Table 11. Mean annual losses and savings, Middle Reedy Lake.

Lake	Mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Middle Reedy Lake	2,202.4	2,153.1	49.2

4.3 Third Reedy Lake

4.3.1 Benchmark scenario

The Benchmark scenario was based on a relatively constant water level held at FSL of 74.56 m. The level is not constant, as, on any day, inflows may not be sufficient to account for evapotranspirative losses. The inflows were the SWET modelled outflows from Middle Reedy Lake (Table 12).

Table 12. SWET model parameter settings for Third Reedy Lake, Benchmark scenario.

Model parameter	Model setting
Inflows and withdrawals	Inflows were REALM modelled flows from Middle Reedy; withdrawals were to supply demand from 1 on 7 Channel according to REALM assumptions
Controlled filling frequency and levels	Relatively constant water level held at FSL of 74.56 m
Durations of filling phases	Not applicable
Assumed maximum rate of rise	Not applicable
Start of filling	Not applicable
Assumed local contributing area	None
Water use calculation period	From 1 September

The SWET modelled water levels for the Benchmark scenario satisfactorily predicted the periods when water level was close to FSL and the range of water level, but predictions for drawdown and flood peaks were not always synchronous with those in the historical record (Figure 22 and Figure 23). The pattern of water levels were dominantly determined by REALM inflow and outflow data, rather than SWET predicted evaporation.

The modelled Benchmark scenario water levels for Third Reedy Lake indicates that the lake was between 74.52 and 74.59 m for 80% of the time, with occasional peaks up to 75.53 m associated with flood inflows, and periodic drawdowns as low as 74.28 m (Figure 24).

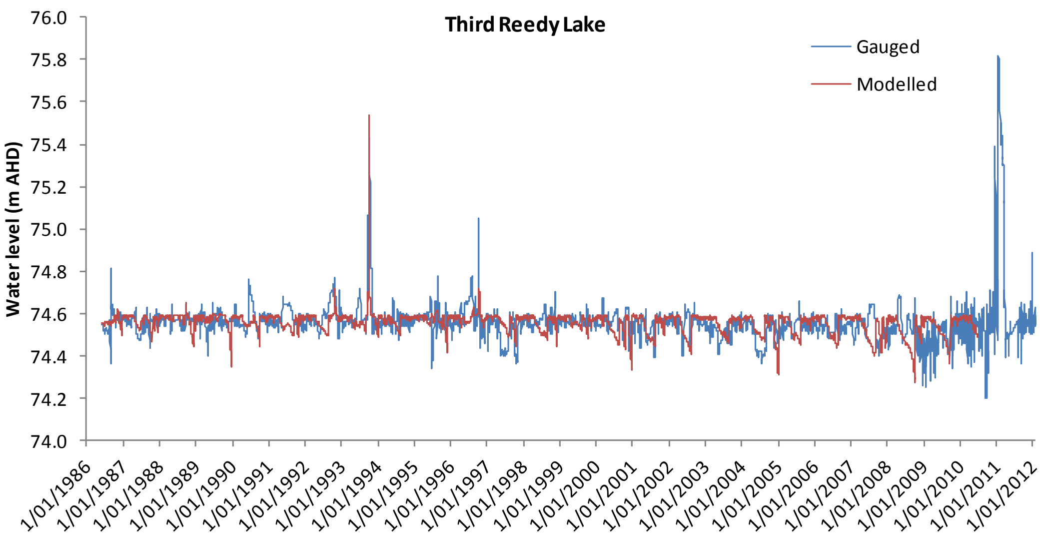

Figure 22. Time series of gauged water levels of Third Reedy Lake from 1986 to 2012, in-filled to form a daily time series, compared with SWET modelled water levels for Benchmark scenario. Original gauged data supplied by G-MW.

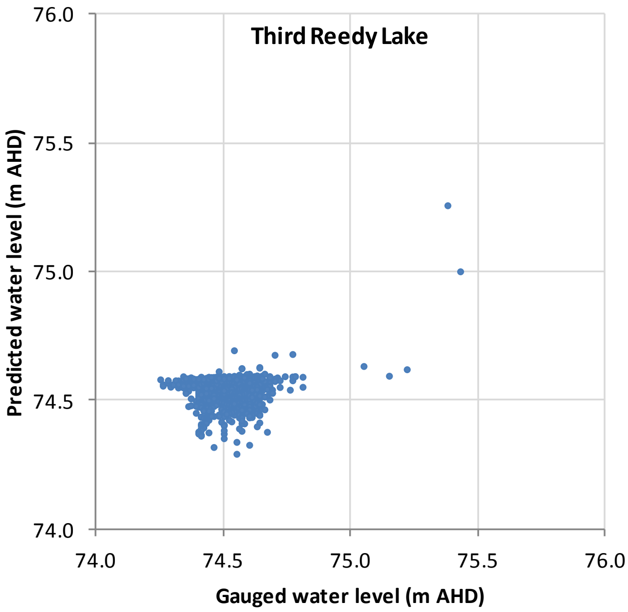

Figure 23. Gauged water levels of Third Reedy Lake from 1986 to 2012 compared with SWET modelled water levels for the Benchmark scenario. Original gauged data supplied by G-MW.

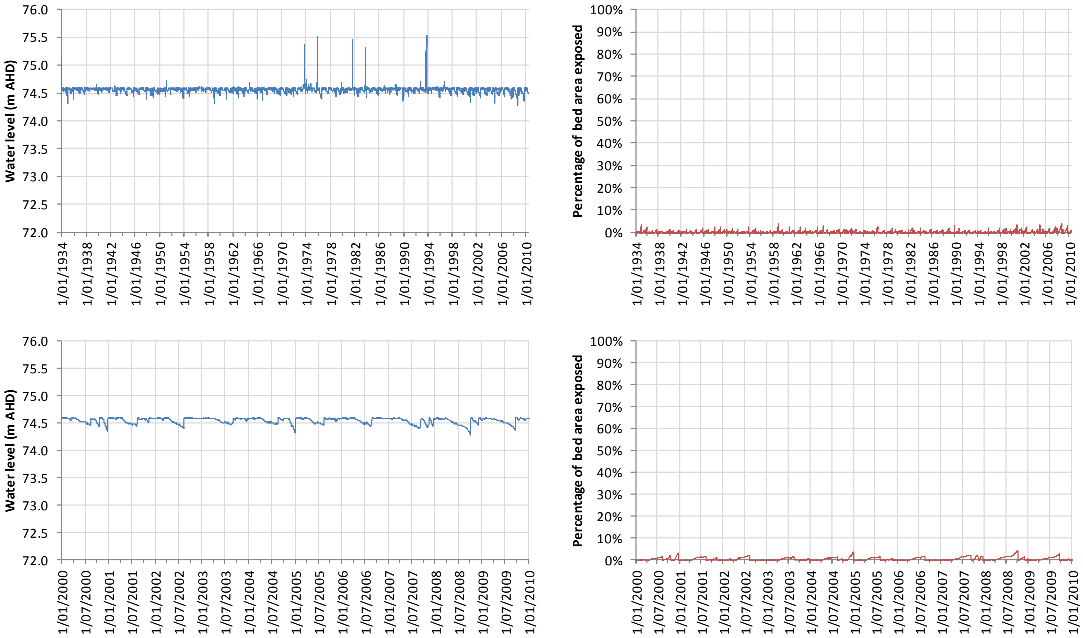

Figure 24. Predicted water levels and percentage of bed dry for Benchmark scenario, Third Reedy Lake.

