prefeasibility on the basis that: • It is assumed that it is unlikely that building damage will be significant within the minor flood level as very few buildings are likely to be inundated under such floods • If buildings are inundated during minor flooding then it can be assumed that the water level above floor level is likely to be small and consequently damages are likely to be minor • If buildings do exist within the minor flood level they are likely to be minor structures that have a history of flooding so that significant costs will be minimised by current practice such as the location of expensive equipment above flood level, or via the use of relocatable equipment • Where significant sheds or houses are found to be subject to inundation under minor flood level it is likely that a more detailed analysis including options for flood protection and or creation of flood easements would need to be considered at later stages of costing.	Not applicable	Given the assumptions that are being made, estimates of these costs were not calculated in any CMS regions.

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Pump Pad & Shed Relocation	Pump pads and sheds	It is considered unlikely that pump pads and sheds will need to be relocated and/or raised to avoid inundation due to a minor flooding event. However, if included it could be assumed that: • The existing pump does not need to be replaced, only relocated • New shed and concrete pad plus delivery, construction and earthworks • Shed up to 4 square metres	• Minimum cost $10,000 per pump & shed • Maximum cost $20,000 per pump & shed.	Estimates were not calculated in any CMS regions, due to lack of data on location and impact on pump pads/sheds.
Levee (Private land)	Levee/embankment on private land	There may be cases where new levees are required. Assumptions include: • A trapezoidal levee has been assumed of height 1 metre, with 3 m width at full height and 1 in 3 batter slopes. • No assessment of flooding depths against levee has been undertaken / utilised. • Allowance for provision for an easement of 20 m for levee construction and farm reinstatement works to allow drainage of farmland (land acquisition) • Unit rates have been doubled (i.e. 100% contingency) to account for the possibility of extensive approvals processes and stakeholder engagement requirements (as well as including design, supervision, management etc. costs)	• Estimated minimum cost for a 1 m levee is $530/m • Estimated maximum cost is $1,200/m • Derived from project cost estimates	Estimates were not calculated in any CMS regions, due to lack of sufficient data to inform what levee works would be required.

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Levee (Public land)	Levee/embankment on public/Crown owned land	As for private levee	• Estimated minimum cost for a 1 m levee is $1,300/m • Estimated maximum cost is $2,800/m • Derived from project cost estimates	Estimates were not calculated in any CMS regions, due to lack of sufficient data to inform what levee works would be required.
Regulator - Small	Small regulators <2 m wide	Regulators are unlikely to be part of an infrastructure management solution in most cases. However, if included in a cost estimate it is considered that: • Small regulators <2 m wide would only require replacement if they present a flow constraint. However, most are likely to be designed to manage flows up to minor flood levels. • Moderate sized regulators (>2 m and <5 m width) would only require replacement if they present a flow constraint. However, most are likely to be designed to manage flows up to minor flood levels.	• The minimum cost of a <2 m wide regulator is $100,000 • The maximum cost of a <2 m wide regulator is $200,000 • Based on Engineering judgement and North Central CMA Environmental Works and Measures Projects (2010-2014)	Estimates were not calculated in any CMS regions, due to lack of sufficient data to inform what levee works would be required. Works on larger regulators costed separately.

INFRASTRUCTURE ITEM	WHAT IT IS	APPROACH/ASSUMPTIONS	UNIT COST/ REFERENCE	COMMENTS
Regulator – Medium	(>2 m and <5 m width)	As per small regulator	• The minimum cost of a >2 m and <=5 m wide regulator is $250,000 • The maximum cost of a >2 m and <=5 m regulator is $500,000	Estimates were not calculated in any CMS regions, due to lack of sufficient data to inform what levee works would be required. Works on larger regulators costed separately.
Block Bank	Block banks can be used in inlet/outlet channels to prevent water entry or exit from the floodplain.	• Requires interpretation of hydraulic modelling results • Typical block bank has a 3 m crest width, 1 in 3 batter slopes and erosion protection • Block banks are constructed using suitable, locally sourced material	• The minimum cost of a 1 m block bank is $180/m • The maximum cost of a 1 m block bank is $600/m • Linear metre rates are based on a minimum $30/m^3 and maximum $100/m^3 earthworks rate	Estimates not calculated in any CMS regions, as it is not feasible to identify location of block banks, and further local input/detailed mapping and modelling would be required.

2.2.2 *Sources of data*

MDBA supplied URS with a series of GIS layers drawn from the following sources:

- The NSW Digital Topographic Database
- Victoria's Vicmap data
- Analysis by WaterTech undertaken in 2010 and updated in 2014 of impacts of higher flows in the Goulburn River
- Modelled GIS inundation extents, developed from the following flow models:
  - RIM-FIM was used to develop inundation extents for the Lower Darling, Murrumbidgee (downstream of Hay), and Yarrawonga to Wakool reaches. The River Murray Floodplain Inundation Model (RIM-FIM) has been developed by the CSIRO as a research decision support tool for environmental flow management in the River Murray.
  - The MIKE hydraulic modelling suite was used in the development of inundation extents for the Goulburn, Murrumbidgee (upstream of Hay), and Hume to Yarrawonga reaches. Various consultants to the MDBA associated with these reaches used the MIKE modelling, mainly MIKE 11, developed by the Danish Hydraulic Institute (DHI) to generate the extents.

These GIS layers provided information on the infrastructure (roads, crossings, bridges, etc.) inundated and assumed impacted by relevant flow regime scenarios for each region. The data contained information which was used for cost estimating purposes such as:

- Length of crossing/road inundated
- Height of crossing
- Road surfacing
- Number of lanes.

It should be noted that no GIS manipulation/analysis was undertaken by URS.

URS was also provided with information supplied by the South Australian Department of Environment, Water and Natural Resources (DEWNR) on roads that would be affected at flows of 60,000 ML/day and 80,000 ML/day in the South Australian Murray region.

In several cases, information was missing. If this data was required for cost estimating, assumptions were made for the missing data. All assumptions made for the missing data are listed below:

- Where road surface type information (i.e. sealed or unsealed) was missing (16 instances in the data for the Goulburn 20K flow scenario), they were assumed to be unsealed
- Where lane numbers for bridges were not supplied (all cases for the Goulburn), they were assumed to be single lane (6.2m total bridge width)
- Where bridge lengths were missing (24 cases for the Goulburn), they were assumed to be 40 m which is the approximate average bridge length in the region.

The MDBA also provided URS with assumptions to be made with regard to the hypothetical increases in the frequency of inundation events (which is referred to as the flow *regime*). URS estimated costs associated with three sets of frequency assumptions:

- Scenario 1: a set of specific frequency assumptions for each flow rate in each region (refer to Appendix C). The assumptions in this scenario were based on modelling outputs from the MDBA's "BP2800RC" model run.[5]
- Scenario 2: assume 5 additional inundation events / 25 years (equivalent to 2 additional inundation events / 10 years) for all flow rates in all regions
- Scenario 3: assume 10 additional inundation events / 25 years (equivalent to 4 additional inundation events / 10 years) for all flow rates in all regions.

The first of these hypothetical flow regimes represents the "primary case" for the purposes of this report. Scenarios 2 and 3 represent alternative sets of assumptions that are intended to help inform analysis of how different hydrological assumptions may affect costs.

In particular, it should be noted that the "BP2800RC" modelled flows are based on an assumption that managed flows would be limited to 40GL/day downstream of Yarrawonga Weir (i.e. the gauge point in the Yarrawonga-Wakool reach)[6] . Given this assumption, the MDBA did not consider it appropriate to rely on BP2800RC modelled flows to estimate costs associated with the higher flow rates in the Yarrawonga-Wakool as listed in Table 1-1. The outputs from Scenarios 2 and 3 therefore informed the MDBA's assessment of costs in the Yarrawonga-Wakool.

It is important to recognise that the assumptions in Scenarios 2 and 3 do not represent what would necessarily be feasible hydrologically. Cost estimates for the hypothetical flows of up to 77 GL/day at Tocumwal should therefore be considered as indicative and in the context of the hydrological assumptions they are based on.

2.3 Outline of approach to infrastructure costings

2.3.1 Roads

Roads inundated under specific flow regimes for each region were provided to URS in the form of GIS layers. These layers included the following GIS outputs that were used for cost estimating:

- Type of road
- Length of road inundated
- Road surface.

Roads were split into categories based on the class code given in the GIS data. The table below outlines the class codes and whether they were considered in this study.

[5] Refer to MDBA (October 2012) *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results.*

[6] CMS prefeasibility work in the Yarrawonga-Wakool drew on information which was generated with reference to both the Tocumwal gauge and downstream of Yarrawonga Weir. Inundation maps (i.e. the areas modelled as inundated at specified flow rates, which informed the assessment of effects and/or impacts of higher flows) were generated with reference to the Tocumwal gauge, while hydrological data (i.e. frequency, timing and duration of flows) were generated with reference to downstream of Yarrawonga Weir. Flow rates at the two sites are similar, but not identical—in general, a given flow rate at Yarrawonga Weir equates to a slightly lower flow rate at Tocumwal. For practical purposes the discrepancy is not material to the prefeasibility cost estimates described in this report.

Table 2-4 Class Codes

CLASS CODE	CLASSIFICATION	USED IN STUDY
0	Freeway	No
1	Highway	No
2	Arterial Road	Yes
3	Sub-Arterial Road	Yes
4	Collector Road	Yes
5	Local Road	Yes
6	2wd Track	No
7	4wd Track	No
9	Proposed Road	No
11	Walking Track	No
12	Bike Path	No

As shown in the table above, major roads (class code 1-2) were not considered in this study as they were assumed to be designed to accommodate extreme flows without needing further works. Furthermore, minor roads/tracks (class code 6-12) were not considered in this study as it was assumed that they would not require works after a flooding event.

Total lengths of inundated road were calculated by adding all relevant individual lengths from the GIS data. All roads included in the study were designated as being sealed or unsealed as outlined in the GIS data.

The number of additional flood events is of critical importance for roads that are assumed to require maintenance after any given flow event as the cost is assessed through a Net Present Value assessment with the cost dependant on the number of events assumed during a 25 year period. As outlined in section 2.2.2, cost estimates were developed for three different flow regime scenarios.

2.3.2 Crossings

Crossings inundated under specific flow regimes for each region were provided to URS in the form of GIS layers. These layers included the following GIS outputs that were used for the cost estimating:

- Type of crossing
- Length of crossing
- Height of crossing
- Number of lanes.

2.3.3 Bridges

Bridges inundated under specific flow regimes for each region were provided to URS in the form of GIS layers. These layers included the following GIS outputs that were used for the cost estimating:

- Length of bridge
- Number of lanes
  - Single lane bridge assumed to be 6.2m wide
  - Dual lane bridge assumed to be 8m wide.

A total length of single lane inundated bridge and dual lane inundated bridge for each flow scenario was calculated by adding all relevant individual lengths from the GIS data.

3 RESULTS

The results of the costing analysis are presented in this section by region and by infrastructure type, for each of the nominated flow rates. To simplify the tables, flow rates are presented as “Xk” which represents X,000 ML/day.

For each region, the length or number of the infrastructure type being costed is first presented, and then the cost estimated by using the adopted unit rates is provided.

The length, number or costs are presented in each table by showing the additional quantum created by each increase in the flow rates. For example, in Table 3-1 below, for the “25K” flow rate, 25 metres of road has been identified as being impacted. An additional 1,042 metres has been identified when the flow rate increases to the “25k-35k” flow rate. Therefore the total length of road being costed in the flow band is 1,067 metres (25 plus 1,042).

Presenting the results this way enables the identification of the additional costs related to each increase in the flow rate.

As well as presenting the costs related to the regional methodology, where relevant the costs related to specific infrastructure has been included. For example, in the Goulburn system the MDBA identified a number of regulators that may require upgrade, and URS provided specific cost estimates for these items.

3.1 Goulburn

3.1.1 Roads

3.1.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Goulburn identified from the GIS data.

Table 3-1 Goulburn - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE					
	REACHES A TO D			REACHES E TO H		
	Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K
Roads Considered in this Costing Estimate						
Sealed Road	0	0	0	25	1,042	719
Unsealed Road	0	0	32	1,644	7,890	11,285
Other Roads Assumed not to Require Works						
Major Roads*	0	26	130	1,335	0	36
Tracks and Other**	683	812	1,084	74,615	81,247	128,886

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.1.1.2 Key results

The tables below summarise the results of the cost estimates for road works in the Goulburn region for the three flow scenarios outlined in Section 2.2.2.

Table 3-2 Goulburn - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE					
			REACHES A TO D			REACHES E TO H		
			Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K
Scenario 1: Additional Inundation Events			5	5	5	2	3.9	4.8
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$6,000	$550,000	$468,000
		High Estimate	$ -	$ -	$ -	$9,000	$740,000	$635,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$8,400	$173,000	$1,600,000	$2,900,000
		High Estimate	$ -	$ -	$14,000	$298,000	$2,800,000	$5,000,000
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$1,000	$36,000	$24,000
		High Estimate	$ -	$ -	$ -	$1,000	$53,000	$36,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$600	$50,000	$240,000	$345,000
		High Estimate	$ -	$ -	$1,000	$78,000	$370,000	$530,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$ -	$40,000	$30,000
		High Estimate	$ -	$ -	$ -	$ -	$60,000	$48,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$ -	$60,000	$300,000	$423,000
		High Estimate	$ -	$ -	$ -	$94,000	$455,000	$655,000
TOTAL		Moderate Estimate	$ -	$ -	$9,000	$290,000	$2,800,000	$4,100,000
		High Estimate	$ -	$ -	$15,000	$430,000	$4,100,000	$6,400,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-3 Goulburn - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE					
			REACHES A TO D			REACHES E TO H		
			Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K
Scenario 1: Additional Inundation Events			5	5	5	5	5	5
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$17,000	$700,000	$480,000
		High Estimate	$ -	$ -	$ -	$23,000	$940,000	$660,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$8,400	$430,000	$2,000,000	$3,000,000
		High Estimate	$ -	$ -	$14,000	$740,000	$3,600,000	$5,100,000
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$1,000	$36,000	$24,000
		High Estimate	$ -	$ -	$ -	$1,000	$53,000	$36,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$600	$50,000	$240,000	$345,000
		High Estimate	$ -	$ -	$1,000	$78,000	$370,000	$530,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$ -	$40,000	$30,000
		High Estimate	$ -	$ -	$ -	$ -	$60,000	$48,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$ -	$60,000	$300,000	$423,000
		High Estimate	$ -	$ -	$ -	$94,000	$455,000	$655,000
TOTAL		Moderate Estimate	$ -	$ -	$9,000	$560,000	$3,340,000	$4,200,000
		High Estimate	$ -	$ -	$15,000	$880,000	$5,120,000	$6,500,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-4 Goulburn - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE					
			REACHES A TO D			REACHES E TO H		
			Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K
Scenario 1: Additional Inundation Events			10	10	10	10	10	10
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$34,000	$1,700,000	$670,000
		High Estimate	$ -	$ -	$ -	$46,000	$1,900,000	$1,300,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$16,000	$870,000	$4,300,000	$6,100,000
		High Estimate	$ -	$ -	$29,000	$1,500,000	$7,300,000	$10,500,000
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$1,000	$36,000	$24,000
		High Estimate	$ -	$ -	$ -	$1,000	$53,000	$36,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$6,000	$50,000	$240,000	$345,000
		High Estimate	$ -	$ -	$1,000	$78,000	$370,000	$530,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -	$ -	$40,000	$30,000
		High Estimate	$ -	$ -	$ -	$ -	$60,000	$48,000
	Unsealed Road	Moderate Estimate	$ -	$ -	$ -	$60,000	$300,000	$423,000
		High Estimate	$ -	$ -	$ -	$94,000	$455,000	$655,000
TOTAL		Moderate Estimate	$ -	$ -	$17,000	$1,000,000	$6,300,000	$7,900,000
		High Estimate	$ -	$ -	$29,000	$1,700,000	$9,800,000	$12,500,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.1.2 Crossings

The GIS layers used to inform the URS analysis did not include any data on inundation of crossings. Therefore no cost estimates were developed for crossings in this region.

3.1.3 Bridges

3.1.3.1 *Key input data*

The table below summarises the number and length of affected bridges (in metres) for Goulburn identified from the GIS data. As per assumptions in Section 2.2.1, costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-5 Goulburn – Number and Lengths of Affected Bridges (metres)

<table>
<tr><th colspan="2" rowspan="3">BRIDGE TYPE</th><th colspan="6">FLOW RATE</th></tr>
<tr><th colspan="3">REACHES A TO D</th><th colspan="3">REACHES E TO H</th></tr>
<tr><th>Up to 12K</th><th>12K to 15K</th><th>15K to 20K</th><th>Up to 25K</th><th>25K to 30K</th><th>30K to 40K</th></tr>
<tr><td rowspan="3">Single Lane Bridge</td><td>Number of Affected Bridges</td><td>2</td><td>1</td><td>3</td><td>4</td><td>11</td><td>5</td></tr>
<tr><td>Total Length of Affected Bridges</td><td>89</td><td>30</td><td>112</td><td>160</td><td>502</td><td>214</td></tr>
<tr><td>5% of Total Length</td><td>5</td><td>1</td><td>6</td><td>8</td><td>26</td><td>11</td></tr>
<tr><td rowspan="3">Dual Lane Bridge</td><td>Number of Affected Bridges</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Total Length of Affected Bridges</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>5% of Total Length</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

3.1.3.2 *Key results*

The table below summarises the results of the cost estimates for bridge works in the Goulburn region.

Table 3-6 Goulburn - Estimated Costs for Bridge Works

BRIDGE TYPE	CATEGORY	FLOW RATE					
		Reaches A to D			Reaches E to H		
		Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K
Single Lane	Moderate Estimate	$85,000	$17,000	$100,000	$140,000	$440,000	$190,000
	High Estimate	$93,000	$19,000	$110,000	$150,000	$480,000	$200,000
Dual Lane	Moderate Estimate	$ -	$ -	$ -	$ -	$ -	$ -
	High Estimate	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL	Moderate Estimate	$85,000	$17,000	$100,000	$140,000	$440,000	$190,000
	High Estimate	$93,000	$19,000	$110,000	$150,000	$480,000	$200,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.1.4 *Inside Levees Analysis*

MDBA requested a further analysis of the affected infrastructure inside current levees be undertaken for the Goulburn region in reaches E to H (noting that ‘inside’ indicates that the infrastructure is protected by the current levee system). A GIS layer of current inside and outside levee areas was supplied to URS. This layer was used to determine which infrastructure was affected inside the levees under the different flow regime scenarios. Originally the costing exercise was undertaken to calculate the infrastructure costs for ‘outside’ the leveed system. To calculate the costs for the infrastructure inside the leveed system, the results for the ‘outside’ calculation were subtracted from the total results. It would be preferable to run the probabilistic costing separately for both the inside and outside data sets, but given the large uncertainties inherent in all the calculations, URS does not envisage that there will be any material differences in the results.

The following sections outline the results of this analysis.

3.1.4.1 Roads

Key input data

The table below summarises the lengths of inundated roads (in metres) for Goulburn in reaches E to H inside levees identified from the GIS data.

Table 3-7 Goulburn - Lengths of Inside Levee Inundated Roads (metres)

TYPE	FLOW RATE		
	REACHES E TO H (Inside Levees)		
	Up to 25K	25K to 30K	30K to 40K
Roads Considered in this Costing Estimate			
Sealed Road	21	666	718
Unsealed Road	94	7,873	10,090
Other Roads Assumed not to Require Works			
Major Roads*	1,335	0	36
Tracks and Other**	72,911	77,016	127,590

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

Key results

The tables below summarise the results of the cost estimates for road works in the Goulburn region in reaches E to H inside levees for the three flow scenarios outlined in Section 2.2.2.

Table 3-8 Goulburn - Estimated Costs for Inside Levee Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			REACHES E to H (Inside Levees)		
			Up to 25K	25K to 30K	30K to 40
Additional Inundation Events			**2**	**3.9**	**4.8**
Maintenance	**Sealed Road**	**Moderate Estimate**	$5,000	$350,000	$468,000
		High Estimate	$7,500	$470,000	$634,000
	Unsealed Road	**Moderate Estimate**	$13,000	$1,600,000	$2,600,000
		High Estimate	$18,000	$2,800,000	$4,475,000

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			REACHES E to H (Inside Levees)		
			Up to 25K	25K to 30K	30K to 40
Additional Inundation Events			2	3.9	4.8
Raise Road	Sealed Road	Moderate Estimate	$1,000	$23,000	$24,000
		High Estimate	$1,000	$34,000	$36,000
	Unsealed Road	Moderate Estimate	$4,000	$240,000	$310,000
		High Estimate	$8,000	$370,000	$475,000
Culverts	Sealed Road	Moderate Estimate	$ -	$24,000	$30,000
		High Estimate	$ -	$36,000	$48,000
	Unsealed Road	Moderate Estimate	$1,000	$300,000	$380,000
		High Estimate	$4,000	$455,000	$585,.000
TOTAL		Moderate Estimate	$20,000	$2,570,000	$3,720,000
		High Estimate	$30,000	$3,800,000	$5,790,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-9 Goulburn - Estimated Costs for Inside Levee Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE REACHES E to H (Inside Levees)		
			Up to 25K	25K to 30K	30K to 40K
Additional Inundation Events			5	5	5
Maintenance	Sealed Road	Moderate Estimate	$14,000	$445,000	$480,000
		High Estimate	$19,000	$590,000	$659,000
	Unsealed Road	Moderate Estimate	$15,000	$2,000,000	$2,680,000
		High Estimate	$25,000	$3,600,000	$4,560,000
Raise Road	Sealed Road	Moderate Estimate	$1,000	$23,000	$24,000
		High Estimate	$1,000	$34,000	$36,000
	Unsealed Road	Moderate Estimate	$4,000	$240,000	$310,000
		High Estimate	$8,000	$370,000	$475,000
Culverts	Sealed Road	Moderate Estimate	$ -	$24,000	$30,000
		High Estimate	$ -	$36,000	$48,000
	Unsealed Road	Moderate Estimate	$1,000	$300,000	$380,000
		High Estimate	$4,000	$455,000	$585,000
TOTAL		Moderate Estimate	$40,000	$3,050,000	$3,800,000
		High Estimate	$40,000	$4,740,000	$5,870,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-10 Goulburn - Estimated Costs for Inside Levee Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			REACHES E to H (Inside Levees)		
			Up to 25K	25K to 30K	30K to 40K
Additional Inundation Events			10	10	10
Maintenance	Sealed Road	Moderate Estimate	$28,000	$1,190,000	$670,000
		High Estimate	$38,000	$1,210,000	$1,300,000
	Unsealed Road	Moderate Estimate	$60,000	$4,300,000	$5,470,000
		High Estimate	$75,000	$7,290,000	$9,400,000
Raise Road	Sealed Road	Moderate Estimate	$1,000	$23,000	$24,000
		High Estimate	$1,000	$34,000	$36,000
	Unsealed Road	Moderate Estimate	$4,000	$240,000	$310,000
		High Estimate	$8,000	$370,000	$475,000
Culverts	Sealed Road	Moderate Estimate	$ -	$24,000	$30,000
		High Estimate	$ -	$36,000	$48,000
	Unsealed Road	Moderate Estimate	$1,000	$300,000	$380,000
		High Estimate	$4,000	$455,000	$585,000
TOTAL		Moderate Estimate	$70,000	$5,760,000	$7,180,000
		High Estimate	$150,000	$9,070,000	$11,340,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.1.4.2 Crossings

The GIS layers used to inform the URS analysis did not include any data on inundation of crossings. Therefore no cost estimates were developed for crossings in this region.

3.1.4.3 Bridges

Key input data

The table below summarises the number and length of affected bridges (in metres) for Goulburn in reaches E to H inside levees identified from the GIS data. As per assumptions in Section 2.2.1, costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-11 Goulburn – Number and Lengths of Inside Levee Affected Bridges (metres)

BRIDGE TYPE		FLOW RATE		
		REACHES E to H (Inside Levees)		
		Up to 25K	25K to 30K	30K to 40K
Single Lane Bridge	Number of Affected Bridges	4	10	4
	Total Length of Affected Bridges	160	462	167
	5% of Total Length	8	24	9
Dual Lane Bridge	Number of Affected Bridges	0	0	0
	Total Length of Affected Bridges	0	0	0
	5% of Total Length	0	0	0

3.1.4.4 *Key results*

The table below summarises the results of the cost estimates for inside levee bridge works in the Goulburn region.

Table 3-12 Goulburn - Estimated Costs for Inside Levee Bridge Works

CROSSING TYPE	CATEGORY	FLOW RATE		
		REACHES E to H (Inside Levees)		
		Up to 25K	25K to 30K	30K to 40K
Single Lane	Moderate Estimate	$140,000	$400,000	$140,000
	High Estimate	$150,000	$450,000	$145,000
Dual Lane	Moderate Estimate	$ -	$ -	$ -
	High Estimate	$ -	$ -	$ -
TOTAL	Moderate Estimate	$140,000	$400,000	$140,000
	High Estimate	$150,000	$450,000	$145,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.1.5 *Overall cost summary for Goulburn region*

The table below summarises the results of the total cost estimates for the entire Goulburn region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-13 Goulburn - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE								
		REACHES A TO D			REACHES E TO H			REACHES E to H (Inside Levees)		
		Up to 12K	12K to 15K	15K to 20K	Up to 25K	25K to 30K	30K to 40K	Up to 25K	25K to 30K	30K to 40K
1	**Additional Inundation Events**	5	5	5	2	3.9	4.8	2	3.9	4.8
	Moderate Estimate	$85,000	$17,000	$110,000	$400,000	$3,200,000	$4,300,000	$160,000	$3,000,000	$3,900,000
	High Estimate	$93,000	$19,000	$130,000	$600,000	$4,600,000	$6,600,000	$180,000	$4,200,000	$5,900,000
2	**Additional Inundation Events**	5	5	5	5	5	5	5	5	5
	Moderate Estimate	$85,000	$17,000	$110,000	$700,000	$3,800,000	$4,400,000	$180,000	$3,500,000	$3,900,000
	High Estimate	$93,000	$19,000	$130,000	$1,000,000	$5,600,000	$6,700,000	$190,000	$5,000,000	$6,000,000
3	**Additional Inundation Events**	10	10	10	10	10	10	10	10	10
	Moderate Estimate	$85,000	$17,000	$120,000	$1,100,000	$6,700,000	$8,100,000	$200,000	$6,200,000	$7,300,000
	High Estimate	$93,000	$19,000	$140,000	$1,900,000	$10,300,000	$12,700,000	$300,000	$9,500,000	$11,500,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.1.6 Specific infrastructure cost estimates in the Goulburn

In addition to the regional costing exercise, a number of existing regulators in the lower Goulburn River were assumed as requiring upgrading and separately costed.

The indicative costs related to upgrading these regulators were estimated between $4 million and $8 million.

More detail can be found in the costing report which is provided in Appendix A.

3.2 Hume-Yarrawonga

3.2.1 Roads

3.2.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Hume-Yarrawonga identified from the GIS data.

Table 3-14 Hume-Yarrawonga - Lengths of Inundated Roads (metres)

CROSSING TYPE	FLOW RATE
	Up to 40K
Roads Considered in this Costing Estimate	
Sealed Road	208
Unsealed Road	71
Other Roads Assumed not to Require Works	
Major Roads*	0
Tracks and Other**	5,796

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.2.1.2 *Key results*

The table below summarises the results of the cost estimates for road works in the Hume-Yarrawonga region for the three flow scenarios outlined in Section 2.2.2.

Table 3-15 Hume-Yarrawonga - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE
			Up to 40K
Additional Inundation Events			0
Maintenance	Sealed Road	Moderate Estimate	$ -
		High Estimate	$ -
	Unsealed Road	Moderate Estimate	$ -
		High Estimate	$ -
Raise Road	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$10,000
	Unsealed Road	Moderate Estimate	$2,000
		High Estimate	$3,000
Culverts	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$12,000
	Unsealed Road	Moderate Estimate	$ -
		High Estimate	$ -
TOTAL		Moderate Estimate	$16,000
		High Estimate	$25,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-16 Hume-Yarrawonga - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE Up to 40K
Additional Inundation Events			5
Maintenance	Sealed Road	Moderate Estimate	$140,000
		High Estimate	$190,000
	Unsealed Road	Moderate Estimate	$19,000
		High Estimate	$33,000
Raise Road	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$10,000
	Unsealed Road	Moderate Estimate	$2,000
		High Estimate	$3,000
Culverts	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$12,000
	Unsealed Road	Moderate Estimate	$ -
		High Estimate	$ -
TOTAL		Moderate Estimate	$170,000
		High Estimate	$230,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-17 Hume-Yarrawonga - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE Up to 40K
Additional Inundation Events			10
Maintenance	Sealed Road	Moderate Estimate	$280,000
		High Estimate	$380,000
	Unsealed Road	Moderate Estimate	$38,000
		High Estimate	$65,000
Raise Road	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$10,000
	Unsealed Road	Moderate Estimate	$2,000
		High Estimate	$3,000
Culverts	Sealed Road	Moderate Estimate	$7,000
		High Estimate	$12,000
	Unsealed Road	Moderate Estimate	$ -
		High Estimate	$ -
TOTAL		Moderate Estimate	$340,000
		High Estimate	$460,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.2.2 Crossings

3.2.2.1 Key input data

The table below summarises the number and lengths of replacement crossings (in metres) for Hume-Yarrawonga identified from the GIS data.

Table 3-18 Hume-Yarrawonga – Number and Lengths (metres) of Replacement Crossings

CROSSING TYPE		FLOW RATE
		Up to 40K
Minor Culvert	Number of Replacement Crossings	4
	Total Length of Replacement Crossings	166
Moderate Culvert	Number of Replacement Crossings	8
	Total Length of Replacement Crossings	253
Major Culvert	Number of Replacement Crossings	0
	Total Length of Replacement Crossings	0

3.2.2.2 Key results

The table below summarises the results of the cost estimates for crossing works in the Hume-Yarrawonga region.

Table 3-19 Hume-Yarrawonga - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE
		Up to 40K
Minor Culvert	Moderate Estimate	$1,900,000
	High Estimate	$2,400,000
Moderate Culvert	Moderate Estimate	$4,000,000
	High Estimate	$5,000,000
Major Culvert	Moderate Estimate	$ -
	High Estimate	$ -
TOTAL	Moderate Estimate	$5,900,000
	High Estimate	$7,400,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.2.3 *Bridges*

No GIS layers of bridges were supplied to URS as part of this study. Therefore it was assumed that no bridges are inundated in this region.

3.2.4 *Overall cost summary for Hume-Yarrawonga region*

The table below summarises the results of the total cost estimates for the entire Hume-Yarrawonga region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-20 Hume-Yarrawonga - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE
		Up to 40K
1	Additional Inundation Events	0
	Moderate Estimate	$5,900,000
	High Estimate	$7,400,000
2	Additional Inundation Events	5
	Moderate Estimate	$6,100,000
	High Estimate	$7,600,000
3	Additional Inundation Events	10
	Moderate Estimate	$6,200,000
	High Estimate	$7,900,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.3 Lower Darling

3.3.1 Roads

3.3.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Lower Darling identified from the GIS data.

