SARFIIP – Preliminary Investigations

Katarapko Floodplain hydraulic model setup and review

DEWNR Technical note 2016/06

Government of South Australia
Department of Environment, Water and Natural Resources

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Contents

List of figures

List of tables

Summary

The purpose of this report is to:

- Document and evaluate the current MIKE FLOOD model version of Katarapko Floodplain, including describing changes that have been progressively implemented since development of the original model scheme and any gaps in its makeup
- Document work that has been conducted as part of this model modification study, including additional survey work and update of structures and model branches to render it fit for purpose for SARFIIP investigations
- To describe existing and potential future SARFIIP-related scenarios.

The original MIKE FLOOD hydraulic model of Katarapko Floodplain was developed by Water Technology and has been progressively updated by MDBA and by Department of Environment, Water and Natural Resources (DEWNR) Science, Monitoring and Knowledge Branch to include the latest structure configurations and bathymetric survey data, with limited recalibration of the River Murray section of the model.

To address previously identified information gaps in the bathymetric data, additional cross section surveys were conducted and included in the model for:

- Eckert Northern Arm
- Bank K Creek
- Sawmill Creek (southern section)
- Piggy Creek
- Carpark Lagoons
- The Splash Outfall (for cross-checking against existing bathymetric survey data)
- Recently collected River Murray bathymetric survey data that had not been included in the model.

Additional updates for the model include:

- Addressing an issue with potential double-counting of flow volumes, with channels that are represented in the 2-D topographic grid underlying coupled 1-D sections requiring filling to eliminate water storage in these locations
- Update of structure configurations and/or locations as designs have been refined.

The model was evaluated against the flow events used to calibrate the model previously in its original development, in 1996 (peak at approximately 75 000 ML/d Flow to South Australia) and 2000 (peak at approximately 65 000 ML/d Flow to South Australia). The most recent River Murray high flow event in 2010–11, which peaked at over 90 000 ML/d Flow to South Australia, was also used as an additional validation event.

A number of hydraulic modelling scenarios have been conducted previously by Water Technology (the original model developers), and subsequently by MDBA and DEWNR using an updated model version. A number of potential future scenarios for SARFIIP investigations have been listed, with the expectation that other as yet undefined hydraulic modelling scenarios will be required as SARFIIP investigations progress.

1 Background

Katarapko Floodplain is an anabranch of the River Murray located in the vicinity of Loxton, South Australia. Its main inlets are located upstream of Lock 4, with return flows reentering the River Murray on the downstream side of Lock 4 through Katarapko Creek. A number of structures and banks have been constructed over the years internal and external to the floodplain, which have modified the natural hydraulics of the system and resulted in a general degradation of the ecological condition of the floodplain and associated wetlands. Figure 1.1 shows the main creeks and structures associated with the floodplain, including proposed structures under the South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP).

Owing to the general degradation of the floodplain condition in comparison to that under natural conditions, SARFIIP has been initiated to improve the flexibility of managing the system via new infrastructure and operational solutions. The following review of information pertaining to the existing hydraulic model of Katarapko Floodplain was conducted to support the Preliminary Investigations phase of SARFIIP. The state of the model and previous hydraulic scenarios conducted have been reviewed, and recommendations for further updates to the model, as well as gaps in the hydraulic scenarios conducted to date, have been identified.

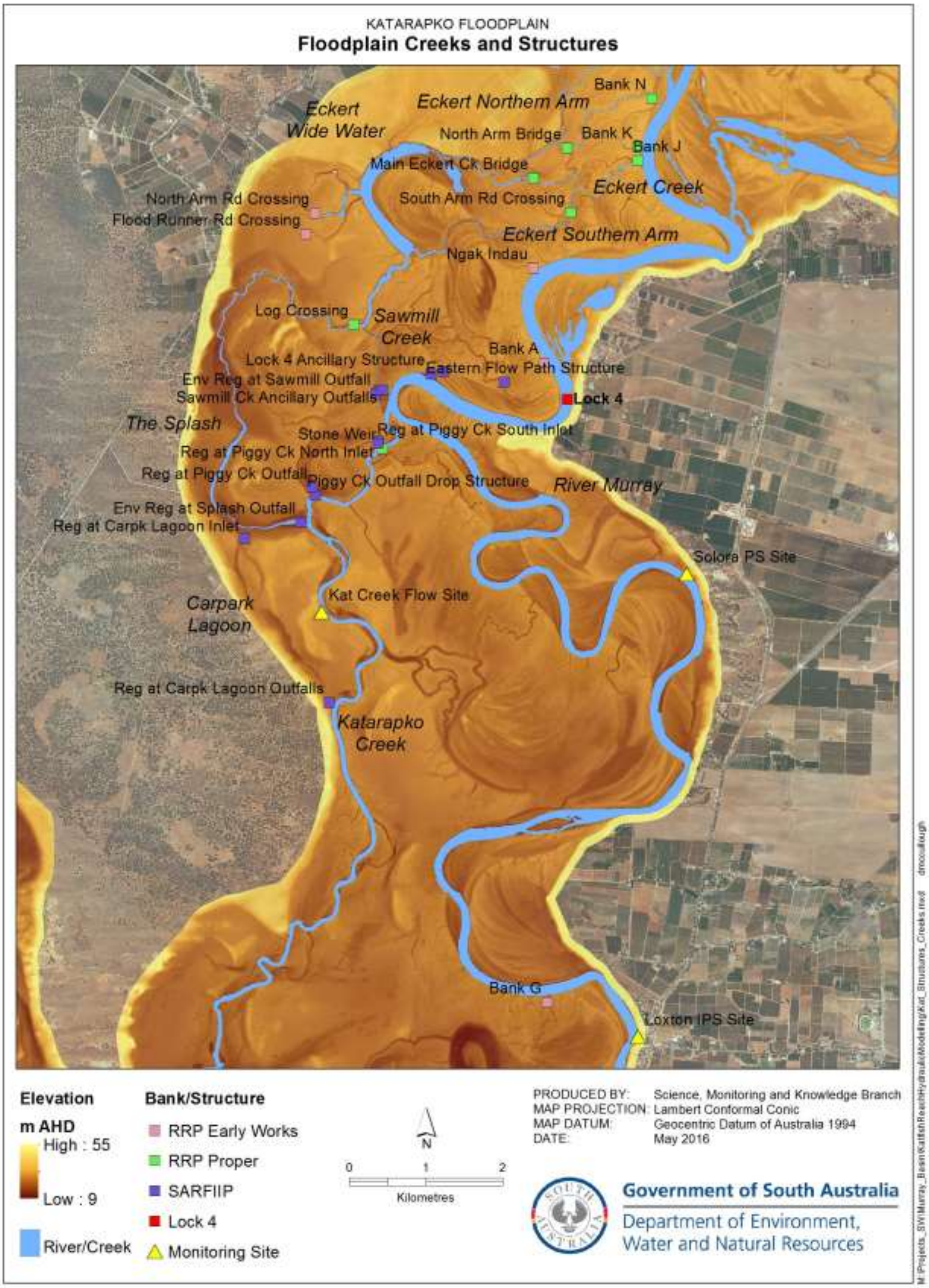

Figure 1.1 Katarapko Floodplain creeks and structures

2 Hydraulic model

2.1 Existing model configuration

Details of the original MIKE FLOOD model configuration (MF-WT) are presented in Water Technology (2010a), and are further summarised (along with updates implemented) in McCullough (2014a). Table 2.1 shows the existing floodplain model versions through the various updates applied, and abbreviations of each model version for reference in the text. Figure 2.1 shows the current MIKE FLOOD hydraulic model setup (MF–DEWNR), comprising selected branches in a one dimensional (1-D) representation coupled to the two dimensional (2-D) topographic map, with 10 m^2 grid size. Coloured areas of the figure represent the topographic grid, with red colouring at the highest elevation (22.3 m AHD) grading to purple at the lowest elevation (9.7 m AHD). 1-D sections of model are represented with node points (black and white) connected with black lines to represent model branches, with cross-sections, structures and boundary conditions represented by rectangles. Axes on the figure represent easting and northing coordinates (i.e. Geocentric Datum of Australia 94 – Map Grid of Australia Zone 54 system).

