



Australian Government



**Modelling of environmental watering on Lindsay
Island 2015/16
(Addendum1 2017 Raising)
(Addendum2 2018 Raising)**

Technical Memo 2010/15_2

December 2015 (Updated November 2017, November 2018)

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Summary

A hydrodynamic model was recalibrated to measured water levels and gauged flow at main locations on Lindsay Island during the 2015/16 Lock 7 weir pool manipulation trial. The model successfully replicates the water level at the upper Lindsay Island north regulator and the modelled flows compared well with observed (modelled flow was within 10 ML/d of the gauged flow on the days of data collection).

The hydrodynamic model was used to estimate the additional flows entering Lindsay Island during raising of the Lock 7 weir pool compared to flows if the weir pool had been maintained at FSL. The additional flow was approx. 1.5 GL in August (the modelled average daily flow at 25 cm above FSL is approx. 70 ML/day), 7 GL in September and October and 6 GL in November (the modelled average daily flow at 50 cm above FSL is 220 ML/day). Of this additional flow, two effluents (Point 4 and 5) flow into the Mullaroo creek upstream of Site 414211 (Mullaroo Creek) and so are measured. The unmeasured additional flow entering Lindsay Island was approx. 1 GL in August (the modelled average daily flow at 25 cm above FSL is approx. 45 ML/day), 5 GL in September and October and 4 GL in November (the modelled average daily flow at 50 cm above FSL is approx. 160 ML/day).

Incremental losses were estimated as increased evaporation, seepage and storage in creeks and wetlands by comparing the modelled inundation area and volume during the weir pool raising to the inundation area and volume at FSL. The incremental area is approx. 60 ha with the Lock 7 weir pool raised by 25cm and 130 ha when the weir pool is raised by 50cm (excluding Lake Wallawalla which is being filled separately by pumping). The estimated losses were small, being approx. 0.6 GL in August and 1.7 GL in September. Losses were lower in subsequent months with the weir pool raised by 50cm since the loss to storage has been satisfied and only increased evaporation and seepage occurred.

The estimated additional flow to South Australia was only small, with no additional flow in August, approx. 0.6 GL during September, 1.75 GL in October and 1.2 GL in November.

1 Introduction

1.1 Project Background

The Lock 7 weir pool is being manipulated during 2015/16 to provide ecological benefits in the weir pool and associated creeks on Lindsay Island. Manipulation of the weir pool water level may provide similar benefits to higher flows in the River Murray, as demonstrated in previous studies of the Lock 8 and 9 floodplain undertaken by the Mallee Catchment Management Authority (Mallee CMA, 2006).

A previous hydrodynamic model has been developed and calibrated to represent the flooding behaviour of Lock 7 and Lindsay Island, river reach and associated creeks (Water Technology 2006 and 2010). This model was used to model the creek flow and floodplain inundation on Lindsay Island and Lock 7 associated with the observed Lock 7 weir pool level and flow in the River Murray downstream of Lock 9.

1.2 Study Objectives and Scope

The modelling study aims to:

- Recalibrate the existing hydrodynamic model of Lock 7 and Lindsay Island to match observed water levels and gauged flows;
- Estimate the ungauged flow entering Lindsay Island during the weir pool manipulation trial;
- Estimate the incremental losses associated with the ungauged flow (increased loss compared to holding the Lock 7 weir pool at FSL); and
- Estimate the flow difference to QSA associated with the weir pool manipulation incorporating the diversion to Lake Wallawalla.

2 Modelling

2.1 MIKEFLOOD model

The hydraulic model used in this study is DHI's MIKEFLOOD (2014), a hybrid model combining MIKE-11 for the one dimensional modelling of the open channel flow and hydraulic controls in combination with MIKE-21, a two dimensional physically based floodplain model for surface flow modelling.

MIKEFLOOD includes the ability to model overbank areas in detail with its two dimensional modelling capacity as well high capacity and finely defined river channels and flood runners within the one dimensional component. MIKEFLOOD models preserve mass, with the amount of water leaving the model equivalent to the amount entering. MIKEFLOOD also accounts for water level gradients within a channel.

A MIKEFLOOD model was previously developed for Lock 7 and Lindsay Island (Water Technology, 2006). The model was modified to incorporate recently acquired LiDAR data on the NSW floodplains but preserved the original model data and resolution. The Lock 7 model has a 2D grid size of 50m.