Table 3-21 Lower Darling - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE	
	Up to 14K	14K to 17K
Roads Considered in this Costing Estimate		
Sealed Road	0	0
Unsealed Road	375	23
Other Roads Assumed not to Require Works		
Major Roads*	0	0
Tracks and Other**	25,163	15,341

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.3.1.2 *Key results*

The tables below summarise the results of the cost estimates for road works in the Lower Darling region for the three flow scenarios outlined in Section 2.2.2.

Table 3-22 Lower Darling - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE	
			Up to 14K	14K to 17K
Additional Inundation Events			**0**	**1.3**
Maintenance	**Sealed Road**	**Moderate Estimate**	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	**Moderate Estimate**	$ -	$ -
		High Estimate	$ -	$ -
Raise Road	**Sealed Road**	**Moderate Estimate**	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	**Moderate Estimate**	$12,000	$1,500
		High Estimate	$18,000	$2,500
Culverts	**Sealed Road**	**Moderate Estimate**	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	**Moderate Estimate**	$15,000	$500
		High Estimate	$23,000	$1,000
TOTAL		**Moderate Estimate**	$27,000	$2,000
		High Estimate	$41,000	$3,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-23 Lower Darling - Estimated Costs for Road Works (Scenario 2)

Works	Road Type	Category	Flow Rate	
			Up to 14K	14K to 17K
Additional Inundation Events			5	5
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$97,000	$5,000
		High Estimate	$170,000	$10,000
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$12,000	$1,500
		High Estimate	$18,000	$1,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$15,000	$500
		High Estimate	$24,000	$1,000
TOTAL		Moderate Estimate	$120,000	$9,000
		High Estimate	$200,000	$9,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-24 Lower Darling - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE	
			Up to 14K	14K to 17K
Additional Inundation Events			10	10
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$200,000	$10,000
		High Estimate	$340,000	$20,000
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$12,000	$1,500
		High Estimate	$18,000	$2,500
Culverts	Sealed Road	Moderate Estimate	$ -	$ -
		High Estimate	$ -	$ -
	Unsealed Road	Moderate Estimate	$15,000	$500
		High Estimate	$23,000	$1,000
TOTAL		Moderate Estimate	$220,000	$20,000
		High Estimate	$370,000	$21,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.3.2 *Crossings*

3.3.2.1 *Key input data*

The table below summarises the number and lengths of replacement crossings (in metres) for Lower Darling identified from the GIS data.

Table 3-25 Lower Darling – Number and Lengths (metres) of Replacement Crossings

CROSSING TYPE		FLOW RATE	
		Up to 14K	14K to 17K
Minor Culvert	Number of Replacement Crossings	0	0
	Total Length of Replacement Crossings	0	0
Moderate Culvert	Number of Replacement Crossings	1	0
	Total Length of Replacement Crossings	150	0
Major Culvert	Number of Replacement Crossings	0	0
	Total Length of Replacement Crossings	0	0

3.3.2.2 *Key results*

The table below summarises the results of the cost estimates for crossing works in the Lower Darling region.

Table 3-26 Lower Darling - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE	
		Up to 14K	14K to 17K
Minor culvert	Moderate Estimate	$ -	$ -
	High Estimate	$ -	$ -
Moderate Culvert	Moderate Estimate	$1,600,000	$ -
	High Estimate	$2,000,000	$ -
Major Culvert	Moderate Estimate	$ -	$ -
	High Estimate	$ -	$ -
TOTAL	Moderate Estimate	$1,600,000	$ -
	High Estimate	$2,000,000	$ -

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.3.3 *Bridges*

The table below summarises the number and length of affected bridges (in metres) for Lower Darling identified from the GIS data. As per assumptions in Section 2.2.1, costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-27 Lower Darling - Lengths of Affected Bridges (metres)

BRIDGE TYPE		FLOW RATE	
		Up to 14K	14K to 17K
Single Lane Bridge	Number of Affected Bridges	2	0
	Total Length of Affected Bridges	126	0
	5% of Total Length	7	0
Dual Lane Bridge	Number of Affected Bridges	2	0
	Total Length of Affected Bridges	222	0
	5% of Total Length	12	0

3.3.3.1 *Key results*

The table below summarises the results of the cost estimates for bridge works in the Lower Darling region.

Table 3-28 Lower Darling - Estimated Costs for Bridge Works

CROSSING TYPE	CATEGORY	FLOW RATE	
		Up to 14K	14K to 17K
Single Lane	Moderate Estimate	$120,000	$ -
	High Estimate	$130,000	$ -
Dual Lane	Moderate Estimate	$260,000	$ -
	High Estimate	$280,000	$ -
TOTAL	Moderate Estimate	$380,000	$ -
	High Estimate	$410,000	$ -

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.3.4 *Overall cost summary for Lower Darling region*

The table below summarises the results of the total cost estimates for the entire Lower Darling region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-29 Lower Darling - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE	
		Up to 14K	14K to 17K
1	**Additional Inundation Events**	0	1.3
	Moderate Estimate	$2,030,000	$2,000
	High Estimate	$2,440,000	$3,000
2	**Additional Inundation Events**	5	5
	Moderate Estimate	$2,120,000	$9,000
	High Estimate	$2,600,000	$9,000
3	**Additional Inundation Events**	10	10
	Moderate Estimate	$2,220,000	$20,000
	High Estimate	$2,770,000	$21,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.3.5 *Specific infrastructure cost estimates in the Lower Darling*

In addition to the regional costing exercise, two new regulators in the lower Darling River were costed.

The indicative costs related to upgrading these regulators were estimated between $2.5 and 4 million.

More detail can be found in the costing report which is provided in Appendix A.

3.4 Lower Murrumbidgee

3.4.1 Roads

3.4.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Lower Murrumbidgee identified from the GIS data.

Table 3-30 Lower Murrumbidgee - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE		
	Up to 30K	30K to 40K	40K to 48.5K
Roads Considered in this Costing Estimate			
Sealed Road	0	0	6
Unsealed Road	5,930	9,112	5,897
Other Roads Assumed not to Require Works			
Major Roads*	0	0	0
Tracks and Other**	211,854	141,020	175,739

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.4.1.2 Key results

The table below summarises the results of the cost estimates for road works in the Lower Murrumbidgee region for the three flow scenarios outlined in Section 2.2.2.

Table 3-31 Lower Murrumbidgee - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			**18.2**	**3.7**	**0.7**
Maintenance	**Sealed Road**	**Moderate Estimate**	$ -	$ -	$500
		High Estimate	$ -	$ -	$800
	Unsealed Road	**Moderate Estimate**	$5,900,000	$1,800,000	$220,000
		High Estimate	$10,000,000	$3,100,000	$375,000

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			18.2	3.7	0.7
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$185,000	$280,000	$180,000
		High Estimate	$280,000	$430,000	$275,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$230,000	$350,000	$220,000
		High Estimate	$350,000	$550,000	$350,000
TOTAL		Moderate Estimate	$6,200,000	$2,400,000	$620,000
		High Estimate	$10,500,000	$3,800,000	$810,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-32 Lower Murrumbidgee - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			5	5	5
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -	$500
		High Estimate	$ -	$ -	$800
	Unsealed Road	Moderate Estimate	$1,600,000	$2,200,000	$1,800,000
		High Estimate	$2,700,000	$4,200,000	$375,000

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WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			5	5	5
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$185,000	$280,000	$180,000
		High Estimate	$280,000	$430,000	$275,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$230,000	$350,000	$220,000
		High Estimate	$350,000	$550,000	$350,000
TOTAL		Moderate Estimate	$2,000,000	$3,000,000	$2,000,000
		High Estimate	$3,200,000	$4,800,000	$3,100,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-33 Lower Murrumbidgee - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			10	10	10
Maintenance	Sealed Road	Moderate Estimate	$ -	$ -	$500
		High Estimate	$ -	$ -	$800
	Unsealed Road	Moderate Estimate	$3,100,000	$5,000,000	$3,000,000
		High Estimate	$5,400,000	$8,300,000	$5,600,000

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			10	10	10
Raise Road	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$185,000	$280,000	$180,000
		High Estimate	$280,000	$430,000	$275,000
Culverts	Sealed Road	Moderate Estimate	$ -	$ -	$ -
		High Estimate	$ -	$ -	$ -
	Unsealed Road	Moderate Estimate	$230,000	$350,000	$220,000
		High Estimate	$350,000	$550,000	$350,000
TOTAL		Moderate Estimate	$3,500,000	$5,600,000	$3,500,000
		High Estimate	$5,800,000	$9,000,000	$6,100,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.4.2 *Crossings*

3.4.2.1 *Key input data*

The table below summarises the lengths of replacement crossings (in metres) for Lower Murrumbidgee identified from the GIS data.

Table 3-34 Lower Murrumbidgee - Lengths of Replacement Crossings (metres)

CROSSING TYPE		FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Minor Culvert	Number of Replacement Crossings	1	0	0
	Total Length of Replacement Crossings	45	0	0
Moderate Culvert	Number of Replacement Crossings	6	1	0
	Total Length of Replacement Crossings	370	25	0
Major Culvert	Number of Replacement Crossings	0	0	0
	Total Length of Replacement Crossings	0	0	0

3.4.2.2 Key results

The table below summarises the results of the cost estimates for crossing works in the Lower Murrumbidgee region.

Table 3-35 Lower Murrumbidgee - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Minor Culvert	Moderate Estimate	$500,000	$ -	$ -
	High Estimate	$650,000	$ -	$ -
Moderate Culvert	Moderate Estimate	$4,800,000	$450,000	$ -
	High Estimate	$5,900,000	$550,000	$ -
Major Culvert	Moderate Estimate	$ -	$ -	$ -
	High Estimate	$ -	$ -	$ -
TOTAL	Moderate Estimate	$5,300,000	$400,000	$ -
	High Estimate	$6,500,000	$500,000	$ -

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.4.3 *Bridges*

The table below summarises the number and length of affected bridges (in metres) for Lower Murrumbidgee identified from the GIS data. As per assumptions in Section 2.2.1, costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-36 Lower Murrumbidgee - Lengths of Affected Bridges (metres)

BRIDGE TYPE		FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Single Lane Bridge	Number of Affected Bridges	0	0	1
	Total Length of Affected Bridges	0	0	27
	5% of Total Length	0	0	2
Dual Lane Bridge	Number of Affected Bridges	0	0	0
	Total Length of Affected Bridges	0	0	0
	5% of Total Length	0	0	0

3.4.3.1 *Key results*

The table below summarises the results of the cost estimates for bridge works in the Lower Murrumbidgee region.

Table 3-37 Lower Murrumbidgee - Estimated Costs for Bridge Works

CROSSING TYPE	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Single Lane	Moderate Estimate	$ -	$ -	$30,000
	High Estimate	$ -	$ -	$40,000
Dual Lane	Moderate Estimate	$ -	$ -	$ -
	High Estimate	$ -	$ -	$ -
TOTAL	Moderate Estimate	$ -	$ -	$30,000
	High Estimate	$ -	$ -	$40,000

Note: Explanation of development of "moderate" and "high" estimates is provided in Section 2.2

3.4.4 Overall cost summary for Lower Murrumbidgee region

The table below summarises the results of the total cost estimates for the entire Lower Murrumbidgee region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-38 Lower Murrumbidgee - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
1	**Additional Inundation Events**	18.2	3.7	0.7
	Moderate Estimate	$11,500,000	$2,800,000	$650,000
	High Estimate	$17,000,000	$4,300,000	$850,000
2	**Additional Inundation Events**	5	5	5
	Moderate Estimate	$7,300,000	$3,400,000	$2,000,000
	High Estimate	$9,700,000	$5,300,000	$3,100,000
3	**Additional Inundation Events**	10	10	10
	Moderate Estimate	$8,800,000	$6,000,000	$3,500,000
	High Estimate	$12,300,000	$9,500,000	$6,100,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.5 Specific infrastructure in the Lower Murrumbidgee

In addition to the regional costing exercise, a cost estimate for a new regulator at Yanco Creek was completed.

The indicative costs related to constructing this new regulator was estimated at between $8 to 10 million.

More detail can be found in the costing report which is provided in Appendix A.

3.6 Mid Murrumbidgee

3.6.1 Roads

3.6.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Mid Murrumbidgee identified from the GIS data.

Table 3-39 Mid Murrumbidgee - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE		
	Up to 30K	30K to 40K	40K to 48.5K
Roads Considered in this Costing Estimate			
Sealed Road	200	298	1,031
Unsealed Road	1,352	2,298	3,177
Other Roads Assumed not to Require Works			
Major Roads*	0	0	0
Tracks and Other**	43,169	79,307	64,465

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.6.1.2 *Key results*

The table below summarises the results of the cost estimates for road works in the Mid Murrumbidgee region for the three flow scenarios outlined in Section 2.2.2.

Table 3-40 Mid Murrumbidgee - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			18.2	3.7	0.7
Maintenance	Sealed Road	Moderate Estimate	$500,000	$150,000	$100,000
		High Estimate	$700,000	$200,000	$150,000
	Unsealed Road	Moderate Estimate	$1,300,000	$450,000	$120,000
		High Estimate	$2,250,000	$800,000	$200,000
Raise Road	Sealed Road	Moderate Estimate	$7,000	$10,000	$35,000
		High Estimate	$10,000	$15,000	$50,000
	Unsealed Road	Moderate Estimate	$40,000	$70,000	$100,000
		High Estimate	$60,000	$110,000	$150,000
Culverts	Sealed Road	Moderate Estimate	$8,000	$10,000	$40,000
		High Estimate	$10,000	$10,000	$50,000
	Unsealed Road	Moderate Estimate	$50,000	$80,000	$120,000
		High Estimate	$80,000	$130,000	$200,000
TOTAL		Moderate Estimate	$1,900,000	$800,000	$500,000
		High Estimate	$3,000,000	$1,100,000	$600,000

Note: Explanation of development of "moderate" and "high" estimates is provided in Section 2.2

Table 3-41 Mid Murrumbidgee - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			5	5	5
Maintenance	Sealed Road	Moderate Estimate	$130,000	$210,000	$700,000
		High Estimate	$180,000	$280,000	$1,100,000
	Unsealed Road	Moderate Estimate	$350,000	$610,000	$800,000
		High Estimate	$610,000	$1,000,000	$1,500,000
Raise Road	Sealed Road	Moderate Estimate	$7,000	$10,000	$35,000
		High Estimate	$10,000	$15,000	$50,000
	Unsealed Road	Moderate Estimate	$40,000	$70,000	$100,000
		High Estimate	$60,000	$110,000	$150,000
Culverts	Sealed Road	Moderate Estimate	$8,000	$10,000	$40,000
		High Estimate	$10,000	$10,000	$50,000
	Unsealed Road	Moderate Estimate	$50,000	$80,000	$120,000
		High Estimate	$80,000	$130,000	$200,000
TOTAL		Moderate Estimate	$600,000	$1,000,000	$1,800,000
		High Estimate	$900,000	$1,500,000	$2,600,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-42 Mid Murrumbidgee - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE		
			Up to 30K	30K to 40K	40K to 48.5K
Additional Inundation Events			10	10	10
Maintenance	Sealed Road	Moderate Estimate	$270,000	$410,000	$1,400,000
		High Estimate	$370,000	$550,000	$1,900,000
	Unsealed Road	Moderate Estimate	$700,000	$1,250,000	$1,700,000
		High Estimate	$1,200,000	$2,200,000	$2,800,000
Raise Road	Sealed Road	Moderate Estimate	$7,000	$10,000	$35,000
		High Estimate	$10,000	$15,000	$50,000
	Unsealed Road	Moderate Estimate	$40,000	$70,000	$100,000
		High Estimate	$60,000	$110,000	$150,000
Culverts	Sealed Road	Moderate Estimate	$8,000	$10,000	$40,000
		High Estimate	$10,000	$10,000	$50,000
	Unsealed Road	Moderate Estimate	$50,000	$80,000	$120,000
		High Estimate	$80,000	$130,000	$200,000
TOTAL		Moderate Estimate	$1,100,000	$1,800,000	$3,400,000
		High Estimate	$1,700,000	$2,800,000	$5,100,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.6.2 Crossings

3.6.2.1 Key input data

The table below summarises the lengths of replacement crossings (in metres) for Mid Murrumbidgee identified from the GIS data.

Table 3-43 Mid Murrumbidgee - Lengths of Replacement Crossings (metres)

CROSSING TYPE		FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Minor Culvert	**Number of Replacement Crossings**	5	2	4
	Total Length of Replacement Crossings	184	105	131
Moderate Culvert	**Number of Replacement Crossings**	6	1	0
	Total Length of Replacement Crossings	235	20	0
Major Culvert	**Number of Replacement Crossings**	0	0	0
	Total Length of Replacement Crossings	0	0	0

3.6.2.2 *Key results*

The table below summarises the results of the cost estimates for crossing works in the Mid Murrumbidgee region.

Table 3-44 Mid Murrumbidgee - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Minor Culvert	Moderate Estimate	$2,200,000	$1,100,000	$1,700,000
	High Estimate	$2,750,000	$1,350,000	$2,200,000
Moderate Culvert	Moderate Estimate	$3,500,000	$300,000	$ -
	High Estimate	$4,250,000	$450,000	$ -
Major Culvert	Moderate Estimate	$ -	$ -	$ -
	High Estimate	$ -	$ -	$ -
TOTAL	Moderate Estimate	$5,700,000	$1,400,000	$1,700,000
	High Estimate	$7,000,000	$1,800,000	$2,200,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.6.3 *Bridges*

The table below summarises the number and length of affected bridges (in metres) for Mid Murrumbidgee identified from the GIS data. As per the assumptions in Section 2.2.1 costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-45 Mid Murrumbidgee - Lengths of Affected Bridges (metres)

BRIDGE TYPE		FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Single Lane Bridge	Number of Affected Bridges	4	1	0
	Total Length of Affected Bridges	153	37	0
	5% of Total Length	8	2	0
Dual Lane Bridge	Number of Affected Bridges	2	0	0
	Total Length of Affected Bridges	84	0	0
	5% of Total Length	5	0	0

3.6.3.1 Key results

The table below summarises the results of the cost estimates for bridge works in the Mid Murrumbidgee region.

Table 3-46 Mid Murrumbidgee - Estimated Costs for Bridge Works

CROSSING TYPE	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
Single Lane	Moderate Estimate	$140,000	$30,000	$ -
	High Estimate	$150,000	$40,000	$ -
Dual Lane	Moderate Estimate	$110,000	$ -	$ -
	High Estimate	$120,000	$ -	$ -
TOTAL	Moderate Estimate	$250,000	$30,000	$ -
	High Estimate	$260,000	$40,000	$ -

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.6.4 Overall cost summary for Mid Murrumbidgee region

The table below summarises the results of the total cost estimates for the entire Mid Murrumbidgee region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-47 Mid Murrumbidgee - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE		
		Up to 30K	30K to 40K	40K to 48.5K
1	Additional Inundation Events	18.2	3.7	0.7
	Moderate Estimate	$7,900,000	$2,200,000	$2,200,000
	High Estimate	$10,300,000	$2,900,000	$2,800,000
2	Additional Inundation Events	5	5	5
	Moderate Estimate	$6,600,000	$2,400,000	$3,500,000
	High Estimate	$8,200,000	$3,300,000	$4,800,000
3	Additional Inundation Events	10	10	10
	Moderate Estimate	$7,100,000	$3,200,000	$5,100,000
	High Estimate	$9,000,000	$4,600,000	$7,300,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.6.5 Specific Infrastructure in the Mid-Murray

In addition to the regional costing exercise, a cost estimate for upgrades to the existing stormwater system at Wagga Wagga was completed.

The indicative costs related to upgrading the stormwater system at Wagga Wagga has been estimated at between $5.5 to 8 million.

More detail can be found in the costing report which is provided in Appendix A.

3.7 South Australia

3.7.1 Roads

3.7.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for South Australia provided by the MDBA.

Table 3-48 South Australia - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE	
	Up to 60K	60K to 80K
Roads Considered in this Costing Estimate		
Sealed Road	873	3,106
Unsealed Road	4,035	5,344
Other Roads Assumed not to Require Works		
Major Roads*	0	0
Tracks and Other**	1,680	2,624

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.7.1.2 *Key results*

The table below summarises the results of the cost estimates for road works in the South Australia region for the three flow scenarios outlined in Section 2.2.2.

Table 3-49 South Australia - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE	
			Up to 60K	60K to 80K
Additional Inundation Events			1.1	2.4
Maintenance	Sealed Road	Moderate Estimate	$130,000	$1,000,000
		High Estimate	$180,000	$1,400,000
	Unsealed Road	Moderate Estimate	$240,000	$300,000
		High Estimate	$400,000	$500,000
Raise Road	Sealed Road	Moderate Estimate	$30,000	$100,000
		High Estimate	$45,000	$160,000
	Unsealed Road	Moderate Estimate	$120,000	$160,000
		High Estimate	$190,000	$250,000
Culverts	Sealed Road	Moderate Estimate	$30,000	$120,000
		High Estimate	$45,000	$190,000
	Unsealed Road	Moderate Estimate	$150,000	$200,000
		High Estimate	$230,000	$300,000
TOTAL		Moderate Estimate	$700,000	$1,900,000
		High Estimate	$900,000	$2,400,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-50 South Australia - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE	
			Up to 60K	60K to 80K
Additional Inundation Events			5	5
Maintenance	Sealed Road	Moderate Estimate	$590,000	$2,100,000
		High Estimate	$800,000	$2,800,000
	Unsealed Road	Moderate Estimate	$1,100,000	$1,400,000
		High Estimate	$1,800,000	$2,500,000
Raise Road	Sealed Road	Moderate Estimate	$30,000	$100,000
		High Estimate	$45,000	$160,000
	Unsealed Road	Moderate Estimate	$120,000	$160,000
		High Estimate	$190,000	$250,000
Culverts	Sealed Road	Moderate Estimate	$30,000	$120,000
		High Estimate	$45,000	$190,000
	Unsealed Road	Moderate Estimate	$150,000	$200,000
		High Estimate	$230,000	$300,000
TOTAL		Moderate Estimate	$2,000,000	$4,100,000
		High Estimate	$2,900,000	$5,800,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-51 South Australia - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE	
			Up to 60K	60K to 80K
Additional Inundation Events			10	10
Maintenance	Sealed Road	Moderate Estimate	$1,200,000	$4,200,000
		High Estimate	$1,600,000	$5,700,000
	Unsealed Road	Moderate Estimate	$2,200,000	$2,700,000
		High Estimate	$3,700,000	$5,000,000
Raise Road	Sealed Road	Moderate Estimate	$30,000	$100,000
		High Estimate	$45,000	$160,000
	Unsealed Road	Moderate Estimate	$120,000	$160,000
		High Estimate	$190,000	$250,000
Culverts	Sealed Road	Moderate Estimate	$30,000	$120,000
		High Estimate	$45,000	$190,000
	Unsealed Road	Moderate Estimate	$150,000	$200,000
		High Estimate	$230,000	$300,000
TOTAL		Moderate Estimate	$3,700,000	$7,600,000
		High Estimate	$5,600,000	$11,000,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.7.2 Crossings

No GIS layers of crossings were supplied to URS as part of this study. Therefore it was assumed that no crossings are inundated in this region.

3.7.3 Bridges

No GIS layers of bridges were supplied to URS as part of this study. Therefore it was assumed that no bridges are affected in this region.

3.7.4 Overall cost summary for South Australia region

The table below summarises the results of the total cost estimates for the entire South Australia region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-52 South Australia - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE	
		Up to 60K	60K to 80K
1	Additional Inundation Events	1.1	2.4
	Moderate Estimate	$700,000	$1,900,000
	High Estimate	$900,000	$2,400,000
2	Additional Inundation Events	5	5
	Moderate Estimate	$2,000,000	$4,100,000
	High Estimate	$2,900,000	$5,800,000
3	Additional Inundation Events	10	10
	Moderate Estimate	$3,700,000	$7,600,000
	High Estimate	$5,600,000	$11,000,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.8 Yarrawonga-Wakool

3.8.1 Roads

3.8.1.1 Key input data

The table below summarises the lengths of inundated roads (in metres) for Yarrawonga-Wakool identified from the GIS data.

Table 3-53 Yarrawonga-Wakool - Lengths of Inundated Roads (metres)

TYPE	FLOW RATE			
	Up to 20K	20K to 35K	35K to 50K	50K to 77K
Roads Considered in this Costing Estimate				
Sealed Road	2,804	376	878	2,832
Unsealed Road	4,172	8,429	12,771	37,878
Other Roads Assumed not to Require Works				
Major Roads*	0	0	0	0
Tracks and Other**	220,840	457,626	293,026	823,796

*Major roads include class codes 0 (freeways) and 1 (highways)

**Tracks and other roads include class codes 6 (2WD tracks), 7 (4WD tracks), 9 (proposed roads), 11 (walking tracks) and 12 (bike paths)

3.8.1.2 *Key results*

The table below summarises the results of the cost estimates for road works in the Yarrawonga-Wakool region for the three flow scenarios outlined in Section 2.2.2.

Table 3-54 Yarrawonga-Wakool - Estimated Costs for Road Works (Scenario 1)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE			
			Up to 20K	20K to 35K	35K to 50K	50K to 77K
Additional Inundation Events			0	20.2	10.7	1.5
Maintenance	Sealed Road	Moderate Estimate	$ -	$1,000,000	nc	nc
		High Estimate	$ -	$1,400,000	nc	nc
	Unsealed Road	Moderate Estimate	$ -	$9,200,000	nc	nc
		High Estimate	$ -	$15,650,000	nc	nc
Raise Road	Sealed Road	Moderate Estimate	$100,000	$13,000	nc	nc
		High Estimate	$140,000	$19,000	nc	nc
	Unsealed Road	Moderate Estimate	$130,000	$260,000	nc	nc
		High Estimate	$200,000	$390,000	nc	nc
Culverts	Sealed Road	Moderate Estimate	$110,000	$15,000	nc	nc
		High Estimate	$170,000	$24,000	nc	nc
	Unsealed Road	Moderate Estimate	$160,000	$320,000	nc	nc
		High Estimate	$250,000	$500,000	nc	nc
TOTAL		Moderate Estimate	$500,000	$10,800,000	nc	nc
		High Estimate	$500,000	$17,600,000	nc	nc

Note: Explanation of development of "moderate" and "high" estimates is provided in Section 2.2"
nc" = not costed. As explained in Section 2.2.2, the "BP2800RC" modelled flows are based on an assumption that managed flows would be limited to 40GL/day downstream of Yarrawonga Weir. It was therefore not appropriate to rely on BP2800RC modelled flows to estimate costs associated with flow rates higher than this.

Table 3-55 Yarrawonga-Wakool - Estimated Costs for Road Works (Scenario 2)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE			
			Up to 20K	20K to 35K	35K to 50K	50K to 77K
Additional Inundation Events			5	5	5	5
Maintenance	Sealed Road	Moderate Estimate	$1,900,000	$210,000	$590,000	$1,900,000
		High Estimate	$2,600,000	$290,000	$800,000	$2,600,000
	Unsealed Road	Moderate Estimate	$1,100,000	$2,300,000	$3,250,000	$9,900,000
		High Estimate	$1,900,000	$3,900,000	$5,700,000	$17,000,000
Raise Road	Sealed Road	Moderate Estimate	$100,000	$13,000	$30,000	$100,000
		High Estimate	$140,000	$19,000	$45,000	$150,000
	Unsealed Road	Moderate Estimate	$130,000	$260,000	$400,000	$1,100,000
		High Estimate	$200,000	$390,000	$600,000	$1,750,000
Culverts	Sealed Road	Moderate Estimate	$110,000	$15,000	$30,000	$100,000
		High Estimate	$170,000	$24,000	$45,000	$170,000
	Unsealed Road	Moderate Estimate	$160,000	$320,000	$500,000	$1,400,000
		High Estimate	$250,000	$500,000	$750,000	$2,200,000
TOTAL		Moderate Estimate	$3,500,000	$3,100,000	$4,800,000	$14,700,000
		High Estimate	$4,800,000	$4,800,000	$7,400,000	$22,300,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

Table 3-56 Yarrawonga-Wakool - Estimated Costs for Road Works (Scenario 3)

WORKS	ROAD TYPE	CATEGORY	FLOW RATE			
			Up to 20K	20K to 35K	35K to 50K	50K to 77K
Additional Inundation Events			10	10	10	10
Maintenance	Sealed Road	Moderate Estimate	$3,800,000	$500,000	$1,200,000	$3,750,000
		High Estimate	$5,200,000	$650,000	$1,600,000	$5,000,000
	Unsealed Road	Moderate Estimate	$2,250,000	$4,500,000	$6,900,000	$20,000,000
		High Estimate	$3,800,000	$7,800,000	$12,000,000	$34,000,000
Raise Road	Sealed Road	Moderate Estimate	$100,000	$13,000	$30,000	$100,000
		High Estimate	$140,000	$19,000	$45,000	$150,000
	Unsealed Road	Moderate Estimate	$130,000	$260,000	$400,000	$1,100,000
		High Estimate	$200,000	$390,000	$600,000	$1,750,000
Culverts	Sealed Road	Moderate Estimate	$110,000	$15,000	$30,000	$100,000
		High Estimate	$170,000	$24,000	$45,000	$170,000
	Unsealed Road	Moderate Estimate	$160,000	$320,000	$500,000	$1,400,000
		High Estimate	$250,000	$500,000	$750,000	$2,200,000
TOTAL		Moderate Estimate	$6,500,000	$5,600,000	$9,000,000	$26,600,000
		High Estimate	$9,300,000	$9,100,000	$14,400,000	$41,800,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.8.2 *Crossings*

3.8.2.1 *Key input data*

The table below summarises the lengths of replacement crossings (in metres) for Yarrawonga-Wakool identified from the GIS data.

Table 3-57 Yarrawonga-Wakool - Lengths of Replacement Crossings (metres)

CROSSING TYPE		FLOW RATE			
		Up to 20K	20K to 35K	35K to 50K	50K to 77K
Minor Culvert	**Number of Replacement Crossings**	14	57	37	27
	Total Length of Replacement Crossings	487	1,213	3,513	1,356
Moderate Culvert	**Number of Replacement Crossings**	38	5	8	3
	Total Length of Replacement Crossings	2,210	284	461	134
Major Culvert	**Number of Replacement Crossings**	15	3	0	5
	Total Length of Replacement Crossings	1,000	221	0	264

3.8.2.2 *Key results*

The table below summarises the results of the cost estimates for crossing works in the Yarrawonga-Wakool region.

Table 3-58 Yarrawonga-Wakool - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE			
		Up to 20K	20K to 35K	35K to 50K	50K to 77K
Minor Culvert	Moderate Estimate	$6,000,000	$31,700,000	$18,200,000	$59,400,000
	High Estimate	$7,500,000	$38,400,000	$24,000,000	$72,300,000
Moderate Culvert	Moderate Estimate	$28,500,000	$3,800,000	$5,900,000	$1,900,000
	High Estimate	$35,100,000	$4,600,000	$7,300,000	$2,400,000
Major Culvert	Moderate Estimate	$14,200,000	$3,100,000	$ -	$4,000,000
	High Estimate	$18,000,000	$3,900,000	$ -	$5,100,000
TOTAL	Moderate Estimate	$48,700,000	$37,900,000	$25,300,000	$64,400,000
	High Estimate	$60,400,000	$46,800,000	$32,400,000	$78,400,000

Note: Explanation of development of “moderate” and “high” estimates is provided in Section 2.2

3.8.3 *Bridges*

The table below summarises the number and length of affected bridges (in metres) for Yarrawonga-Wakool identified from the GIS data. As per assumptions in Section 2.2.1, costing assumptions were then applied to 5% of the total length of affected bridges. This value is also presented in the table below.