Table 2.1 Existing MIKE FLOOD model versions for Katarapko Floodplain

Model version	Abbreviation	Description
Water Technology, MIKE FLOOD	MF–WT	Original model configuration, 10 m^2 grid sizing
Water Technology, MIKE SHE	MS–WT	Revised floodplain model under MIKE SHE for limited inundation scenarios only, 30 m^2 grid sizing
MDBA, MIKE FLOOD	MF–MDBA	Original model configuration with updates to in-stream structures
DEWNR, MIKE FLOOD	MF–DEWNR	Incorporating updates to the MF–MDBA model, including: • Adjustment of River Murray portion of the model to address an issue of overestimation of River Murray levels and water levels/flows in Katarapko Creek • Relocation of the Eckert Creek Northern Arm Bridge structure to its actual location (i.e. defined approximately 1 km upstream of its actual location in the MF–WT model) • Adjustment of previous cross-sectional data in Eckert Creek Southern Arm following a point survey downstream of South Arm Road Crossing • Changed grid resolution to 20 m^2

The following branches are specified in the model as 1-D representations (refer to Figure 1.1 for locations of creeks and structures):

- River Murray (between Locks 3 to 5)
- Main Eckert Creek
- Eckert Creek Northern Arm and Southern Arm
- The Splash
- Sawmill Creek
- Katarapko Creek
- Piggy Creek
- Ngak Indau Wetland inlet
- Wetland 1541
- Bank A creek

Structures represented in the model are as follows:

- Lock 4
- Banks J, K and N inlet regulators
- Log crossing regulator
- Piggy Creek inlet and outlet structures
- Main Eckert Creek bridge and North Arm bridge
- South Arm road crossing regulator
- Sawmill Creek culvert structure
- Katarapko Creek stone weir
- Ngak Indau inlet and outlet structures
- Car Park Lagoon inlet and outlet regulators
- Bank A regulator

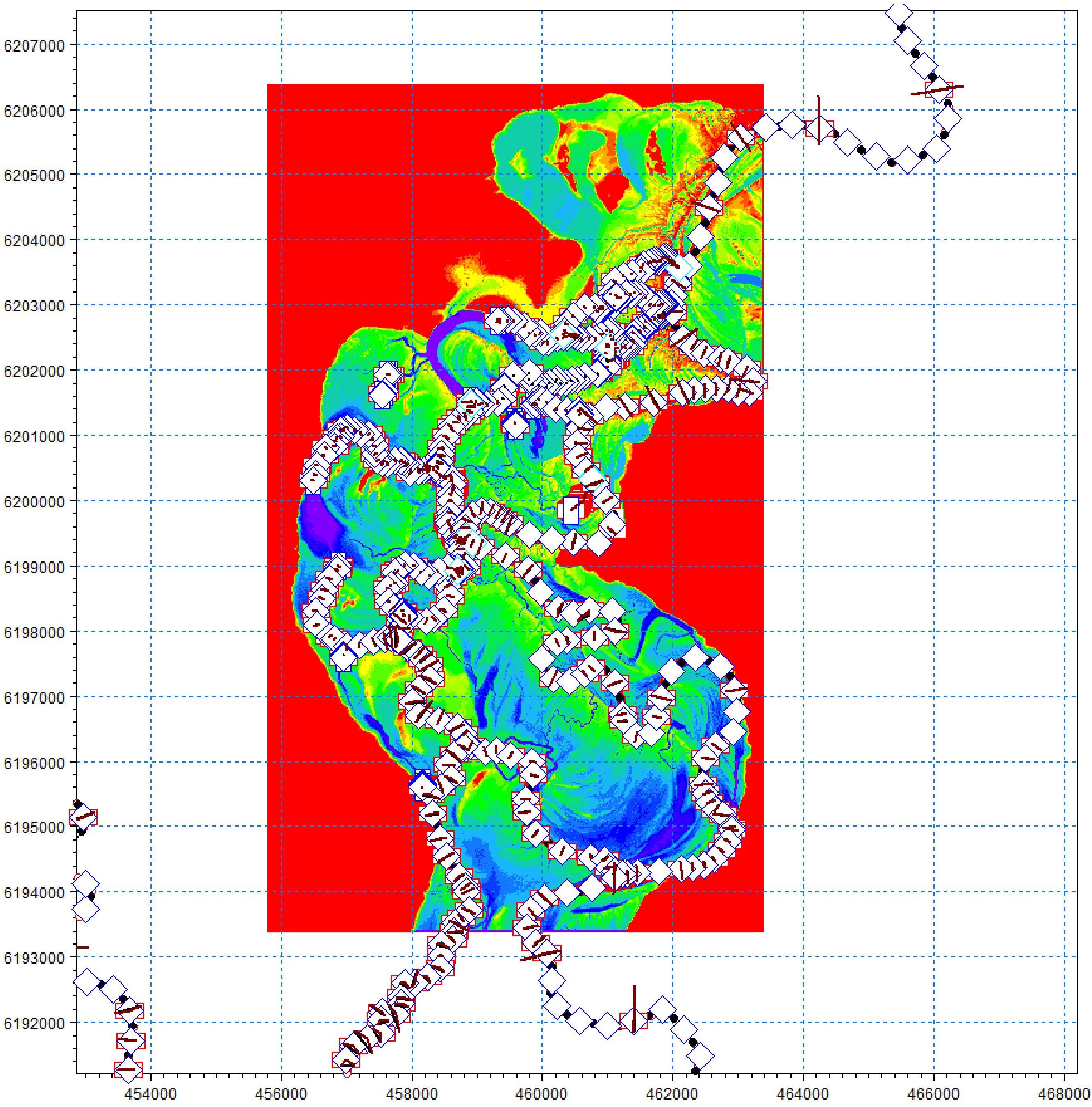

Figure 2.1 MIKE FLOOD 1-D/2-D coupled model of Katarapko Floodplain

Bathymetric data included in the hydraulic model configuration is extracted from a number of sources, including:

- Digital Elevation Model (DEM), developed from 2 m^2 LiDAR
- Bathymetric survey data collected from a combination of boat mounted and land-based survey techniques.

Figure 2.2 indicates the extent of existing DEM and bathymetric survey data that has been used in the previous hydraulic model, as well as new survey data collected as part of this study, and also track surveys conducted as part of the design process. Note that the detailed bathymetric data shown in the River Murray supersedes previous bathymetry used in the original model configuration (MF–WT), and this is included in the updated model configuration.

Note that only the floodplain area is of interest for results from the model, while areas outside of this region are expected to produce results of poorer quality compared to those within the main section of floodplain.