Lateral links

The most important links used within this model are the lateral links. Lateral links are used to provide a connection between the left and right banks for the MIKE-11 model and the MIKE-21 model. Lateral flows are governed as a weir spilling, whereby a threshold level is reached before general spilling. MIKE-11 flows are distributed between correspondingly linked MIKE-21 cells. A description of the process involved is provided in Figure 1.

Lateral links have been used to define spilling between the River Murray and creeks and the associated floodplain.

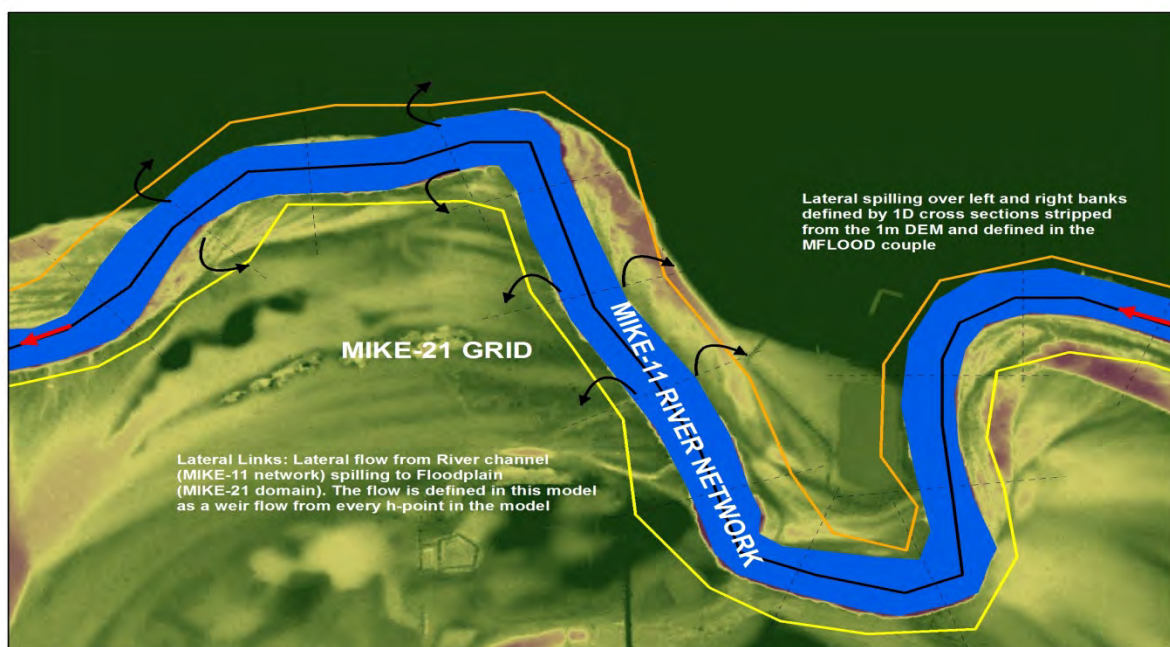


Figure 1 – MIKEFLOOD couple schematic of lateral link operation

2.2 Lock 7 Model Description

The area of interest involved in this study include the floodplains, wetlands and creek systems associated with the Lock 7 weir pool. The extent of the Lock 7 hydrodynamic model is shown in Figure 2.

Lock 7 model

M11 Model

The Lock 7 1D model extends from Lock 9 to downstream of the confluence of Lindsay River and the River Murray and includes the main creeks on Lindsay Island.

M21 Model

The Lock 7 2D model covers approx. 77,500 ha of floodplain and includes the Lindsay Island floodplain on the Victorian side of the River Murray at 50m resolution.