Table 3-59 Yarrawonga-Wakool - Lengths of Affected Bridges (metres)

BRIDGE TYPE		FLOW RATE			
		Up to 20K	20K to 35K	35K to 50K	50K to 77K
Single Lane Bridge	Number of Affected Bridges	20	8	2	4
	Total Length of Affected Bridges	1128	279	65	215
	5% of Total Length	57	14	3	11
Dual Lane Bridge	Number of Affected Bridges	8	1	0	0
	Total Length of Affected Bridges	509	30	0	0
	5% of Total Length	26	1	0	0

3.8.3.1 *Key results*

The table below summarises the results of the cost estimates for bridge works in the Yarrawonga-Wakool region.

Table 3-60 Yarrawonga-Wakool - Estimated Costs for Crossing Works

CROSSING TYPE	CATEGORY	FLOW RATE			
		Up to 20K	20K to 35K	35K to 50K	50K to 77K
Single Lane	Moderate Estimate	$970,000	$230,000	$60,000	$190,000
	High Estimate	$1,100,000	$210,000	$70,000	$200,000
Dual Lane	Moderate Estimate	$570,000	$30,000	$ -	$ -
	High Estimate	$600,000	$50,000	$ -	$ -
TOTAL	Moderate Estimate	$1,540,000	$260,000	$60,000	$190,000
	High Estimate	$1,650,000	$270,000	$70,000	$200,000

Note: Explanation of development of "moderate" and "high" estimates is provided in Section 2.2

3.8.4 *Overall cost summary for Yarrawonga-Wakool region*

The table below summarises the results of the total cost estimates for the entire Yarrawonga-Wakool region. This includes all infrastructure works for roads, crossings and bridges from the above sections.

Table 3-61 Yarrawonga-Wakool - Overall Cost Summary

FLOW REGIME SCENARIO	CATEGORY	FLOW RATE			
		Up to 20K	20K to 35K	35K to 50K	50K to 77K
1	Additional Inundation Events	0	20.2	10.7	1.5
	Moderate Estimate	$50,700,000	$49,000,000	$34,900,000	$70,900,000
	High Estimate	$62,600,000	$64,700,000	$47,800,000	$87,200,000
2	Additional Inundation Events	5	5	5	5
	Moderate Estimate	$53,700,000	$41,300,000	$30,200,000	$79,300,000
	High Estimate	$66,900,000	$51,900,000	$39,900,000	$100,900,000
3	Additional Inundation Events	10	10	10	10
	Moderate Estimate	$56,700,000	$43,800,000	$34,400,000	$91,200,000
	High Estimate	$71,400,000	$56,200,000	$46,900,000	$120,400,000

Note 2: Explanation of development of "moderate" and "high" estimates is provided in Section 2.2

3.9 Overall summary of costing outputs

The table below presents a summary of the regional costing outputs for scenario one for all regions from the above sections.

Table 3-62 Cost Overview for Regional Estimates

CMS REGION	CATEGORY								
Goulburn (Reaches A to D)	Flow rate (ML/day)	Up to 12K		12K to 15K		15K to 20K		Total up to 20k	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings
	Moderate Estimate	$ -	$85,000	$ -	$17,000	$9,000	$100,000	$9,000	$202,000
	High Estimate	$ -	$93,000	$ -	$19,000	$15,000	$110,000	$15,000	$222,000
Goulburn (Reaches E to H)	Flow rate (ML/day)	Up to 25K		25K to 30K		30K to 40K		Total up to 40k	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings
	Moderate Estimate	$290,000	$140,000	$2,800,000	$440,000	$4,100,000	$190,000	$7,190,000	$770,000
	High Estimate	$430,000	$150,000	$4,100,000	$480,000	$6,400,000	$200,000	$10,930,000	$830,000
Goulburn (Reaches E to H – Inside Levees)	Flow rate (ML/day)	Up to 25K		25K to 30K		30K to 40K		Total up to 40k	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings
	Moderate Estimate	$20,000	$140,000	$2,570,000	$400,000	$3,720,000	$140,000	$6,310,000	$680,000
	High Estimate	$30,000	$150,000	$3,800,000	$450,000	$5,790,000	$145,000	$9,620,000	$745,000

CMS REGION	CATEGORY								
Hume-Yarrawonga	**Flow rate (ML/day)**	Up to 40K						**Total up to 40k**	
	Infrastructure type	Roads	Bridges and crossings					**Roads**	**Bridges and crossings**
	Moderate Estimate	$16,000	$5,900,000					**$16,000**	**$5,900,000**
	High Estimate	$25,000	$7,400,000					**$25,000**	**$7,400,000**
Lower Darling	**Flow rate (ML/day)**	Up to 14K		14K to 17K				**Total up to 17k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$27,000	$2,000,000	$2,000	$ -			**$29,000**	**$2,000,000**
	High Estimate	$41,000	$2,400,000	$3,000	$ -			**$44,000**	**$2,400,000**
Murrumbidgee (Mid and Lower)	**Flow rate (ML/day)**	Up to 30K		30K to 40K		40K to 48.5K		**Total up to 48.5k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$8,100,000	$11,250,000	$3,200,000	$1,830,000	$1,120,000	$1,730,000	**$12,420,000**	**$1,810,000**
	High Estimate	$13,500,000	$13,760,000	$4,900,000	$2,340,000	$1,410,000	$2,240,000	**$19,810,000**	**$18,340,000**

CMS REGION	CATEGORY								
South Australia	**Flow rate (ML/day)**	Up to 60K		60K to 80K				**Total up to 80k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$700,000	$ -	$1,900,000	$ -			**$2,600,000**	**$ -**
	High Estimate	$900,000	$ -	$2,400,000	$ -			**$3,300,000**	**$ -**
Yarrawonga-Wakool	**Flow rate (ML/day)**	Up to 20K		20K to 35K				**Total up to 50k**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings			**Roads**	**Bridges and crossings**
	Moderate Estimate	$500,000	$50,240,000	$10,800,000	$38,160,000			**$11,300,000**	**$88,400,000**
	High Estimate	$500,000	$62,050,000	$17,600,000	$47,070,000			**$18,100,000**	**$109,120,000**

Note: All cost estimates presented in this table are for the flow regime as defined by the MDBA's "BP2800RC" model run as explained in section 2.2.2 of this report.[7]

[7] Refer to MDBA (October 2012) *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results.*

As discussed in the body of this report, URS also developed cost estimates for two alternative sets of hydrological assumptions. The outputs from these alternative hydrological assumptions also informed the MDBA's assessment of costs. In particular, the MDBA considers that the flow regime as defined by the "BP2800RC" model run should not be relied on to estimate costs associated with higher flow rates in the Yarrawonga-Wakool. Cost estimates for the Yarrawonga-Wakool associated with these alternative assumptions are presented below.

Table 3-63 Cost overview of Alternative Scenarios for Yarrawonga-Wakool

CMS REGION	CATEGORY										
Yarrawonga-Wakool (Scenario 2 hydrological assumptions – assume 5 additional events / 25 years)	**Flow rate (ML/day)**	Up to 20K		20K to 35K		35K to 50K		50K to 77K		**Total up to 77k flow rate**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$3,500,000	$50,240,000	$3,100,000	$38,160,000	$4,800,000	$25,360,000	$14,700,000	$64,590,000	$26,100,000	$178,350,000
	High Estimate	$4,800,000	$62,050,000	$4,800,000	$47,070,000	$7,400,000	$32,470,000	$22,300,000	$78,600,000	$39,300,000	$220,190,000
Yarrawonga-Wakool (Scenario 3 hydrological assumptions – assume 10 additional events / 25 years)	**Flow rate (ML/day)**	Up to 20K		20K to 35K		35K to 50K		50K to 77K		**Total up to 77k flow rate**	
	Infrastructure type	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	Roads	Bridges and crossings	**Roads**	**Bridges and crossings**
	Moderate Estimate	$6,500,000	$50,240,000	$5,600,000	$38,160,000	$9,000,000	$25,360,000	$26,600,000	$64,590,000	$47,700,000	$178,350,000
	High Estimate	$9,300,000	$62,050,000	$9,100,000	$47,070,000	$14,400,000	$32,470,000	$41,800,000	$78,600,000	$74,600,000	$220,190,000

3.10 Overall summary of specific infrastructure cost estimates

Table 3-64 provides an overview of the estimated costs related to infrastructure across the four regions where specific infrastructure needs were identified by the MDBA.

Table 3-64 Specific infrastructure costing summary

REGION	ITEM	MODERATE COST ESTIMATE	HIGH COST ESTIMATE
Goulburn	Regulators	$4 million	$8 million
Mid-Murrumbidgee	Wagga Wagga stormwater control	$5.5 million	$8 million
Lower Murrumbidgee	Yanco Creek Regulator	$8 million	$10 million
Lower Darling	Regulators	$2.5 million	$4 million

4 DISCUSSION

This regional costing exercise has pragmatically made a number of significant assumptions to enable a pre-feasibility level assessment of potential costs of infrastructure works that may be required to mitigate the impacts of higher managed environmental flows. These are described in Appendix A and are summarised below, along with a discussion on what these assumptions mean in terms of the cost estimate, and what would be required to create more definitive cost estimates.

4.1 Roads

Assumptions related to length of roads requiring works

Given the desktop nature of the costing exercise and the data utilised, it was not possible to identify actual areas and length of roads potentially requiring remedial works, and therefore all roads identified as being within the flood extent of the flow were assumed to be impacted. It was assumed that a percentage of roads would require additional maintenance due to environmental flow inundation, and that a small percentage would require remedial upgrade works.

There was no guidance available or previous project experience on which to base the percentage of roads that may require additional maintenance and the percentage that may require upgrading, and the decision to allocate 95% as requiring increased maintenance and 5% as requiring upgrade works was a totally pragmatic decision based upon the experience of the people involved in the project from the MDBA and URS.

It was also assumed that 2WD and 4WD tracks would not require works as they were assumed to be largely unformed, and essentially unmaintained, and would not require any further action other than a period of closure given the relatively low frequencies of additional flow events being considered in this analysis. While it is possible that a small proportion of these tracks may provide essential access to property, it was not possible from the information available to ascertain the extent to which this may need to be considered.

Therefore there is large uncertainty in the actual length of road requiring works.

Assumptions related to unit costs and the NPV analysis

Unit rates for road related works were generically developed based on assumptions on what would be implemented, with these unit rates applied to the length of roads within GIS layers provided by the MDBA.

A maintenance regime was developed to then create a unit rate, and this was cross checked against known examples of road maintenance from local government councils in the Basin.

Road width was not always known, so assumptions were made on the width of the roads.

The NPV analysis was undertaken using inundation frequencies adopted by the MDBA. Further modelling and analysis may be required to confirm potential inundation frequencies.

Areas of uncertainty

It is difficult to determine whether this uncertainty could result in increases or decreases in actual costs if feasibility studies were to be progressed. Some reasons either way are presented below:

Some reasons why the estimate may go up:

- 2WD and 4WD tracks require some form of maintenance
- Site specific studies ascertain that there are more roads impacted than identified in this desktop exercise
- A much greater percentage of roads require upgrade works (as opposed to maintenance)
- Upgrades are more expensive as the works required are greater than what has been assumed
- Roads are wider than what has been assumed
- Some major roads like highways are impacted by these flows and require works
- Where major works are required, significant environmental investigations are required to asses potential impacts on downstream flows and flooding
- The frequency of inundation is higher than what has been adopted.

Some reasons why the estimate may go down:

- Not all roads require works and/or further site specific investigations ascertain that less roads are impacted than identified in this desktop exercise
- The assumptions around the maintenance works required, and the upgrade works needed are excessive and less works are needed
- Roads are not as wide as what has been assumed
- The frequency of inundation is lower than what has been adopted.

Studies required to decrease uncertainty

Site specific studies would be required to provide more certainty around the roads impacted by the environmental flows and the works needed. This would seek to provide more detail on the infrastructure contained within each region, and to identify the actual impacts of the proposed flows. This would then provide more certainty on the length of roads impacted, the type of impact, the required works, and the costs associated with those works.

This may include detailed hydrological and hydraulic modelling which provides information on the depth of inundation and the velocity of flows. This could also identify how any works proposed on the floodplain like raising the road level impacts on water levels. Optimally, this kind of technical analysis would be cross-checked against local knowledge.

4.2 Bridges

Assumptions related to length of bridges requiring works

As with the roads, the desktop exercise was not able to identify which bridges may require works or replacement. It was therefore pragmatically decided to assume 5% of the length of identified bridges would require replacement. Again, there was no previous report or analysis that was available to support the assessment and 5% was chosen as a reasonable assumption. Site specific studies may reveal a significantly different length requiring works.

Culvert crossings were not included in the data provided to URS, so there was no assessment of possible culvert replacement/upgrades needs. This may also significantly impact costs.

Assumptions related to unit costs

A unit rate was adopted assuming that the works would relate to the replacement of a clear span bridge.

Areas of uncertainty

It is difficult to determine whether this uncertainty could result in increases or decreases in actual costs if feasibility studies were to be progressed. Some reasons either way are presented below:

Some reasons why the estimate may go up:

- More bridges and culvert crossings are identified as requiring works or upgrades
- The bridges are longer/wider than assumed
- Works are more extensive that envisaged, and unit rates increase

Some reasons why the estimate may go down:

- Less bridges are identified as requiring works or upgrades
- The bridges are smaller than assumed
- The desktop analysis assumes bridges require replacement, whereas the site specific studies may show they only need some maintenance/improvement works
- It is possible to replace bridges with culverts, or lower vehicle loadings are possible

Studies required to decrease uncertainty

- Identify all bridges and culvert crossings through GIS and aerial photography, and confirm attributes such as length, width, type (e.g. clear span bridge, culvert) and level/height
- Ground truth as necessary
- Undertake modelling to ascertain flow levels and impacts on the bridges and cross check with local knowledge

4.3 Crossings

Assumptions related to the number of crossings requiring works

The level of detail available to support the costings associated with the crossings was somewhere in between that of the regional costing exercise, and the costing of specific infrastructure. More specific information was available on the length and height of individual crossings, and the existing structure at each location. The MDBA also provided information on which crossings were impacted by which flow rates. Therefore there is more certainty around which crossings need replacement, and their attributes.

Assumptions related to unit costs

Unit costs were established by assuming the crossings would be either clear span bridges or culverts. A typical solution was then adopted which formed the basis for the unit rates.

The length of the crossing was provided, and the width was assumed.

Areas of uncertainty

It is deemed more likely that the actual costs related to crossings would decrease if a more detailed site specific assessment were made. This is because:

- It would be likely that some of the crossings are not needed and can be rationalised
- It may be possible to pay compensation to crossing users for impeded access in some situations rather than having to replace the crossing
- It may be less expensive to purchase the land that requires access, compared to replacing the crossing
- Many crossings seem to be exceedingly long, and site surveys may reveal a much reduced length
- The solutions assumed in this report are not necessarily a ‘like for like’ replacement, and are likely to vastly improve the level of service currently provided by the crossings. A cost-sharing arrangement could be negotiated with the owners to share the costs related to this improvement.

Studies required to decrease uncertainty

- Site specific survey to ascertain attributes of current crossings and needs of future crossings
- More information on how each flow rate impacts at each crossing point and specific crossing hydraulics. This would include flow levels at each site, bank heights, and waterway areas
- A program of stakeholder engagement to ascertain real needs and opportunities for rationalisation and other solutions.

4.4 Other infrastructure

As noted, URS created a list of infrastructure types that may require replacement/upgrade including levees, regulators, and pump pads/sheds. However a lack of data meant that these infrastructure types could not be included in this desktop assessment. Apart from the levees, it is likely that costs related to these infrastructure types will be minor when compared to costs related to roads, bridges and crossings. Levees could however be a major cost that has not been accounted for in this study, either through upgrading of existing levees or the construction of new levees. Detailed site specific hydraulic and hydrological modelling is required in each region to enable decision making around levees.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This project undertook a desktop pre-feasibility study on the potential infrastructure costs related to the delivery of higher volume environmental flows through six regions of the Murray-Darling Basin. The study concentrated on roads, bridges, and crossings because of data availability, and also undertook costings of specific infrastructure needs. The project relied on a number of significant assumptions to enable the costings to be completed, and a high level of uncertainty exists over the actual works required, and their associated costs.

This study provides a starting point for a feasibility assessment which would undertake a more detailed, site specific study. The aim of such a feasibility assessment should be to concentrate on identifying the most likely set of works required in each region, and then develop site specific cost estimates.

5.2 Recommendations

A number of key assumptions have been made to enable this costing exercise to proceed and a full feasibility assessment is now required to provide a robust cost estimate. This feasibility assessment needs to:

- Use the best available knowledge to identify actual impacts of the proposed flows. This would include:
  - Engagement with government agencies who manage the infrastructure potentially impacted by the flows. This includes local government and water authorities
  - Engagement with local communities and other stakeholders to ascertain the impacts at a local scale
- Develop new knowledge as needed to fill current information gaps. This could include:
  - Specific hydraulic and hydrological modelling to identify the extent of the inundation, flow velocities and heights across the regions, at all flow rates
  - Site specific engineering and technical studies to identify infrastructure needs and design solutions
  - Environmental and social studies to identify and manage impacts.

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6 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Murray-Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

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APPENDIX A INFRASTRUCTURE COSTING ASSUMPTIONS – COMMON BASELINE ASSESSMENT

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Final Report

Constraints Management Strategy Prefeasibility

AUSTRALIA

Infrastructure Costing Assumptions - Common Baseline Assessment

1 September 2014
43157204/01/06

Prepared for:
Murray-Darling Basin Authority

Prepared by URS Australia Pty Ltd

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6	1/9/2014	Final Draft incorporating updates from the regional costing exercise

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EXECUTIVE SUMMARY

This report describes an infrastructure costing method and tool that has been developed to assist the Murray-Darling Basin Authority and its partners to address constraints in delivering environmental water in seven target regions across the Basin – Hume to Yarrawonga, Goulburn River, Yarrawonga to Wakool, Murrumbidgee, Lower Darling River, Gwydir Wetlands and the River Murray in South Australia.

The aim is to inform preliminary and high level management discussions by providing indicative infrastructure costs using consistent assumptions across each of the regions.

It is important to note that these unit rates, and the assumptions that underpin them, do not indicate the design solution that needs to be adopted in each area. They are a mechanism to provide an assessment of a possible package of costs for each region. In all cases, a more detailed and thorough exercise will be needed to identify the actual works required and their subsequent cost.

The costing method is based on the desktop identification of potential infrastructure issues/options using available GIS information layers, GIS data analysis summary tables (provided by others) and the use of unit costs for different infrastructure types. Unit rates have been developed based on cost estimates developed for recent engineering works in regional areas across the Basin adjusted to 2014 dollars. Where recent cost estimates could not be referenced, unit rates were developed based on current Australian Construction Handbook rates and the use of engineering judgement. No difference in unit rates is assumed between regions at this time.

A Microsoft Excel VBA model has been developed to calculate costs for each region based on user infrastructure selections for up to 20 zones (sub-regions) within each region. Model outputs include total cost of infrastructure by zone, and total cost of infrastructure type by region.

Costs of major infrastructure are assumed to be generated outside the model based upon specific cost estimates developed for individual infrastructure, and the adjustment of recent cost estimates for similar infrastructure using appropriate metrics. For example, the cross-section width and passing flow requirements including no of bays and/or size of gates would be useful metrics to estimate costs of a large regulator based on recent project cost estimates. Costs of major infrastructure can be entered into each relevant zone in the model as required.

The model includes Monte Carlo simulation using 2000 replicates to provide lower and upper bound cost estimates. Model outputs include what can be deemed the most likely or best estimate of infrastructure cost, and an upper estimate of costs.

The model has been developed to be as general as possible to allow for future variations in unit costing methodology.

Future improvements in costing methods will be dependent on the availability of improved information on hydraulics (e.g. water velocities and depths), topography and existing infrastructure including the use of local knowledge. Such analyses would allow improved identification of infrastructure options as well as the development of feasibility, conceptual and/or detailed design level costs using standard engineering methods.

A summary of the infrastructure costings adopted is presented in Table ES 1. A more detailed table is provided in Appendix C.

Table ES 1 Infrastructure costing summary

INFRASTRUCTURE ITEM	WHAT IT IS	UNIT COST	INPUT TO COST MODEL
Levee (Private land)	Levee/embankment on private land	Estimated minimum cost for a 1m high levee is $530/m Estimated maximum cost for a 1m high levee is $1,200/m	Length (metres)
Levee (Public land)	Levee/embankment on public/Crown owned land	Estimated minimum cost for a 1m high levee is $1,300/m Estimated maximum cost for a 1m high levee is $2,800/m	Length (metres)
Bridge	Bridge on a minor road	Estimated minimum cost for a road bridge is $2,500/m^2 Estimated maximum cost for a road bridge is $3,000/m^2	Length (metres)
Crossings	Mixture of public and private crossings on the floodplain	Estimates based on assuming crossings are replaced with new culverts or bridges Cost estimate based on length and height dimensions of existing structures	* Cost
Pump Pad & Shed Relocation	Landholder pump setup	Minimum cost $10,000 per pump & shed Maximum cost $20,000 per pump & shed	Number
Regulator - Small	Small regulators <2 m wide	The minimum cost of a <2 m wide regulator is $100,000 The maximum cost of a <2 m wide regulator is $200,000	Number
Regulator – Medium	(>2 m and <5 m width)	The minimum cost of a >2 m and <=5 m wide regulator is $250,000 The maximum cost of a >2 m and <=5 m regulator is $500,000	Number
Block Bank	Block banks can be used in inlet/outlet channels to prevent water entry or exit from the floodplain.	The minimum cost of a 1 m block bank is $180/m. The maximum cost of a 1 m block bank is $600/m	Number

INFRASTRUCTURE ITEM	WHAT IT IS	UNIT COST	INPUT TO COST MODEL
Road Maintenance	Assume 95% of roads require maintenance rather than capital works	The lower bound cost for an unsealed road is $30/m and the upper $190/m The lower bound cost for a sealed road is $180/m and the upper $380/m	Length (metres) and additional flooding events
Road Upgrade (Box culverts)	Assume 0.5% of roads require a full box culvert solution	The lower bound cost for an unsealed road is $3,470/m and the upper $11,760/m The lower bound cost for an sealed road is $3,510/m and the upper $11,850/m	Length (metres)
Road Upgrade (Raise road)	Assume 4.5% of roads require lifting by 500mm with culverts placed every 1km	The lower bound cost for an unsealed road is $330/m and the upper $1,040/m The lower bound cost for a sealed road is $370/m and the upper $1,130/m	Length (metres)
* Crossings are costed separately and then inputted into the cost model			

1 INTRODUCTION

Constraints are river management practices and structures that govern the volume and timing of regulated water delivery through the river system. Constraints to delivering water to environmental assets within the Basin include:

- **Physical constraints** - such as structures along or near the river, like bridges or roads, or activities by landholders, which may be affected by higher environmental flows,
- **Operational and management constraints** - relating to the river management practices which have been developed over the past century, mostly to support navigation and irrigation. Some practices, or the absence of them, mean that environmental water may not be managed as effectively as it could be.

Through the Constraints Management Strategy, Basin Governments and the MDBA are investigating the potential to relax or remove key constraints in the Murray-Darling Basin. This could allow for more flexibility in water delivery, and improve outcomes of environmental watering. However, higher managed environmental flows could also result in negative impacts as a result of more frequent inundation of land or infrastructure.

As part of the Constraints Management Strategy, the potential for these impacts to be mitigated is being considered.

URS was engaged by the MDBA to undertake a ‘pre-feasibility’ investigation of the costs that might be associated with infrastructure works that could be required to mitigate these impacts. Non-structural measures such as easements were not considered by URS.

The aim is to provide a consistent but preliminary and indicative set of cost estimates for infrastructure required to overcome constraints for each of seven regions - Hume to Yarrawonga, Goulburn River, Yarrawonga to Wakool, Lower Murrumbidgee, Lower Darling River, Gwydir Wetlands and the River Murray in South Australia.

In the first instance, the data used to support the cost estimates is derived from desktop assessment of GIS data including water inundation mapping layers, topography and assets. It is intended that local knowledge will be used to refine the infrastructure requirements and cost estimates in the future.

This report:

1. Discusses the costing methodology and assumptions.
2. Describes the Preliminary Infrastructure Costing for the Environment Model (PICEM) (included as an Appendix).

2 COSTING METHODOLOGY AND ASSUMPTIONS

As indicated earlier, the aim of the costing methodology developed in this project is to provide indicative and consistent costs across each region for high level constraints management review. More detailed costing of infrastructure options requires additional information including more detailed/improved GIS layers, more detailed hydraulic modelling and local knowledge. This information was not available and/or used at the time of writing this report.

This section provides a summary of the infrastructure types considered, the rationale for unit costs and the GIS information assumed to be available.

2.1 Unit Infrastructure Costs

Unit infrastructure costs have been derived for the following infrastructure types:

1. Levee (Private land)
2. Levee (Public land)
3. Bridge
4. Crossings
5. Pump Pad & Shed Relocation
6. Regulator - Small
7. Regulator – Medium
8. Block Bank
9. Road Maintenance (sealed and unsealed)
10. Road Upgrades (sealed and unsealed) for two scenarios:
11. Box culvert upgrade
12. Road raising by 500mm with culverts

Costs are conservatively assumed to be replacement or new costs unless otherwise specified.

2.1.1 Buildings

The costs of pump sheds/pumps are considered in this analysis (see Section 2.1.5). However, the cost of buildings such as sheds or houses has been excluded from this analysis as:

- It was assumed that it is unlikely that building damage will be significant within the minor flood level as very few buildings are likely to be inundated under such floods.
- If buildings are inundated during minor flooding then it can be assumed that the water level above floor level is likely to be small and consequently damages are likely to be minor.
- If buildings do existing within the minor flood level they are likely to be minor structures that have a history of flooding so that significant costs will be minimised by current practice such as the location of expensive equipment above flood level, or via the use of relocatable equipment.

- Where significant sheds or houses are found to be subject to inundation under minor flood level it is likely that a more detailed analysis including options for flood protection and or creation of flood easements would need to be considered at later stages of costing.

2.1.2 *Levees*

Environmental flows are generally to be delivered at water levels at or below minor flood levels. Consequently the depth of water over floodplains during environmental water deliveries is likely to be shallow. It is assumed that the depth of water is likely to be of the order of 0.5 m. Under such circumstances a 1 m high levee would be sufficient to protect private land and the unit costs of levee construction are based on construction cost estimates for levees of this size.

It is assumed that new levees would only be required where:

- New areas of private land might be flooded beyond the minor flood level. For example, if flooding outside of the existing levee system occurs during an environmental water delivery.
- Sensitive areas are to be flooded – namely areas which are not subject to an easement, or contain sensitive environmental or cultural areas and/or critical infrastructure such as houses or critical access roads.

The location of levees would be identified using GIS layers including flood inundation extents, flooding depths, cadastre and/or planning zones. Advice from river operators and locals on critical levels where local flooding may be exacerbated will be required in the future. In the interim, if hydraulic modelling results and/or analysis including water level layers or levee longitudinal section information are available for moderate and/or major flooding, these can be used to indicate where levees could be placed to protect private land and assets.

Unit Costs:

Unit costs for levees are based on the following assumptions:

- A trapezoidal levee with 3 m width at full height and 1 in 3 batter slopes.
- If depth of water is <=0.7 m the height of the levee is 1 m.
- If the depth of water is >0.7 m, the height of the levee is the depth of water plus 0.3 m (nominal) freeboard.
- A 5% allowance for minor works to facilitate drainage of adjacent land (e.g. drainage outlets including regulators/syphons).
- Allowance for provision for an easement of 20 m for levee construction and farm reinstatement works to allow drainage of farmland (for levees located on private land).
- 50% of locally sourced suitable earth fill (within approximately 30km).
- Private land - estimated minimum cost for a 1 m levee is $530/m; estimated maximum cost is $1200/m.
- Public land - estimated minimum cost for a 1 m levee is $1300/m; estimated maximum cost is $2800/m.

- No provision has been made for operational and/or maintenance costs.

The difference in costs of private and public land positioned levees is primarily associated with clearance of vegetation required to construct a new replacement levee. Public land is normally more vegetated than private land, so there are much greater requirements and costs in removing vegetation. Private land is assumed to be cleared for production purposes and/or require minor clearance only.

Minimum and maximum unit cost rates have been developed based on comparison of previously developed construction cost estimates based on conceptual and/or detailed design projects which consider mobilisation and demobilisation costs, vegetation removal and locally sourced (within 30km approx.) and/or disposed material. They represent cost variations for construction of similar designed levees and incorporate economies of scale.

The unit rates include a 100% contingency to cover costs related to design, project management, and construction supervision, and importantly approvals and stakeholder engagement. This large contingency has been applied to cover the possibility of a significant approvals process (incorporating environmental and cultural heritage) with extensive stakeholder engagement.

Minimum and maximum unit cost estimates are treated as the 10^{th} and 90^{th} percentile costs for probabilistic costing.

In the event that additional data becomes available for levees with height in excess of 1 metre the unit rate can be modified. Unit rates for > 1 metre high levees will need to be determined. These could be determined based on factorisation of unit rates for the 1 metre high levee construction.

Input to PICEM:

- Length (metres) of levee

2.1.3 Bridges

Bridges on public roads are not likely to require replacement under minor flood levels. However, there may be isolated instances where small bridges are inundated.

It is assumed that GIS output will:

- Identify bridges subject to inundation; and identify the type (number of lanes) and length of each bridge.

It is further assumed that:

- All bridges will be designed to the same load standards.
- Single lane bridges are 6.2 m wide.
- Double lane bridges are 8 m wide

In lieu of detailed GIS data and local knowledge of which bridges are inundated, an assumption on the percentage of bridges needing replacement could be made and introduced as an input parameter. It could be assumed that 5% of bridges require replacement. There is no basis for choosing 5% at this stage.

Unit Costs:

Unit costs for bridges are based on the surface area that is width by length of the bridge.

- Estimated minimum cost for a road bridge is $2,500/m^2. (rule-of-thumb)
- Estimated maximum cost for a road bridge is $3,000/m^2. (rule-of-thumb)

Rule of thumb unit cost estimates have been derived based on advice from experienced URS bridge design engineers and those currently being adopted by the construction industry for bridge construction tender submissions. Minimum and maximum unit costs represent possible variations in construction complexity/bridge type (e.g. clear span vs. crown units) and site conditions. Rule of thumb estimates are based on bridges designed and constructed to AS 5100 standards.

If bridges on major multi-lane each way roads are subject to inundation then costs would need to be considered separately and entered into PICEM as major infrastructure.

It should be noted that unit cost estimates do not distinguish between private or public roads and/or any variation of design standards.

Input to PICEM:

- Length (metres) of bridges assumed to be replaced

2.1.4 Crossings

As well as bridges on public roads, there can also be a mix of private and public crossings within the floodplain that are impacted by minor flows. These crossings can be explicitly identified through GIS analysis, and information can be available on their length, width and structure type.