These poorer quality areas in the model include those to north of Bank N/Eckert Northern Arm and east of the River Murray, which present gaps in the DEM that have been filled in through estimation only, and have therefore not been considered in calibration/verification exercises. The impact of these areas on the results from the remainder of the model is considered negligible due to their characteristics however. For instance, the Berri Evaporation Basin to the north of Eckert Northern Arm is a terminal lake, and thus its operation does not adversely impact on flows or levels through the rest of the system, while areas to the east of the River Murray also act in similar fashion while being surrounded by land (i.e. non-wetted) values.

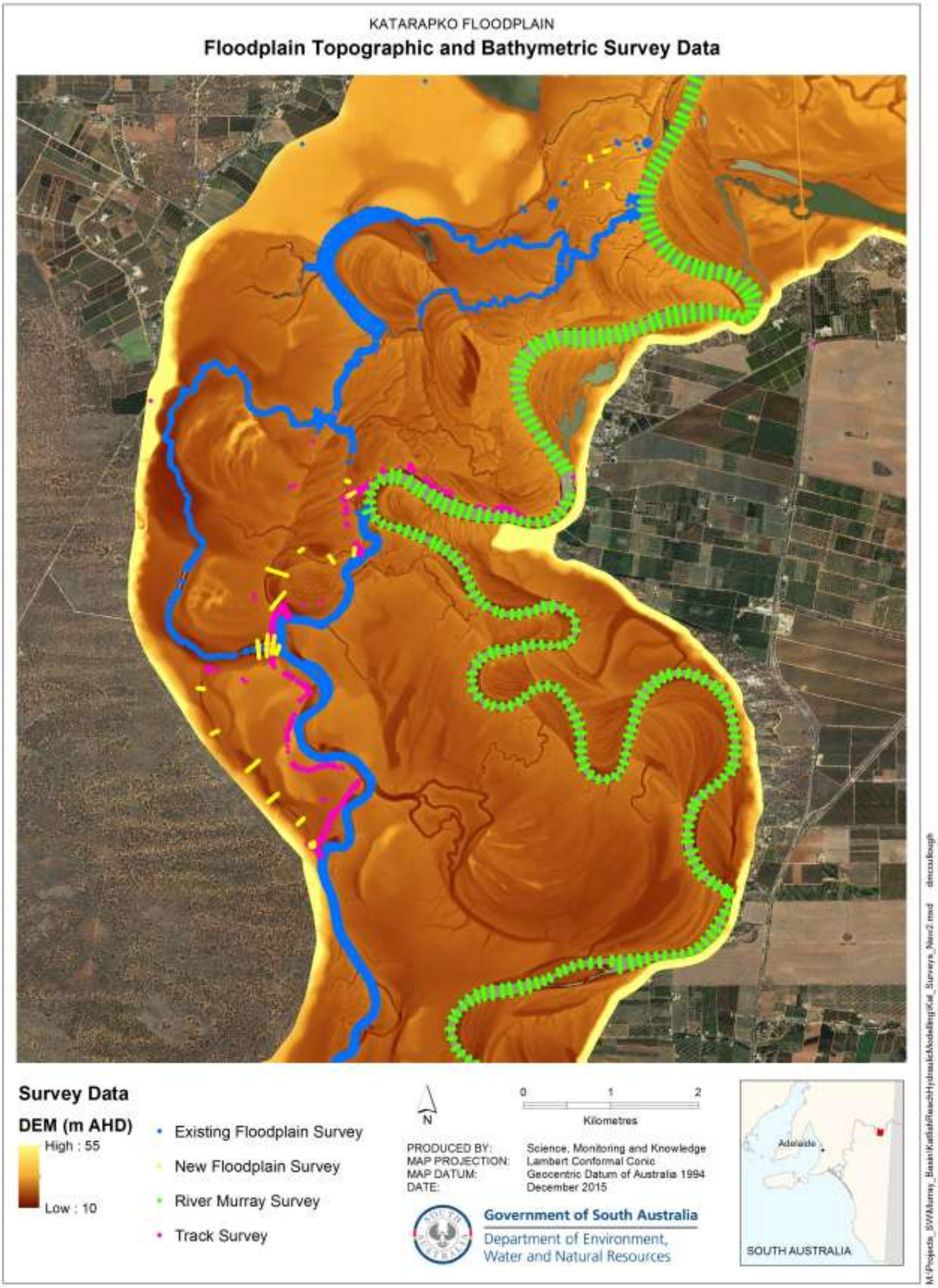

Figure 2.2 Topographic and bathymetric survey data for Katarapko Floodplain

2.2 Addressing hydraulic model gaps

2.2.1 Bathymetric data

As shown in Figure 2.2, bathymetric and topographic survey data presents reasonably comprehensive coverage throughout the waterways of the anabranch and within the River Murray reach relevant to the hydraulic model, providing the basis for a reliable representation of much of the floodplain. DEM data covers the majority of the floodplain except for permanently inundated waterways within the floodplain.

Comparison of the DEM grid with surveyed locations indicates a reasonable reliability of the DEM in parts of the floodplain not inundated at the time of data collection, generally falling within approximately 0.1 m of ground-based survey results (note that larger discrepancies appear to exist on steep surfaces such as the sides of banks). Note that the modelled topographic grid resamples this data to a coarser cell size (i.e. 10 m^2 in the original model configuration) to provide a balance between detail and simulation run times, which may impact on this accuracy.

Boat mounted bathymetric survey was used to cover the areas not represented by the DEM in reaches that were navigable by boat and also not impacted by submerged weeds. This type of survey covers:

- River Murray
- Main Eckert Creek
- Eckert wide waters
- The Splash
- Katarapko Creek.

Other sections have been surveyed using traditional survey techniques, with creek cross-sections collected at:

- Eckert Northern and Southern Arms
- Bank K Creek
- Sawmill Creek
- Katarapko Creek stone weir.

At these particular locations the cross-sections surveyed are relatively isolated from one another, leaving gaps in the bathymetry that are estimated within the model. Other areas, such as Piggy Creek and Carpark Lagoon have their bathymetries taken from the DEM, and as such would benefit from on-ground survey data to validate the elevations used. Additional cross-sectional surveys have since been conducted and added to the model as part of this model review component for the following locations (refer also to Figure 2.2):

- Eckert Northern Arm (two intermediate locations)
- Bank K Creek (two intermediate locations)
- Sawmill Creek (southern reach)
- Piggy Creek (full length of reach at regular spacing)
- Car Park Lagoon (full length of reach at regular spacing)
- The Splash Outfall into Katarapko Creek (for a cross-check of existing bathymetric survey cross-sections).

2.2.2 Structures

The majority of structures have been defined at least to the concept design phase, with several having their detailed design completed and others that have been fully constructed. Table 2.2 indicates the pending infrastructure in Katarapko Floodplain against program and current status, which has been extracted from sources including Concept Design (URS, 2009), Draft Detailed Design (URS, 2013) and Operational Strategy (DENR, 2012) reports. The latest structure configurations and their positioning, based on detailed or concept designs, have been included in the current model (MF–DEWNR). Any further updates to structure designs or positioning will be progressively implemented in the model as SARFIIP investigations progress.