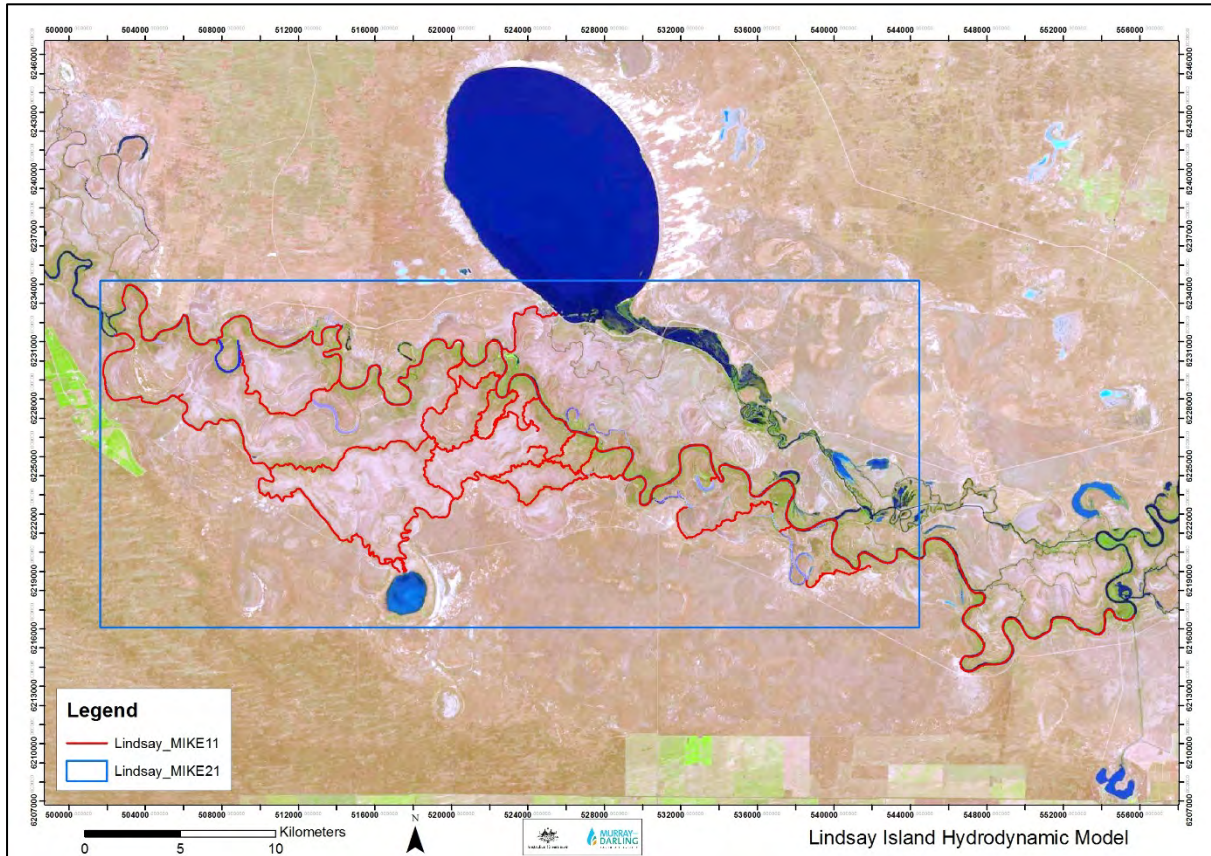


Figure 2 Extent of the Lock 7 hydrodynamic model

Model Roughness

Key model roughness parameters in the 1D and 2D models were set during initial calibration (Water Technology, 2006) and were adjusted to match gauged flows in the Lindsay Island effluents.

Regulators

Structures in the model included:

- Lock 8;
- Lock 7;
- upper Lindsay Island north and south regulators; and
- the Mullaroo Creek regulator.

Daily time series of actual upstream water levels were provided for Locks 7 and 8 and the River Murray flow at Lock 9. The upper Lindsay Island north and south regulators were fully open and the Mullaroo Creek regulator discharged a target flow of 600 ML/d (the combined flow from the Mullaroo Creek regulator and effluents 4 and 5 are measured at Site 414211 and included in QSA).

2.3 Weir Pool manipulation trial

The weir pool manipulation trial was developed by Ecological Associates Pty Ltd to increase the flows into Lindsay Island for 2 to 3 months in spring by raising the weir pool to a maximum of 0.5m above FSL and then drawdown the weir pool level to expose benches and dry wetlands over late spring and summer. An equivalent natural flood of approx. 18,000 ML/d would be required to raise the water levels by 0.5m in the River Murray adjacent to the upper Lindsay Island creeks and produce similar inflows.

The increased flows into Lindsay River through September-November 2015 allowed pumping of water to Lake Wallawalla. The proposed Lock 7 weir pool manipulation trial during 2015/16 is shown in Table 1.

Table 1 Proposed Lock 7 weir pool manipulation 2015/16

Month	Adjustment (m)	Target Level LOCK7US (m AHD)
July 2015	0	22.1
August 2015	+0.25	22.35
September 2015	+0.5	22.6
October 2015	+0.5	22.6
November 2015	+0.5	22.6
December 2015	-0.5	21.6
January 2016	-0.25	21.85
February 2016	-0.25	21.85
March 2016	-0.25	21.85
April 2016	-0.25	21.85
May 2016	0	22.1

Note – the 0.5m raising was extended through November 2015 to assist with the pumping of water from the Lindsay River to Lake Wallawalla.