Where this information is available, a separate costing exercise can be undertaken.

For all crossings identified as bridges, the unit rates apply as described in Section 2.1.3. The costing assumptions for culverts are described below.

Culverts

A bottom up cost estimate was performed for the culvert replacements based on URS previous experience. The following elements were adopted for the cost estimate with each element consisting of an estimated minimum and maximum cost.

Box culvert sections have been adopted as it has been assumed that these provide hydraulic conditions for fish passage.

1. Mobilisation and Site Establishment – itemised rate
2. Removal of Existing Structure – itemised rate
3. Earthworks – per m^3 rate
   a) Volume based on height, length and width of crossing (assuming triangular channel cross section).
4. Precast Culvert Supply and Installation – per m rate

a) Number of culverts based on assumption of square culverts across entire length of crossing as given in the GIS data supplied by MDBA
b) Length of culverts based on assumption of number and width of lanes. 1 lane was assumed for all locations where number of lanes was not supplied in the GIS data.

5. Deck Slab – per m^2 rate
   a) Assumed 300 mm thickness
6. Base Slab – per m^2 rate
   a) Assumed 300 mm thickness and 4 m wider than top width
7. Riprap – per m rate
   a) Assumed 300mm thickness and 2 m width on either side of crossing
8. Wing Walls – per m rate
   a) Assumed 300 mm thickness and same height and length as structure height
9. Approach/Access Road Works – itemised rate
   a) Assumed 25 m of approach/access road works needed at each end of crossing.
   b) Assumed minimal cut and fill and no allowance was made for importation/disposal of materials
10. Guardrails or Equivalent – per m rate
    a) Assumed rails cover entire length of both sides of crossings with an additional 4 m length at each end
11. Barrier Kerb – per m rate
    a) Assumed 150 mm x 150 mm kerb
12. Demobilisation – itemised rate
13. Contract Costs – percentage of total construction cost
    a) Assumed as 20%.
14. Contingency – percentage of total construction cost
    a) Assumed as 20%

Table 2-1 Costing detail for crossings

CATEGORY	ITEM	ESTIMATED COST (lower)	ESTIMATED COST (upper)	UNIT	SOURCE	COMMENT
Culvert	Mobilisation and Site Establishment	$40,000	$80,000	item	Blamey Road Bridge Detailed Design	
	Demolition/Removal/Disposal of Existing Structure	$25,000	$50,000	item	Blamey Road Bridge Detailed Design	
	Earthworks	$10	$20	m3	Hipwell Road Detailed Design	Assume excavated material for wing walls
	1.2 x 1.2 Precast Culvert	$524	$900	m	Rocla	Lower bound based on quote from Rocla, upper bound based on Rawlinsons
	2.1 x 2.1 Precast Culvert	$1,571	$2,500	m	Rocla	Lower bound based on quote from Rocla, upper bound based on Rawlinsons
	3.6 x 3.6 Precast Culvert	$2,979	$5,400	m	Rocla	Lower bound based on quote from Rocla, upper bound based on Rawlinsons
	Base Slab	$69	$87	m2	Rawlinsons 2013, P236	300mm, 25Mpa reinforced concrete slab. Assume 4m additional width
	Deck Slab	$69	$87	m2	Rawlinsons 2013, P236	300mm, 25Mpa reinforced concrete slab
	Riprap	$60	$80	m	Hipwell Road Detailed Design	300mm deep, 2m width on either side of crossing. Hipwell Road rate for lower bound
	Wing Walls	$69	$87	m	Rawlinsons 2013, P236	300mm, 25Mpa reinforced concrete slab. Assume area is height squared x 4 walls
	Approach/Access Road Works	$21,300	$26,700	item	Rawlinsons 2012, p683	Assume 50m of approach works needed. Assumes minimal cut and fill (no allowance for importation/disposal of material)

CATEGORY	ITEM	ESTIMATED COST (lower)	ESTIMATED COST (upper)	UNIT	SOURCE	COMMENT
	Guardrails or Equivalent	$200	$250	m	Rawlinsons 2013, p227	Assume 2xlength + 16m
	Barrier Kerb	$50	$100	m	Rawlinsons 2013, p224	
	Demobilisation	$10,000	$20,000	item	Blamey Road Bridge Detailed Design	
	Contract Costs	20%	20%	add		
	Contingency	20%	20%	add		
Bridge	Bridge	$2,500	$3,000	per m2	Based on Rule of Thumb rates	

Choosing the crossing type

When undertaking a costing exercise for crossings in a region, it is also appropriate to make some assumptions on the type of crossing solution that will be adopted. For example, an existing crossing may be a low level ford, and it may be more realistic to assume that it is replace with a culvert solution, particularly for higher flow rates.

This type of decision needs to be made on a regional by region basis.

As an example, in the Edward-Wakool region, five categories of crossing replacement were adopted:

EXISTING CROSSING TYPE	ASSUMED REPLACEMENT CROSSING TYPE BY FLOW RATE		
	0 to 20 GL/d	**20 to 50 GL/d**	**>50 GL/d**
Low Level Causeway/Ford	Do Nothing	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)
Culvert (height ≤ 1.2m)	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)	Minor Culvert (height 1.2m)
Culvert (1.2 ≤ height ≤ 2.1)	Moderate Culvert (height 2.1m)	Moderate Culvert (height 2.1m)	Moderate Culvert (height 2.1m)
Culvert (height > 2.1m)	Major Culvert (height 3.6m)	Major Culvert (height 3.6m)	Major Culvert (height 3.6m)
Bridge	Bridge	Bridge	Bridge

Assumptions were also made on the width of the crossings required based on local needs. For example, although a ‘single lane’ crossing could commonly be assumed to be 4 metres wide, given the needs of farmers to cross with large machinery, a wider width of 7.4 metres was assumed for single lane crossings and 8 metres for dual lane.

Reductions in costs through rationalisation of crossings

Also, it may be realistic to assume a certain percentage of the crossings are rationalised, particularly the most expensive crossings. Without detailed specific investigations, it is difficult to quantify what the saving may be. In the absence of any specific information, it may be appropriate to just assume 10-20% of the total cost is reduced through rationalisation of crossings.

Input to PICEM:

- Minimum and maximum bound estimated costs ($)

(Note: Minimum and maximum unit cost estimates are treated as the 10^{th} and 90^{th} percentile costs for probabilistic costing).

2.1.5 *Pump Pad & Shed Relocation*

It is unlikely that pump pads and sheds will need to be relocated and/or raised to avoid inundation due to a minor flooding event. It could be assumed that existing pump infrastructure would be positioned above historically higher flood levels and that only a few pumps may be affected. However, they have been included in the cost model in case.

If they were to be included, the location of pump pads and sheds would need to be identified using existing GIS layers. In the absence of any additional information it could be assumed that a) either all irrigation properties with river or creek frontages will require one relocation; or alternatively b) that 20% of all properties will require their pads and sheds to be moved or raised by ~1 m. Documentation of this decision is required for each model scenario. Alternatively the number of irrigators with pumping operations could be determined through liaison with local water authorities.

Unit Costs:

Unit costs for pump pad & shed relocation are based on the following assumptions:

- The existing pump does not need to be replaced, only relocated.
- New shed and concrete pad plus delivery, construction and earthworks.
- Shed up to 4 metres square.
- Minimum cost $10,000 per pump & shed (provisional amount).
- Maximum cost $20,000 per pump & shed (provisional amount).

Minimum and maximum unit cost estimates are treated as the 10^{th} and 90^{th} percentile costs for probabilistic costing.

Input to PICEM:

- Number of relocations

2.1.6 *Regulators*

Regulators are unlikely to be part of an infrastructure management solution in most cases. However, they have been included in the cost model in case a costing is required.

Small regulators <2 m wide would only require replacement if they present a flow constraint. However, most are likely to be designed to manage flows up to minor flood levels.

Moderate sized regulators (>2 m and <5 m width) would only require replacement if they present a flow constraint. However, most are likely to be designed to manage flows up to minor flood levels.

GIS data is unlikely to identify regulator or levee outlet structures. This information is likely to be held by water authorities/CMA/communities who would have a knowledge of their capacity and need of replacement/upgrade. If GIS information did include regulators, but no other information was available to assess their condition/capacity, a defined percentage of replacements may be used, eg 5 – 10% of the total number of regulators. This is a guestimate, and there is no current basis for this percentage. PICEM can be modified to accept as input a percentage number of regulators to be replaced if so required.

Unit Costs:[1]

Unit costs for small regulators are:

- The minimum cost of a <2 m wide regulator is $100,000 (indicative cost, actual cost related to local hydraulic conditions/requirements).
- The maximum cost of a <2 m wide regulator is $200,000 (indicative cost, actual cost related to local hydraulic conditions/requirements).

Unit costs for moderate sized regulators are:

- The minimum cost of a >2 m and <=5 m wide regulator is $250,000 (indicative cost, actual cost related to local hydraulic conditions/requirements).
- The maximum cost of a >2 m and <=5 m regulator is $500,000 (indicative cost, actual cost related to local hydraulic conditions/requirements).

Minimum and maximum unit cost rates have been developed based on comparison of previously developed construction cost estimates only and are based on conceptual and/or detailed design project construction cost estimates which consider mobilisation and demobilisation costs and locally sourced (zero cost) and/or disposed material. They represent cost variations for construction of similar designed structures. Cost estimates do not consider cost related to provision of construction access. Cost estimates do not include cost associated with obtaining approvals as it is assumed that works are related to existing structures. If a new structure was required, it would be appropriate to add costs to cover approvals. This may require location specific advice on potential approval costs.

Any regulators beyond 5 metres in width should be treated as 'large infrastructure' and costed separately. (Any large regulators on the floodplain are most likely there to manage larger flood flows and are unlikely to be impacted by minor flood events).

Minimum and maximum unit cost estimates are treated as the 10th and 90th percentile costs for probabilistic costing.

Input to PICEM:

- Number of regulators (small)
- Number of regulators (moderate)

2.1.7 Block Bank

Block banks can be used in inlet/outlet channels to prevent water entry or exit from the floodplain. The location of block banks will be difficult to identify at pre-feasibility level without local input or detailed mapping/modelling. In the interim, if water level layers are available for moderate and/or major flooding these may indicate definite channels where block banks could be placed to protect private land and assets from minor flooding events. However, their effectiveness/impact can only be determined based on a hydraulic assessment and should be considered together with levee placement.

It is likely that block banks will not be required as part of a pre-feasibility assessment. However, they have been included in the cost model in case a cost is needed.

[1] Engineering judgement – based North Central Catchment Management Authority Environmental Works and Measures Projects (2010-2014).

Unit Costs:

Unit costs for block banks are based on the following assumptions:

- Block bank has a 3 m crest width, 1 in 3 batter slopes and erosion protection.
- If depth of water is <=0.7 m the height of the block bank is 1 m.
- If the depth of water is >0.7 m, the height of the block bank is the depth of water plus 0.3 m freeboard.
- The minimum cost of a 1 m block bank is $180/m. [2]
- The maximum cost of a 1 m block bank is $600/m. [3]
- Block banks are constructed using suitable, locally sourced material.
- Linear meter rates are based on a minimum $30/m^3 and maximum $100/m^3 earthworks rate.

Minimum and maximum unit cost estimates are treated as the 10th and 90th percentile costs for probabilistic costing.

Input to PICEM:

- Number of block banks

2.1.8 Roads

At a workshop held between URS and MDBA staff in Canberra on the 23rd June 2014, it was agreed that a maintenance and capital works regime would be the most likely construction activity related to roads.

An important philosophy that underpins the approach adopted is that the environmental watering that will be undertaken will generally be below or up to 'minor flood levels' and therefore, by definition, represent nuisance flooding rather than a significant flood impact. Therefore it has been assumed that landholder and user access needs are not significantly impeded.

Indeed the Australian Water Information Dictionary defines "minor flooding" as "*Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged".*

See: http://www.bom.gov.au/water/awid/id-333.shtml

Based on this, it was agreed that a sensible and realistic approach to capturing the possible costs related to roads was to assume 95% of roads within the "minor flood" extent of the inundation caused by environmental watering would require maintenance/repair after the flow had receded, and that 5% would require more substantial works. Of the 5% it was assumed that 90% require lifting by 500mm and the construction of culverts at regulator intervals to provide drainage, and it was assumed that 10% require a full replacement with a series of box culverts. This is summarised in the table below.

[2] Engineering judgement, pers. comm Gavan Hunter, 27 March 2014.
[3] Engineering judgement, pers. comm Gavan Hunter, 27 March 2014.

Table 2-2 Assumptions of required solutions for roads

ASSUMED SOLUTION	SUB-SOLUTION	% OF ROADWAY LENGTH
Maintenance	NA	95%
Upgrade	Full replacement with a row of box culverts	0.5%
	Raise roadway by 500mm and add in box culverts at regular intervals	4.5%

This rule would apply to all unsealed roads and all secondary roads. It was deemed safe to assume that higher priority roads such as highways would be designed to cater for much higher flow rates and would therefore not be impacted by the flows envisaged for environmental watering.

With regards to the roads requiring maintenance, a unit rate to undertake the maintenance will be adopted, and a Net Present Value (NPV) assessment will be undertaken to capitalise this cost which can then be provided to the relevant local roads authority as a payment to cover the additional maintenance requirement. It is proposed that this NPV will be undertaken over a 25 year period at a 7% discount rate.

The number of additional environmental watering events that will occur over the period is required for the NPV analysis. As the actual years when the inundation event will occur are unknown, expected value analysis will be utilised within the NPV where the average probability is multiplied by the discounted cost of replacement in each year over the full period of analysis.

It was acknowledged that some sections of road may face higher levels of inundation which require specific design solutions, and these will be individually costed outside of the generic method referenced here if required.

2.1.8.1 Maintenance Methodology

The assumptions that underpin the unit rates for maintenance following impacts associated with “minor flooding” have been provided below for unsealed and sealed roads. No design has been carried out to determine pavement details for the methodologies provided below. The methodologies have been developed for indicative costing purposes only.

Unsealed Road

The following tasks have been allowed for as maintenance of an unsealed road following impacts from “minor flooding”:

1. Grade and reshape road surface to profile;
2. Scarify and recompact <=150mm of road surface;
3. Grade and reshape table drains including cleaning out existing drains (both sides of road);
4. Place a new 150mm thick layer of granular material (gravel).

Sealed Road

The following tasks have been allowed for as maintenance of a sealed road following impacts from “minor flooding”:

1. Scarify existing road surface;
2. Place, grade, roll and compact 150mm of unbound granular road base (full formation width);
3. Grade and reshape shoulders (unsealed) and table drains including cleaning out existing drains (both sides of road);
4. Provide a new 7-14mm two-coat spray seal;
5. Provide line marking.

2.1.8.2 *Road Upgrade / Improvement Design Solution 1: 600 x 450mm multi-cell box culverts full length of road*

This option assumes that the installation of the culverts and road pavement over can be undertaken without modifying the crest height of the road.

No design has been carried out to determine details for the methodology provided below. The methodology has been developed for indicative costing purposes only.

The following tasks have been allowed for with this option:

1. Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements;
2. Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons);
3. Install cast in-situ reinforced concrete base slabs and aprons;
4. Install pre-cast concrete box culverts (450mm clear internal height);
5. Install cast in-situ reinforced concrete headwalls and wingwalls;
6. Backfill culvert ends and wingwalls with granular material;
7. Construct 300mm thick unbound granular base over culverts and approaches;
8. Grade and shape shoulder / batters;
9. Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only);
10. Provide line marking (applicable to sealed roads only);
11. Install erosion protection to:
    - upstream / downstream of culvert (rip rap rock fill); and,
    - road batters (soil and grass).

The above tasks are applicable for a sealed or unsealed road, with the exception of Items 9 and 10 which are applicable for sealed roads only.

2.1.8.3 *Road Upgrade / Improvement Design Solution 2: Raised road by 500mm and install 1200 x 1200mm four-cell box culverts at 1km intervals*

This option assumes that the crest height of the road for the full length (approaches and over the culvert) is increased uniformly by 500mm. It also assumes that the existing road height is sufficient to allow installation of the nominated culverts.

No design has been carried out to determine details for the methodology provided below. The methodology has been developed for indicative costing purposes only.

The following tasks have been allowed for with this option:

1. Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements;
2. Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons);
3. Install cast in-situ reinforced concrete base slabs and aprons;
4. Install pre-cast concrete box culverts (1200mm clear internal height);
5. Install cast in-situ reinforced concrete headwalls and wingwalls;
6. Backfill culvert ends and wingwalls with granular material;
7. Scarify existing remaining road surface for full length between culverts;
8. Construct 500mm thick unbound granular base over full length of road;
9. Grade and shape shoulder / batters;
10. Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only);
11. Provide line marking (applicable to sealed roads only);
12. Install erosion protection to:
    - upstream / downstream of culvert (rip rap rock fill); and,
    - road batters (soil and grass).

The above tasks are applicable for a sealed or unsealed road, with the exception of Items 10 and 11 which are applicable for sealed roads only.

2.1.8.4 *Estimated Costs*

Costings have been developed with reference to the following resources:

- Rawlinsons *Australian Construction Handbook 2014;*
- Department of Infrastructure and Regional Development, *Infrastructure Investment* website (http://investment.infrastructure.gov.au/) ;
- Moira Shire Council website (http://www.moira.vic.gov.au/Home);
- Wakool Shire Council website (http://www.wakool.nsw.gov.au/).

No allowance has been made for insurances, fees, permits, environmental management, investigation / design or relocation of utilities. Cost estimates do not consider cost related to provision of construction access, approvals and or traffic management.

Estimated costs for the maintenance and design solution methodologies outlined above have been provided below.

Table 2-3 Cost Estimates

		LOWER BOUND ($/m)	UPPER BOUND ($/m)
Maintenance	Unsealed Road	30	190
	Sealed Road	180	380
Design Solution 1 (box culverts)	Unsealed Road	3,470	11,760
	Sealed Road	3,510	11,850
Design Solution 2 (raise road)	Unsealed Road	330	1,040
	Sealed Road	370	1,130

To cater for unknown widths, the formation width has been assumed as 11 metres for the upper bound unit rates, and 9 metres for the lower bound. Any roads with two or more lanes one-way would most likely be a major road with different design standards. Such roads should be treated as a major infrastructure item and costed separately.

Minimum and maximum unit cost estimates are treated as the 10^{th} and 90^{th} percentile costs for probabilistic costing.

Input to PICEM:

- Length of road (metres) requiring maintenance AND frequency of inundation change (sealed or unsealed)
- Length of road (metres) requiring a ‘box culvert’ solution (sealed or unsealed)
- Length of road (metres) requiring a ‘raise road’ solution (sealed or unsealed)

2.2 Large Infrastructure Costs

Large infrastructure costs including Channels, Major Roads, Major Bridges and Major Regulators are costed separately. In some cases scaling of costs from existing recent major infrastructure projects may be appropriate.

Input to PICEM:

- Minimum and maximum bound estimated costs ($)

(Note: Minimum and maximum unit cost estimates are treated as the 10^{th} and 90^{th} percentile costs for probabilistic costing).

2.3 Catering for additional costs such as approvals, and contingency

There has been a pragmatic decision to incorporate factors such as contingency, design costs, supervision costs, and approvals costs within the unit rates adopted. Different levels of these factors have been used based on the complexity of the infrastructure items and engineering judgement. For example, road maintenance activities would not require approvals, whereas upgrading or building a new levee would most likely require significant costs related to environmental and cultural approvals, as well as considerable stakeholder engagement.

2.4 Probabilistic Costing

Probabilistic costing is based on the use of Monte Carlo methods applied to the lowest and highest unit rates entered into the model and the lowest and highest cost of major infrastructure. Care has been taken to use independent unit costs where possible. Costs are assumed to be normally distributed with the lowest cost assumed to be the 10th percentile and highest cost the 90th percentile in the distribution.

Since independence in unit costs has been managed, all Monte Carlo simulations are undertaken independently. Two thousand (2,000) replicates are used to derive the total infrastructure costs by adding independent estimates of costs from each of the infrastructure items selected including major infrastructure. This provides a distribution of total infrastructure costs from which the median (50th percentile) and highest (90th percentile) costs are outputted by PICEM. The use of upper and lower bounds unit costs, combined with the Monte Carlo simulations, is being used to provide an indication of the 'likely' costs, and the possible 'upper bound' costs for initial planning purposes at a whole of strategy level. It should not be interpreted or reported as the 50th and 90th percentile costs given the large assumptions inherent in the costings.

More detail on the probabilistic costing method is provided in Appendix B.

3 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Murray-Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract agreed 18th October 2013.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between July and September 2014 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

APPENDIX A THE COSTING MODEL – PICEM

The Preliminary Infrastructure Costing for the Environment Model (PICEM) is a Microsoft Excel probabilistic costing model. The user interface and many of the algorithms are developed in Visual Basic for Applications to prevent inadvertent corruption of the model.

The model presents a user interface with a splashscreen; an infrastructure selection and data entry screen; and three Excel spreadsheets for model outputs that provide tabular and graphical summaries of infrastructure selections and costs. Users can trial different infrastructure scenarios and save the selections and costs to separate workbooks.

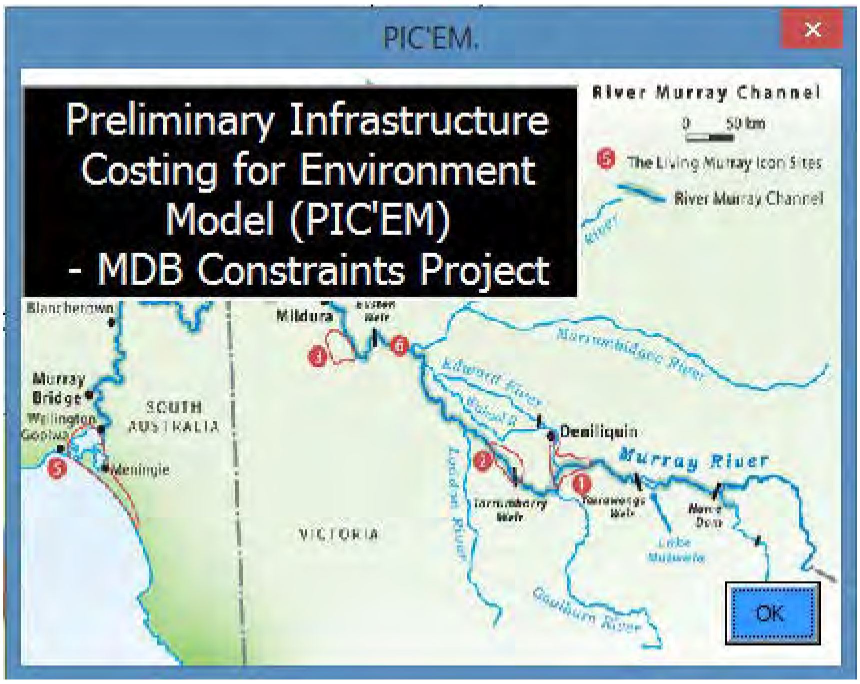


Figure-A-1 PICEM Splashscreen

A.1 Interface Design

The interface has been designed to be as intuitive and robust as possible. User access to spreadsheets is prevented with the exception of new output spreadsheets containing the saved scenarios.

To run the application simply open the Excel spreadsheet application, select a zone requiring infrastructure, then select and save infrastructure types and characteristics for that zone. Once all infrastructure for all zones is finalised, costing can begin by pressing the <Estimate Costs> button.

Users can identify each model scenario using a text field and make notes on the assumptions underlying that scenario. These fields are saved with each model run.

Definition of scenarios is up to the user. For example, scenarios can be used to consider different water levels and/or combinations of infrastructure.

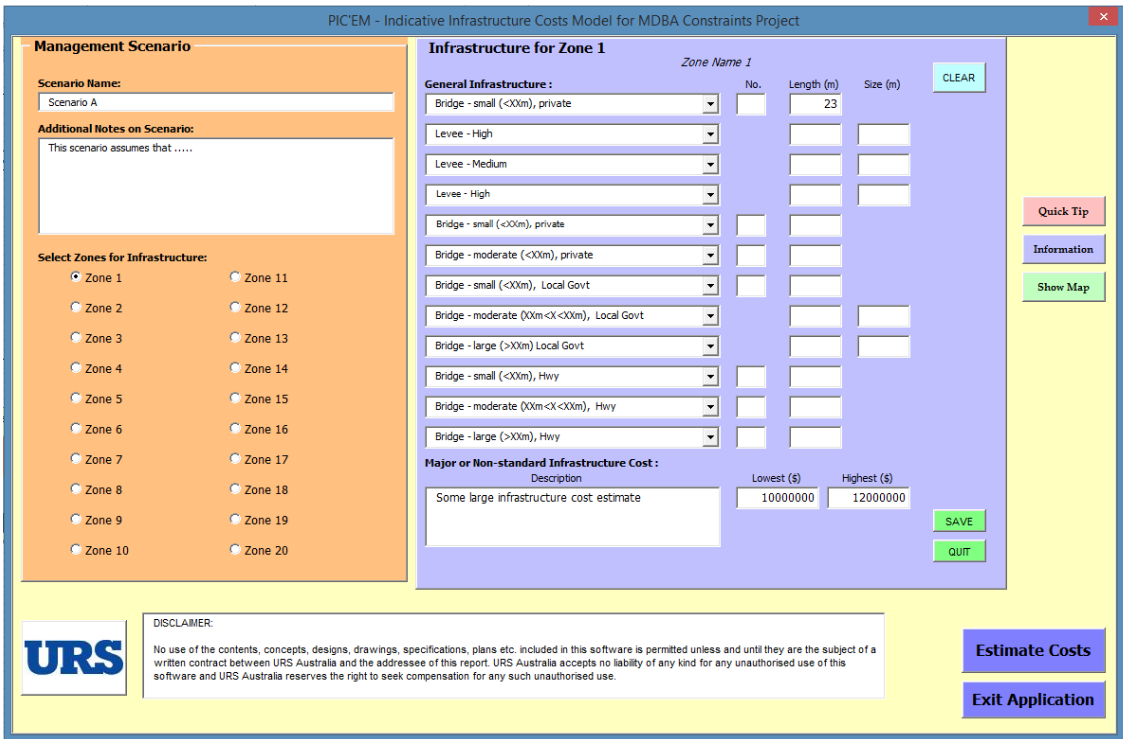


Figure-A-2 Main User Interface - Zone Infrastructure Selection

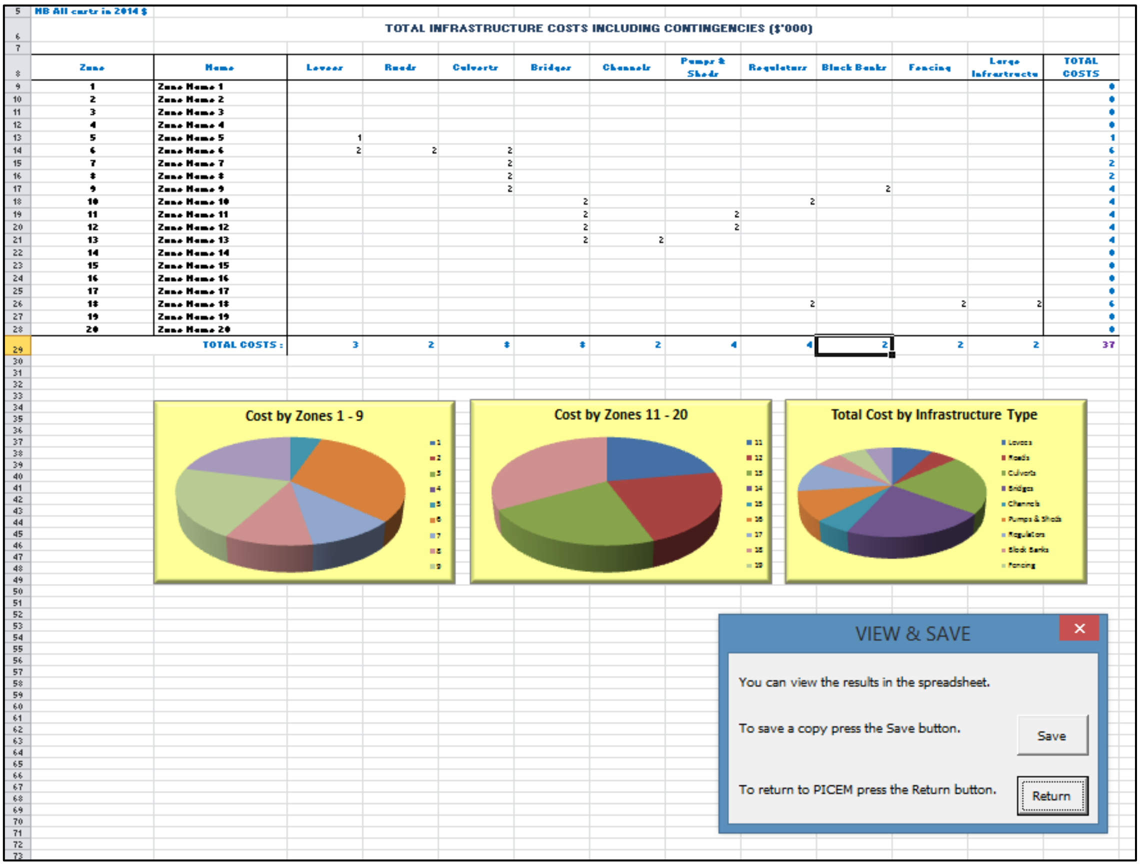
Infrastructure may be selected for up to 20 zones (sub-regions) during each model run. The use of the concept of zones allows discrimination of specific areas of concern and/or areas of dense infrastructure requirements. However, zones can also be used by the user to simply categorise infrastructure requirements according to their reporting needs – they do not need to be physical zones.

For each zone users can select 'general infrastructure' from pre-defined infrastructure types. Once an infrastructure type is selected, relevant input boxes appear to prompt the user for input that will allow costs to be derived. Only numeric data can be entered in these boxes.

In each zone the user may also provide a description of the major or non-standard infrastructure required and enter an estimate of the upper and lower bound cost of that infrastructure excluding contingencies.

The interface also includes a disclaimer regarding the use of the PICEM tool.

Once infrastructure selections and data entry are complete the user initiates costing by pressing the <Estimate Costs> button. This will commence the probabilistic costing algorithms and populate the output sheets including the following summary A4 sheet. Users will also be prompted to save the results at this time.



NB All costs in 2014 $

TOTAL INFRASTRUCTURE COSTS INCLUDING CONTINGENCIES ($'000)

Zone	Name	Levees	Roads	Culverts	Bridges	Channels	Pumps & Sheds	Regulators	Block Banks	Fencing	Large Infrastructure	TOTAL COSTS
1	Zone Name 1											0
2	Zone Name 2											0
3	Zone Name 3											0
4	Zone Name 4											0
5	Zone Name 5	1										1
6	Zone Name 6	2	2	2								6
7	Zone Name 7			2								2
8	Zone Name 8			2								2
9	Zone Name 9			2					2			4
10	Zone Name 10				2			2				4
11	Zone Name 11				2		2					4
12	Zone Name 12				2		2					4
13	Zone Name 13				2	2						4
14	Zone Name 14											0
15	Zone Name 15											0
16	Zone Name 16											0
17	Zone Name 17											0
18	Zone Name 18							2		2	2	6
19	Zone Name 19											0
20	Zone Name 20											0
	TOTAL COSTS :	3	2	8	8	2	4	4	2	2	2	37

Figure-A-3 A4 Summary Output Sheet and Prompt to Save (Example only)

APPENDIX B FURTHER DETAILS OF THE PROBABILISTIC COSTING METHOD

Probabilistic costing is a method used to provide decision makers with information on the level of confidence which can be assigned to the provided cost estimates.