4.3.2 Future scenario

The future scenario for Third Reedy Lake operated over a 3-year cycle. An establishment regime would run for 2 or 3 cycles, and then be replaced by a long-term regime. The difference in these two regimes was in the second year of the cycle (Table 13).

The filling cycle was assumed here to apply in late winter/spring (interpreted here to begin on 1 September), followed by drawdown at the natural rate determined by net evapotranspiration (Table 13).

The Future scenario for Third Reedy Lake involved a significant opportunity for complete drawdown, which meant that the lake bed was periodically fully exposed, more so for the long-term regime (Figure 25 and Figure 26).

Table 13. SWET model parameter settings for Third Reedy Lake, Future scenario.

Model parameter	Model setting
Supply of inflows	Assumed unlimited capacity to supply, and SWET modelled outflows from Middle Reedy Lake
Controlled filling frequency and levels	Year 1: Fill to 74.56 m AHD in late winter/spring Year 2: Fill to 74.20 m AHD in late winter/spring (establishment regime only, long term regime has no filling) Year 3: no filling
Durations of filling phases	Year 1: 3 months (includes fill time) to give 2 - 2.5 months at target, then allow to recede naturally over the remainder of the year Year 2: 2 months (includes fill time) to give 1 - 1.5 months at target, then allow to recede naturally over the remainder of the year (establishment regime only, long term regime has no filling) Year 3: no filling
Assumed maximum rate of rise	50 mm/day
Start of filling	1 September
Drawdown rule	No minimum water level
Assumed local contributing area	None
Water use calculation period	From 1 September

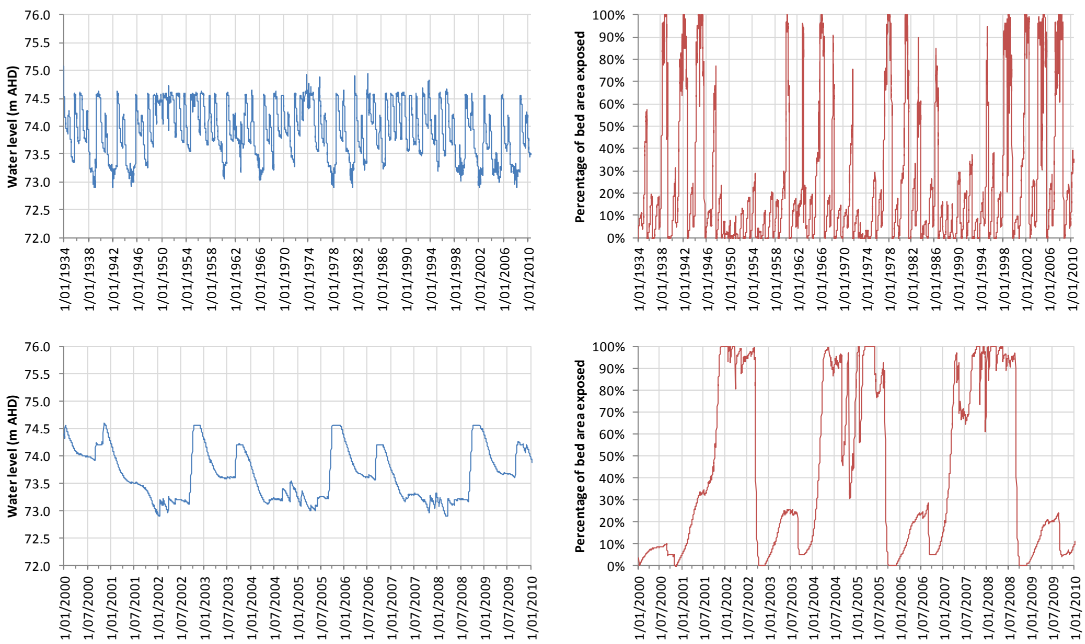

Figure 25. Predicted water levels and percentage of bed dry for Future scenario (establishment regime), Third Reedy Lake.

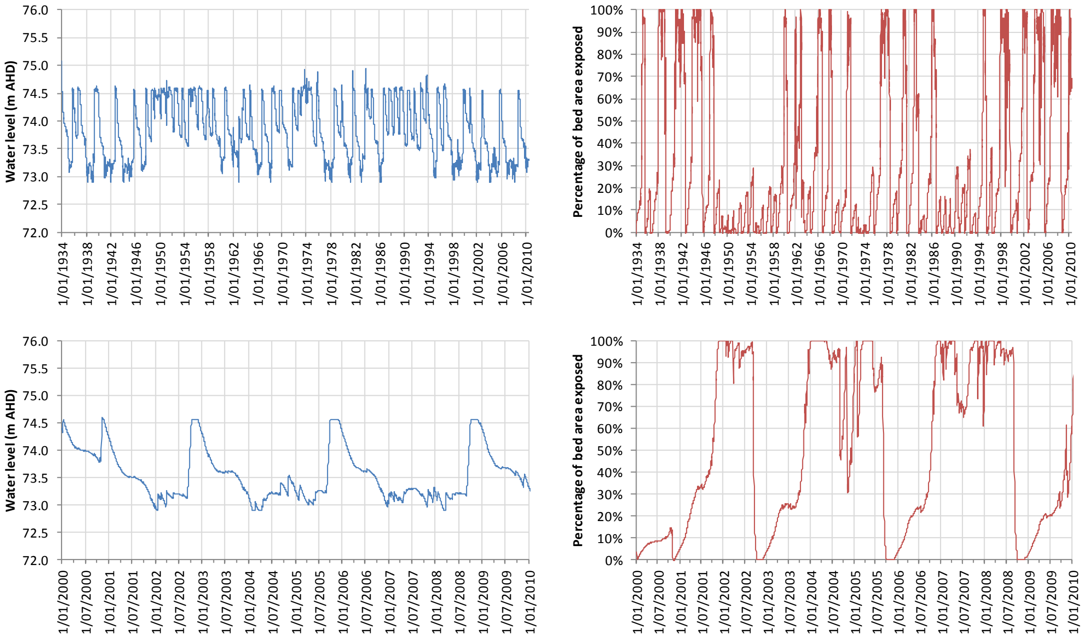

Figure 26. Predicted water levels and percentage of bed dry for Future scenario (long-term regime), Third Reedy Lake.