2.4 Model Recalibration

Regular water level measurements have been undertaken by SA Water and the water level measurement upstream of the upper Lindsay Island north regulator were used to compare to model predictions.

Two sets of flow gaugings were undertaken at each of the sites shown in Figure 3 (one gauging at ~25 cm above FSL and one gauging at ~50 cm above FSL). The gauged effluent flows were compared to model predictions and head loss parameters for regulators and Manning's roughness for unregulated effluents modified until an acceptable comparison was achieved.

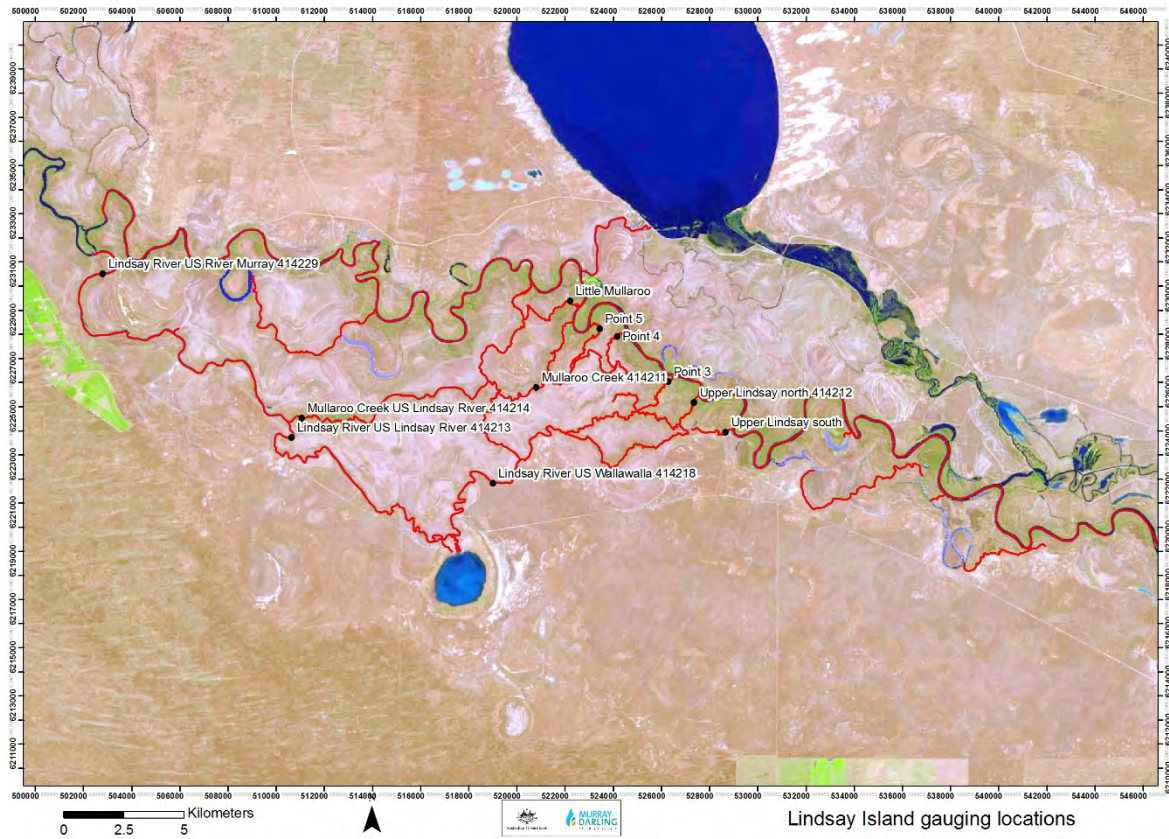


Figure 3 Lindsay Island gauging locations

3 Model Results

3.1 Comparison with Measured Data

The recalibrated model results in comparison with the observed water level upstream of the upper Lindsay north regulator and gauged effluent flows are shown in Figure 4 and Figure 5 respectively. The water levels and modelled flows compared well with observed data. Modelled flow was within 10 ML/d of the gauged flow on the days of data collection. Model verification will continue with collection of additional data.