Table 2.2 Katarapko Floodplain pending infrastructure with associated program and current status

Structure	Program	Current status
Bank J	RRP Proper – design and geotech / SARFIIP – construction	Detailed design complete, planning on construction in 2015/16 under SARFIIP Early Works
Bank K	RRP Proper	Detailed design complete
Bank N	RRP Proper	Detailed design complete
Eckert Southern Arm Road Crossing	RRP Proper	Detailed design complete
Eckert Creek Log Crossing	RRP Proper	Detailed design complete
Katarapko Creek Stone Weir	RRP Proper	Detailed design complete
The Splash Outfall Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Piggy Creek Outfall Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Piggy Creek North & South Arm Inlet Regulators	SARFIIP	Concept design complete, for review by SARFIIP
Sawmill Creek Outfall Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Sawmill Creek Ancillary Regulators x2	SARFIIP	Concept design complete, for review by SARFIIP
Lock 4 Ancillary Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Carpark Lagoons Inlet Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Carpark Lagoons Outlet Regulator	SARFIIP	Concept design complete, for review by SARFIIP
Eckert Northern Arm Bridge	RRP Proper	No designs or specification or project scope
Main Eckert Creek Bridge	RRP Proper	Detailed design complete

2.2.3 Model configuration

Issues have been identified with the coupling of the 1-D/2-D model with regards to potential double counting of water volumes within the Katarapko Floodplain system. This occurs when a stream branch defined in the 1-D portion of the model is also represented in the underlying 2-D portion of the model, resulting in both 1-D and 2-D sections containing water that is erroneously counted separately in calculations. In addition to double counting, this also gives rise to potential bypassing of 1-D structures within the model at certain elevations, which was encountered during modelling of the Log Crossing regulator in McCullough (2014b), in which flow into The Splash continued despite full closure of the Log Crossing at sufficiently high flows. To address these issues, areas of the bathymetric grid at which flow paths were being represented in both 1-D and 2-D forms were essentially "filled in" to ensure that the 1-D branch conveyed the flow preferentially to the 2-D grid, thereby mitigating potential double counting and erroneous bypass of flow through the 2-D portion of the model.

Model instability has been additionally identified as an issue at River Murray flows exceeding approximately 40 000 ML/d, which prevents successful completion of scenarios above these flows. Previous scenarios conducted by DEWNR using the original MIKE FLOOD model configuration (McCullough 2014a) did not exceed 30 000 ML/d, and thus instability issues were not encountered in this earlier work. Troubleshooting of the model suggested that the time step set for model calculations in the original model version (i.e. 3 seconds) was too large for the cell size used (i.e. 10 m^2) – as a guide, the timestep should ideally be set at one tenth of the cell size for greater model stability (DHI Water and Environment 2015, pers. comm., 20 January) which would require a 1 second timestep for the case of the 10 m^2 cell size of the original Katarapko hydraulic model. A reduction in time step to 2 seconds was trialled, which increased the time of simulation by approximately 50% (compared to the original 3 second time step), but yet was still resulting in model instability. A time step of 1 second was also trialled but abandoned after it became clear that the increase in simulation run time (i.e. a 200% increase compared to the original 3 second time step) was prohibitive to providing model outputs in a timely manner, particularly under full inundation scenarios. Since reducing the time step was not feasible, the stability issues were addressed by increasing grid cell size by resampling the grid from 10 m^2 to 20 m^2, providing an appropriate balance between simulation run time and model detail, while addressing instability issues. Note that this will likely further reduce detail in smaller flood runners that are only specified in 2-D, however this compromise is considered acceptable when considering the hydraulics on a whole of floodplain level in particular.

Another issue with the original model configuration was at the Ngak Indau wetland area of the 2-D bathymetric grid. Surrounding the depression area (in the centre of Figure 2.3), the elevation in the original model was set to a constant elevation of 13.2 m AHD (i.e. typical Lock 4 upper pool level). It appears that this area of the grid was originally implemented in the model to facilitate a greater exchange of water into the wetland at higher river flows, but resulted in inundation of the entire area. As a result, post-processing was required in early modelling to display inundation only in the wetland area. Although this issue is unlikely to have impacted adversely on previous modelled outputs, given that they were typically in-channel scenarios and were able to be post-processed, for completeness the missing topography was added to the grid in this area, allowing simplification of post-processing requirements.

Another part of the model configuration that may require modification in the future is the blocking bank alignment, which was not included in the original MIKE FLOOD model (MF-WT) due to its development primarily for in-channel flow scenarios. The concept alignment was therefore added to the grid directly for managed inundation scenario modelling, noting that the alignment is subject to change pending future SARFIIP investigations. Such changes are currently undefined, but will be updated in the model as required.