4.3.3 Filling and drawdown

The target filling level for Third Reedy Lake of 74.56±0.01 m was achieved in 100% of fill cycles, for both establishment and long-term regimes. For the establishment regime, the Year 2 target fill level of 74.2±0.01 m was achieved in 100% of fill cycles. Third Reedy Lake fully dried in 46% of years in the establishment regime, and in 69% of years in the long-term regime.

4.3.4 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Third Reedy Lake future scenario was 894 ML in the establishment regime and 567 in the long-term regime (Table 14), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 27 and Figure 28) assumed automatic daily adjustments as required to maintain the target levels.

Table 14. Third Reedy Lake annual inflow and outflow statistics for the future regime. P95 is 95th percentile.

Lake	Inflows (ML/yr)			Outflows (-ML/yr)		
	Mean	P95	Max.	Mean	P95	Max.
Establishment regime						
Third Reedy Lake (all inflows)	22,651	83,535	174,772	20,644	80,234	173,061
Third Reedy Lake (unregulated inflows)	21,757	81,515	174,772	-	-	-
Third Reedy Lake (additional inflows required)	894	3,265	3,569	-	-	-
Long-term regime						
Third Reedy Lake (all inflows)	22,324	88,535	174,772	20,592	80,234	173,066
Third Reedy Lake (unregulated inflows)	21,757	81,515	174,772			
Third Reedy Lake (additional inflows required)	567	3,265	3,569			

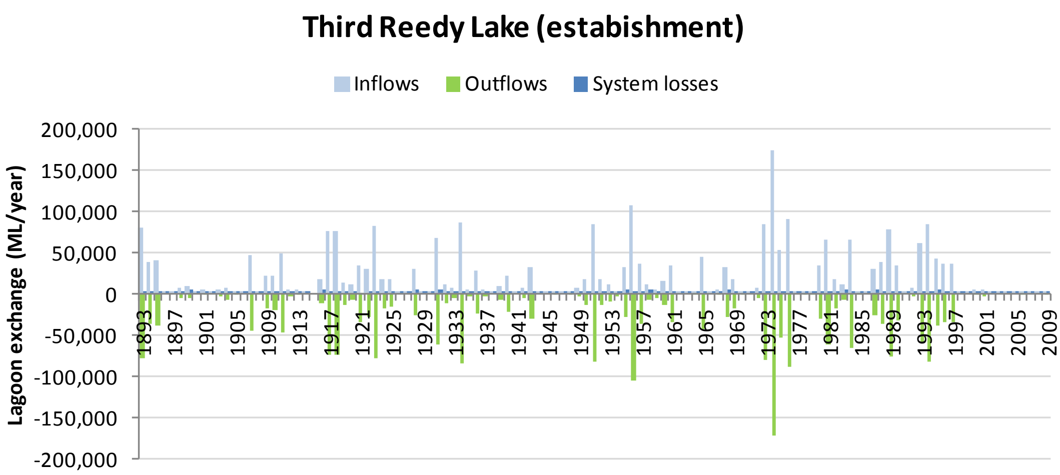

Figure 27. Third Reedy Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario, establishment regime. Outflows are denoted with a negative sign. System losses are inflows minus outflows.

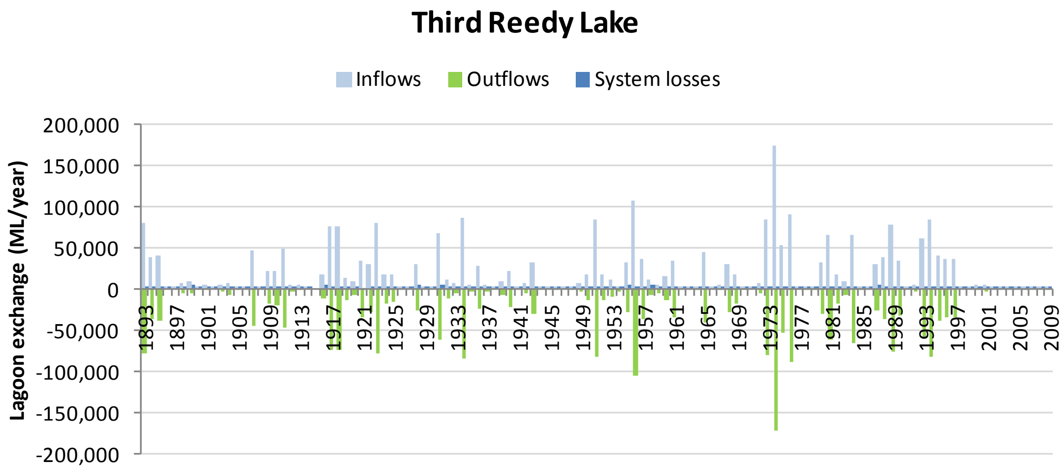

Figure 28. Third Reedy Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario, long-term regime. Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.3.5 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 29 and Figure 30). The losses for the Future scenario were significantly lower than under the Benchmark scenario because the complete, or near-complete, drawdown significantly reduced the lake surface area. Thus, under the Future scenario, mean annual saving were 641.5 ML for the establishment regime, and 915.7 ML for the long-term regime (Table 15).

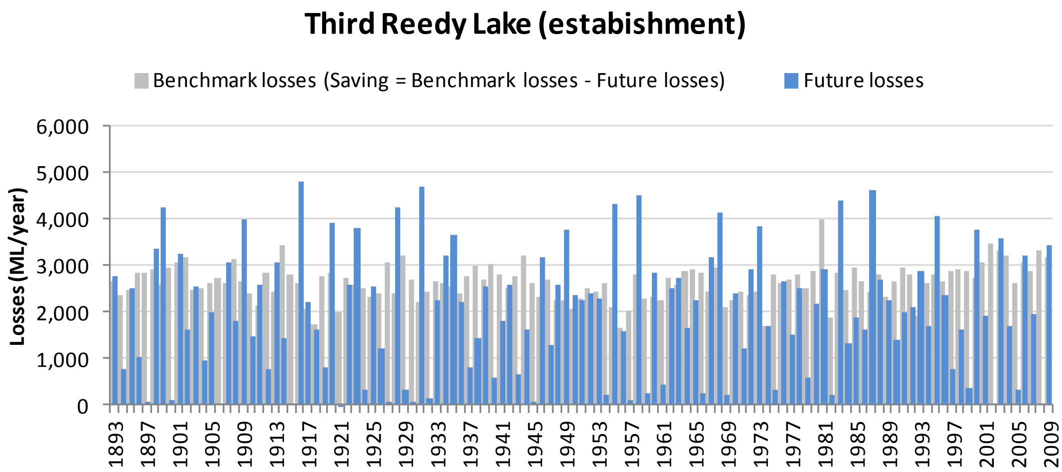

Figure 29. Third Reedy Lake time series of losses under Benchmark scenario and Future scenario, establishment regime, with the difference representing savings.