The essence of probabilistic unit costing is to assume that the true unit cost of an infrastructure item is currently unknown. Estimates of unit cost can be made by experienced practitioners using past projects as a guide. In this project, engineering experts and previous case studies have been used to identify the likely least unit cost and the reasonable maximum unit cost for each infrastructure item considered. These costs have been used to estimate the true probability distribution of unit costs for each piece of infrastructure by assuming that these estimates represent percentiles from that distribution.

Once the probability distribution of unit costs is identified, random sampling of that probability distribution is undertaken to estimate the unit cost to be applied to any individual cost estimate for that particular type of infrastructure (i.e. for one replicate). Doing this many times provides a series of cost estimates (replicates) for that piece of infrastructure. The replicates have their own probability distribution from which cost estimates with nominated probabilities can be derived.

This is not a very revealing exercise for any one piece of infrastructure since the probability distribution of the replicates should simply be the same as the unit cost probability distribution scaled according to the length, height or other unit measure being used. However, when more than one type of infrastructure is being considered the probability distribution of the total cost of infrastructure will be some combination of the probability distributions of the individual unit costs scaled according to the relevant unit measure. The form of this probability distribution is dependent on the distribution of each unit cost and the level of correlation between the unit costs.

For this project, significant care has been taken during identification of unit costs to avoid cross-correlation between the costs of different infrastructure, This is an important step since statistical independence (i.e. zero correlation) leads to a straightforward way of determining the probability distribution of total infrastructure costs.

Under independence of unit costs, independent random samples of unit costs can be taken for each piece of infrastructure under consideration, scaled according to the length, height or other unit measure of the infrastructure, then added together to provide replicates of the total infrastructure costs. Furthermore, by assuming normally distributed unit costs it is clear from basic statistical theory that the replicates of total infrastructure costs will also be distributed according to a normal distribution.

The final infrastructure costs reported for each zone in the model are the nominal 50% and 90% confidence level estimates from the total infrastructure cost distribution. That is, the reported results are the most likely estimate of total costs (median = mode for a normal distribution), and the upper estimate of total costs with a 90% chance of the true cost being less than that number. As these estimates are based on regional scale unit rates, with large inherent assumptions, they should not be viewed as definitive 50th and 90th percentile cost estimates. Rather, they provide a reasonable indication of the variation in potential costs for initial planning purposes.

To provide additional clarity, a simple schematic of the process is shown for two infrastructure types only.

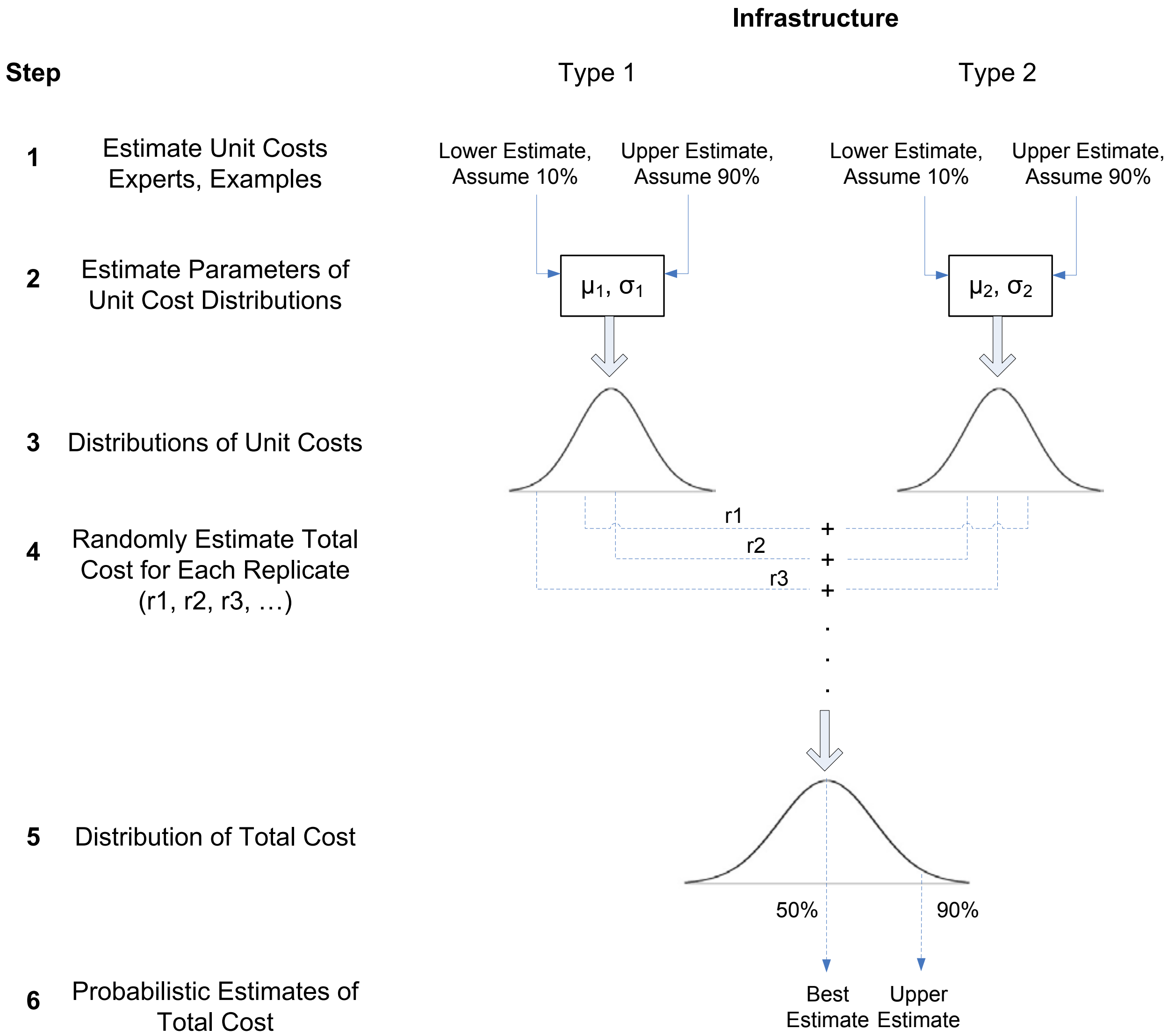


Figure-B-1 Schematic of Probabilistic Costing for Two Infrastructure Elements

APPENDIX C INFRASTRUCTURE SUMMARY

INFRASTRUCTURE ITEM	WHAT IT IS	ASSUMPTIONS/IMPROVEMENTS	UNIT COST/REFERENCE
Levee (Private land)	Levee/embankment on private land	Key assumptions: • A trapezoidal levee with 3 m width at full height and 1 in 3 batter slopes. • If depth of water is <=0.7 m the height of the levee is 1 m. • If the depth of water is >0.7 m, the height of the levee is the depth of water plus 0.3 m (nominal) freeboard. • No assessment of flooding depths against levee has been undertaken / utilised. • Allowance for provision for an easement of 20 m for levee construction and farm reinstatement works to allow drainage of farmland (land acquisition) • Unit rates have been doubled (i.e. 100% contingency) to account for the possibility of extensive approvals processes and stakeholder engagement requirements (as well as including design, supervision, management etc. costs) Information required to improve cost estimate: • Detailed hydraulic modelling to determine actual levee requirements	• Estimated minimum cost for a 1 m levee is $530/m; • Estimated maximum cost is $1,200/m • Previous URS project cost estimates
Levee (Public land)	Levee/embankment on public/Crown owned land	• As for private levee	• Estimated minimum cost for a 1 m levee is $1,300/m; • Estimated maximum cost is $2,800/m • Previous URS project cost estimates
Bridge	Applies to any bridge identified in the GIS information	Key assumptions: • Single lane bridges are 6.2 m wide. • Double lane bridges are 8 m wide • 5% of bridge lengths in each region require replacement/upgrade at the unit rates adopted Information required to improve cost estimate • Identify bridges subject to inundation; and identify the type (number of lanes) and length of each bridge. • Identify actual works required	• Estimated minimum cost for a road bridge is $2,500/m^2. (rule-of-thumb) • Estimated maximum cost for a road bridge is $3,000/m^2. (rule-of-thumb) • Unit rates are for bridges designed and built to AS 5100.
Crossings	Box culvert of bridge solution for existing low level causeways/fords, or culverts	Key assumptions: • Full replacement cost • Small, medium or large box culverts according to depth and length required • Adopted solution at each crossing point a function of existing crossing type, length, depth, and flow regime • Assume that single lane crossings are 7.4m wide to allow passage of large machinery Information required to improve cost estimate: • Site specific investigation of hydraulics • Confirmation of length and depth information • Investigation of crossing needs and rationalisation opportunities	• Cost based on a variety of unit rates for the main components of the works (e.g. culverts, wingwalls, earthworks etc) • Unit rates based on a variety of sources including previous design estimates, box culvert costs, Rawlinsons unit rates data • Overall cost calculated separately for each crossing
Pump Pad & Shed Relocation		Key assumptions: • The existing pump does not need to be replaced, only relocated. • New shed and concrete pad plus delivery, construction and earthworks. • Shed up to 4 metres square. Information required to improve cost estimate: • Site specific investigation	• Minimum cost $10,000 per pump & shed • Maximum cost $20,000 per pump & shed.

INFRASTRUCTURE ITEM	WHAT IT IS	ASSUMPTIONS/IMPROVEMENTS	UNIT COST/REFERENCE
Regulator - Small	Small regulators <2 m wide	Key assumptions: • Regulators are unlikely to be part of an infrastructure management solution in most cases • Minimum and maximum unit cost rates have been developed based on comparison of previously developed construction cost estimates • Based on conceptual and/or detailed design project construction cost estimates which consider mobilisation and demobilisation costs and locally sourced (zero cost) and/or disposed material. • Cost estimates exclude cost related to provision of construction access. • Cost estimates exclude cost associated with obtaining approvals • If a new structure was required, it would be appropriate to add costs to cover approvals. This may require location specific advice on potential approval costs. Information required to improve cost estimate: • Site specific investigation	• The minimum cost of a <2 m wide regulator is $100,000. • The maximum cost of a <2 m wide regulator is $200,000 • Based on Engineering judgement and NCCMA Environmental Works and Measures Projects (2010-2014).
Regulator – Medium	(>2 m and <5 m width)	• As per small regulator	• The minimum cost of a >2 m and <=5 m wide regulator is $250,000 • The maximum cost of a >2 m and <=5 m regulator is $500,000 • Based on Engineering judgement and NCCMA Environmental Works and Measures Projects (2010-2014).
Block Bank	Block banks can be used in inlet/outlet channels to prevent water entry or exit from the floodplain.	Key assumptions: • Typical block bank has a 3 m crest width, 1 in 3 batter slopes and erosion protection. • If depth of water is <=0.7 m the height of the block bank is 1 m. • If the depth of water is >0.7 m, the height of the block bank is the depth of water plus 0.3 m freeboard. • Block banks are constructed using suitable, locally sourced material Information required to improve cost estimate: • Site specific investigation	• The minimum cost of a 1 m block bank is $180/m. • The maximum cost of a 1 m block bank is $600/m • Linear meter rates are based on a minimum $30/m3 and maximum $100/m3 earthworks rate • Based on engineering judgement, pers. comm Gavan Hunter, 27 March 2014

INFRASTRUCTURE ITEM	WHAT IT IS	ASSUMPTIONS/IMPROVEMENTS	UNIT COST/REFERENCE
Road Maintenance	Assume 95% or roads require maintenance rather than capital works	Key assumptions: • Does not apply to major roads as it is assumed they are designed to above the minor flood level • For unsealed roads, assume the following works: o Grade and reshape road surface to profile; o Scarify and recompact <=150mm of road surface; o Grade and reshape table drains including cleaning out existing drains (both sides of road); o Place a new 150mm thick layer of granular material (gravel). • For sealed roads, assume: o Scarify existing road surface; o Place, grade, roll and compact 150mm of unbound granular road base (full formation width); o Grade and reshape shoulders (unsealed) and table drains including cleaning out existing drains (both sides of road); o Provide a new 7-14mm two-coat spray seal; o Provide line marking. Information required to improve cost estimate: • Pilot study in one region to test assumptions • Specific investigation to identify actual inundation impacts • Liaison with local government to cross check unit rates	• The lower bound cost for an unsealed road is $30/m and the upper $190/m • The lower bound cost for an sealed road is $180/m and the upper $380/m • Based on Rawlinsons, Australian Construction Handbook, 2014, and cross checking with costs to do similar works

INFRASTRUCTURE ITEM	WHAT IT IS	ASSUMPTIONS/IMPROVEMENTS	UNIT COST/REFERENCE

Road Upgrade (Box culverts)	Assume 0.5% or roads require a full box culvert solution	Key assumptions:
		• The installation of the culverts and road pavement over can be undertaken without modifying the crest height of the road.
		• A culvert depth of 1200mm is sufficient
		• The following tasks have been allowed for with this option:
		  o Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements;
		  o Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons);
		  o Install cast in-situ reinforced concrete base slabs and aprons;
		  o Install pre-cast concrete box culverts (450mm clear internal height);
		  o Install cast in-situ reinforced concrete headwalls and wingwalls;
		  o Backfill culvert ends and wingwalls with granular material;
		  o Construct 300mm thick unbound granular base over culverts and approaches;
		  o Grade and shape shoulder / batters;
		  o Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only);
		  o Provide line marking (applicable to sealed roads only);
		  o Install erosion protection to:
		    – upstream / downstream of culvert (rip rap rock fill); and,
		    – road batters (soil and grass).
		• The above tasks are applicable for a sealed or unsealed road, with the exception of the two-coat spray and line marking
		Information required to improve cost estimate:
		• Pilot study in one region to test assumptions
		• Specific investigation to identify actual inundation impacts
			• The lower bound cost for an unsealed road is \$3,470/m and the upper \$11,760/m
			• The lower bound cost for an sealed road is \$3,510/m and the upper \$11,850/m
			• Based on Rawlinsons, Australian Construction Handbook, 2014

<table>
<tr><th>INFRASTRUCTURE ITEM</th><th>WHAT IT IS</th><th>ASSUMPTIONS/IMPROVEMENTS</th><th>UNIT COST/REFERENCE</th></tr>
<tr><td>Road Upgrade (Raise road)</td><td>Assume 4.5% of roads require lifting by 500mm with culverts placed every 1km</td><td>Key assumptions:
The crest height of the road for the full length (approaches and over the culvert) is increased uniformly by 500mm. It also assumes that the existing road height is sufficient to allow installation of the nominated culverts.
The culvert size has been assumed as adequate to pass the required flows
The following tasks have been allowed for with this option:
Excavate existing road (full formation width and drains) with sufficient allowance (over-excavation) for installation of all culvert elements;
Place and compact 150mm crushed granular base material (over area to receive culvert base slabs and aprons);
Install cast in-situ reinforced concrete base slabs and aprons;
Install pre-cast concrete box culverts (1200mm clear internal height);
Install cast in-situ reinforced concrete headwalls and wingwalls;
Backfill culvert ends and wingwalls with granular material;
Scarify existing remaining road surface for full length between culverts;
Construct 500mm thick unbound granular base over full length of road;
Grade and shape shoulder / batters;
Provide a new 7-14mm two-coat spray seal (applicable to sealed roads only);
Provide line marking (applicable to sealed roads only);
Install erosion protection to:
upstream / downstream of culvert (rip rap rock fill); and,
road batters (soil and grass).
The above tasks are applicable for a sealed or unsealed road, with the exception of the two-coat spray and line marking
Information required to improve cost estimate:
Pilot study in one region to test assumptions
Specific investigation to identify actual inundation impacts</td><td>The lower bound cost for an unsealed road is $330/m and the upper $1,040/m
The lower bound cost for a sealed road is $370/m and the upper $1,130/m
Based on Rawlinsons, Australian Construction Handbook, 2014</td></tr>
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GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

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APPENDIX B SPECIFIC INFRASTRUCTURE COSTING REPORTS

B.1 Goulburn River Regulators

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Report

Constraints Management Strategy Prefeasibility

AUSTRALIA

Goulburn Region Leveed Floodplain Options

05 September 2014
43157204/3/1

Prepared for:
Murray Darling Basin Authority

Prepared by URS Australia Pty Ltd

URS

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1 INTRODUCTION

URS Pty Ltd (URS) was engaged by the Murray Darling Basin Authority (MDBA) to develop indicative cost estimates of specific outlet infrastructure to be upgraded located throughout the Lower Goulburn Floodplains. The existing infrastructure is located throughout a series of levees throughout the lower Goulburn River in Victoria designed to alleviate high flows and protect properties from floodwaters.

URS conducted a desktop of review of information received for each location. Based on the available data each location was evaluated by the following criteria:

1. Current functionality; and
2. Desired future functionality.

In each location a preferred upgrade achieving the desired future functionality was assumed For each structure the upgrade was determined with the following design criteria:

- Upgrade to a Work, Health and Safety (WHS) compliant structure;
- Improve efficiency at high flow; and
- Limit costs where appropriate.

The costing exercise has been undertaken to support the MDBA in its pre-feasibility assessment of the potential costs related to relieving constraints related to the delivery of environmental flows.

The infrastructure options proposed at each location were developed to enable the costing exercise to be undertaken. Actual solutions that provide the required outcomes at each site would need further detailed investigation.

2 STRUCTURE UPGRADE OPTIONS

2.1 Deep Creek Outlet

Structure Description:

Deep Creek outlet, located on the northern bank several kilometres downstream of Loch Garry, is a single rectangular concrete structure measuring approximately 7.8 meters wide and 3.3 metres high with an access bridge at crest height. It was modified by local farmers after floods during 1993 to reduce what was considered to be additional flood flows through Deep Creek. The modification included three bays with stop logs that can raise and lower the invert, but pose difficulties accessing during high flows.

Figure 2-1 Deep Creek Outlet (Source: Guy Tierney - GBCMA)

Assumed Functionality:

The structure is currently operated manually by local landowners. The stop logs are lifted up but during high flows this becomes difficult. It is assumed that the new structure needs to be managed during high flows and thus preferably remotely controlled. However, without knowledge of the current service in the area as well as line of sights it impossible to provide cost estimation for supplying any form remote technology.

Design Criteria:

The proposed upgrade and preliminary cost estimate for Deep Creek Outlet is based on the following design criteria:

- Replace existing stop logs with 3 penstock gates fitted with a manual actuator or remote technology, this includes stripping the foundation and installing filter material;
- Install hand railing along the existing access bridge; and
- Strip upstream and downstream of regulator foundation and install erosion control.

- If the existing concrete structure and access bridge are not suitable for the retrofitting of penstock gates then additional design criteria is required:
- Remove existing head wall, wing walls and bridge access;
- Excavate and prepare foundation;
- Install concrete structure;
- Install new bridge access and hand railing;

Cost Estimation:

If the concrete structure is suitable to allow for retrofitting of penstock gates, then the approximate cost to upgrade the existing Deep Creek outlet to a compliant structure is approximately $500,000.

If the concrete structure is replaced than the total cost would be approximately $1,300,000.

Assumptions:

The following assumptions have been made during the preparation of the cost estimates:

- It has been assumed that all works are carried out during the dry season;
- Geotechnical investigation and analysis has not been estimated;
- The structural integrity of the headwall and wing walls are subject to a comprehensive site inspection;
- Construction access via existing tracks. No allowances have been made for construction via new tracks.
- No delivery or installation costs of gates have been provided;
- The current size of opening is adequate for existing flows;
- The existing concrete apron and downstream energy dissipaters are adequate;
- The current access to the crossing is adequate during high flows;
- No allowance for the construction of a coffer dam has been made but may be required.

Recommendations:

URS believe that more certainty and accuracy could be provided by gaining additional information. In particular the following items would be required:

- Site visit;
- Site survey;
- Existing regulator dimensions;
- Flow data; and
- Comprehensive inspection of structure.

2.2 Hancocks Creek Outlet

Structure Description:

Hancocks Creek Outlet, located on the northern bank several kilometres downstream of McCoy Bridge, comprises three 1.7 metre diameter pipes (22.1 metres long). The pipes run under the newly constructed level, at the time, to allow the creek to function. The levee is approximately 1.8m high. Upstream of the structure is a debris rack comprising a number of rail-irons subject to debris capture. Currently the existing pipes are set relatively low and would commence flowing with relatively low flow.

Figure 2-2 Hancocks Creek Outlet (Source: Guy Tierney - GBCMA)

Assumed Functionality:

The structure is currently a passive structure with active management. At 20,000 ML/d the structure is not engaged, however at 40,000 ML/d and 60,000 ML/d it passes 4,500 ML/d (Water Technology 2011). However the modelled information is inconsistent with community experience.

Design Criteria:

The proposed upgrade and preliminary cost estimate for Hancocks Creek Outlet is based on the following design criteria:

- Temporarily excavate the levee bank;
- Replace the existing pipes with a Work Health and Safety (WHS) compliant series of pre-cast concrete culverts this includes stripping the foundation and installing filter material;
- Install penstock gates with manual actuators on each culvert to control high flows;
- Strip upstream and downstream foundation of regulator and install erosion control; and
- Remove debris rack and install screen.

Cost Estimate:

The cost estimate allows for the removal of the existing pipes and installation of three new box culverts with an increased capacity. The box culverts would also be fitted with penstock gates with manual actuators to allow for closure at times of high flows.

The approximate cost of upgrading Hancocks Creek Outlet is $550,000.

Assumptions:

The following assumptions have been made during the preparation of the cost estimates:

- It has been assumed that all works are carried out during the dry season;
- Geotechnical investigation and analysis has not been estimated;
- Construction access via existing tracks. No allowances have been made for construction via new tracks.
- No delivery or installation costs of gates have been provided;
- The current size of opening is adequate for existing flows;
- The current access to the crossing is adequate during high flows;
- The stability of the existing levee bank is adequate and the current materials can be reused.
- No concrete apron has been estimated at this stage but may be required depending on flows; and
- No allowance for the construction of a coffer dam has been made but may be required.

Recommendations:

URS believe that more certainty and accuracy could be provided by gaining additional information. In particular the following items would be required:

- Site visit;
- Site survey;
- Geotechnical analysis of the existing levee bank; and
- Flow data.

2.3 Wakiti Creek Outlet

Structure Description:

Wakiti Creek Outlet, located on the northern banks several kilometres upstream of McCoy Bridge, is an original brick 2 metre wide broad crested weir.

Figure 2-3 Wakiti Creek Outlet (Source: Guy Tierney - GBCMA)

Assumed Functionality:

The weir does not flow at 20,000 ML/d, however, at 40,000 Ml/d and 60,000 ML/d the structure passes approximately 1,000 ML/d and 1,400 ML/d respectively (Water Technology 2011) with a maximum flow rate of 3,100 ML/d (SKM 1998).

Design Criteria:

The proposed upgrade and preliminary cost estimate for Hancocks Creek Outlet is based on the following design criteria:

- Remove the existing brick work and install 2 penstock gates with manual actuators to allow for access at high flows, this includes stripping the foundation and installing filter material;
- Install hand railing and walkway structure; and
- Install a new concrete apron and place erosion control.

Cost Estimate:

The cost estimate allows the removal of existing brickwork and the installation of a 2 gate regulator with manual penstock gates. The regulator would include concrete wing walls, a galvanised steel walkway, hand rails and frame. Based on the preliminary data it is suggested that the upstream concrete apron would require being replaced. In addition, upstream and downstream erosion control would be placed.

The approximate cost of upgrading Wakiti Creek Outlet is $1,000,000.

Assumptions:

- The following assumptions have been made during the preparation of the cost estimates:
- It has been assumed that all works are carried out during the dry season;
- Geotechnical investigation and analysis has not been estimated;
- Construction access via existing tracks. No allowances have been made for construction via new tracks.
- No delivery or installation costs of gates have been provided;
- The current size of opening is adequate for existing flows;
- The current access to the outlet is adequate during high flows;
- No allowance for the construction of a coffer dam has been made but may be required.

Recommendations:

URS believe that more certainty and accuracy could be provided by gaining additional information. In particular the following items would be required:

- Site visit;
- Site survey;
- Flow data; and
- Existing structure dimensions.

2.4 Loch Garry Regulator

Structure Description:

The Loch Garry Regulator comprises a concrete structure with 48 bays, each approximately 2.2 metres wide, which contains slots to allow bars to be inserted or removed as required. The structure was constructed as part of the Loch Garry Minor Flood Protection Scheme which was introduced after repeated failure of levees constructed near the river bank at Loch Garry.

Figure 2-4 Loch Garry Regulator (Source: Guy Tierney - GBCMA)

Assumed Functionality:

The regulator was constructed to control flows into the Bunbartha Creek. The structure is operated by Goulburn-Murray Water, supported by a levy paid by property owners in the Loch Garry flood protection district. The regulator protects Deep Creek against nuisance floods and restricts flows for less frequent floods.

Design Criteria:

The proposed upgrade and preliminary cost estimate for Loch Garry is based on the following design criteria:

- Replace existing stop log gates with new penstock gates with either manual actuators or remote technology;
- Upgrade the upstream and downstream area of the regulator with erosion control; and
- Address the existing levees.

Cost Estimate:

The cost estimate allows for the removal existing stop logs and installation of new penstock gates with manual actuators. In addition it is recommended based the preliminary data that the both upstream and downstream foundation should be stripped and upgraded with erosion control.

The approximate cost of upgrading Loch Garry Regulator is $2,000,000.

Currently no estimate for levee repair has been completed. Additional information is required.

Assumptions:

The following assumptions have been made during the preparation of the cost estimates:

- It has been assumed that all works are carried out during the dry season;
- Geotechnical investigation and analysis has not been estimated;
- Construction access via existing tracks. No allowances have been made for construction via new tracks.
- No delivery or installation costs of gates have been provided;
- The current size of opening is adequate for existing flows;
- The current access to the outlet is adequate during high flows; and
- No allowance for the construction of a coffer dam has been made but may be required.

Recommendations:

URS believe that more certainty and accuracy could be provided by gaining additional information. In particular the following items would be required:

- Site visit;
- Site survey;
- Flow data; and
- Existing structure dimensions.

2.5 Hagans Creek Outlet

Structure Description

Hagans Creek Outlet is a single 300mm pipe at Hagans Lane. It is 14.6 metres long and passes up to 100ML/d (SKM 1998).

Figure 2-5 Hagans Creek Outlet (Source: Guy Tierney - GBCMA)

Assumed Functionality:

There is currently no data on the functionality of this outlet.

Design Criteria:

The proposed upgrade and preliminary cost estimate for Hagans Creek is based on the following design criteria:

- Replace existing pipe with new precast box culvert with a single penstock gates with a manual actuator; and
- Upgrade the upstream and downstream area of the regulator with erosion control.

Cost Estimate:

The cost estimate allows for the removal of existing pipe and installation a box culvert with a single penstock gate and actuator. The installation of box culvert includes foundation stripping and installation of filter material. In addition it is recommended based on the preliminary data that the both upstream and downstream should be stripped and upgraded with erosion control.

The approximate cost of upgrading Hagen's Creek Outlet is $200,000.

Assumptions:

The following assumptions have been made during the preparation of the cost estimates:

- It has been assumed that all works are carried out during the dry season;
- Geotechnical investigation and analysis has not been estimated;
- Construction access via existing tracks. No allowances have been made for construction via new tracks.
- No delivery or installation costs of gates have been provided;
- The current size of opening is adequate for existing flows;
- The current access to the outlet is adequate during high flows;
- No allowance for the construction of a coffer dam has been made but may be required.

Recommendations:

URS believe that more certainty and accuracy could be provided by gaining additional information. In particular the following items would be required:

- Site visit;
- Site survey;
- Flow data; and
- Geotechnical analysis of existing levee bank.

2.6 Madowla Lagoon

Structure Description:

Madowla Lagoon is described as a natural opening in the Bama Sandhills. At this stage URS does not have any additional information about his site and is not in a position to provide a cost estimate.

3 CONCLUSION

The proposed upgrade for each structure was determined by using limited information and understanding and as a result the cost estimates provided are only indicative. The costs reflect the size of the structure as well as the complexity of it.

Table 3-1 below is a comparison of the indicative cost of construction of each structure.

Table 3-1 Comparison of Construction Costs

LOCATION TABLE	INDICATIVE COST
Deep Creek Outlet	$500,000/1,300,000 [1]
Hancocks Creek Outlet	$550,000
Wakiti Creek Outlet	$1,000,000
Loch Garry Regulator	$2,000,000
Hagans Creek Outlet	$200,000
Madowla Lagoon	N/A [2]

[1] – Two costs provided depending on the structural integrity of the existing structure.

[2] – Unable to provide a cost without further information.

Based on this preliminary assessment, URS is suggesting that the costs relating to upgrading these regulators are in the order of $4million to $8 million.

If more information is given for each structure and further investigation is undertaken there is the ability to create a more accurate cost estimate.

4 REFERENCES

Goulburn Broken CMA, “Lower Goulburn Floodplain Rehabilitation Project”, brief prepared by Goulburn Broken CMA, June 2001.

Sinclair Knight Merz, “Lower Goulburn Waterway and Floodplain Management Plan, *Final Report Vol. 1*” report prepared for Goulburn Broken Catchment Management Authority, May 1998.

Sinclair Knight Merz, “Lower Goulburn Waterway and Floodplain Management Plan, *Executive Summary*” report prepared for Goulburn Broken Catchment Management Authority, July 1998.

Water Technology, “Lower Goulburn Floodplain Rehabilitation Scheme”, report prepared for Goulburn Broken Catchment Management Authority, December 2005

Water Technology, “Hydraulic Modelling Analysis for the Lover Goulburn River, report prepared for Goulburn Broken Catchment Management Authority, February 2011.

5 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Murray Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 8th of May 2014.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

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APPENDIX A COST ESTIMATES

The cost estimates presented here are construction costs only.