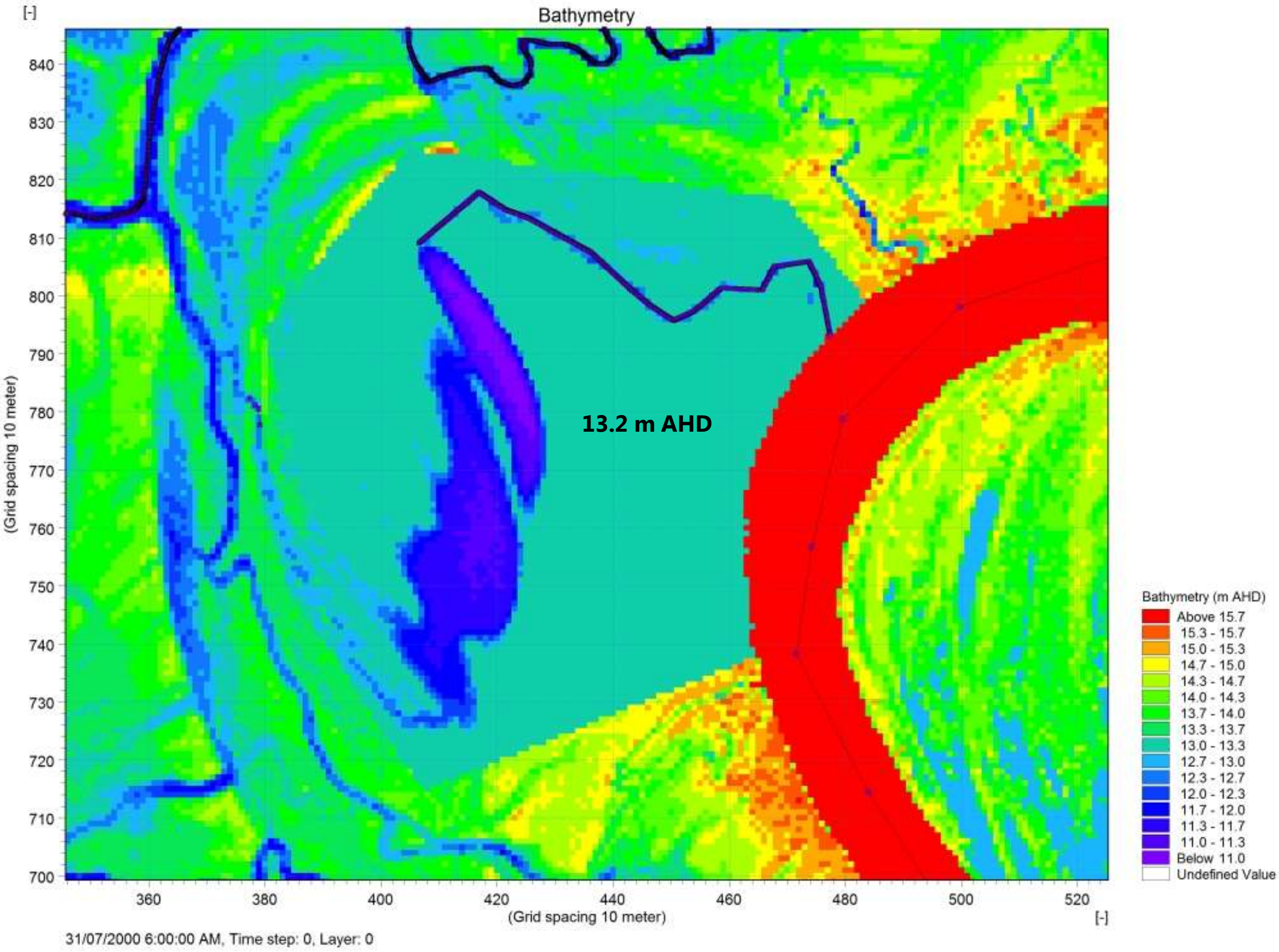

Figure 2.3 MIKE FLOOD 2-D bathymetric grid in Ngak Indau wetland area, with altered topography to 13.2 m AHD in MF–DEWNR version (identified by teal colouring)

2.3 Model evaluation

2.3.1 Available data

The original version of the model (MF–WT, Table 2.1) was calibrated against flow events in 1996 and 2000 as described in Water Technology (2009), which reportedly covered River Murray flows up to approximately 60 000 ML/d based on the imagery dates available for comparison (note this does not represent the peak flow of the events tested, but rather the flows corresponding to the dates of available imagery). The latest high flow event in 2011, which occurred after the original calibration was conducted, reached a peak Flow to South Australia exceeding 90 000 ML/d, providing additional data for validation of the modified model. Table 2.3 shows relevant imagery dates available for recent high flow events and corresponding river flows where available (i.e. Flow to South Australia and rated flow at Lyrup gauging station, upstream of Katarapko Floodplain). Imagery was selected as close as possible to the peak of each event.

Table 2.3 Available USGS Landsat Imagery dates and corresponding Flow to South Australia and rated flow at Lyrup gauging station (A4260663)

USGS Landsat imagery date	Flow to South Australia ML/d	Rated flow, Lyrup gauging station ML/d
9 December 1996	72 430	66 650
13 December 2000	60 399	46 500
7 March 2011	77 569	73 570

In-stream data sources available within the vicinity of Katarapko Floodplain are as follows:

- Continuous monitoring data from the State Water Data Archive, including:
  - Rated flow: Flow to South Australia, Lyrup Gauging Station (>35 000 ML/d), Locks 5 and 4 (less than ~ 50 000 ML/d and ~45 000 ML/d, respectively), Katarapko Creek (since mid-2013)
  - Water level: Lyrup Gauging Station, Lock 5, 4 and 3 (upstream and downstream), Solora and Loxton Pump Stations, Katarapko Creek downstream of The Splash outfall (since mid-2013)
- Single flow gaugings conducted at various dates and locations within the floodplain by DEWNR Resource Monitoring Unit, providing flow and velocity data
- Inundation imagery for high flow events in 2011, 2000 and 1996 (from United States Geological Survey (USGS) Landsat Imagery).

Hydrographs for selected high flow events are shown in Figure 2.4 to Figure 2.6, with the time step corresponding to the available inundation imagery closest to the peak of each event indicated by a dashed line.

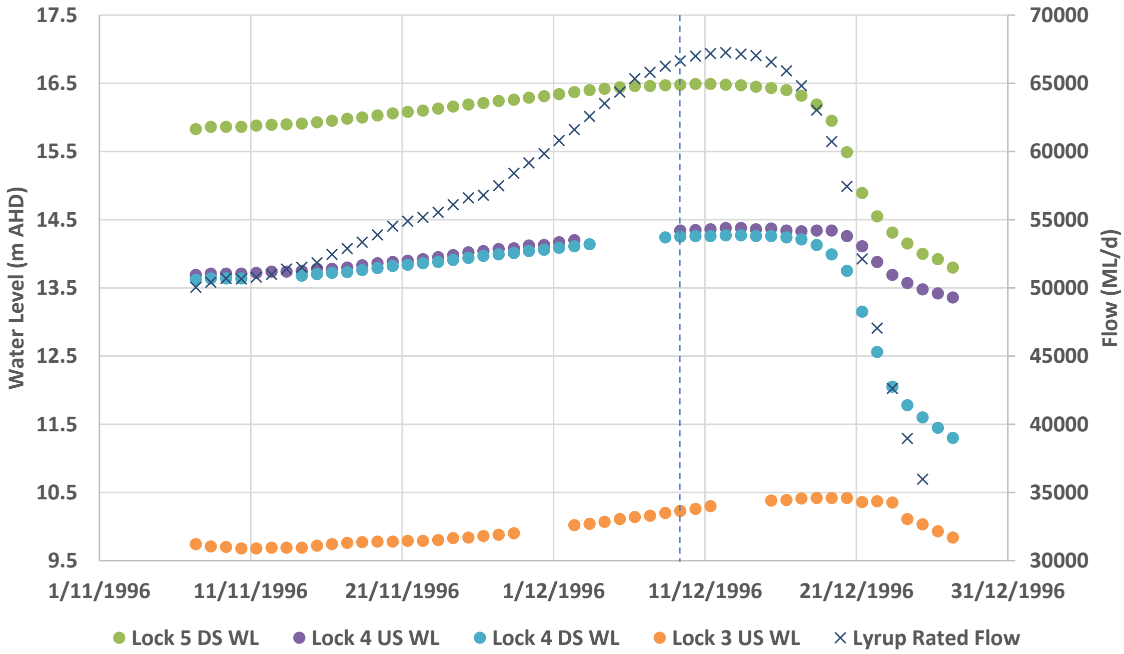

Figure 2.4 Lock levels and Lyrup gauging station rated flow for 1996 event (modelled event shown by dashed vertical line)