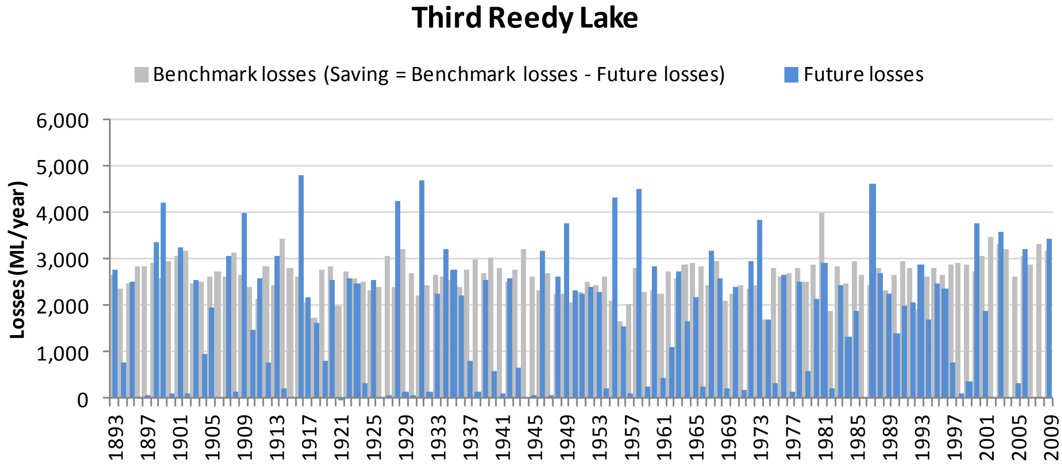

Figure 30. Third Reedy Lake time series of losses under Benchmark scenario and Future scenario, long-term regime, with the difference representing savings.

Table 15. Mean annual losses and savings, Third Reedy Lake.

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Third Reedy Lake (establishment)	2,637.4	1,995.9	641.5
Third Reedy Lake (long-term)	2,637.4	1721.7	915.7

4.4 Little Lake Charm (including Scotts Creek)

4.4.1 Benchmark scenario

The Benchmark scenario for Little Lake Charm (including Scotts Creek) (hereafter abbreviated to Little Lake Charm) was based on a relatively constant water level held at FSL of 73.90 m. The level is not constant, as, on any day, inflows may not be sufficient to account for evapotranspirative losses. The inflows were the SWET modelled outflows from Third Reedy Lake (Table 16).

Table 16. SWET model parameter settings for Little Lake Charm, Benchmark scenario.

Model parameter	Model setting
Inflows and withdrawals	Inflows were REALM modelled flows from Third Reedy; withdrawals were diversions and flood flows to Lake Charm according to REALM assumptions
Controlled filling frequency and levels	Relatively constant water level held at FSL of 73.90 m
Durations of filling phases	Not applicable
Assumed maximum rate of rise	Not applicable
Start of filling	Not applicable
Assumed local contributing area	None
Water use calculation period	From 1 September

The gauged water levels for Lake Charm (which is connected to Little Lake Charm through a regulator) were lower than the FSL of 73.90 m AHD for Little Lake Charm (Figure 31). The values higher than FSL were not predictable on the basis of the inflows from Third Reedy Lake. Thus, the hydraulic constraint at the outlet of Little Lake Charm was simulated to be similar to the constraints at First/Middle and Third Reedy Lakes. The SWET modelled water levels for the Benchmark scenario were close to FSL most of the time (Figure 31 and Figure 32). The gauged data indicated that historically Lake Charm fell to lower levels than were predicted by SWET for the Benchmark scenario for Little Lake Charm (Figure 31 and Figure 32). The pattern of water levels were dominantly determined by REALM inflow and outflow data, rather than SWET predicted evaporation.

The modelled Benchmark scenario water levels for Little Lake Charm indicates that the lake is between 73.80 and 73.90 m for 80% of the time, with periodic drawdowns as low as 73.54 m (Figure 33).

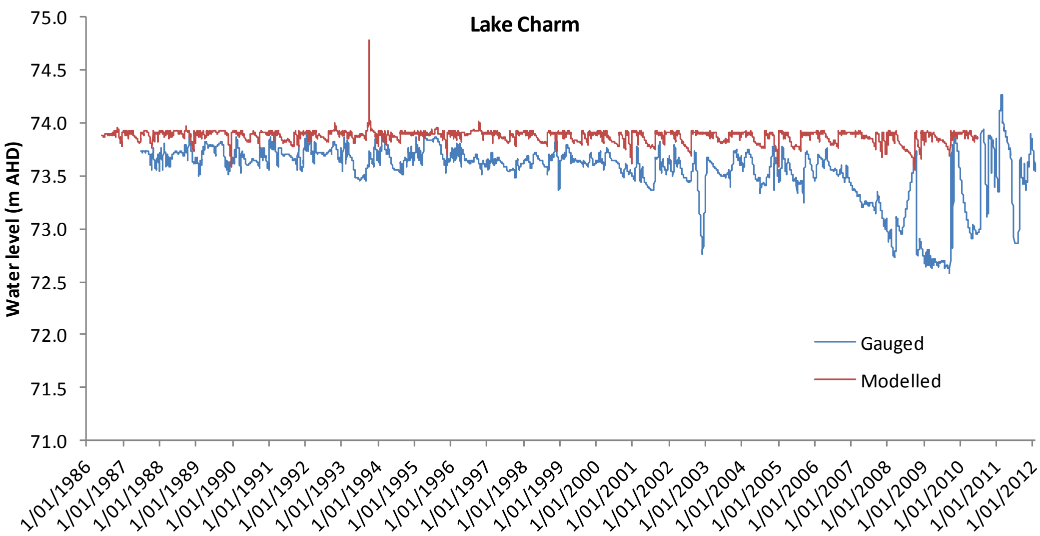

Figure 31. Time series of gauged water levels of Lake Charm from 1986 to 2012, in-filled to form a daily time series, compared with SWET modelled water levels for Little Lake Charm Benchmark scenario. Original gauged data supplied by G-MW.