Deep Creek Regulator Cost Estimate

Project:	MDBA Constriants Management Strategy	Computed by:	ST
Job No:	43157204	Checked by:	RV
Client:	MDBA	Date:	5-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000	$ 50,000	
1.2	Coffer Dam and Dewater	1	Item	$ 35,000	$ 35,000	
1.3	Temporary Fencing	1	Item	$ 10,000	$ 10,000	
1.4	Tree removal	1000	m^2	$ 4	$ 4,000	
						$ 99,000.00
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 3 days)	15	days	$ 600	$ 9,000	
2.1.2	Excavator (2 x 3 days)	6	days	$ 1,500	$ 9,000	
2.1.3	Haul Truck (1 x 3 days)	3	days	$ 1,000	$ 3,000	
2.1.4	Roller (1 x 3 days)	3	days	$ 1,500	$ 4,500	
						$ 25,500.00
3	**Earthworks**					
3.1	Supply and place earthfill clay	350	m^3	$ 30	$ 10,500	
3.2	Supply and place filters	100	m^3	$ 100	$ 10,000	
3.3	Supply and place geofabric (Bidim A44)	350	m^2	$ 12	$ 4,200	
3.4	Supply and place transition gravel	100	m^3	$ 100	$ 10,000	
3.5	Supply and place rip rap	150	m^3	$ 60	$ 9,000	
						$ 43,700.00
4	**Miscellaneous**					
4.1	3 Penstock gates (1560mm x 3260mm) inc. manual actuators	3	Item	$ 25,000	$ 75,000	
4.2	Handrailing	1	Item	$ 5,000	$ 5,000	
4.3	Walkway	1	Item	$ 5,000	$ 5,000	
						$ 85,000.00
Contract Costs					**$ 253,200**	
	Contractor O/H Profit	20%			**$ 50,640**	
Base or Contract Construction Costs					**$ 303,840**	
	Superintendence, Project Management and QC Support	18%			**$ 54,691**	
	Contingency 40%	40%			**$ 121,536**	
Total Project Costs					**$ 480,067**	
Final Cost					**$ 500,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Deep Creek Regulator Cost Estimate (inc. Structure)

Project:	MDBA Constriants Management Strategy			Computed by:	ST	
Job No:	43157204			Checked by:	RV	
Client:	MDBA			Date:	5-Sep-14	

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000	$ 50,000	
1.2	Coffer Dam and Dewater	1	Item	$ 35,000	$ 35,000	
1.3	Temporary Fencing	1	Item	$ 10,000	$ 10,000	
1.4	Tree removal	1000	m^2	$ 4	$ 4,000	
						$ 99,000
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 5 days)	25	days	$ 600	$ 15,000	
2.1.2	Excavator (2 x 5 days)	10	days	$ 1,500	$ 15,000	
2.1.3	Haul Truck (1 x 5 days)	5	days	$ 1,000	$ 5,000	
2.1.4	Roller (1 x 5 days)	5	days	$ 1,500	$ 7,500	
						$ 42,500
3	**Earthworks**					
3.1	Supply and place earthfill clay	350	m^3	$ 30	$ 10,500	
3.2	Supply and place filters	100	m^3	$ 100	$ 10,000	
3.3	Supply and place geofabric (Bidim A44)	350	m^2	$ 12	$ 4,200	
3.4	Supply and place transition gravel	100	m^3	$ 100	$ 10,000	
3.5	Supply and place rip rap	150	m^3	$ 60	$ 9,000	
						$ 43,700
4	**New Structure**					
4.1	Supply and place in-situ concrete. Price includes placement of reinforcement, formwork, labour, machinery and scaffolding	110	m^3	$ 3,000	$ 330,000	
4.2	Abutments	2	Item	$ 25,000	$ 50,000	
4.3	Road surface	50	m^2	$ 500	$ 25,000	
						$ 405,000
4	**Miscellaneous**					
4.1	3 Penstock gates (1560mm x 3260mm) inc. manual actuat	3	Item	$ 25,000	$ 75,000	
4.2	Handrailing	1	Item	$ 5,000	$ 5,000	
4.3	Walkway	1	Item	$ 5,000	$ 5,000	
						$ 85,000
Contract Costs					**$ 675,200**	
	Contractor O/H Profit	20%			**$ 135,040**	
Base or Contract Construction Costs					**$ 810,240**	
	Superintendence, Project Management and QC Support	18%			**$ 145,843**	
	Contingency 40%	40%			**$ 324,096**	
Total Project Costs					**$ 1,280,179**	
Final Cost					**$ 1,300,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Hancocks Creek Outlet Cost Estimate

Project:	MDBA Constriants Management Strategy	Computed by:	ST		
Job No:	43157204	Checked by:	RV		
Client:	MDBA	Date:	5-Sep-14		

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 20,000	$ 20,000	
1.2	Coffer Dam and Dewater	1	Item	$ 5,000	$ 5,000	
1.3	Temporary Fencing	1	Item	$ 5,000	$ 5,000	
1.4	Tree removal	100	m^2	$ 4	$ 400	
						$ 30,400.00
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 3 days)	15	days	$ 600	$ 9,000	
2.1.2	Excavator (2 x 3 days)	6	days	$ 1,500	$ 9,000	
2.1.3	Haul Truck (1 x 3 days)	3	days	$ 1,000	$ 3,000	
2.1.4	Roller (1 x 3 days)	3	days	$ 1,500	$ 4,500	
						$ 25,500.00
3	**Earthworks**					
3.1	Excavate Embankment	100	m^3	$ 20	$ 2,000	
3.1	Supply and place earthfill clay	75	m^3	$ 30	$ 2,250	
3.2	Supply and place filters	25	m^3	$ 100	$ 2,500	
3.3	Supply and place geofabric (Bidim A44)	75	m^2	$ 12	$ 900	
3.4	Supply and place transition gravel	25	m^3	$ 100	$ 2,500	
3.5	Supply and place rip rap	50	m^3	$ 60	$ 3,000	
						$ 13,150.00
4	**Miscellaneous**					
4.1	1 Box Culverts 400mm x 400mm - 15m long	1	Item	$ 10,000	$ 10,000	
4.2	Penstock gates (400mm x 4000mm) inc. manual actuators	1	Item	$ 5,000	$ 5,000	
4.3	Handrailing	1	Item	$ 5,000	$ 5,000	
4.4	Walkway	1	Item	$ 5,000	$ 5,000	
4.5	Debris screen	1	Item	$ 5,000	$ 5,000	
						$ 30,000.00
Contract Costs					**$ 99,050**	
	Contractor O/H Profit	20%			**$ 19,810**	
Base or Contract Construction Costs					**$ 118,860**	
	Superintendence, Project Management and QC Support	18%			**$ 21,395**	
	Contingency 40%	40%			**$ 47,544**	
Total Project Costs					**$ 187,799**	
Final Cost					**$ 200,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Wakiti Creek Outlet Cost Estimate

Project:	MDBA Constriants Management Strategy			Computed by:	ST	
Job No:	43157204			Checked by:	RV	
Client:	MDBA			Date:	5-Sep-14	

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 20,000	$ 20,000	
1.2	Coffer Dam and Dewater	1	Item	$ 5,000	$ 5,000	
1.3	Temporary Fencing	1	Item	$ 5,000	$ 5,000	
1.4	Tree removal	200	m^2	$ 4	$ 800	
						$ 30,800.00
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 3 days)	15	days	$ 600	$ 9,000	
2.1.2	Excavator (2 x 3 days)	6	days	$ 1,500	$ 9,000	
2.1.3	Haul Truck (1 x 3 days)	3	days	$ 1,000	$ 3,000	
2.1.4	Roller (1 x 3 days)	3	days	$ 1,500	$ 4,500	
						$ 25,500.00
3	**Earthworks**					
3.1	Supply and place earthfill clay	200	m^3	$ 30	$ 6,000	
3.2	Supply and place filters	80	m^3	$ 100	$ 8,000	
3.3	Supply and place geofabric (Bidim A44)	200	m^2	$ 12	$ 2,400	
3.4	Supply and place transition gravel	100	m^3	$ 100	$ 10,000	
3.5	Supply and place rip rap	300	m^3	$ 60	$ 18,000	
						$ 44,400.00
4	Concrete Structure					
4.1	Supply and place in-situ concrete. Price includes placement of reinforcement, formwork, labour, machinery and scaffolding	120	m^3	$ 3,000	$ 360,000	
						$ 360,000.00
5	**Miscellaneous**					
5.2	2 Penstock gates (1500mm wide x 2750mm high)) inc. manual actuators	2	Item	$ 17,000	$ 34,000	
5.3	Handrailing	1	Item	$ 5,000	$ 5,000	
5.4	Walkway	1	Item	$ 5,000	$ 5,000	
						$ 44,000.00
Contract Costs					**$ 504,700**	
	Contractor O/H Profit	20%			**$ 100,940**	
Base or Contract Construction Costs					**$ 605,640**	
	Superintendence, Project Management and QC Support	18%			**$ 109,015**	
	Contingency 40%	40%			**$ 242,256**	
Total Project Costs					**$ 956,911**	
Final Cost					**$ 1,000,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Hagens Creek Outlet Cost Estimate

Project:	MDBA Constriants Management Strategy			Computed by:	ST	
Job No:	43157204			Checked by:	RV	
Client:	MDBA			Date:		5-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 20,000	$ 20,000	
1.2	Coffer Dam and Dewater	1	Item	$ 5,000	$ 5,000	
1.3	Temporary Fencing	1	Item	$ 5,000	$ 5,000	
1.4	Tree removal	100	m^2	$ 4	$ 400	
						$ 30,400.00
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 3 days)	15	days	$ 600	$ 9,000	
2.1.2	Excavator (2 x 3 days)	6	days	$ 1,500	$ 9,000	
2.1.3	Haul Truck (1 x 3 days)	3	days	$ 1,000	$ 3,000	
2.1.4	Roller (1 x 3 days)	3	days	$ 1,500	$ 4,500	
						$ 25,500.00
3	**Earthworks**					
3.1	Excavate Embankment	300	m^3	$ 20	$ 6,000	
3.1	Supply and place earthfill clay	150	m^3	$ 30	$ 4,500	
3.2	Supply and place filters	80	m^3	$ 100	$ 8,000	
3.3	Supply and place geofabric (Bid	150	m^2	$ 12	$ 1,800	
3.4	Supply and place transition grav	80	m^3	$ 100	$ 8,000	
3.5	Supply and place rip rap	150	m^3	$ 60	$ 9,000	
						$ 37,300.00
4	**Miscellaneous**					
4.1	3 Box Culverts 1.8mx1.8mx22m	3	Item	$ 35,000	$ 105,000	
4.2	3 Penstock gates (2000mm x 20	3	Item	$ 20,000	$ 60,000	
4.3	Handrailing	1	Item	$ 5,000	$ 5,000	
4.4	Walkway	1	Item	$ 5,000	$ 5,000	
4.5	Debris screen	1	Item	$ 5,000	$ 5,000	
						$ 180,000.00
Contract Costs					**$ 273,200**	
	Contractor O/H Profit		20%		**$ 54,640**	
Base or Contract Construction Costs					**$ 327,840**	
	Superintendence, Project Mana		18%		**$ 59,011**	
	Contingency 40%		40%		**$ 131,136**	
Total Project Costs					**$ 517,987**	
Final Cost					**$ 550,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Loch Barry Regulator Cost Estimate

Project:	MDBA Constriants Management Strategy			Computed by:	ST		
Job No:	43157204			Checked by:	RV		
Client:	MDBA			Date:	5-Sep-14		
Group	**Item Description**	**Quantity**	**Unit**	**Rate**	**Cost**	**Sub Total**
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000	$ 50,000	
1.2	Coffer Dam and Dewater	1	Item	$ 35,000	$ 35,000	
1.3	Temporary Fencing	1	Item	$ 10,000	$ 10,000	
1.4	Tree removal	0	m^2	$ 4	$ -	
						$ 95,000
2	**Foundation Prepartion**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 5 days)	25	days	$ 600	$ 15,000	
2.1.2	Excavator (2 x 5 days)	10	days	$ 1,500	$ 15,000	
2.1.3	Haul Truck (1 x 5 days)	5	days	$ 1,000	$ 5,000	
2.1.4	Roller (1 x 5 days)	5	days	$ 1,500	$ 7,500	
						$ 42,500
3	**Earthworks**					
3.1	Supply and place earthfill clay	800	m^3	$ 30	$ 24,000	
3.2	Supply and place filters	200	m^3	$ 100	$ 20,000	
3.3	Supply and place geofabric (Bidim A44)	500	m^2	$ 12	$ 6,000	
3.4	Supply and place transition gravel	200	m^3	$ 100	$ 20,000	
3.5	Supply and place rip rap	500	m^3	$ 60	$ 30,000	
						$ 100,000
4	**Miscellaneous**					
4.1	48 Penstock gates (2400mm wide x 2000mm high) inc. manual actuators	48	Item	$ 15,000	$ 720,000	
4.2	Handrailing	1	Item	$ 20,000	$ 20,000	
4.3	Walkway	1	Item	$ 20,000	$ 20,000	
						$ 760,000
Contract Costs					**$ 997,500**	
	Contractor O/H Profit	20%			**$ 199,500**	
Base or Contract Construction Costs					**$ 1,197,000**	
	Superintendence, Project Management and QC Support	18%			**$ 215,460**	
	Contingency 40%	40%			**$ 478,800**	
Total Project Costs					**$ 1,891,260**	
Final Cost					**$ 2,000,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

URS is a leading provider of engineering, construction, technical and environmental services for public agencies and private sector companies around the world. We offer a full range of program management; planning, design and engineering; systems engineering and technical assistance; construction and construction management; operations and maintenance; and decommissioning and closure services for power, infrastructure, industrial and commercial, and government projects and programs.

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B.2 Yanco Creek Regulator

URS

Report

Constraints Management Strategy Prefeasibility

AUSTRALIA

Yanco Creek Offtake Regulator Investigation Report

4 September 2014
43157204/4/1

Prepared for:
Murray Darling Basin Authority

Prepared by URS Australia Pty Ltd

DOCUMENT PRODUCTION / APPROVAL RECORD				
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Checked by	Rocco Vivarelli		4 Sept 2014	Senior Associate
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Murray Darling Basin Authority

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APPENDICES

1 INTRODUCTION

URS Pty Ltd (URS) has been engaged to support the Murray Darling Basin Authority (MDBA) in the development of a pre-feasibility cost estimate of potential infrastructure costs related to relieving flow constraints in the Murray Darling Basin to promote the delivery of environmental flows.

As part of this role, URS was commissioned to develop an indicative cost estimate for the potential construction of a regulator on the Yanco Creek offtake, located on the Murrumbidgee River in southern New South Wales.

URS conducted a desktop review of information provided by MDBA. The data included photographs of Yanco Offtake gauge point (including upstream and downstream), a surveyed cross section of the Yanco Creek cutting, rating table measured at the same location, and a comparison of flows between Wagga Wagga, Narrandera and Yanco Creek. In addition to the data, MDBA also provided the functional requirements for the Offtake Regulator.

The proposed regulating structure functionality is based on existing functional requirements of the cutting, including delivery of irrigation supply to downstream users and required functionality (requested by future asset owners and operators) to better manage future Murrumbidgee and or Yanco Creek flow events. The proposed structure consists of a concrete regulator with 2 overshot style gates, an optional fishway, access walkways, platforms and erosion protection works. An indicative cost estimate was developed based on a pre-conceptual design structure.

2 PROJECT BACKGROUND

2.1 Site Location

Yanco Creek is located in southern New South Wales, approximately 30 km west of Narrandera (Figure 2-1) and supplies water to a vast area of the Riverine Plains of New South Wales for agricultural production and water supply to a number of downstream townships. Yanco creek has a number tributaries flowing into it before it flows into the Murrumbidgee River.

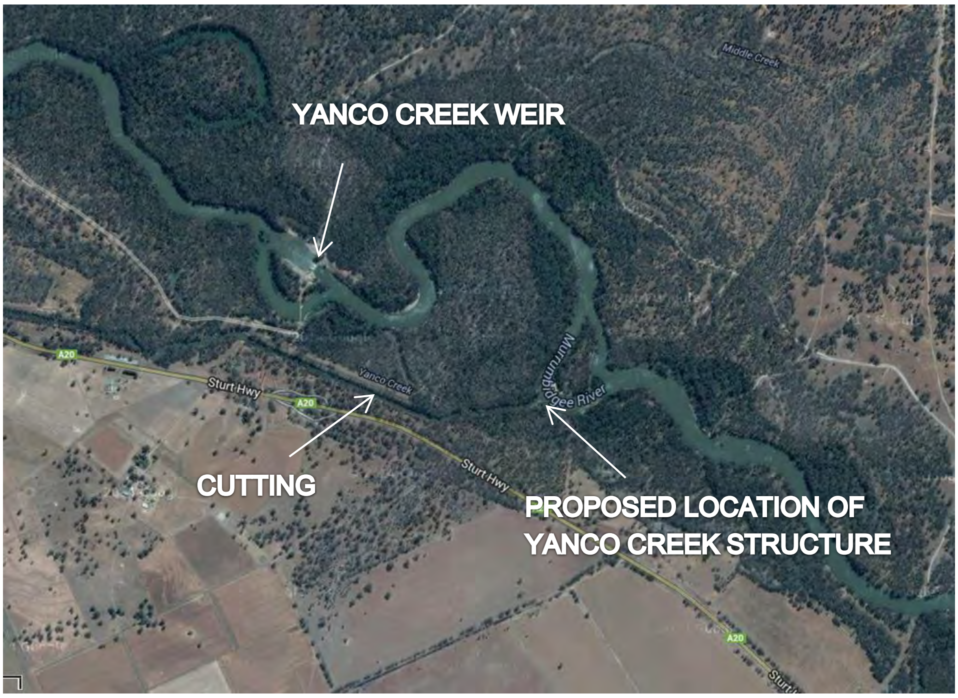

Figure 2-1 Site Location (Google Maps – 2014)

Figure 2-1 indicates the proposed location of the Yanco Creek structure. For the purposes of this prefeasibility study the location of the structure has not been investigated and has been approximated. During a concept design phase it assumed that the exact location of the proposed structure would be determined based on the constructability, proximity to access and hydraulic efficiency.

Plate 2-1 Downstream of Yanco Offtake Gauge (Source: MDBA)

As part of the Yanco Creek system there is a cutting to introduce permanent flows into the Yanco Creek. This cutting is within the Yanco Creek Weir pool and is influenced by flow and level control at Yanco Creek Weir (Plate 2-3) located downstream of the cutting.

Plate 2-2 Yanco Creek Cutting (Source: State Water)

The Yanco Creek Weir was built in 1929 and is a gated control structure that regulates flows to the Murrumbidgee area. In 1980 it was reconstructed with a fixed wall and gated structure on the Murrumbidgee River.

Plate 2-3 Yanco Creek Weir (Source: MDBA)

2.2 Purpose of Yanco Creek Offtake Regulator

The purpose of this pre-feasibility study is to investigate the potential costs to provide a regulating structure in Yanco Creek. The purpose of the structure is to reduce unwanted inundation in the upper Yanco region. URS understands that this is not the only option that is being investigated and that there may be alternatives to a new regulating structure. However, it is beyond the scope of this project to investigate alternative solutions. .

Yanco Creek was originally an ephemeral creek with downstream users not receiving adequate volumes of water. The Yanco Creek Weir and cutting were constructed to ensure the creek flows continually. When environmental flows are delivered through the Murrumbidgee, the Yanco Weir and cutting divert flows into the Yanco Creek and reduces peak flows in the Murrumbidgee River downstream; thus also reduces flooding in downstream Murrumbidgee wetland/forests.

A regulator at Yanco Creek offtake would be able to regulate diversion flows entering the Yanco Creek system and direct Murrumbidgee River flows to environmental assets downstream.

2.3 Existing Information

2.3.1 Flows Rating Table

A flow rating table was provided by MDBA comparing water level and flow at the proposed Yanco Creek offtake location, approximately 2 km upstream of Yanco Creek Weir. The rating table was used to undertake preliminary hydraulic analysis to determine the approximate size of the offtake regulating structure, including the number of and size of gates required. The data was measured from gauge 410007 located within the Yanco Creek offtake. The tables are shown in Appendix A.

2.3.2 *Channel Cross Section*

A surveyed cross section (Figure 2-2) of the offtake channel was provided by MDBA and was also used to determine a typical regulator arrangement. This included the geometric layout and levels with respect to the existing channel bed and banks.

The cross section is taken at the gauge point within the Yanco Creek cutting. (see Figure 2-1).

Based on the provided surveyed channel cross section the channel has a stream bed width of 12m, and a top bank width of 35m. The cross section also shows an approximate channel depth of 7m.

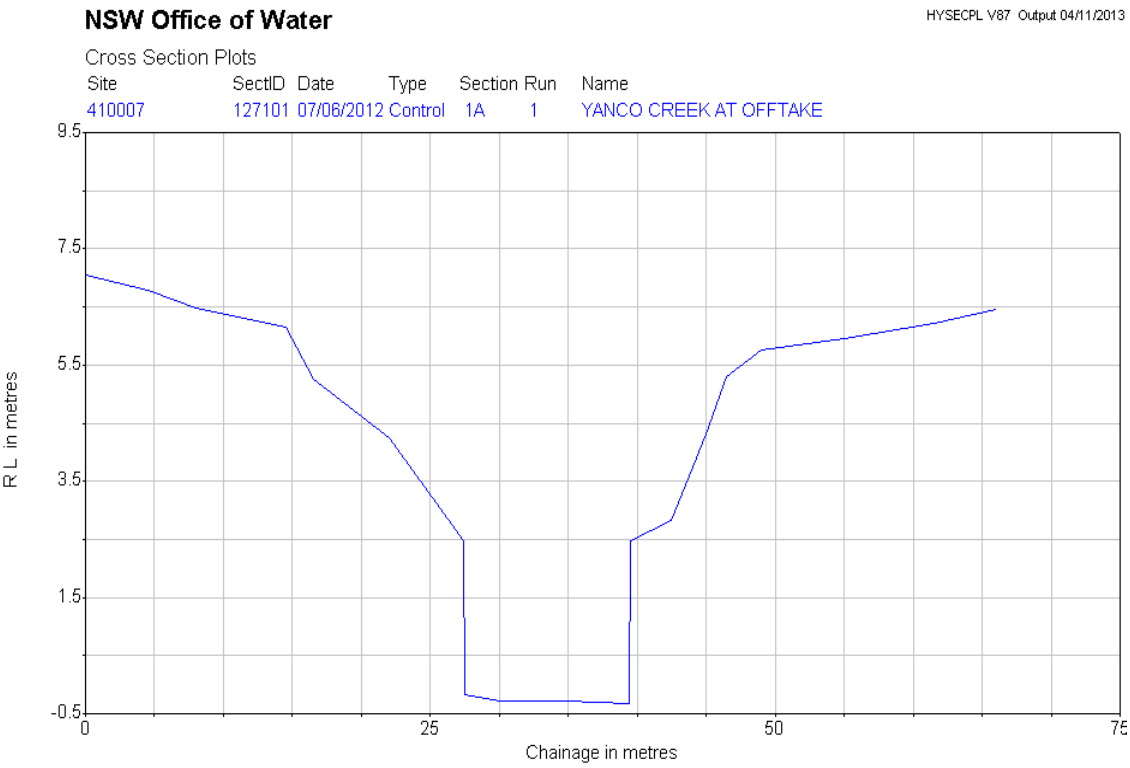

Figure 2-2 Surveyed Cross Section

3 YANCO CREEK OFFTAKE REGULATOR DESIGN

3.1 Design Functionality

The development of this pre-feasibility Yanco Creek Offtake Regulator is based on the following design criteria:

- Contain a flow of approximately 36,000 ML/day within the Murrumbidgee River at the Yanco Creek Weir (existing Murrumbidgee River weir);
- While the regulator is to control flows into Yanco Creek, it must also be able to pass the flows during a natural high flow without any restrictions. That is, it must be able to pass flows of up to 4,000 ML/day into the Yanco Creek at 36,000 ML/day at Narrandera;
- Flows greater than 36,000 ML/day at Narrandera are not affected by the regulator (that is, it would allow the same amount of water through as would have happened without the regulator); and
- The regulator must be able to allow low flows to enter the creek.

3.2 Design

The primary component for the pre-feasibility design is the sizing and specification of the type of regulator gates to achieve the functionality of the potential structure. For similar type regulating structures URS has preferred the use of overshot gates as they provide two major benefits over undershot gates. These are:

- Flow rates can be more accurately measured/gauged; and
- Safer downstream fish passage, as fish pass over the gate crest into downstream plunge pool and are not subjected to large hydrostatic pressures.

For the design of the Yanco Creek structure, URS undertook a preliminary hydraulic analysis of the design requirements and existing channel to determine the size and number of gates required to pass the target flow of 4000 ML/d at the normal upstream water level of 139.43 AHD, which was determined from flow rating tables (Appendix A).

Based on the preliminary hydraulic analysis the offtake regulator requires two gates 4.0 meters high and 2.25 metres wide. The two gates (Plate 3-2) would be used to supply flows up to 4000 ML/d into Yanco Creek. These sizes would need to be confirmed and are preliminary estimates only. The gates allow for a freeboard of approximately 300mm.

The design assumes a sill height equal to the current stream bed level. This allows for low flows from the Murrumbidgee to enter the Yanco Creek.

For the purpose of this study a cost estimate was developed for the structure which was assumed to be a reinforced concrete structure with the following features:

- Three piers;
- Abutment walls;
- Footings;
- Floor slab and apron;

- Cut off walls (sheet piles) upstream and downstream. The downstream cut off walls would be keyed into the underlying soil materials to provide protection from seepage, scour and erosion beneath the structure;
- Walkways and handrails would be fitted to the structure to enable safe operation and maintenance;
- Rock beaching and erosion protection would be placed upstream, downstream and around the structure; and
- An Energy dissipation structure located downstream. This may be via a stilling basin or plunge pool.

An example of the type of structure proposed is shown in Plate 3-1 below.

Plate 3-1 Example Concrete Structure Arrangement

Plate 3-2 Example Gates – Flume Style (may be substituted with lay flat type gates)

4 COST ESTIMATE

The construction cost for the offtake regulator would be approximately $3,500,000.

This is primarily based on the following items:

- Concrete structure approximately 5 meters wide and 5 metres tall and with wing walls with 600mm freeboard;
- Steel grating platform and walkway;
- Manually operated gates, 2 overshot, 4 metres high x 2.25 metres wide and allowing 300mm freeboard;
- Earthworks at either abutment; and
- Erosion protection placed upstream and downstream of the structure.

The following allowances have been applied to the total construction contract cost as follows:

- 20% for Contractor overheads and profit,
- 40% for contingency; and
- 18% for superintendence, project management and quality control support.

The 40% contingency is considered appropriate for this pre-feasibility exercise and includes a 10% allowance for unlisted items. This amount should decrease after detailed design has been completed, as the uncertainties associated with the project are reduced. The contingency applied to the cost estimate allows for change in market conditions and the remote location of the project.

4.1 Assumptions

The cost estimate was developed with the following assumptions:

- No upgrade work has been assumed for Yanco Creek Weir or Murrumbidgee River levee banks, as there may be low points or channels where water can bypass the regulator. This would require further earthworks and levee construction;
- A simple coffer dam was assumed however flow bypass and dewatering of excavations during construction have not be accounted for;
- Construction rates have been obtained from construction cost estimates developed for recently designed and built structures similar in type;
- No allowance for land acquisition;
- Geotechnical investigation and (design cost) has not been included, the results of the geotechnical investigation would influence the design and could increase the final cost;
- No hydraulic modelling has been assumed, this would be required before commencing concept design as it would inform hydraulic design;
- No location survey has been included. A survey would be a pre-requisite before commencing a concept design;
- Concrete rates are cost sensitive and will depend on supply rates and location of the concrete mixing plant;
- Rates for sheet piles are based on a permanent rate. No allowance has been made for whalers and ground anchors;

- Costs related to approvals and associated studies are not included (discussed in Section 5.2);
- Assumed local supply and disposal of material;
- Rates for rock beaching assume locally sourced rock;
- No major excavations within the creek would be required; and
- No ground foundation improvement works have been included.

Given these assumptions, and the associated possibility of additional costs, it may be prudent to consider the costs for construction to be in the $3.5-5.0 million range.

5 ADDITIONAL CONSIDERATIONS

In addition to offtake regulator, URS has considered a number of additional issues and have provided an indicative cost for each.

5.1 Design Criteria and Operation Method

The design life for the structure has been assumed to be:

- All concrete works – 100 year; and
- All mechanical works – 50 year.

These are considered an appropriate design life for these types of structures.

It is assumed that all mechanical components (i.e. gates) would need to be replaced after 50 years, based on current pricing (2014) this would approximately cost $300,000.

It is understood that automation is preferred for structures in this area however the indicative cost estimate has been based on manually operated gates as there is currently insufficient information such as line of site and network coverage to provide an indicative cost estimate for automated gates. The manually gates would operate with an actuator that lifts and closes the gates.

If automation was preferred it is expected that the total cost of the project could increase significantly based on the factors outlined above.

5.2 Approvals

Based on the cost of obtaining approvals for previous projects of similar scope as well as discussions with State Water (Mano Manorathan) it can be assumed that approvals may cost between $250,000 and $500,000 and is dependent on location of structure.

The approvals are likely to include:

- Environmental impacts studies;
- Cultural heritage studies;
- Planning Permits scheme considerations;
- Federal, State and Local government legislative approvals;
- Catchment Management Authority legislative approvals;
- Local Water Authority legislative approvals; and
- Liaison with local stakeholders.

5.3 Fish Passage

URS has investigated the potential costs required to provide fish passage as part of the regulator structure. There are a number of fishway options and without additional information it is difficult to determine which option is most appropriate. The three primary options are:

- Vertical slot fishway – These are best suited to all fish sizes and are suited to stable upstream water levels and low head loss;
- Denil Fishway – Suited to large fish sizes and only suitable for stable upstream water levels; and
- Fishlocks – Suited to all fish size and suited to variable upstream water levels and high head loss.

It is understood that due to the Yanco Creek Weir the water level would be generally constant. However there is no information on the fish biology of this area and therefore each option is applicable.

The fishway entrance would be offset from the gates; this allows fish to enter the fishway without having to travel in the high velocity zone produced around the gates.

The cost estimate has been based on a simple approach determined from previous projects whereby the construction cost of a fishway is relative to the head differential. The average cost of previous projects suggests that per metre of head differential costs between $700,000 and $1,000,000. The limited data received indicates the head differential at this site could be up to four metres and therefore cost of a fishway would be between $2,800,000 and $4,000,000.

6 CONCLUSION

The proposed upgrade for each structure was determined by using limited information and understanding and as a result the cost estimate provided is only indicative.

Table 6-1 Total Costs

COMPONENT	INDICATIVE COST
Regulator	$3,500,000-$5,000,000
Approvals	$250,000-$500,000
Fish passage	$2,800,000-$4,000,000

Based on this preliminary assessment, URS is suggesting that the costs relating to the providing a regulator at Yanco Creek Offtake is in the order of $3.5-5 Million with the addition of a fish ladder adding another $3-4 million. Including provision of up to $500,000 for approvals, in round numbers this leads to an indicative prefeasibility cost of $8-10 million.

If automation was required this cost could increase significantly, however URS does not have access to enough information to make an informed estimate of this potential additional cost.