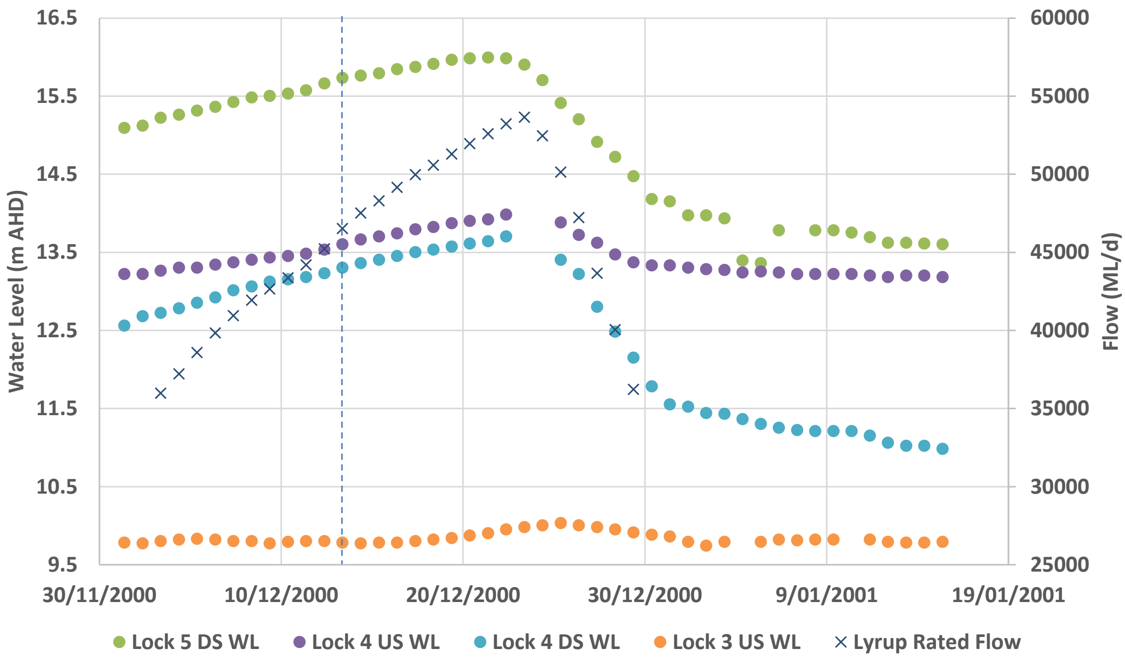

Figure 2.5 Lock levels and Lyrup gauging station rated flow for 2000 event (modelled event shown by dashed vertical line)

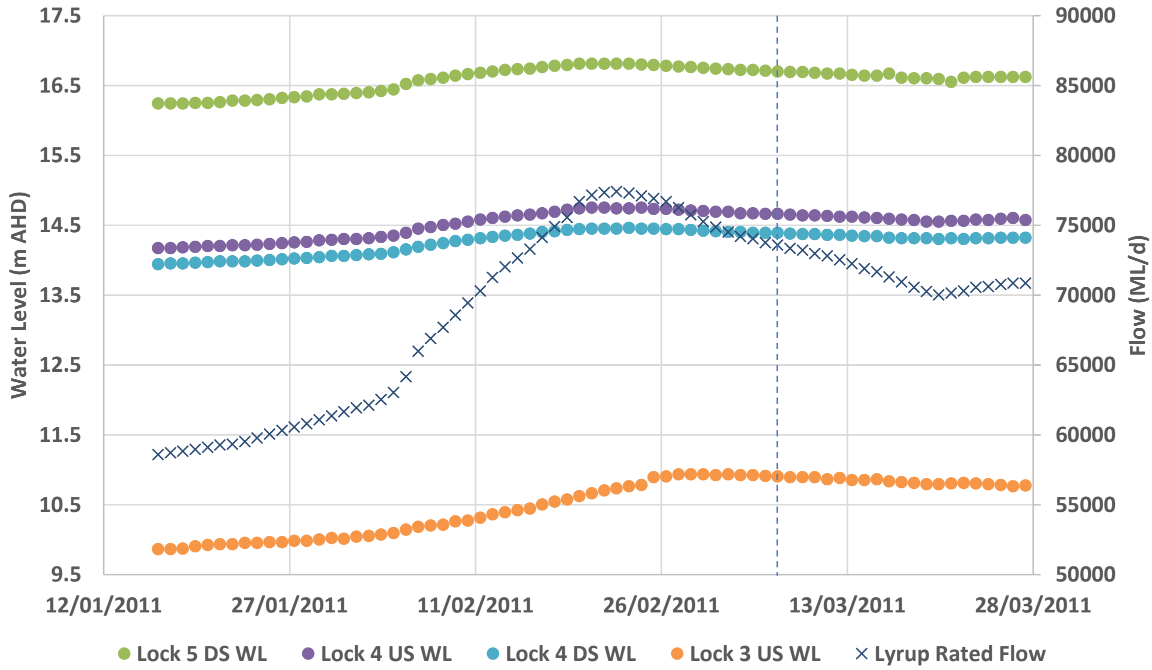

Figure 2.6 Lock levels and Lyrup gauging station rated flow for 2011 event (modelled event shown by dashed vertical line)

2.3.2 Selected data for comparison

The most relevant sites for comparison of modelled and observed data are water levels at Lock 4 downstream, Solora and Loxton pump stations, and Katarapko Creek water levels and flows under low flow conditions only, with locations of each monitoring site shown in Figure 1.1. Lock 3 and River Murray flow upstream of Lock 4 form boundary conditions for the model setup, while Lock 4 upstream level is also set within the model to match observed data for each simulated event. Note that the preceding data is only relevant for River Murray comparisons (and in Katarapko Creek for low flows only), with a distinct lack of continuous monitoring data available within the floodplain channels. This lack of data limits the ability to evaluate floodplain hydraulic conditions, as identified in Water Technology (2009), and thus the hydraulic representation of floodplain channels may be compromised. Due to this issue, satellite imagery forms the main basis for evaluating floodplain hydraulics by necessity.

2.3.3 Runs

Following updates implemented in the model as part of this study (MF–DEWNR), evaluation events were run as identified in Table 2.3 for comparison with available Landsat imagery and continuous monitoring data. Imagery for each event was selected as close as possible to the peak of each event, as identified in Figure 2.4 to Figure 2.6. Additionally, a baseflow comparison run was conducted at 10 000 ML/d for evaluation of in-stream conditions against continuous monitoring data. Note that since the 1996 and 2000 events were used to calibrate the original model (MF-WT), we cannot use them for validating the updated model (MF-DEWNR), and we refer to these comparisons as model evaluation; however, the 2011 events were not used in the original calibration, and can therefore be used for validating the model. Model boundary conditions for each of the simulated events are indicated in Table 2.4. Note that Lock 4 upstream level is controlled to the observed level for each event.

Table 2.4 Model boundary and Lock 4 control parameters for comparison simulations

Simulation	Model inflow ML/d	Model tail water m AHD	Lock 4 U/S level m AHD
1996 Event	66 650	10.23	14.34
2000 Event	46 500	9.78	13.60
2011 Event	73 570	10.90	14.66
Low flow	10 000	9.80	13.20

Inflow into the model for the high flow runs was approximated based on the Lyrup gauging station (site number A4260663). Flow at the gauging station was calculated using the current high flow rating developed at the site, which was updated following the 2011 high flow event. Due to the proximity of this gauging station to Katarapko Floodplain, flows calculated from this site may provide a more reliable indication of inflow to the model upstream of Lock 4 than Flow to South Australia at the imagery dates. The rated flows at Lyrup gauging station are only relevant to medium to high flow conditions however, with backwater influence from the locks invalidating the rating at low flows. Thus, in the baseflow case, flows at Lock 4 were used to approximate model inflow conditions. Note that the Lock 4 flow rating is only valid up to approximately 35 000 to 45 000 ML/d due to the lock weir typically being removed above these flows, and therefore Lock 4 flow cannot be used to approximate model inflows during high flow events.

Steady state simulations were used in preference to dynamic flooding runs, primarily as gaps in available flow and level data complicated the development of a dynamic hydrograph for all flow events tested, while a similar approach was also used for the MIKE FLOOD model validation of the Pike Floodplain, as in McCullough (2016). Instead, the steady-state approach was used to provide a ‘snapshot’ of the state of inundation over the floodplain at defined flow conditions.

Limitations of the approach used here are that:

- Running the model to steady state conditions allows the hydraulics to reach equilibrium over the floodplain and the river reach between Locks 5 and 3, where under actual conditions the duration of the peak flow may not have permitted this to occur
- Using data for a given time step may not account for the dynamic nature of hydraulics between upstream and downstream states in the model despite being close to the peak of the event, and as such may create a difference to observed inundation
- Differences in approximated and actual flow values between Lyrup gauging station and Lock 4, where no lock flow data is available, may exist due to attenuation of the event.