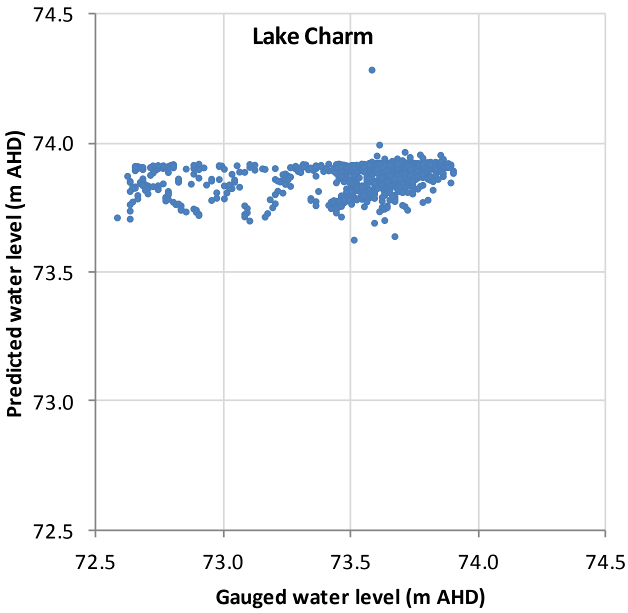

Figure 32. Gauged water levels of Lake Charm from 1986 to 2012 compared with SWET modelled water levels for the Little Lake Charm Benchmark scenario. Original gauged data supplied by G-MW.

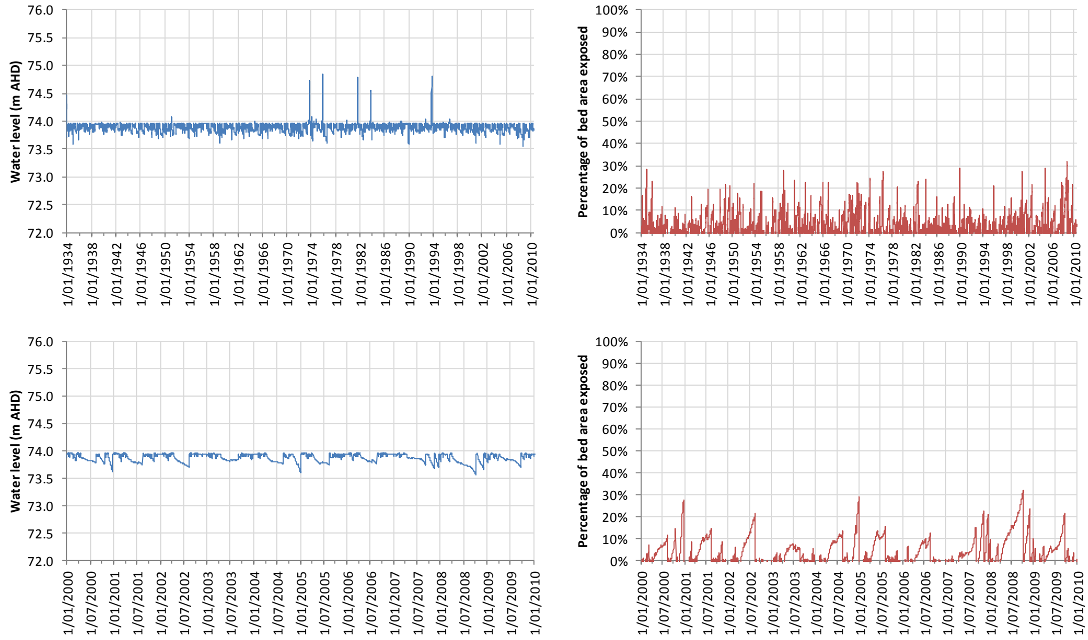

Figure 33. Predicted water levels and percentage of bed dry for Benchmark scenario, Little Lake Charm.

4.4.2 Future scenario

The future scenario for Little Lake Charm simply involved maintaining the lake at FSL year round (Table 17).

The Future scenario for Little Lake Charm had no variation in water level and the bed was never exposed (Figure 34).

Table 17. SWET model parameter settings for Little Lake Charm, Future scenario.

Model parameter	Model setting
Supply of inflows	Assumed unlimited capacity to supply, and SWET modelled outflows from Third Reedy Lake
Controlled filling frequency and levels	Fill to 73.90 m AHD at all times
Durations of filling phases	Maintain full all year
Assumed maximum rate of rise	50 mm/day
Start of filling	1 September
Drawdown rule	No drawdown
Assumed local contributing area	None
Water use calculation period	From 1 September

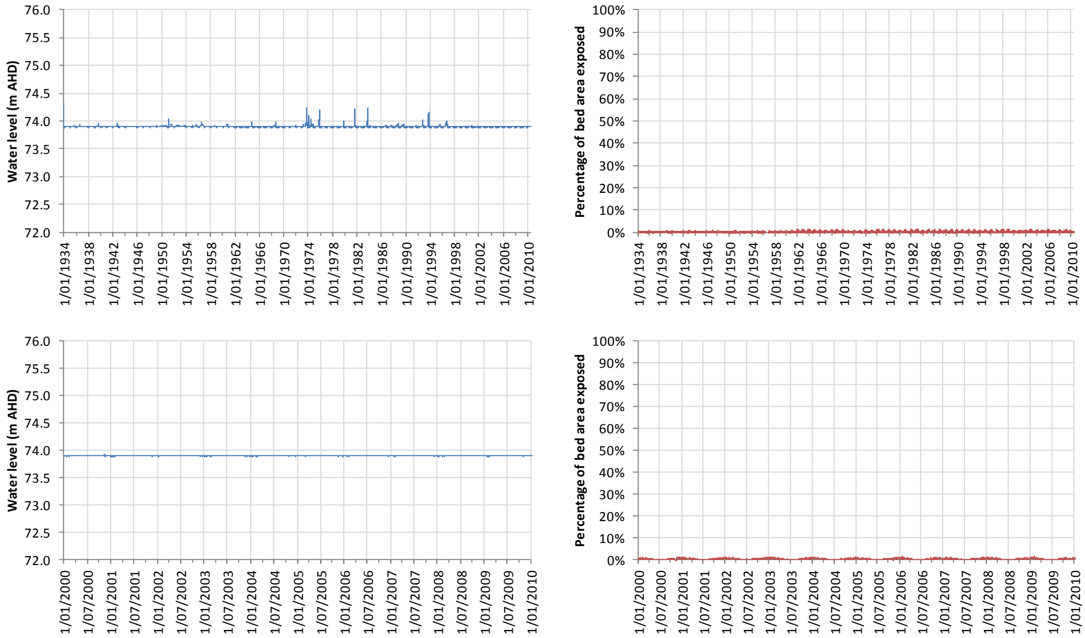

Figure 34. Predicted water levels and percentage of bed dry for Future scenario, Little Lake Charm.