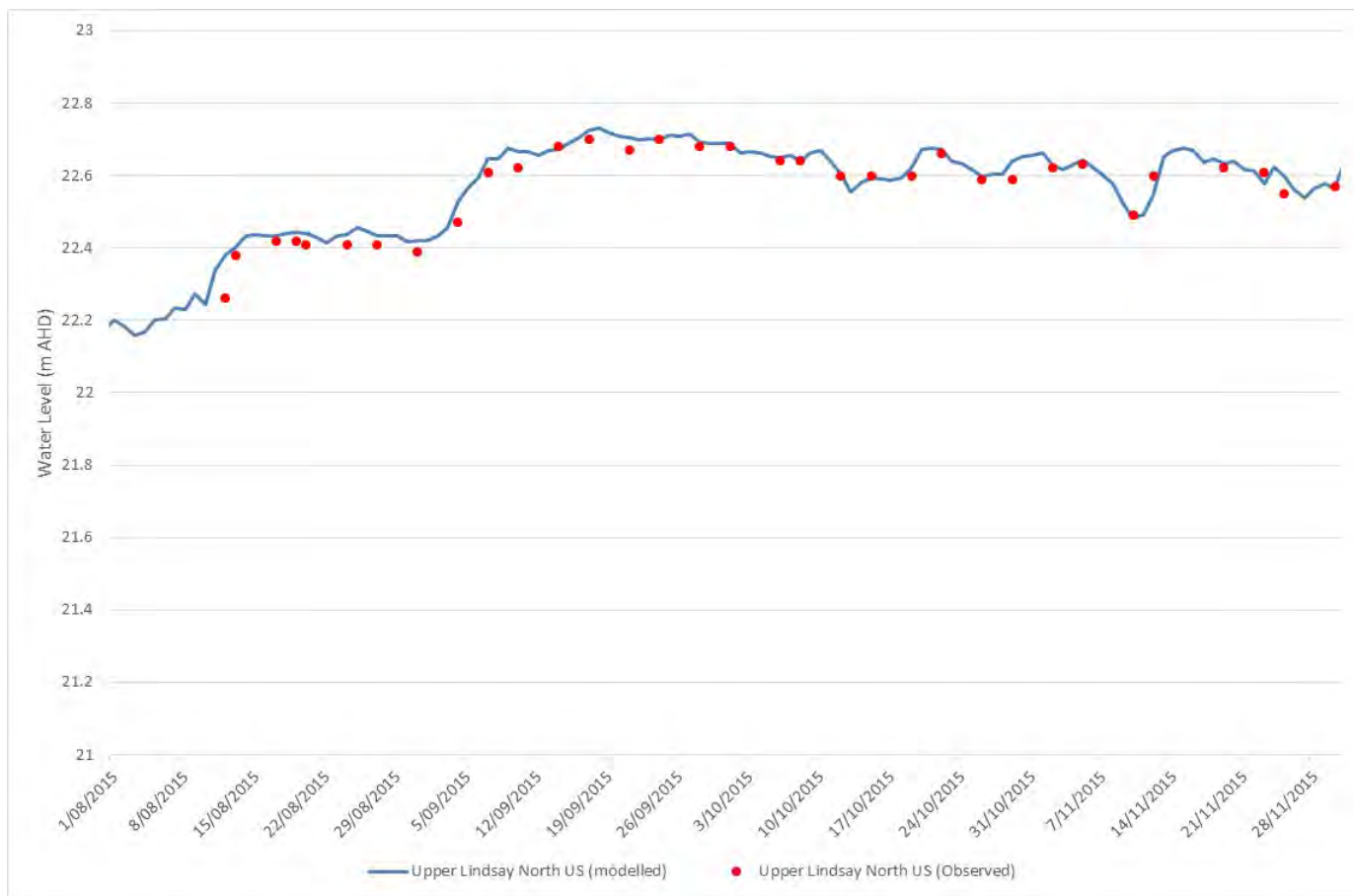


Figure 4 Lindsay Island model comparison with measured water level data

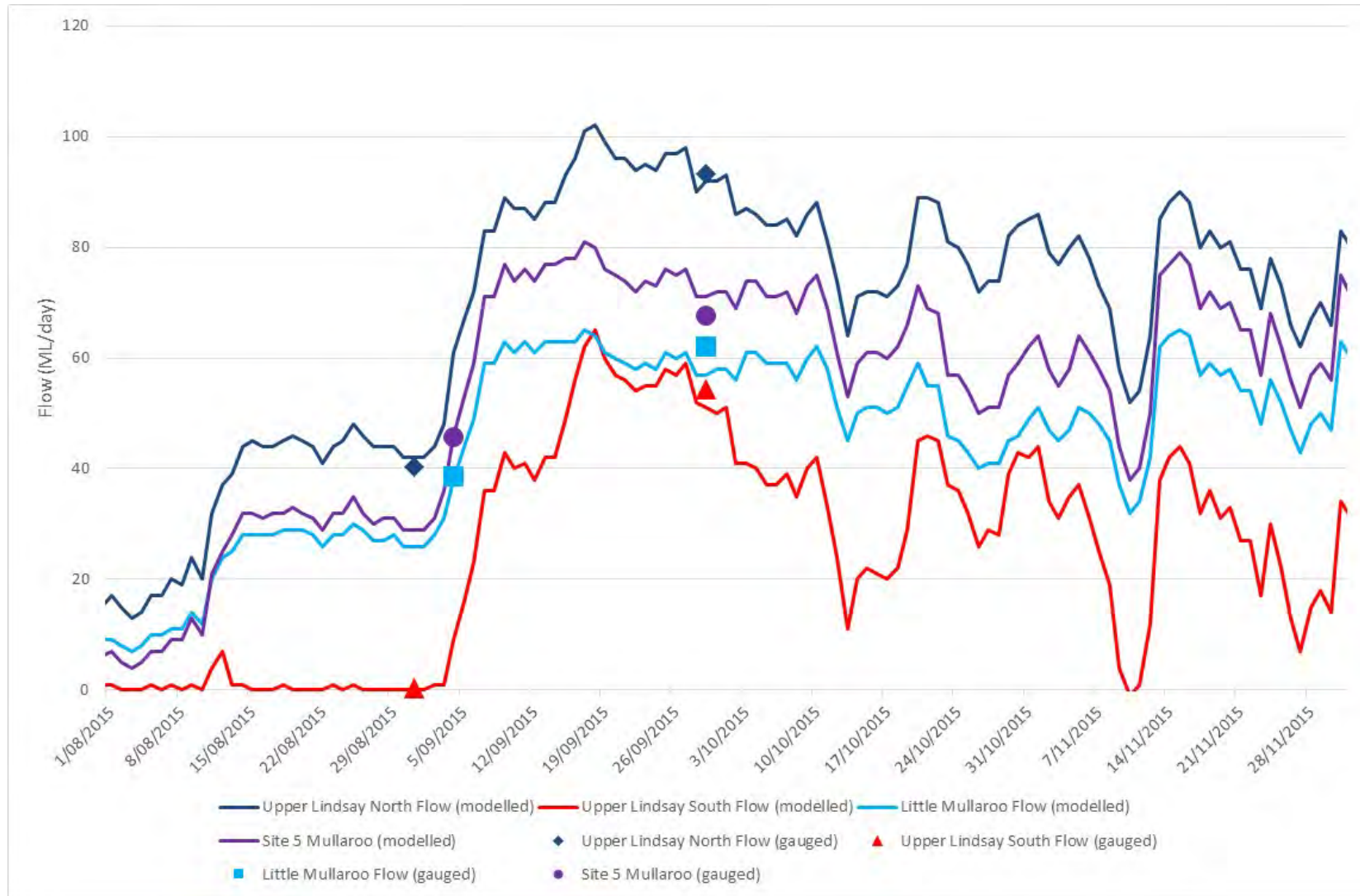


Figure 5 Lindsay Island model comparison with gauged flows

3.2 Estimation of Additional Flow into Lindsay Island Effluents

The recalibrated model was used to estimate the additional flow into the Lindsay Island effluents in comparison with the effluent baseflow if Lock 7 was held at FSL.

Table 2 Modelled Increment Flow into Lindsay Island effluents

	Incremental Flow (ML)			
	Upper Lindsay north	Upper Lindsay south	Little Mullaroo	TOTAL
August (from 10/8/15)	577	0	370	947
September	2,151	1,226	1,421	4,798
October	2,132	1,069	1,410	4,611
November	1,780	731	1,244	3,755
TOTAL	6,640	3,026	4,445	14,111

Note – the flow into the effluents at Point 5 (Figure 3) is measured at Site 414211 so was not included in this assessment, however the modelled flow at this point compared well with the gaugings (Figure 4). No flow was observed or modelled entering Points 3 or 4.

3.3 Estimation of Incremental Loss

The modelled incremental area (increase in surface area compared to FSL) was used with daily evaporation and seepage to estimate the incremental loss. Daily evaporation was obtained from monthly average Lake Victoria pan evaporation (pan coefficient of 0.83) and seepage was assumed as 5mm/day. The seepage rate has been used previously for modelling of Lindsay, Mulcra and Wallpolla Islands (Water Technology, 2006, 2008) and is considered to be a conservative estimate compared to the 3mm/day used for the SDL modelling of Lindsay Island (Water Technology, 2014). The incremental area inundated during raising of the Lock 7 weir pool is small so the incremental loss is also small.