These differences in inundation may tend to result in an overestimation of inundation extent in the model compared to observed extent, depending on the extent of dynamic changes occurring in the hydrograph at the time of each event. For example, referring to Figure 2.4, the imagery available for comparison with the 1996 event simulation is close to the peak of the event, and so hydraulic conditions may be closer to representing steady state conditions than the 2000 (Figure 2.5) and 2011 (Figure 2.6) events, which are on rising and falling limbs of each event, respectively.

For these evaluation runs, the model was configured with existing infrastructure only to remain consistent with the condition of the floodplain under the events chosen.

2.3.4 Results and discussion

Comparisons between modelled and observed water levels (and flows in Katarapko Creek) are presented in Figure 2.7, indicating historical observed data against modelled outputs for the three high flow events tested (Figure 2.7a), and also for steady low flow conditions at 10 000 ML/d (Figure 2.7b). Modelled and observed water levels are comparable at low flow and for the 1996 event at each monitoring location, while for the 2000 and 2011 events water levels appear higher than observed levels at the sites below Lock 4 for the tested flows.

For the simulated events of 2000 and 2011, the discrepancies between observed and modelled results may be directly related to their respective hydrographs not directly aligning with the peak of each event, as shown in Figure 2.4 to Figure 2.6. For instance, under the 2000 event, the hydrograph is observed to be rapidly rising in the Lock 5 to 3 reach, which would be expected to contribute to additional inundation under steady state conditions than the observed inundation extent under dynamic conditions. Conversely, under the simulated 2011 event, the hydrograph is on a receding limb following the peak. In particular, a delay of approximately 6 to 7 days between the peak levels at Lock 4 and Lock 3 is observed (Figure 2.6). This delay highlights that future comparisons may benefit from simulation of a dynamic rather than steady state hydrograph to better represent the inundation extent at the available imagery date.

In contrast, the conditions modelled for the 1996 event are close to the peak of the event and hydraulic conditions are relatively close to steady state conditions over the Lock 5 to 3 reach, resulting in modelled water levels that create a reasonable match with the observed conditions. These comparisons suggest that the 2000 and 2011 may not have been ideally suited for comparisons under steady state conditions in the case of Katarapko Floodplain, and closer matches in inundation results may have been derived from dynamic simulations of each event.

Flow in Katarapko Creek against Lock 4 flow (Figure 2.7c) is also presented for the low flow condition, which indicates a good correspondence of modelled to observed flow at 10 000 ML/d River Murray flow.

Comparisons of modelled events to available satellite imagery (USGS Landsat Imagery) for each flow event are shown in Figure 2.8 to Figure 2.10. These results correspond to the preceding comparisons of observed to modelled water levels, with the 1996 event appearing to show the closest comparison of modelled to observed inundation, while the model predicts additional inundation in the 2000 and 2011 events than seen in observations, particularly in the southern section of the system. It should be noted that inundation in the USGS Landsat Imagery becomes obscured in areas of thick vegetation, which reduces the ability to delineate flooded from dry areas, which thus complicates visual assessment of inundation in the satellite imagery. Despite these differences, which are clarified above, the evaluation overall indicates that the model is fit for purpose for future SARFIIP modelling investigations.

Figure 2.7 Comparison between modelled and observed flows (a) high flow event water levels against Lyrup gauging station flow; (b) steady flow event at 10 000 ML/d water levels against Lock 4 flow; (c) steady flow event at 10 000 ML/d Katarapko Creek flow against Lock 4 flow.

(a)

(b)

Figure 2.8 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 1996 flood event (9 December 1996, Flow to SA of ~72 400 ML/d)

(a) (b)

Figure 2.9 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 2000 flood event (13 December 2000, Flow to SA of ~60 400 ML/d)


(a)


(b)

Figure 2.10 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 2011 flood event (7 March 2011, Flow to SA of ~77 600 ML/d)

3 Hydraulic scenarios

3.1 Previous hydraulic scenario modelling

Water Technology conducted the initial hydraulic modelling of scenarios using the original MIKE FLOOD model. Additional modelling was subsequently conducted by MDBA and by DEWNR (Science, Monitoring and Knowledge Branch). The various primary model versions used through each phase of scenario modelling are listed in Table 2.1.

3.1.1 External scenarios

Water Technology developed a number of hydraulic scenarios to investigate both in-channel and managed inundation scenarios, using MF–WT (and MS–WT for managed inundation scenarios only).

Scenarios 1 to 4 were all run with River Murray flow of 10 000 ML/d and Lock 3 upper pool level (UPL) of 9.8 m AHD, representing the lower boundary of the hydraulic model. Scenarios 1 and 2 represented quasi-natural conditions within the floodplain, while Scenarios 3 and 4 investigated proposed management options with concept design structures in place. One of the outcomes of this work included a revision of the design crest of Eckert Creek Log Crossing to 12.3 m AHD. Refer to Water Technology (2010a) for further details. Specific scenario configurations are summarised as follows:

- Scenario 1 with all structures removed in the floodplain (excluding locks in the River Murray) and Lock 4 UPL set to 13.2 m AHD
- Scenario 2 with all structures removed in the floodplain as per Scenario 1, with Lock 4 UPL set to 13.8 m AHD
- Scenario 3 with Lock 4 UPL set to 13.8 m AHD and concept design structures implemented including the blocking alignment. All inlet structures are set to fully open, and outlet structures at Sawmill, Piggy Creek, The Splash and Carpark Lagoon set to operate at an upstream level of 13.5 m AHD.
- Scenario 4 with Lock 4 UPL set to 13.2 m AHD and concept design structures implemented including the blocking alignment. All structures are closed except Eckert Creek inlet with a flow of 200 ML/d, Northern Arm inlet with flow of 100 ML/d and Sawmill Creek outlet regulator fully open.

Scenarios 5 to 7 were each conducted with Lock 3 UPL of 9.8 m AHD and Lock 4 UPL of 13.2 m AHD. Scenario 5 investigated existing operating conditions while Scenarios 6 and 7 included new structures from the concept designs, with a focus on different operational options for the inlet structures and their effects on flow and velocity patterns. The results of the modelling are presented in Water Technology (2010b). Specific scenario conditions are summarised as follows:

- Scenario 5 at River Murray flow of 5000 ML/d, with present in-stream conditions and existing structures, including Main Eckert Creek fully open, Northern Arm at 5 ML/d, all other inlets closed and South Arm open
- Scenarios 6a–d, all at River Murray flow of 5000 ML/d and concept design structures implemented (including blocking bank and log crossing structure height of 12.3 m AHD), and the following variations:
  - Scenario 6a – Main Eckert Creek 200 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm fully open and Log Crossing fully open.
  - Scenario 6b – Main Eckert Creek 400 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm fully open and Log Crossing fully open.
  - Scenario 6c – Main Eckert Creek fully open, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm fully open and Log Crossing fully open.
  - Scenario 6d – Main Eckert Creek 200 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm fully open and Log Crossing fully open.

- Scenario 7 run with same setup as Scenario 6a (i.e. Main Eckert Creek passing 200 ML/d) but with incremental increases in River Murray flow from 6000 to 10 000 ML/d (in 1000 ML/d increments).