4.4.3 Filling and drawdown

The target filling level for Little Lake Charm of 73.90±0.01 m was achieved in 100% of years. There was no drawdown cycle.

4.4.4 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Little Lake Charm future scenario was 1,648 ML (Table 18), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 35) assumed automatic daily adjustments as required to maintain the target levels.

Table 18. Little Lake Charm annual inflow and outflow statistics for the future regime. P95 is 95th percentile.

	Inflows (ML/yr)			Outflows (-ML/yr)		
Lake	Mean	P95	Max.	Mean	P95	Max.
Little Lake Charm (all inflows)	22,293	81,680	173,967	20,788	80,356	172,959
Little Lake Charm (unregulated inflows)	20,644	80,234	173,061	-	-	-
Little Lake Charm (additional inflows required)	1,648	1,914	2,125	-	-	-

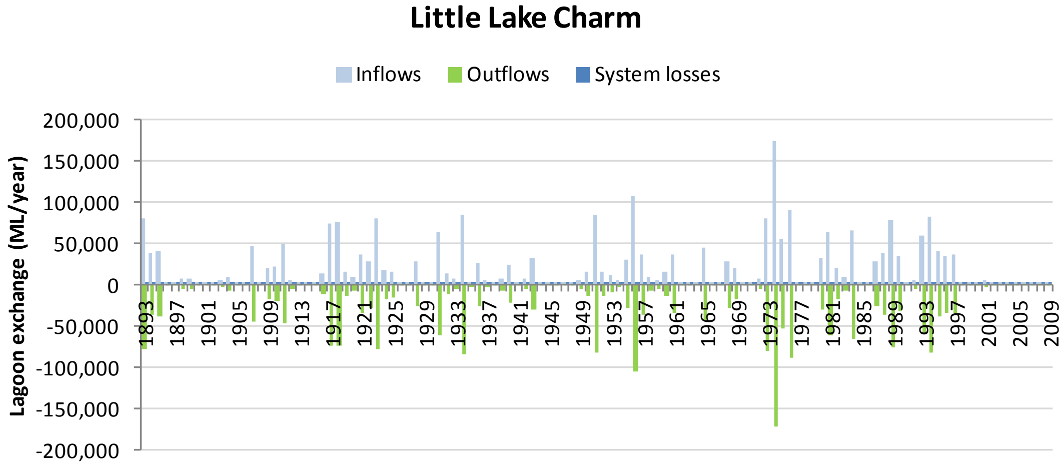

Figure 35. Little Lake Charm time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario. Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.4.5 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 36). The losses for the Future scenario were similar to those of the Benchmark scenario because the surface area was similar in both cases. The differences in water levels between the scenarios resulted from higher unregulated inflows in the case of the Benchmark scenario (under the Future regime, unregulated inflows were partially trapped by upstream lakes) and regular contributions to maintain the desired water level under the Future regime. Overall, the Future scenario generated a water saving of 8.7 ML (Table 19), but considering the uncertain assumptions regarding the outflow hydraulics (Figure 7) and the difference between observed and modelled water levels (Figure 31), this estimate would likely fall within error bounds.

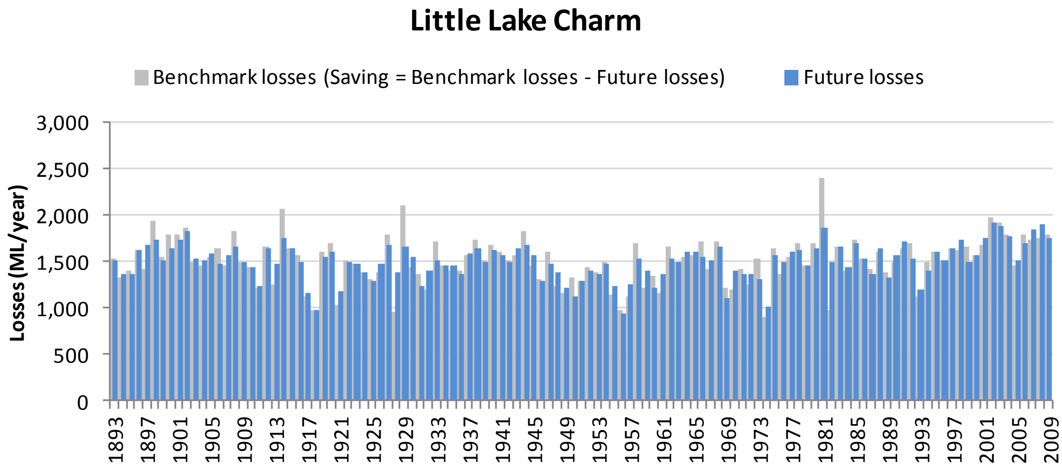

Figure 36. Little Lake Charm time series of losses under Benchmark scenario and Future scenario, with the difference representing savings.

Table 19. Mean annual losses and savings, Little Lake Charm. Negative saving means a cost in water.

Lake	Mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Little Lake Charm	1,513.3	1,504.6	8.7

4.5 Racecourse Lake - entire lake

4.5.1 Benchmark scenario

The Benchmark scenario for Racecourse Lake was based on a relatively constant water level held at FSL of 73.93 m. The level is not constant, as, on any day, inflows may not be sufficient to account for evapotranspirative losses. The inflows were the SWET modelled outflows from Little Lake Charm (Table 20).

Table 20. SWET model parameter settings for Racecourse Lake, Benchmark scenario.

Model parameter	Model setting
Inflows and withdrawals	Inflows were SWET modelled flows from Little Lake Charm (REALM data series not available); withdrawals were diversions to Cullans Lake according to REALM assumptions
Controlled filling frequency and levels	Relatively constant water level held at FSL of 73.93 m
Durations of filling phases	Not applicable
Assumed maximum rate of rise	Not applicable
Start of filling	Not applicable
Assumed local contributing area	None
Water use calculation period	From 1 September

The gauged water levels for Racecourse Lake were unexpectedly lower than the FSL of 73.93 m AHD with only a few observations exceeding FSL (Figure 37). The values higher than FSL were not predictable on the basis of the inflows from Little Lake Charm. Thus, the hydraulic constraint at the outlet of Racecourse Lake was simulated to be similar to the constraints at First/Middle and Third Reedy Lakes. The SWET modelled water levels for the Benchmark scenario were close to FSL most of the time (Figure 37 and Figure 38). The gauged data indicated that historically the lake fell to lower levels than were predicted by SWET for the Benchmark scenario, with differences up to 0.9 m (Figure 37 and Figure 38). The pattern of water levels were dominantly determined by REALM inflow and outflow data, rather than SWET predicted evaporation.