7 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Murray Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 13th of May 2014.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between the 13th of May 2014 and the 5th September 2014 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

URS

APPENDIX A RATING TABLE FLOWS

G.H.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.20	0.0@	0.00241@	0.0136@	0.0376@	0.0771@	0.135@	0.213@	0.313@	0.436@	0.585@
0.30	0.761@	0.965@	1.20@	1.46@	1.76@	2.09@	2.44@	2.83@	3.25@	3.71@
0.40	4.20@	4.73@	5.30@	5.86@	6.40@	6.97@	7.56@	8.19@	8.84@	9.53@
0.50	10.2@	11.0@	11.8@	12.6@	13.5@	14.4@	15.3@	16.3@	17.3@	18.3@
0.60	19.4@	20.5@	21.7@	22.9@	24.1@	25.3@	26.5@	27.8@	29.1@	30.4@
0.70	31.8@	33.2@	34.7@	36.1@	37.6@	39.1@	40.7@	42.3@	43.9@	45.6@
0.80	47.3@	49.2@	51.0@	52.9@	54.8@	56.8@	58.8@	60.8@	62.8@	64.9@
0.90	67.0@	69.2@	71.4@	73.6@	75.9@	78.2@	80.6@	83.1@	85.6@	88.1@
1.00	90.7@	93.4@	96.0@	98.8@	102@	104@	107@	110@	112@	115@
1.10	118@	121@	124@	127@	130@	133@	136@	139@	142@	145@
1.20	148@	152@	155@	159@	162@	166@	170@	173@	177@	181@
1.30	185@	189@	193@	197@	201@	205@	209@	212@	216@	220@
1.40	225@	229@	233@	237@	241@	245@	250@	254@	259@	263@
1.50	267@	272@	277@	281@	286@	291@	295@	300@	305@	310@
1.60	315@	320@	325@	329@	334@	340@	345@	350@	355@	360@
1.70	365@	371@	376@	381@	387@	392@	397@	402@	407@	412@
1.80	417@	422@	427@	432@	437@	442@	448@	453@	458@	464@
1.90	470@	475@	481@	487@	492@	498@	504@	510@	516@	522@
2.00	528@	534@	540@	546@	552@	557@	563@	569@	575@	581@
2.10	587@	593@	599@	606@	612@	618@	624@	630@	637@	643@
2.20	650@	656@	663@	670@	677@	683@	690@	697@	704@	711@
2.30	718@	725@	732@	739@	747@	754@	761@	769@	776@	783@
2.40	791@	798@	806@	813@	821@	829@	836@	844@	852@	859@
2.50	867@	874@	882@	890@	897@	905@	913@	920@	928@	936@
2.60	944@	952@	960@	968@	976@	984@	992@	1000@	1010@	1020@
2.70	1030@	1030@	1040@	1050@	1060@	1070@	1080@	1080@	1090@	1100@
2.80	1110@	1120@	1130@	1140@	1150@	1160@	1160@	1170@	1180@	1190@
2.90	1200@	1210@	1220@	1230@	1240@	1250@	1260@	1270@	1280@	1290@
3.00	1300@	1310@	1310@	1320@	1330@	1340@	1350@	1360@	1370@	1380@
3.10	1390@	1400@	1410@	1420@	1430@	1440@	1450@	1460@	1470@	1480@
3.20	1490@	1500@	1510@	1520@	1530@	1540@	1550@	1560@	1570@	1580@
3.30	1590@	1600@	1610@	1620@	1630@	1650@	1660@	1670@	1680@	1690@
3.40	1700@	1710@	1720@	1730@	1740@	1750@	1770@	1780@	1790@	1800@
3.50	1810@	1820@	1830@	1850@	1860@	1870@	1880@	1890@	1910@	1920@
3.60	1930@	1940@	1960@	1970@	1980@	2000@	2010@	2020@	2030@	2050@
3.70	2060@	2070@	2090@	2100@	2110@	2130@	2140@	2150@	2160@	2180@
3.80	2190@	2210@	2220@	2230@	2250@	2260@	2270@	2290@	2310@	2320@

G.H.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
3.90	2340@	2360@	2380@	2390@	2410@	2430@	2450@	2460@	2480@	2500@
4.00	2520@	2540@	2560@	2570@	2590@	2610@	2630@	2650@	2670@	2690@
4.10	2710@	2730@	2740@	2760@	2780@	2800@	2820@	2840@	2860@	2880@
4.20	2900@	2920@	2940@	2960@	2980@	3000@	3020@	3040@	3070@	3090@
4.30	3110@	3130@	3150@	3180@	3200@	3220@	3240@	3270@	3290@	3310@
4.40	3330@	3360@	3380@	3400@	3430@	3450@	3470@	3500@	3520@	3540@
4.50	3570@	3600@	3630@	3660@	3700@	3730@	3760@	3800@	3830@	3870@
4.60	3900@	3940@	3970@	4010@	4040@	4080@	4120@	4150@	4190@	4230@
4.70	4260@	4300@	4340@	4370@	4410@	4450@	4490@	4530@	4560@	4600@
4.80	4640@	4680@	4720@	4760@	4800@	4850@	4910@	4960@	5010@	5060@
4.90	5110@	5170@	5220@	5270@	5330@	5380@	5430@	5490@	5540@	5600@
5.00	5660@	5710@	5770@	5820@	5880@	5940@	6000@	6050@	6110@	6180@
5.10	6250@	6320@	6380@	6450@	6520@	6590@	6660@	6730@	6800@	6870@
5.20	6940@	7010@	7080@	7160@	7230@	7300@	7380@	7450@	7520@	7600@
5.30	7670@	7740@	7820@	7890@	7970@	8040@	8120@	8190@	8270@	8350@
5.40	8420@	8500@	8580@	8660@	8740@	8820@	8900@	8980@	9060@	9140@
5.50	9220@	9300@	9380@	9470@	9550@	9640@	9720@	9810@	9900@	9990@
5.60	10100@	10200@	10300@	10300@	10400@	10500@	10600@	10700@	10800@	10900@
5.70	11000@	11100@	11200@	11300@	11400@	11500@	11600@	11700@	11800@	11900@
5.80	12000@	12100@	12200@	12300@	12400@	12500@	12600@	12700@	12800@	12800@
5.90	12900@	13000@	13100@	13200@	13300@	13400@	13500@	13600@	13700@	13800@
6.00	13900@	14000@	14100@	14300@	14400@	14500@	14600@	14700@	14800@	14900@
6.10	15000@	15100@	15200@	15300@	15400@	15500@	15600@	15700@	15900@	16000@
6.20	16100@	16200@	16300@	16400@	16500@	16600@	16800@	16900@	17000@	17100@
6.30	17200@	17300@	17400@	17600@	17700@	17800@	17900@	18000@	18200@	18300@
6.40	18400@	18500@	18600@	18800@	18900@	19000@	19100@	19300@	19400@	19500@
6.50	19600@	19800@								

URS

APPENDIX B COST ESTIMATE

The cost estimates presented here are construction costs only. The full cost of these options which include design, investigation and approval costs are presented in the body of this report.

Yanco Creek - Regulator

Project:	MDBA Constraints Management Strategy	Computed by:	ST
Job No:	43152704	Checked by:	MS
Client:	MDBA	Date:	5-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000	$ 50,000	
1.2	Survey/Set Out	1	Item	$ 20,000	$ 20,000	
1.3	Tree Removal	1000	m^2	$ 4	$ 4,000	
1.4	Temporary Fencing	1	Item	$ 10,000	$ 10,000	
						$ 84,000
2	**Sheet Piling**					
2.1	Site Establishment (includes constructing piling pad)	1	Item	$ 60,000	$ 60,000	
2.2	Supply and place piles (assume Larrsen 601/602)	200	m^2	$ 400	$ 80,000	
						$ 224,000
3	**Foundation Preparation**					
3.1	Excavate to design levels					
3.1.1	Labour (5 x 4 days)	20	days	$ 600	$ 12,000	
3.1.2	Excavator (1 x 4 days)	4	days	$ 1,500	$ 6,000	
3.1.3	Haul Truck (1 x 4 days)	4	days	$ 1,000	$ 4,000	
						$ 22,000
4	**Concrete Structure (Regulator)**					
4.1	Supply and place in-situ concrete. Price includes placement of reinforcement,	300	m^3	$ 2,000	$ 600,000	
						$ 600,000
5	**Rubicon Flume Gates and Superstructure**					
5.1	Flume Gates (2 No. manually operated) supply and install Rubicon (4 m height)	2	Item	$ 100,000	$ 200,000	
						$ 200,000
6	**Earthworks/Embankment Construction**					
6.1	Supply and place earthfill clay	1350	m^3	$ 30	$ 40,500	
6.2	Supply and place filters	220	m^3	$ 100	$ 22,000	
6.3	Supply and place geofabric (Bidim A44)	1100	m^2	$ 10	$ 11,000	
6.4	Supply and place transition gravel	160	m^3	$ 100	$ 16,000	
6.5	Supply and place rip rap	450	m^3	$ 60	$ 27,000	
						$ 116,500
7	**Dewatering**					
7.1	Coffer Dam	1	Item	$ 500,000	$ 500,000	
						$ 500,000
8	**Demoblisation and Reinstatement Works**					
8.1	Restore and landscape site	1	Item	$ 20,000	$ 20,000	
8.2	Demobilise from site	1	Item	$ 20,000	$ 20,000	
8.3	Permanent Security Fencing (1.8m high)	100	m	$ 54	$ 5,400	
						$ 45,400
Contract Costs					**$ 1,791,900**	
	Contractor O/H and Profit	20%			$ 358,380	
Base or Contract Construction Costs					**$ 2,150,280**	
	Superintendence, Project Management and QC Support	18%			$ 387,050	
	Contingency	40%			$ 860,112	
Total Project Costs					**$ 3,397,442**	
Final					**$ 3,500,000**	

Notes: These costs are based on previous projects of simiarl size and scope and Rawlinson 2014
The cost of fishway was determined through head differentials and guidelines rather than top down cost estimate

GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

URS is a leading provider of engineering, construction, technical and environmental services for public agencies and private sector companies around the world. We offer a full range of program management; planning, design and engineering; systems engineering and technical assistance; construction and construction management; operations and maintenance; and decommissioning and closure services for power, infrastructure, industrial and commercial, and government projects and programs.

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B.3 Lower Darling Regulators

URS

Report

Constraints Management Strategy Prefeasibility

AUSTRALIA

Great Darling Anabranch Regulator and Yartla Lake Regulator

04 September 2014
43157204/5/1

Prepared for:
Murray Darling Basin Authority

Prepared by URS Australia Pty Ltd

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APPENDICES

1 INTRODUCTION

URS Pty Ltd (URS) has been engaged to support the Murray Darling Basin Authority (MDBA) in the development of a pre-feasibility cost estimate of potential infrastructure costs related to relieving flow constraints in the Murray Darling Basin to support the delivery of environmental flows.

As part of this role, URS was commissioned to develop an indicative cost estimate for the potential construction of a regulator at the Great Darling Anabranch and a regulator at an existing culvert crossing at Yartla Lake, located on the Darling River in South West New South Wales (Figure 2-1 and Figure 2-2).

URS conducted a desktop review of information provided by MDBA. The data included photographs of The Great Darling Anabranch and Yartla Lake, Inundation images of both regions, a list of physical constraints for the Lower Darling and an existing business case for a new Yanga regulator as proposed in 2011. In addition to the data, MDBA also provided the functional requirements for the Great Darling Anabranch regulator.

Two different concepts for The Great Darling Anabranch are developed based on known functional requirements and proposed functionality of a structure to better manage future flow events. Both options have seven stop-board gates with a walkway, platform and erosion protection. Option one was a concrete structure and option two a sheet pile structure. An indicative cost estimate was developed based on each concept structure design.

Similarly, two different concept crossing structures were developed for Yartla Lake based on functional requirements to better manage future flow events in the region. The first concept assumes that the existing infrastructure at the crossing is suitable, and only requires the installation of two stopboard gates. In addition to the gates the structure has a platform and erosion protection. The second design includes construction of a new culvert and headwall crossing.

2 PROJECT BACKGROUND

2.1 Project Location

The Great Darling Anabranch (GDA) is located in south-west New South Wales. The anabranch extends approximately 460 km from the Darling River to the Murray River. The anabranch junctions at The Darling River south of Menindee Lakes and meets the Murray River 20km west of Wentworth. The anabranch is a naturally ephemeral system providing water to a number of adjacent landholders.

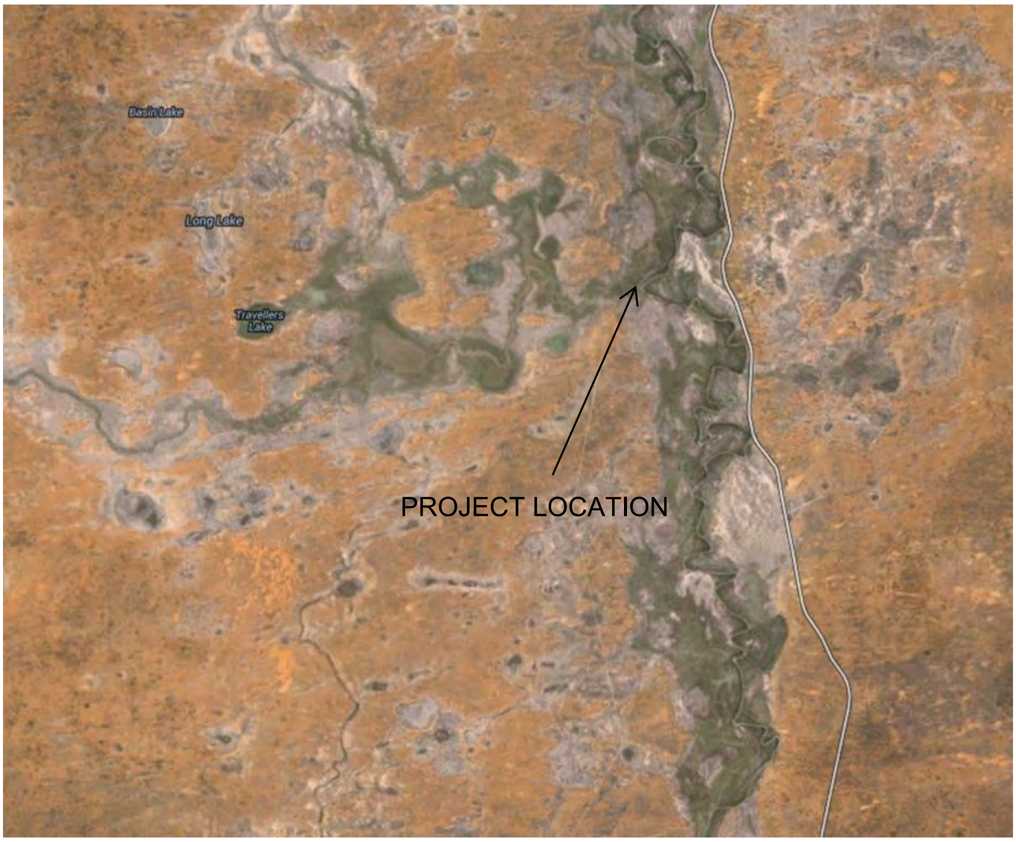

Figure 2-1 The Great Darling Anabranch Location Map

Plate 2-1 Sill on the cutting at the main Great Darling Anabranch

Yartla Lake is located adjacent to the Darling River in lower New South Wales and covers an area of 1000 hectares. The lake is connected to the River by Yartla Lake channel.

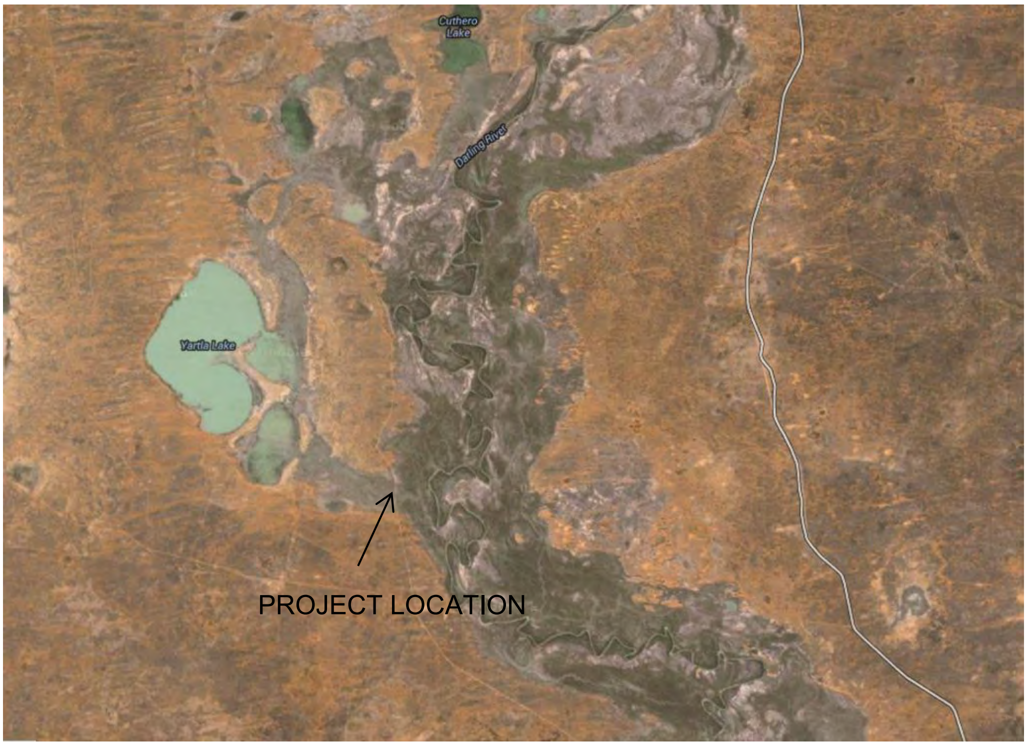

Figure 2-2 Yartla Lake Location Map

Plate 2-2 Yartla Lake offtake from the Lower Darling

2.2 Purpose of the Great Darling Anabranch Offtake Regulator

A regulator at GDA offtake could control flows into GDA system and confine Darling River flows to environmental assets in the Lower Darling region and enable flows to combine with a higher flood event in the Murray River at Wentworth.

The Great Darling Anabranch is an ephemeral creek with a low commencement to flow threshold which currently prevents the delivery of regulated flows above 10,000 ML/d within the Darling River. Regulating and controlling flows into the anabranch will increase flexibility for the delivery of higher environmental flows.

A regulator at the Great Darling Anabranch offtake would be able to regulate and/or prevent diversion flows entering the Great Darling Anabranch system and maintain high environmental flows in the Darling River.

2.3 Purpose of Yartla Lake Regulator

The channel between Yartla Lake and Darling River has a low commencement to flow threshold that constrains the delivery of flows above 12,500 ML/d. A regulating structure within the channel could contain flows to the Darling River.

The channel is crossed by Coona Point Bindara Road with an existing culvert controlling flows beyond this point. By installing a regulating structure as part of this existing infrastructure it would be more cost effective than constructing a new regulator at the intersection of the Yartla Lake channel and the Darling River..

A regulator at Coona Point Bindara Road crossing would be able to regulate and/or prevent flows entering Yartla Lake and maintain high flows in the Darling River.

Plate 2-3 Yartla Lake road crossing

2.4 Existing Information

2.4.1 Inundation Extents

Images of modelled inundation extents for both locations were provided by MDBA. These inundation images were based on a simulation of flows at 14,000 ML/d and 17,000 ML/d at Weir 32.

2.4.1.1 The Great Darling Anabranch

Flows at 14,000 ML/d were contained within the Darling River but created a continuous flow in the Anabranch. Flows at 17,000 ML/d were still contained within the Darling River but started to display greater extents of inundation around the anabranch with smaller flood runners and billabongs being filled.

Both inundation extents figures display the current constraints to delivering environmental flows in the Darling River. Due to the large length of the Great Darling Anabranch as well as local billabongs and flood runners in the same system it is apparent that the Great Darling Anabranch can divert large flows from the Darling River. A regulator at the Great Darling Anabranch could confine flow to the Lower Darling main channel during a regulated environmental flow.

2.4.1.2 Yartla Lake

Flows of 14,000 ML/d and 17,000 Ml/d allowed flows from the Darling River to enter Yartla Lake. In both flows cases the Yartla Lake channel connecting the river and lake only had localised minor inundation, however at the 17,000 ML/d flow, water entered Yartla Lake increasing the area of lake inundated.

Due to the large capacity of Yartla Lake as well as low commencement to flows within the Yartla Lake channel it is apparent that higher flows within the Darling River are likely to be diverted into Yartla Lake. Furthermore due to the limited inundation occurring within the channel under the two flow cases considered there is no need to construct a regulating structure at the intersection of the Yartla Lake channel and the Darling River.

2.4.2 Lower Darling Physical Constraints

Below is a table highlighting key locations within the Lower Darling region and at what flow they are triggered. The table shows that the Great Darling Anabranch and Lake Yartla commence flowing very early on during a flow event.

Table 2-1 Key trigger levels for constraints (Provided by NOW 28th of April 2014)

LOCATIONS	TRIGGER FLOWS (ML/d)
Tandou Creek flow commence	16,700
Flowing right through Tandou Creek	18,700
Charlie Stone	10,000
Charlie Stone Creek Bank and Bridge Access	12,000
Emu Lake commences filling	16,500
Menindee Town starts to become affected	17,000
Menindee Residents begin to move out	19,800
The Great Darling Anabranch commence to flow and fill billabong	10-11,000
Yartla Lake commences	12,500
Numerous billabongs and swamps	11-12,000

3 OFFTAKE REGULATOR DESIGN

3.1 Design Functionality

3.1.1 The Great Darling Anabranch

The development of this pre-feasibility Great Darling Anabranch Offtake Regulator is based on the following design criteria:

- Contain a flow of approximately 10,000 ML/day within the Darling River at the anabranch offtake, which is equivalent to passing a 5,000 ML/d within the anabranch. It is estimated that a structure of 1.5m high and 15m would be needed to prevent flow entering the anabranch beyond this point.
- While the regulator is to control flows into the anabranch, it must also be able to pass the flows during a natural high flow without any restrictions. That is, it must be able to pass flows up to 5,000 ML/day into the anabranch due to a natural flood event.
- The regulator is likely to only be engaged (close gates) once every 5 years and therefore must be cost effective.

3.1.2 Yartla Lake

The development of this pre-feasibility Great Darling Anabranch Offtake Regulator is based on the following design criteria:

- Contain a flow of approximately 12,000 ML/day within the Darling River at Yartla Lake.
- The regulator will be installed onto an existing culvert or constructed as part of a new culvert.
- The regulator is likely to only be engaged (close gates) once every 5 years and therefore must be cost effective.

3.2 Design

3.2.1 The Great Darling Anabranch

The primary component for the pre-feasibility design is the sizing and specification of the type of regulator gates to achieve the functionality of the potential structure. Based on the frequency of use (approximately once every 5 years) as well as the remote location URS believe segmented stopboards are appropriate as the means to control flow rather than a gated structured. They provide the following benefits:

- Stopboards are cheaper than gates;
- Stopboards can be installed manually and therefore don’t require expensive automation systems; and
- They can provide an adjustable weir function through manual means.

For the design of the Great Darling Anabranch structure, URS undertook a preliminary hydraulic analysis of the design requirements and existing channel to determine the size and number of gates required to pass the target flow of 5000 ML/d. We concluded that a structure size of 15m in length and 1.5m in height would be appropriate.

Based on the preliminary hydraulic analysis the offtake regulator requires seven gates 1.5 meters high and 1.5 metres wide. The seven gates would be used to supply flows up to 5000 ML/d into the anabranch. These sizes would need to be confirmed and are preliminary estimates only. The gates allow for a freeboard of approximately 300mm.

For the purpose of this study two alternative structures were developed. The first option is a concrete regulating structure. A concrete structure provides a greater design life (50-100 years), however the construction requires more time and at a greater cost. The second option is to construct a sheet pile structure. Sheet piling is considerably quicker and more cost effective than concrete but greatly reduces the design life (20 years). The options are provided below:

1 A concrete structure, including the following specific features:

   a. 6 concrete piers;

   b. Abutment walls;

   c. Footings;

   d. Floor slab and apron;

   e. Cut off walls (sheet piles) upstream and downstream. The downstream cut off walls would be keyed into the underlying soil materials to provide protection from seepage, scour and erosion beneath the structure;

2 A sheet pile structure, including the following specific features;

   a. Sheet pile 1.5m high and approximately 7m the below ground surface. Extending 2.5m either side of the banks;

   b. The sheet pile would be installed before using an oxy torch to remove spacing for the gates to be installed.

In addition the specific features the following aspects would be part of either option:

- Walkways and handrails would be fitted to the structure to enable safe operation and maintenance;
- Rock beaching and erosion protection would be placed upstream, downstream and around the structure; and
- An Energy dissipation structure located downstream. This may be via a stilling basin or plunge pool.

Plate 3-1 Example Stopboard Gate Arrangement (Source: AWMA Water Solutions)

Plate 3-2 Example Sheet Pile Structure – (Source: AWMA Water Solutions)

3.2.2 *Yartla Lake*

The primary component for the pre-feasibility design is the sizing and specification of the type of regulator structure to achieve the functionality required.

Based on the frequency of use as well as the remote location URS believe segmented stopboard gates are again an appropriate solution.

For the design of the Coona Point Bindara Road crossing structure, URS investigated the existing size of culverts at the location. It was advised that the culverts had a diameter of 750mm, and therefore based on guidelines a gate size of 1000mm x 1000mm was selected.

Without any knowledge of the current culvert condition URS provided two cost estimates, where one assumes that the installation of a new headwall and culvert.

For both solutions the following features would be required:

- Two 100mmx1000mm stopboard gates;
- Prefabricated platform –to enable safe maintenance and removal or installation of the boards;
- Handrails and crash barrier – due to the close proximity of a major road, protection of vehicles is required;
- Erosion protection placed upstream of the gates;

It is also recognised however that the existing road crossing may not be an appropriate location for such a structure due to safety concerns with having a regulating structure attached to a road crossing. An alternative is to construction a new regulator at some point upstream of the crossing. Without basic information on the width and depth of the channel upstream of the existing crossing, it is not possible to undertake a pre-feasibility cost estimate. URS can only advise that assuming that the regulator required is similar in scope to what has been proposed at the Great Darling Anabranch, and accepting the possibility that it likely to be smaller than the regulator at The Great Anabranch, $1 million to $3 million may be an acceptable range to adopt. However, without even the most basic information on the channel dimensions and hydraulics, URS cannot provide advice on the potential cost, and if a cost estimate is needed, then information such as the width and depth of the existing channel is needed.

Plate 3-3 Example Stopboard Gate crossing - (Source AWMA)

4 COST ESTIMATE

4.1 The Great Darling Anabranch

The cost estimate was developed based on the following key aspects:

- Steel grating platform and walkway;
- Manually operated gates, 7 stopboard, 1.5m metres high x 1.5 metres wide and allowing 300mm freeboard;
- Earthworks at either abutment; and
- Erosion protection placed upstream and downstream of the structure.

For the new concrete structure the following items are included:

a) Six concrete piers;

b) Abutment walls;

c) Footings; and

d) Floor slab and apron.

For the sheet pile structure, 20m of sheet pile would be installed allowing 2.5m either side of the embankment. The cost estimate allows for 7m of sheet pile to be anchored below the ground surface. This depth would need to be revised after a geotechnical investigation was completed. Similarly the sheet pile material assumed is 74 Kg/m but would be confirmed based on a later structural analysis should this option be preferred.

The construction cost for the offtake concrete regulator was estimated at $2,750,000, and a sheet pile regulator was estimated at $1,500,000.

The following allowances have been applied to the base construction cost to develop a complete cost estimate:

- 20% for Contractor overheads and profit,
- 40% for contingency; and
- 18% for superintendence, project management and quality control support.

The 40% contingency is considered appropriate for this pre-feasibility exercise and includes a 10% allowance for unlisted items. This amount should decrease after detailed design has been completed, as the uncertainties associated with the project are reduced. The contingency applied to the cost estimate allows for change in market conditions and the remote location of the project.

More detail on the items contained within the cost estimate, unit rates, and calculated costs, are provided in Appendix A.

4.1.1 Assumptions

The cost estimate was developed with the following assumptions:

- A simple coffer dam was assumed however flow bypass and dewatering of excavations during construction have not be accounted for;
- Construction rates have been obtained from construction cost estimates developed for recently designed and built structures similar in type;
- No allowance for land acquisition;
- Geotechnical investigation and (design cost) has not been included;
- Concrete rates are cost sensitive and will depend on the location of the nearest concrete plant;
- Rates for sheet piles are based on a permanent rate. No allowance has been made for whalers and ground anchors;
- Assumed local supply and disposal of material;
- Rates for rock beaching assume locally sourced rock;
- No major excavations within the creek would be required;
- No ground foundation improvement works have been included; and
- Assume the frequency of use is twice every 10 years as per the project scope.

It was also assumed that significant costs related to approvals could be required, including:

- Environmental impacts studies;
- Cultural heritage studies;
- Planning Permits scheme considerations;
- Federal, State and Local government legislative approvals;
- Catchment Management Authority legislative approvals;
- Local Water Authority legislative approvals; and
- Liaison with local stakeholders.

Including a nominal $250,000-$500,000 for approvals, this provides for an overall cost estimate of $1,750,000 at the lower end, and $3,250,000 at the higher end. Given these assumptions, and the associated possibility of additional costs, it may be prudent to consider the costs estimate to be $2.0-3.5 million depending on whether it is a sheet pile or concrete structure.

4.2 Yartla Lake

The cost estimate was developed based on the following key aspects:

- Two concrete reinforced headwalls;
- Two pipe culverts;
- Traffic management; and
- Road crossing excavation.

This is primarily based on the following items:

- Two stop board gates 1000mmx1000mm bolted to the headwall.
- Steel grating platform handrails;
- Earthworks upstream and downstream of the crossing; and
- Erosion protection placed upstream and downstream of the structure.

The construction cost for the regulator structure was estimated at $350,000 if the existing culvert was structurally sound. If the culvert requires replacement then the cost has been estimated at approximately $400,000. Further detail on the cost estimate is included in Appendix A.

The replacement of the culvert would be determined through a site structural investigation.

The following allowances have been applied to the base construction cost to develop a complete cost estimate:

- 20% for Contractor overheads and profit,
- 40% for contingency; and
- 18% for superintendence, project management and quality control support.

The 40% contingency is considered appropriate for this pre-feasibility exercise and includes a 10% allowance for unlisted items. This amount should decrease after detailed design has been completed, as the uncertainties associated with the project are reduced. The contingency applied to the cost estimate allows for change in market conditions and the remote location of the project.

4.2.1 Assumptions

The cost estimate was developed with the following assumptions:

- A simple coffer dam was assumed however flow bypass and dewatering of excavations during construction have not be accounted for;
- Construction rates have been obtained from construction cost estimates developed for recently designed and built structures similar in type;
- No allowance for land acquisition;
- Geotechnical investigation and (design cost) has not been included;
- Concrete rates are cost sensitive and will depend on the location of the nearest concrete plant;
- Rates for sheet piles are based on a permanent rate. No allowance has been made for whalers and ground anchors;
- Assumed local supply and disposal of material;
- Rates for rock beaching assume locally sourced rock;
- No major excavations within the creek would be required; and
- No ground foundation improvement works have been included.

Given these assumptions, the associated possibility of additional costs, and the possibility of extensive approvals similar to what has been outlined for The Great Darling Anabranch, it may be prudent to adopt an estimated cost of between $500,000-550,000 depending on whether the culvert requires replacing (this is assuming approvals costs are $150,000). As noted previously, safety concerns may discount this option entirely and URS would advise a full and detailed safety assessment before any options are progressed.

5 ADDITIONAL CONSIDERATIONS

In addition to offtake regulator, URS has considered a number of additional issues and have provided an indicative cost for each.

5.1 Design Criteria and Operation Method

The design life for the structure has been suggested to be:

- Concrete Regulation Structure – 50-75 years;
- Sheet Pile Regulating Structure – 20-30 years; and
- Stop board gates– 25 years.