Scenario 8 investigated the operation of the proposed new structures under low River Murray flows, in particular the inlet structures and Log Crossing. The scenario was run with four variations (A to D), all at River Murray flow of 5000 ML/d, Lock 4 UPL at 13.2 m AHD, Lock 3 UPL at 9.8 m AHD, and setup with all new concept design structures (including blocking banks, Log Crossing structure height at 12.3 m AHD, and SA Water structures at Banks A and C). The modelled results are presented in Water Technology (2011a). The various scenarios were run with the following details:

- Scenario 8a with Main Eckert Creek at 200 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm open, and Log Crossing set to 150 ML/d
- Scenario 8b with Main Eckert Creek at 400 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm open, and Log Crossing set to 300 ML/d
- Scenario 8c with Main Eckert Creek at 200 ML/d, Northern Arm fully open, Bank K fully open, all other inlets closed, South Arm open, and Log Crossing with boards in to 12.0 m AHD
- Scenario 8d with Main Eckert Creek at 100 ML/d, all other inlets closed, South Arm closed and Log Crossing closed.

Scenarios 9, 10 and 12 were developed to test alternative operational schemes of the proposed environmental regulators for managed inundation events. As indicated above, these scenarios were conducted using an alternative MIKE SHE model version (MS–WT), which was reportedly developed in order to reduce model run times in comparison to the MIKE FLOOD model version, with an increase in cell size to 30 m^2. Refer to Water Technology (2012a) for further details. Details of model configurations for the specific scenarios are as follows:

- Scenario 9 with River Murray flow of 10 000 ML/d, Locks 3 and 4 UPLs set to 9.8 and 13.2 m AHD, respectively, all concept design structures in place, and all inlets (Northern Arm, Bank K and South Arm) fully open. The environmental regulators were controlled using a simple methodology of inundating the area behind the blocking alignment at a filling rate of less than 10 cm/d up to a water level of 12.7 m AHD, holding the water level at this constant height for a period of 40 days, and subsequently draining the inundated volume at a drawdown rate of less than 10 cm/d. During the holding period, flow distribution over the floodplain is modified by varying flow over the regulators in coupled pairs (Sawmill and Piggy Creek regulators as one pair, Carpark and The Splash regulators as the other pair).
- Scenario 10 with River Murray flow of 10 000 ML/d, Locks 3 and 4 UPLs set to 9.8 and 13.8 m AHD, respectively, all concept design structures in place, and all inlets (Northern Arm, Bank K and South Arm) fully open. Filling and draining of the area behind the Scenario 9 is conducted at similar rates to that of Scenario 9 but with differences in operation of the holding period and maximum water level reached – the level is held at approximately 13.2 m AHD for 20 days, raised to 13.5 m AHD for 10 days, and then held again for 7 days prior to draining, with flow distribution again modified by varying flow over the coupled regulator pairs as for Scenario 9.
- Scenario 12 with River Murray flow of 20 000 ML/d, Lock 3 UPL set to 9.8 m AHD and Lock 4 UPL varied in two phases – set to 13.5 m AHD in the first phase, and to 13.8 m AHD in the second phase, corresponding to floodplain holding water levels of 13.2 and 13.5 m AHD, respectively. Each phase is modelled to extend over a period of 1 month, with flow distribution over the floodplain varied as per Scenarios 9 and 10. As for the previous scenarios, all concept design structures were modelled, and all inlet structures were set to fully open.

Scenario 11 (Water Technology, 2011b) was developed to investigate the impact on the current in-stream conditions with removal of Katarapko Creek Stone Weir. A River Murray flow of 5 000 ML/d was used with Lock 3 and 4 UPLs of 9.8 and 13.2 m AHD, respectively, and all existing structures modelled.

Additional scenarios (unnumbered) were developed to investigate the impacts of seasonal conditions (August to February) on flows through the Katarapko Floodplain system, modelling all the proposed new structures within the floodplain at a River Murray flow of 8000 ML/d. Further details are presented in Water Technology (2012b).

Following the completion of the aforementioned Water Technology scenarios, the model was audited by MDBA and updated using the latest design dimensions of several structures including Banks J, K and N inlet regulators, Eckert Creek Southern Arm

Road Crossing and Log Crossing regulator, while also including the latest survey results at various locations in the system. Subsequently, Scenarios 5, 8, 9, 10 and 11 were rerun by MDBA using the updated version of the model.

3.1.2 DEWNR scenarios

A number of hydraulic scenarios were completed by DEWNR (MF–DEWNR, Table 2.1). McCullough (2014a) presents a number of scenarios requested directly by the Detailed Designer for informing engineering designs of structures at the detailed design phase. A total of 12 scenarios were developed, implementing a variation of structure control configurations, River Murray flows and Lock 4 upper pool level across the set of scenarios within the following ranges:

- River Murray flows between 5000 ML/d and 30 000 ML/d
- Lock 4 UPL up to 13.8 m AHD and Lock 3 UPL at 9.8 m AHD
- Flow through Bank J altered from 62 ML/d (base level) up to flow through a fully opened operational configuration
- Other inlets at Banks K and N upgraded and fully open
- South Arm Road Crossing upgraded and fully open
- Log Crossing regulator upgraded and operation varied from a configuration to pass 150 ML/d up to fully open configuration
- Stone Weir crest level lowered to 10.24 m AHD with trapezoidal fishway included and fully open.

McCullough (2014b) presents further hydraulic scenarios designed to investigate specific situations for decision making purposes, including:

- North Arm bridge investigation, to determine whether the existing bridge would require replacement or whether ancillary improvement works could be conducted on the structure to achieve desired ecological outcomes through the bridge section
- Scenario investigating the impact on River Murray flows and levels between Lock 3 and 4 of reduction or removal of the Katarapko Creek stone weir
- The impact on the system of reducing flow into Eckert Creek Main through Bank J during construction activities, and an assessment of whether current hydraulic conditions could be maintained through various measures
- Investigation of the viability of partial drying of Eckert Southern Arm through proposed infrastructure measures
- The impact on the system of removing Log Crossing, in particular on the level in Eckert Wide Waters.

3.2 Hydraulic scenario modelling gaps

Future hydraulic modelling will be required to inform a number of different investigations within SARFIIP:

- Further modelling required to determine the impact of expected basin plan return flows against baseline conditions, and also the impact of the proposed inundation management options when compared to inundation expected under "natural" conditions in the floodplain. Hydrologic modelling would be conducted to identify event magnitudes, durations and frequencies under natural, current and basin plan flow regimes, which will then identify the various flow scenarios to test in the hydraulic model for producing inundation extents and other hydraulic data.
- To date, the SARFIIP managed inundation scenarios conducted have not been tested with the latest versions of the model, comprised of updated structure configurations and additional survey data. These runs have also only been conducted with fixed locations of the environmental regulators, and have not specifically investigated and change to the location of these regulators and blocking alignment if required. It will thus be necessary to conduct further hydraulic scenarios involving operation and alternative structure placement of the environmental regulators proposed through SARFIIP.

- As indicated in Table 2.2, a number of structures under SARFIIP are at the concept design phase, requiring further investigation through SARFIIP that may result in an alteration of structure dimensions, placements, etc. Hydraulic modelling will be required to inform the detailed design of these structures.

It is expected that other hydraulic modelling scenarios will be required that are as yet undefined, and these will need to be included in the hydraulic modelling program.

4 References

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