The modelled Benchmark scenario water levels for Racecourse Lake indicates that the lake is between 73.82 and 73.95 m for 80% of the time, with periodic drawdowns as low as 71.5 m, during rare times when flows are diverted to Cullens Lake, and occasional spikes due to high flood inflows that exceed the assumed outlet capacity (Figure 39). The difference between the observed and modelled lake levels would be due to either REALM inflows that do not reflect historical inflows, or significant water losses through the lake system that were not accounted for in the SWET model, e.g. additional diversions. Although there is an apparently large difference in levels in the observed and Benchmark modelled data, the reduction in lake surface area from 73.93 m (FSL) to 73.61 m (the median observed level from 1986 to 2010) was only 3%. Thus, if the SWET modelled water levels are erroneously high by this amount, the estimate of evaporative loss would be over-estimated by about 3%.

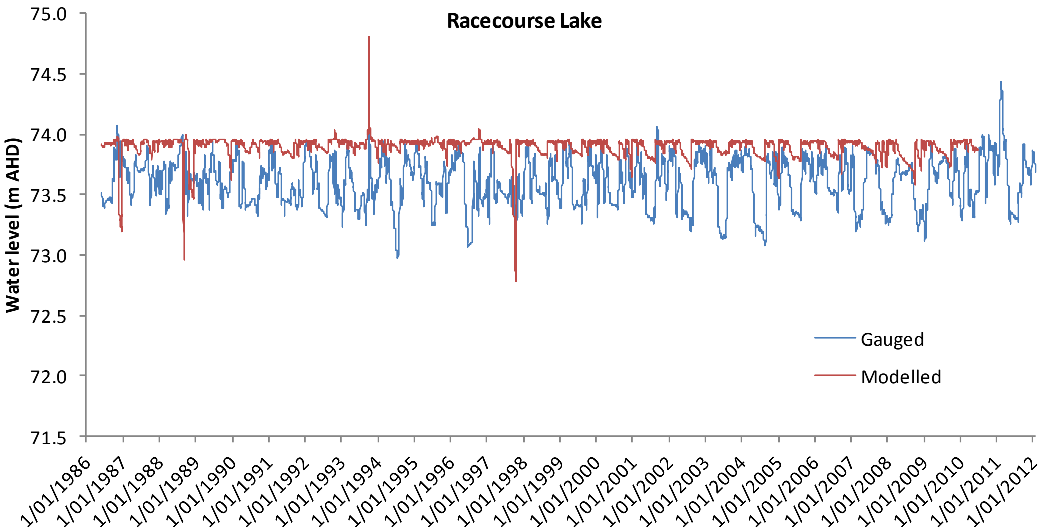

Figure 37. Time series of gauged water levels of Racecourse Lake from 1986 to 2012, in-filled to form a daily time series, compared with SWET modelled water levels for Racecourse Lake Benchmark scenario. Original gauged data supplied by G-MW.

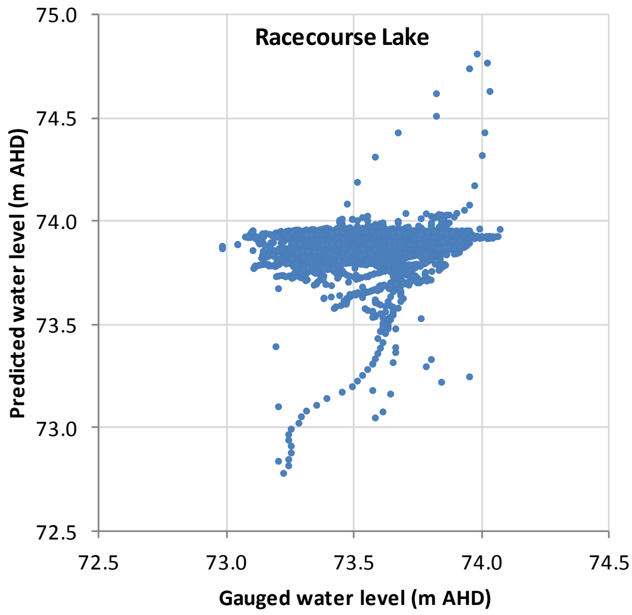

Figure 38. Gauged water levels of Racecourse Lake from 1986 to 2012 compared with SWET modelled water levels for the Racecourse Lake Benchmark scenario. Original gauged data supplied by G-MW.

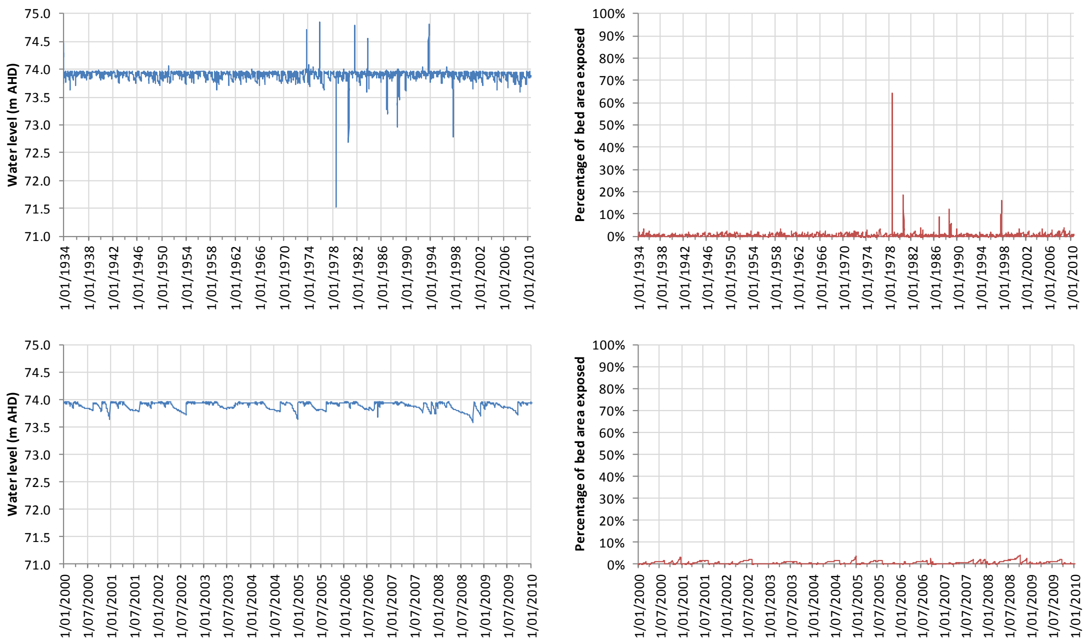

Figure 39. Predicted water levels and percentage of bed dry for Benchmark scenario, Racecourse Lake.