The initial loss to storage was estimated as the difference between the total storage in the Lindsay Island model with the Lock 7 weir pool raised (excluding the River Murray) and the total storage at FSL and represents the water filling the creeks and wetlands and is assumed to not return.

Table 3 Estimated Incremental evaporation, seepage and storage loss

	Incremental evaporation and seepage (ML)	Incremental storage (ML)	TOTAL (ML)
August (from 10/8/15)	69	512	581
September	270	1,437	1,706
October	341		341
November	287		287
TOTAL	967	1,949	2,915

3.4 Estimation of Additional Flow to South Australia

The estimated additional flow to South Australia through Lindsay Island is shown in Table 4, including the diversion of water from Lindsay River to Lake Wallawalla.

Table 4 Estimated additional flow to South Australia through Lindsay Island

	Incremental Flow (ML)	Incremental Loss (ML)	Pumping to Lake Wallawalla (ML)	Additional QSA Estimate (ML)
August (from 10/8/15)	947	581	440	-74
September	4,798	1,706	2,528	564
October	4,611	341	2,521	1,749
November	3,755	287	2,267	1,201
TOTAL	14,111	2,915	7,756	3,440

*Note the incremental loss for October and November does not include a storage loss since the weir pool level has been maintained through September.

4 Conclusions

A hydrodynamic model was recalibrated to measured water levels and gauged flow at main locations on Lindsay Island during the 2015/16 Lock 7 weir pool manipulation trial. The model successfully replicates the water level at the upper Lindsay Island north regulator and the modelled flows compared well with observed (modelled flow was within 10 ML/d of the gauged flow on the days of data collection).

The hydrodynamic model was used to estimate the additional flows entering Lindsay Island during raising of the Lock 7 weir pool compared to flows if the weir pool had been maintained at FSL. The additional flow was approx. 1.5 GL in August (the modelled average daily flow at 25 cm above FSL is approx. 70 ML/day), 7 GL in September and October and 6 GL in November (the modelled average daily flow at 50 cm above FSL is 220 ML/day). Of this additional flow, two effluents (Point 4 and 5) flow into the Mullaroo creek upstream of Site 414211 (Mullaroo Creek) and so are measured. The unmeasured additional flow entering Lindsay Island was approx. 1 GL in August (the modelled average daily flow at 25 cm above FSL is approx. 45 ML/day), 5 GL in September and October and 4 GL in November (the modelled average daily flow at 50 cm above FSL is approx. 160 ML/day).

Incremental losses were estimated as increased evaporation, seepage and storage in creeks and wetlands by comparing the modelled inundation area and volume during the weir pool raising to the inundation area and volume at FSL. The incremental area is approx. 60 ha with the Lock 7 weir pool raised by 25cm and 130 ha when the weir pool is raised by 50cm (excluding Lake Wallawalla which is being filled separately by pumping). The estimated losses were small, being approx. 0.6 GL in August and 1.7 GL in September. Losses were lower in subsequent months with the weir pool raised by 50cm since the loss to storage has been satisfied and only increased evaporation and seepage occurred.

The estimated additional flow to South Australia was only small, with no additional flow in August, approx. 0.6 GL during September, 1.75 GL in October and 1.2 GL in November.

5 References

1. Mallee CMA (2006) Feasibility Investigations of Options for Lindsay, Mulcra and Wallpolla Islands. Stage II. Ecological Associates AL007-3-A.
2. Water Technology (2006) Lindsay and Mulcra Island Hydraulic Model Calibration Report. J164/R02.
3. Water Technology (2008) Memo: Mulcra Island Flooding Scenario Water Use Estimate. July 2008. Report for the Mallee CMA.
4. Water Technology (2010) Upper Lindsay Regulators – Hydraulic assessment. J1372/R01v02.
5. Water Technology (2014) Lindsay Island Hydrodynamic Modelling Report. October 2014. Report for the Mallee CMA.

6 Addendum 1 – Lock 7 Raising 2017

Estimation of Additional Flow into Lindsay Island Effluents

The recalibrated model was used to estimate the additional flow into the Lindsay Island effluents in comparison with the effluent baseflow if Lock 7 was held at FSL.