These are considered an appropriate design life for these types of structures and based on Australian Standards and manufacturer and supplier standards.

It is assumed that all mechanical components (i.e. gates) would need to be replaced after 25 years.

It is understood that automation is generally preferred for structures in this area however the indicative cost estimates have been based on manually operated gates as there is currently insufficient information such as line of site and network coverage to provide an indicative cost estimate for automated gates. Given that the gates would be operated only once every five years, it is also likely that automation would not be required.

For both locations stop board gates have been assumed for this costing exercise. This has been adopted due to the proposed infrequency of use. URS suggest that the boards either be stored at an existing depot or lockable compounds be constructed at each location. An allowance for a lockable compound has not been included in the cost estimates.

6 CONCLUSION

The proposed upgrade for each structure was determined by using limited information and understanding and as a result the cost estimates provided is only indicative order of magnitude costs.

Based on this preliminary assessment, URS is suggesting that the costs relating to providing a regulator at the Great Darling Anabranch Offtake is in the order of $2.0-3.5 Million, and that the costs for adding a regulating structure at the nominated road crossing is $500,000-$550,000.

Therefore in round figures the total estimated cost range is **$2.5 – 4.0 million.**

If the option of providing a regulating structure at the existing road crossing is not able to be pursued because of safety concerns, then a new regulator would be required. This would be expected to be more expensive than the option costed by URS.

If more information is given and further investigation and design is undertaken there is the ability to create a more accurate cost estimate.

7 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Murray Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 13th of May 2014.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between the 13th of May 2014 and the 4th September 2014 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

APPENDIX A COST ESTIMATES

The cost estimates presented here are construction costs only. The full cost of these options which include design, investigation and approval costs are presented in the body of this report.

Great Darling Anabranch Regulator

Project:	MDBA Constraints Management Strategy	Computed by:	ST
Job No:	43152704	Checked by:	RV
Client:	MDBA	Date:	3-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000	$ 50,000	
1.2	Survey/Set Out	1	Item	$ 20,000	$ 20,000	
1.3	Tree Removal	1000	m^2	$ 4	$ 4,000	
1.4	Temporary Fencing	1	Item	$ 10,000	$ 10,000	
						$ 84,000
2	**Sheet Piling**					
2.1	Site Establishment (includes constructing piling pad)	1	Item	$ 50,000	$ 50,000	
2.2	Supply and place piles (assume Larrsen 601/602)	450	m^2	$ 700	$ 315,000	
						$ 365,000
3	**Foundation Preparation**					
3.1	Excavate to design levels					
3.1.1	Labour (5 x 4 days)	20	days	$ 600	$ 12,000	
3.1.2	Excavator (1 x 4 days)	4	days	$ 1,500	$ 6,000	
3.1.3	Haul Truck (1 x 4 days)	4	days	$ 1,000	$ 4,000	
						$ 22,000
4	**Rubicon Flume Gates and Superstructure**					
4.1	Stop Log gates - No. 7 - 1500mm High and 1500mm Wide	7	Item	$ 15,000	$ 105,000	
						$ 105,000
5	**Walkway and Rails**					
5.1	Pre-Fabricated Walkway	1	Item	$ 10,000	$ 10,000	
5.2	Pre-Fabricated Handrails	1	Item	$ 5,000	$ 5,000	
						$ 15,000
6	**Earthworks/Embankment Construction**					
6.1	Supply and place geofabric (Bidim A44)	1000	m^2	$ 12	$ 12,000	
6.2	Supply and place transition gravel	215	m^3	$ 100	$ 21,500	
6.3	Supply and place rip rap	500	m^3	$ 60	$ 30,000	
						$ 63,500
7	**Dewatering**					
7.1	Coffer Dam	1	Item	$ 15,000	$ 15,000	
						$ 15,000
8	**Demoblisation and Reinstatement Works**					
8.1	Restore and landscape site	1	Item	$ 20,000	$ 20,000	
8.2	Demobilise from site	1	Item	$ 20,000	$ 20,000	
8.3	Permanent Security Fencing (1.8m high)	100	m	$ 60	$ 6,000	
						$ 46,000
Contract Costs					**$ 715,500**	
	Contractor O/H and Profit	20%			$ 143,100	
Base or Contract Construction Costs					**$ 858,600**	
	Superintendence, Project Management and QC Support	18%			$ 154,548	
	Contingency	40%			$ 343,440	
Total Project Costs					**$ 1,356,588**	
Say					**$ 1,500,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Great Darling Anabranch Regulator

Project:	MDBA Constraints Management Strategy	Computed by:	ST
Job No:	43152704	Checked by:	MS
Client:	MDBA	Date:	5-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 50,000.00	$ 50,000	
1.2	Survey/Set Out	1	Item	$ 20,000.00	$ 20,000	
1.3	Tree Removal	1000	m^2	$ 4.00	$ 4,000	
1.4	Temporary Fencing	1	Item	$ 10,000.00	$ 10,000	
						$ 84,000
2	**Sheet Piling**					
2.1	Site Establishment (includes constructing piling pad)	1	Item	$ 25,000	$ 25,000	
2.2	Supply and place piles (assume Larrsen 601/602)	300	m^2	$ 500	$ 150,000	
						$ 175,000
3	**Concrete Structure**					
3.1	Supply and place in-situ concrete. Price includes placement of reinforcement, formwork, labour, machinery and scaffolding	250	m^3	$ 3,000	$ 750,000	
						$ 750,000
4	**Foundation Preparation**					
4.1	Excavate to design levels					
4.1.1	Labour (5 x 4 days)	20	days	$ 600	$ 12,000	
4.1.2	Excavator (2 x 4 days)	8	days	$ 1,500	$ 12,000	
4.1.3	Haul Truck (2 x 4 days)	8	days	$ 1,000	$ 8,000	
4.1.4	Roller (1 x 4 days)	4	days	$ 1,500	$ 6,000	
						$ 38,000
5	**Rubicon Flume Gates and Superstructure**					
5.1	Stop Log gates - No. 7 - 1500mm High and 1500mm wide	7	Item	$ 15,000	$ 105,000	
						$ 105,000
5	**Walkway and Rails**					
5.1	Pre-Fabricated Walkway	1	Item	$ 10,000	$ 10,000	
5.2	Pre-Fabricated Handrails	1	Item	$ 5,000	$ 5,000	
						$ 15,000
7	**Earthworks/Embankment Construction**					
7.1	Supply and place earthfill clay	1800	m^3	$ 30	$ 54,000	
7.2	Supply and place filters	300	m^3	$ 100	$ 30,000	
7.3	Supply and place geofabric (Bidim A44)	1200	m^2	$ 12	$ 14,400	
7.4	Supply and place transition gravel	215	m^3	$ 100	$ 21,500	
7.5	Supply and place rip rap	500	m^3	$ 60	$ 30,000	
						$ 149,900
8	**Dewatering**					
8.1	Coffer Dam	1	Item	$ 20,000	$ 20,000	
						$ 20,000
9	**Demoblisation and Reinstatement Works**					
9.1	Restore and landscape site	1	Item	$ 20,000	$ 20,000	
9.2	Demobilise from site	1	Item	$ 20,000	$ 20,000	
9.3	Permanent Security Fencing (1.8m high)	100	m	$ 60	$ 6,000	
						$ 46,000
Contract Costs					**$ 1,382,900**	
	Contractor O/H and Profit	20%			$ 276,580	
Base or Contract Construction Costs					**$ 1,659,480**	
	Superintendence, Project Management and QC Support	18%			$ 298,706	
	Contingency	40%			$ 663,792	
Total Project Costs					**$ 2,621,978**	
Final					**$ 2,750,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Yartla Lake

Project:	MDBA Constraints Management Strategy	Computed by:	ST
Job No:	43152704	Checked by:	RV
Client:	MDBA	Date:	3-Sep-14

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 25,000.00	$ 25,000	
1.2	Survey/Set Out	1	Item	$ 10,000.00	$ 10,000	
1.3	Tree Removal	100	m^2	$ 4.00	$ 400	
1.4	Temporary Fencing	1	Item	$ 5,000.00	$ 5,000	
						$ 40,400
2	**Foundation Preparation**					
2.1	Excavate to design levels					
2.1.1	Labour (5 x 1 days)	5	days	$ 600	$ 3,000	
2.1.2	Excavator (1 x 1 days)	1	days	$ 1,500	$ 1,500	
2.1.3	Haul Truck (1 x 1 days)	1	days	$ 1,000	$ 1,000	
						$ 5,500
3	**Rubicon Flume Gates and Superstructure**					
3.1	Stop Log gates - No. 2 - 1000mm High and 1000mm wide	2	Item	$ 12,000	$ 24,000	
						$ 24,000
4	**Miscellaenous Items**					
4.1	Prefrabricated Handrails	1	item	$ 10,000	$ 10,000	
4.2	Prefrabicated Platform	1	item	$ 5,000	$ 5,000	
						$ 15,000
5	**Earthworks/Embankment Construction**					
5.1	Supply and place geofabric (Bidim A44)	500	m^2	$ 12	$ 6,000	
5.2	Supply and place transition gravel	200	m^3	$ 100	$ 20,000	
5.3	Supply and place rip rap	300	m^3	$ 60	$ 18,000	
						$ 44,000
6	**Dewatering**					
6.1	Coffer Dam	1	Item	$ 10,000	$ 10,000	
						$ 10,000
7	**Demoblisation and Reinstatement Works**					
7.1	Restore and landscape site	1	Item	$ 20,000	$ 20,000	
7.2	Demobilise from site	1	Item	$ 20,000	$ 20,000	
7.3	Permanent Security Fencing (1.8m high)	100	m	$ 60	$ 6,000	
						$ 46,000
Contract Costs					**$ 184,900**	
	Contractor O/H and Profit	20%			$ 36,980	
Base or Contract Construction Costs					**$ 221,880**	
	Superintendence, Project Management and QC Support	18%			$ 39,938	
	Contingency	40%			$ 88,752	
Total Project Costs					**$ 350,570**	
Say					**$ 350,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

Yartla Lake

Project:	MDBA Constraints Management Strategy			Computed by:	ST	
Job No:	43152704			Checked by:	RV	
Client:	MDBA			Date:	3-Sep-14	

Group	Item Description	Quantity	Unit	Rate	Cost	Sub Total
1	**Mobilisation/Site Establishment**					
1.1	Move to site	1	Item	$ 25,000.00	$ 25,000	
1.2	Survey/Set Out	1	Item	$ 10,000.00	$ 10,000	
1.3	Tree Removal	100	m^2	$ 4.00	$ 400	
1.4	Temporary Fencing	1	Item	$ 5,000.00	$ 5,000	
						$ 40,400
2	**Concrete Structure**					
2.1	Suppy and Install head wall	2	Item	$ 4,000	$ 8,000	
2.2	Supply and Install culverts	4	Item	$ 800	$ 3,200	
2.3	Traffic Management	1	Item	$ 7,500	$ 7,500	
2.4	Road Excavation	1	Item	$ 5,000	$ 5,000	
						$ 23,700
3	**Foundation Preparation**					
3.1	Excavate to design levels					
3.1.1	Labour (5 x 1 days)	5	days	$ 600	$ 3,000	
3.1.2	Excavator (1 x 1 days)	1	days	$ 1,500	$ 1,500	
3.1.3	Haul Truck (1 x 1 days)	1	days	$ 1,000	$ 1,000	
						$ 5,500
6	**Rubicon Flume Gates and Superstructure**					
6.1	Stop Log gates - No. 2 - 1000mm High and 1000mm wide	2	Item	$ 12,000	$ 24,000	
						$ 24,000
7	**Miscellaneous Items**					
7.1	Prefrabricated Handrails	1	item	$ 10,000	$ 10,000	
7.2	Prefrabicated Platform	1	item	$ 5,000	$ 5,000	
						$ 15,000
8	**Earthworks/Embankment Construction**					
8.1	Supply and place geofabric (Bidim A44)	500	m^2	$ 12	$ 6,000	
8.2	Supply and place transition gravel	200	m^3	$ 100	$ 20,000	
8.3	Supply and place rip rap	300	m^3	$ 60	$ 18,000	
						$ 44,000
9	**Dewatering**					
9.1	Coffer Dam	1	Item	$ 10,000	$ 10,000	
						$ 10,000
10	**Demoblisation and Reinstatement Works**					
10.1	Restore and landscape site	1	Item	$ 20,000	$ 20,000	
10.2	Demobilise from site	1	Item	$ 20,000	$ 20,000	
10.3	Permanent Security Fencing (1.8m high)	100	m	$ 60	$ 6,000	
						$ 46,000
Contract Costs					**$ 208,600**	
	Contractor O/H and Profit	20%			$ 41,720	
Base or Contract Construction Costs					**$ 250,320**	
	Superintendence, Project Management and QC Support	18%			$ 45,058	
	Contingency	40%			$ 100,128	
Total Project Costs					**$ 395,506**	
Say					**$ 400,000**	

Notes: These costs are based on previous projects of similar size and scope and Rawlinson 2014

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B.4 Wagga Wagga flood control works

URS

Report

Constraints Management Strategy Prefeasibility

AUSTRALIA

Wagga Wagga Stormwater Flood Mitigation – Pumping Option

30 October 2014
43157204/06/02

Prepared for:
Murray Darling Basin Authority

Prepared by URS Australia Pty Ltd

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1 INTRODUCTION

URS Pty Ltd (URS) has been engaged to support the Murray Darling Basin Authority (MDBA) in the development of a pre-feasibility cost estimate of potential mitigation options to improve or upgrade the drainage capacity of the stormwater system in Wagga Wagga, New South Wales (Wagga).

The purpose of this report is to present an indicative cost estimate for pumping mitigation options for a number of flood gates located along the levee bank of the Murrumbidgee River.

1.1 Project Scope

URS conducted a desktop review of information provided by MDBA and Wagga Wagga City Council (WWCC). The data included photos of a typical flood gate, catchment areas for each flood gate, detailed information including pump curves and costs for the recently installed pump at the flood gate 15a adjacent to Tony Ireland Reserve and Tarcutta Street (FG15aTIR) and the corresponding gauge heights to flood gate closure.

The costing methodology was to compare the flood mitigation needs at other sites to the known functionality of the FG15aTIR, and scale costs accordingly. No hydraulic analysis to assess pump performance and efficiency was undertaken and only limited hydrological analysis for the contributing catchments was completed.

The opportunity to provide retarding basins or detention storages was not considered due to lack of availability of land and as advised by the WWCC.

2 PROJECT BACKGROUND AND INFORMATION

2.1 Project Location

The city of Wagga Wagga is at the eastern end of the Riverina weather district in New South Wales. The city currently has a population of almost 50,000. The Murrumbidgee River runs through the city with a series of levee banks providing flood protection.

Figure 2-1 Wagga Wagga City Location Map

2.2 Project Description

Flood gates in the Main (Wagga Wagga) Levee and North Wagga Wagga Levee allow flows to drain from the city at non-high flow events in the Murrumbidgee River.

During high flows in the Murrumbidgee River, stormwater gates throughout the city are closed to stop water from the rising river entering the city (see Figure 2-1 and Plate 2-1). As a result stormwater builds up behind the flood protection levee within Wagga Wagga and cannot be discharged to the Murrumbidgee River in a high flow event (defined as 50,000 ML/d at Wagga).

Flows greater than 26,000 ML/d are considered as environmental flows and therefore have the capacity to impact the stormwater system in Wagga Wagga.

Table 2-1 shows the flood gates throughout Wagga that are shut with flows greater than 26,000 ML/d. These gates have been investigated as part of this prefeasibility study.

Table 2-1 Flood Gates Closing Height and Corresponding Murrumbidgee River Flow – Source: MDBA

GATE NUMBER	GATE NAME	HEIGHT (m) AT WAGGA GAUGE WHEN GATE IS SHUT	FLOW AT WAGGA (ML/DAY)
6	Wiradjuri Reserve	4.8	26,600
13	Bathing Beach	4.8	26,600
18	Mason Street Pump	4.9	27,400
8	Travers Street	5.7	34,300
15	Tarcutta Street	6.2	38,900
7	Day Care Centre	7.3	50,100
NW7	Gardiner Street	6.4	40,800
NW9	Chinamans – Old Narrandera Road	6.4	40,800
NW3	Hampden Avenue	6.7	43,800
NW8	Gardiner Street	6.7	43,800
NW5	Wall Street	7.3	50,100

* NW – Denotes North Wagga

Plate 2-1 Flood Gate 15a outlet Source: Geoffrey Veneris Wagga City Council

Plate 2-2 Flood Gate 15a Pump Station – Source: Geoffrey Veneris Wagga City Council

3 PROJECT METHOD

Due to the limited scope of this project, the preliminary data set available, and the desktop nature of the costing exercise, URS developed this pumping option by assuming that the newly constructed pumping station at FG15aTIR was appropriate to manage stormwater peak flow pumping over the levee system.

URS calculated the peak flow for each additional flood gate location based on the catchment area. The peak flow was used to determine a suitable pump for each location.

URS did not consider the use of detention basins due to the considerable size required to store local flood flows with the River in flood. The preferred option is to develop flood levee pump over systems similar to the pump systems at FG15aTIR.

3.1 Existing Information

3.1.1 Catchment Areas

Catchment areas for each flood gate were provided by WWCC. The areas were used to determine the peak flow rate (1 in 20 year ARI) for each flood gate (See section 4.2).

3.1.2 Wagga Wagga City Council Public Documents

URS reviewed the following publically available documents:

- Wagga Wagga Floodplain Risk Management Plan (2009);
- Wagga Wagga City Council Murrumbidgee River Model Conversion Project (2010);
- City of Wagga Wagga Stormwater Strategic Management Plan (2010); and
- Wagga Wagga Major Overland Flow Flood Study (2011).

The documents provided an overall understanding of the stormwater concerns throughout Wagga Wagga including the effects of the Murrumbidgee River rising during floods.

3.1.3 Tony Ireland Reserve and Flood Gate 15a

Considering the limited available data for this project it was agreed that using comparative costs from the recently constructed pump station at FG15aTIR would be suitable for this level of prefeasibility assessment. To facilitate this, WWCC provided URS with drawings of the recently constructed pump, existing junction pit/well pit, cost estimates and this was supplemented by ongoing communication with Geoffrey Veneris of WWCC.

4 FLOOD GATE PUMP STUDY

4.1 Study Objectives

The development of the pre-feasibility flood gates pumping options are based on the following design criteria:

- Ease stress on existing stormwater infrastructure; and
- Develop a pumping system at each gate similar to that used at FG15aTIR.

4.2 Hydrological Analysis/Hydraulic Design

URS undertook a preliminary hydrological analysis of each flood gate. URS received the estimated catchment area for each flood gate, however the catchment slope and length was not provided. The time of concentration was therefore approximated based on Adams method. The rational method was used to calculate the peak flow for a 1 in 20 year ARI at each flood gate location.

Table 4-1 Flood Gate Estimated Design Flow

FLOOD GATE NAME	CATCHMENT AREA (Km^2)	TIME OF CONCENTRATION (mins)	DESIGN FLOW (L/s)
Wiradjuri Reserve	0.050	14.6	30
Bathing Beach	0.071	16.6	40
Mason Street Pump	0.094	18.6	45
Travers Street	0.671	39.2	200
Tarcutta Street	5.507	87.2	600
Day Care Centre	0.026	11.3	30
Gardiner Street	0.172	23.4	50
Chinamans - Old Narrandera Road*	0	0	10
Hampden Avenue	0.031	12.3	20
Gardiner Street	0.063	15.9	35
Wall Street	0.013	8.8	10

*- The catchment area for Chinamans Old Narrandera Road was estimated to be zero (WWCC) and therefore unable to provide a peak flow. So a pump system with a capacity of 10 l/s has been adopted

4.3 Pump Design

The primary component of the prefeasibility design is the sizing and identification of the type of pump to achieve the peak design flow over the levee. Based on the design used for the recently constructed pump station at FG15aTIR, URS assumed an axial pump would be appropriate for each flood gate pumping application where the peak/design flow rate is greater than 50 L/s as it provides the following benefits:

- High discharge at a relative low head;
- Adjusted to run at peak efficiency at low flow/high pressure using a variable speed;
- Small size suited to confined spaces; and
- Self-priming application.

For situations where the flow is less than 50 L/s it is suggested that a self-priming pump is used. They still provide the same functionality as that of the axial pump but are more appropriate for smaller flows which occur in the smaller catchments.

4.4 Pump Selection

Based on the results of the analysis as well discussions with a pump supplier Macquarie Pumps, the following pump sizes and models were identified as being suitable based on their pump curve and the peak design flow at each flood gate location:

Table 4-2 Pump Specifications

FLOW RANGE (L/s)	PUMP MODEL	MOTOR
10-30	NS80	3 kW
30-100	MC 200	11 kW
100-300	MC 250	30 kW
600 +	20ZLB	55 kW

In addition to the pump and motor, the cost estimate includes the following design components:

- Control panel;
- Pipework;
- Transformer to provide power to the motor;
- Telemetry System;
- Penstock Gates; and
- New junction pit.

5 COST ESTIMATE

WWCC advised that the total cost of the flood gate 15a adjacent to Tony Ireland Reserve and Tarcutta Street was $280,000. This cost did not include the civil works, which included a junction pit, pump sump pit and penstock control gates. URS estimated the cost of civil works based on current costs and applied CPI since construction of the M&E cost for FG15aTIR. This resulted in a total cost of raw construction cost of $481,600 in 2014 dollars for Tony Ireland Pump Station. Business case, contractor profit, tender design and client cost and an overall contingency was applied to this cost bringing the total cost for Tony Ireland to $915,000.

To provide a cost estimate for each of the proposed locations, URS assumed that items such as telemetry and civil works were assumed to have a similar size and depth to Tony Ireland Reserve and are generally independent of the size of the pumps required.

Each pump station has the following features incorporated in the estimate the overall cost:

- A axial or self-priming pump and appropriate motor;
- Transformer providing power to the motor;
- Control panel and telemetry system allowing remote control;
- A upgraded junction pit including a third well allowing overflow and pump capacity; and
- Pipework connecting the 3 wells within the junction pit.

Cost estimates have been developed based on advice from Macquarie Pumps and WWCC.

Using this advice and FG15aTIR as a basis, costs were scaled to match the peak flows at each site. Table 5-1 shows the estimated costs for each location with further detailed provided in Appendix A.

Table 5-1 Cost Estimate without Contingency

FLOOD GATE NAME	INDICATIVE COST
Wiradjuri Reserve	$499,110
Bathing Beach	$499,110
Mason Street Pump	$499,110
Travers Street	$539,610
Tarcutta Street	$604,110
Day Care Centre	$499,110
Gardiner Street	$499,110
Chinamans - Old Narrandera Road	$473,610
Hampden Avenue	$473,610
Gardiner Street	$499,110
Wall Street	$473,610
TOTAL	**$5,559,212**
SAY	**$5,500,000**

The above direct costs include 10% allowance for business case and 10% allowance for contractor profit and 30% allowance for investigation, design, tender and client costs.

5.1 Uncertainties

Due to the limited scope of this project, the preliminary nature of data and the nature of this costing exercise this study was completed with the following uncertainties:

- Only catchment areas were provided and therefore peak flows were calculated without taking into consideration the topography of the catchment resulting in a conservative value or no value (which is the case with Chinamans – Old Narrandera Road);
- No additional upgrade to the existing stormwater drainage systems connecting to the junction pit or the stormwater drainage leading from the junction pit to the Murrumbidgee River;
- Due to the prefeasibility of this study land acquisition was not included;
- It is assumed that these structures will be similar to Tony Ireland Reserve cost estimate. It was assumed that geotechnical investigation and (design cost) were not included, the results of the geotechnical investigation could influence the design and could increase the final cost;
- No hydrological and hydraulic modelling has been undertaken. This would be required before commencing concept design and could influence the overall design;
- No location survey has been provided for each flood gate, as a result each flood gate is assumed to have similar positioning to that of the flood gate at Tony Ireland Reserve;
- A 1 in 20 year ARI peak flow rate was assumed as the peak flow required for each flood gate catchment as it is understood that this what Tony Ireland Reserve Pump station was designed for;
- No inter-catchment flows were assumed, this refers to flows travelling between catchments;
- The height of the levee bank has been assumed to the same as at Tony Ireland Reserve, differences in height will change the overall head and effect the size of pump;
- Each existing flood gate consists of a penstock gate, junction pit and discharge pipe to the Murrumbidgee River similar in design to Tony Ireland Reserve pump station; and
- The pump system used at Tony Ireland Reserve provides a suitable level of service for each flood gate.

It is suggested that because of these uncertainties a contingency of 40% should be applied to each location. As a result the final cost estimate for each location is showed below in Table 5-2.

Table 5-2 Cost Estimate with Contingency

FLOOD GATE NAME	INDICATIVE COST
Wiradjuri Reserve	$632,000
Bathing Beach	$632,000
Mason Street Pump	$632,000
Travers Street	$684,000
Tarcutta Street	$765,000
Day Care Centre	$632,000
Gardiner Street	$632,000
Chinamans - Old Narrandera Road	$600,000
Hampden Avenue	$600,000
Gardiner Street	$632,000
Wall Street	$600,000
TOTAL	**$7,041,000**
SAY	**$7,000,000**

Based on this analysis, URS is suggesting that an appropriate pre-feasibility cost range is $5.5 Million to $8 Million.

6 CONCLUSION

The propose upgrade for each flood gate was determined by using limited information and as a result the cost estimate provided is only indicative.

URS received data from both MDBA and WWCC and determined design peak flows for each location. Based on a cost comparison with the recently constructed flood gate 15a pumping station a pumping option was provided for each flood gate identified by MDBA.

Based on this preliminary assessment, URS is suggesting that the costs relating to providing a stormwater mitigation option at 11 flood gates within Wagga Wagga Council is in the order of $5.5 Million to $8 Million.

7 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Murray Darling Basin Authority and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 18th of June 2014.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 18th June 2014 and 30th October 2014 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

APPENDIX A COST ESTIMATES

These cost estimates are for the investigation, design and construction. While they include an estimate of 10% of construction cost for Client and business case costs this is an estimate only of these costs.

Wagga Wagga Pumping Option

Project: MDBA Constraints Management Strategy
Job No: 43152704
Client: MDBA

Computed by: ST
Checked by: MS
Date: 28-Oct-14

Gate No.	Location	Catchment flows	Junction Pit	Penstock gates and Actuators	Well Cost	Pump Size	Pump Cost	Core Drilling Cost	Control Panel Cost	Control Panel Installation	Pipework Cost	Pole Transformer Cost	Telemtry System Cost	Miscellaneous Cost	Total Cost	Buisness Case and Contractor Profit 20%	Tender Design and Client Cost 30%	Total Direct Costs	Contingency 40%	Final Cost
16	*Tony Ireland Reserve*		*$ 72,000.00*	*$ 60,000.00*	*$ -*	*700HDS*	*$ 126,645.75*	*$ 5,676.00*	*$ 73,603.53*	*$ 12,900.00*	*$ 10,500.60*	*$ 62,223.15*	*$ 40,000.00*	*$ 18,060.00*	*$ 481,609.03*	*$ 96,321.81*	*$ 144,482.71*	*$ 722,413.55*	*$ 192,643.61*	*$ 915,000.00*
6	Wiradjuri Reserve	30	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
13	Bathing Beach	40	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
18	Mason Street Pump	45	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
8	Travers Street	200	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC250	$ 30,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 27,000.00	$ 25,000.00	$ 18,060.00	$ 359,740.13	$ 71,948.03	$ 107,922.04	*$ 539,610.20*	$ 143,896.05	$ 684,000.00
15	Tarcutta Street	600	$ 72,000.00	$ 60,000.00	$ 25,000.00	20ZLB	$ 60,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 35,000.00	$ 30,000.00	$ 18,060.00	$ 402,740.13	$ 80,548.03	$ 120,822.04	*$ 604,110.20*	$ 161,096.05	$ 765,000.00
7	Day Care Centre	30	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
NW7	Gardiner Street	50	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
NW9	Chinamans - Old Narrandera Road	10	$ 72,000.00	$ 60,000.00	$ 25,000.00	NS80	$ 3,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 20,000.00	$ 15,000.00	$ 18,060.00	$ 315,740.13	$ 63,148.03	$ 94,722.04	*$ 473,610.20*	$ 126,296.05	$ 600,000.00
NW3	Hampden Avenue	20	$ 72,000.00	$ 60,000.00	$ 25,000.00	NS80	$ 3,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 20,000.00	$ 15,000.00	$ 18,060.00	$ 315,740.13	$ 63,148.03	$ 94,722.04	*$ 473,610.20*	$ 126,296.05	$ 600,000.00
NW8	Gardiner Street	35	$ 72,000.00	$ 60,000.00	$ 25,000.00	MC200	$ 5,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 25,000.00	$ 25,000.00	$ 18,060.00	$ 332,740.13	$ 66,548.03	$ 99,822.04	*$ 499,110.20*	$ 133,096.05	$ 632,000.00
NW5	Wall Street	10	$ 72,000.00	$ 60,000.00	$ 25,000.00	NS80	$ 3,000.00	$ 5,676.00	$ 73,603.53	$ 12,900.00	$ 10,500.60	$ 20,000.00	$ 15,000.00	$ 18,060.00	$ 315,740.13	$ 63,148.03	$ 94,722.04	*$ 473,610.20*	$ 126,296.05	$ 600,000.00
														Total Cost	**$ 4,187,750.46**			**$ 5,559,212.15**		**$ 7,041,000.00**
																				$ 7,041,000.00

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APPENDIX C FLOW REGIME SCENARIO

CMS REGION	FLOW BAND (ML/DAY)	NUMBER OF ADDITIONAL EVENTS IN 25 YEARS – SCENARIO 1[8]	NUMBER OF ADDITIONAL EVENTS IN 25 YEARS – SCENARIO 2	NUMBER OF ADDITIONAL EVENTS IN 25 YEARS – SCENARIO 3
Goulburn (reaches A to D)	Up to 12K	5.0	5.0	10.0
	12K to 15K	5.0	5.0	10.0
	15K to 20K	5.0	5.0	10.0
Goulburn (reaches E to H)	20K to 25K	2.0	5.0	10.0
	25K to 30K	3.9	5.0	10.0
	30K to 40K	4.8	5.0	10.0
Hume-Yarrawonga	Up to 40K	0.0	5.0	10.0
Lower Darling	Up to 14K	0.0	5.0	10.0
	14K to 17K	1.3	5.0	10.0
Murrumbidgee (lower and mid)	Up to 30K	18.2	5.0	10.0
	30K to 40K	3.7	5.0	10.0
	40K to 48.5K	0.7	5.0	10.0
South Australia	Up to 60K	1.1	5.0	10.0
	60K to 80K	2.4	5.0	10.0
Yarrawonga-Wakool	Up to 20K	0.0	5.0	10.0
	20K to 35K	20.2	5.0	10.0
	35K to 50K	10.7	5.0	10.0
	50K to 77K	1.5	5.0	10.0

[8] "Scenario 1" is based on modelled changes in flows from the MDBA's "BP2800RC" model run as described in MDBA (October 2012) *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results.* Note that modelled outputs were not available for Goulburn reaches A-D, so for those reaches, 5 additional events per 25 years were assumed. This assumption is considered adequate for the purposes of prefeasibility cost estimates.

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