Table 5 Modelled Incremental Flow into Lindsay Island effluents (2017 Raising Event)

	Incremental Flow (ML)			
	Upper Lindsay north	Upper Lindsay south	Little Mullaroo	TOTAL
September	1,369	647	989	3,005
October	1,966	920	1,461	4,347
November	2,256	1,435	1,543	5,234
December	1,117	387	189	1,693
TOTAL	6,708	3,389	4,182	14,279

Estimation of Incremental Loss

The modelled incremental area (increase in surface area compared to FSL) was used with daily evaporation and seepage to estimate the incremental loss. Daily evaporation was obtained from monthly average Lake Victoria pan evaporation (pan coefficient of 0.83) and seepage was assumed as 5mm/day. The seepage rate has been used previously for modelling of Lindsay, Mulcra and Wallpolla Islands (Water Technology, 2006, 2008) and is considered to be a conservative estimate compared to the 3mm/day used for the SDL modelling of Lindsay Island (Water Technology, 2014). The incremental area inundated during raising of the Lock 7 weir pool is small so the incremental loss is also small.

The initial loss to storage was estimated as the difference between the total storage in the Lindsay Island model with the Lock 7 weir pool raised (excluding the River Murray) and the total storage at FSL and represents the water filling the creeks and wetlands and is assumed to not return.

Table 6 Estimated Incremental evaporation, seepage and storage loss

	Incremental evaporation and seepage (ML)	Incremental storage (ML)	TOTAL (ML)
September	145	795	940
October	205	0	205
November	224	0	224
December	200	0	200
TOTAL	774	795	1,569

Estimation of Additional Flow to South Australia

The estimated additional flow to South Australia through Lindsay Island is shown in Table 7, including the diversion of water from Lindsay River to Lake Wallawalla.

Table 7 Estimated additional flow to South Australia through Lindsay Island

	Incremental Flow (ML)	Incremental Loss (ML)	Pumping to Lake Wallawalla (ML)	Additional QSA Estimate (ML)
September	3,005	940	473	1,592
October	4,347	205	2,708	1,434
November	5,234	224	2,701	2,309
December	1,693	200	2,119	-626
TOTAL	14,279	1,569	8,001	4,709

7 Addendum 2 – Lock 7 Raising 2018

Comparison with Gauged data at Lindsay River North

DATE	Modelled Flow (ML/d)	Measured Flow (ML/d)	Modelled Level (m AHD)	Measured Level (m AHD)
6/09/2018	22	23.5	22.26	22.26
13/11/2018	54	55	22.475	22.47

Estimation of Additional Flow into Lindsay Island Effluents

The recalibrated model was used to estimate the additional flow into the Lindsay Island effluents in comparison with the effluent baseflow if Lock 7 was held at FSL.

Table 8 Modelled Incremental Flow into Lindsay Island effluents (2018 Raising Event)

	Incremental Flow (ML)			
	Upper Lindsay north	Upper Lindsay south	Little Mullaroo	TOTAL
September	127	0	149	276
October	726	0	467	1,193
November	1,068	0	702	1,770
December	375	0	248	623
TOTAL	2,296	0	1,566	3,862

Estimation of Incremental Loss

The modelled incremental area (increase in surface area compared to FSL) was used with daily evaporation and seepage to estimate the incremental loss. Daily evaporation was obtained from monthly average Lake Victoria pan evaporation (pan coefficient of 0.83) and seepage was assumed as 5mm/day. The seepage rate has been used previously for modelling of Lindsay, Mulcra and Wallpolla Islands (Water Technology, 2006, 2008) and is considered to be a conservative estimate compared to the 3mm/day used for the SDL modelling of Lindsay Island (Water Technology, 2014). The incremental area inundated during raising of the Lock 7 weir pool is small so the incremental loss is also small.

The initial loss to storage was estimated as the difference between the total storage in the Lindsay Island model with the Lock 7 weir pool raised (excluding the River Murray) and the total storage at FSL and represents the water filling the creeks and wetlands and is assumed to not return.

Table 9 Estimated Incremental evaporation, seepage and storage loss

	Incremental evaporation and seepage (ML)	Incremental storage (ML)	TOTAL (ML)
September	12	-105	-93
October	52	736	788
November	85	399	484
December	26	163	189
TOTAL	175	1193	1368

Note modelled storage was still below FSL at the end of September 2018 so no extra flow would be passing through Lindsay Island to South Australia in that month.

Estimation of Additional Flow to South Australia

The estimated additional flow to South Australia through Lindsay Island is shown in Table 10.

Table 10 Estimated additional flow to South Australia through Lindsay Island

	Incremental Flow (ML)	Incremental Loss (ML)	Additional QSA Estimate (ML)
September	276	-93	0
October	1,193	788	405
November	1,770	484	1,286
December	623	189	434
TOTAL			2,125