4.5.2 Future scenario Regime No. 1

The future scenario Regime No. 1 for Racecourse Lake involved annual filling every 2 in 6 years in late winter/spring for the spring period (interpreted here to begin on 1 September and finish on 30 November), followed by drawdown at the natural rate determined by net evapotranspiration (Table 21). The first fill is to FSL at 73.93 m and the second fill is to 73.50 m. In the year following the second fill the spring level should not fall below 72.50 m (Table 21).

It was intended for the lake to fully draw down every 2 years in 6, but the drawdown cycle was often interrupted by unregulated inflows (Figure 40).

Table 21. SWET model parameter settings for Racecourse Lake, Future scenario, Regime No. 1.

Model parameter	Model setting
Supply of inflows	Assumed unlimited capacity to supply, and SWET modelled outflows from Little Lake Charm
Controlled filling frequency and levels	Year 1: Fill to 73.93 m AHD in late winter/spring Year 2: Drawdown naturally Year 3: Drawdown naturally to the bed Year 4: Fill to 73.50 m AHD in late winter/spring Year 5: Fill to 72.50 m AHD as necessary over spring Year 6: Drawdown naturally to the bed
Durations of filling phases	4 months (includes filling phase) then allow to recede naturally over the remainder of the year
Assumed maximum rate of rise	50 mm/day
Start of filling	1 September
Drawdown rule	No minimum level, except Year 5
Assumed local contributing area	None
Water use calculation period	From 1 September

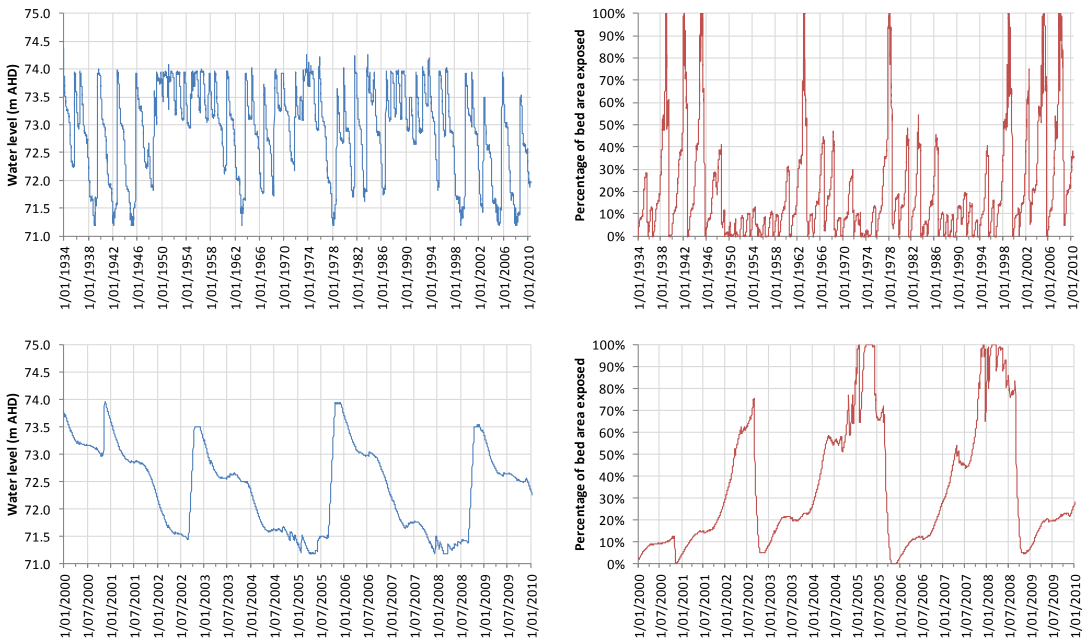

Figure 40. Predicted water levels and percentage of bed dry for Future scenario, Regime No. 1, entire Racecourse Lake.

4.5.3 Filling and drawdown

The target filling level for Racecourse Lake of 73.93±0.01 m was achieved in 100% of intended filling years. It was intended for the lake to fully draw down every 2 years in 6, but this only occurred in 33% of those years. In the other years, the drawdown cycle was interrupted by unregulated inflows. A draw down level of at least 71.7 m (49% of bed exposed) was achieved in 44% of the intended drawdown years.

4.5.4 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Racecourse Lake future scenario was 670 ML (Table 22), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 41) assumed automatic daily adjustments as required to maintain the target levels.

Table 22. Entire Racecourse Lake annual inflow and outflow statistics for the future scenario, Regime No. 1. P95 is 95th percentile.

	Inflows (ML/yr)			Outflows (-ML/yr)		
Lake	Mean	P95	Max.	Mean	P95	Max.
Racecourse Lake (all inflows)	21,458	81,863	172,959	19,235	78,138	171,101
Racecourse Lake (unregulated inflows)	20,788	80,356	172,959	-	-	-
Racecourse Lake (additional inflows required)	670	4,454	5,508	-	-	-

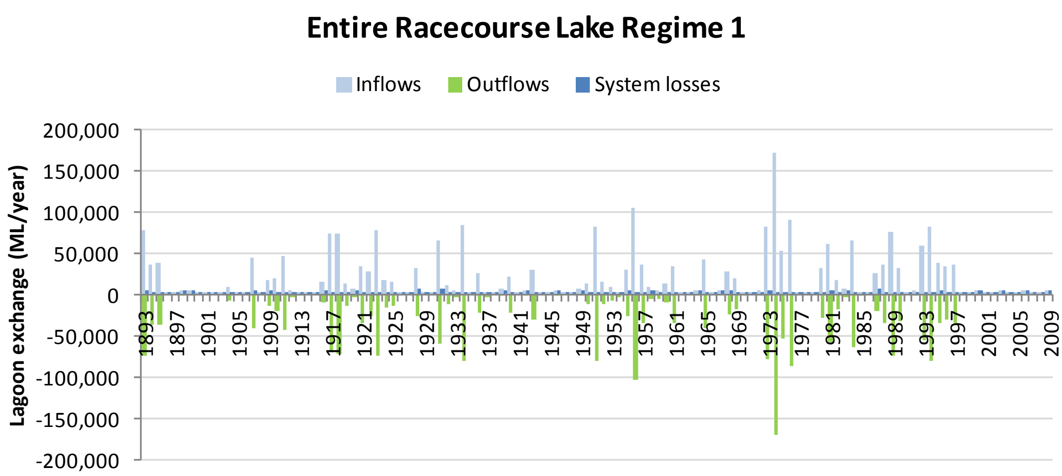

Figure 41. Entire Racecourse Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 1. Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.5.5 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 42). Under the Future scenario Regime No. 1, the mean annual saving was 585.2 ML (Table 23).

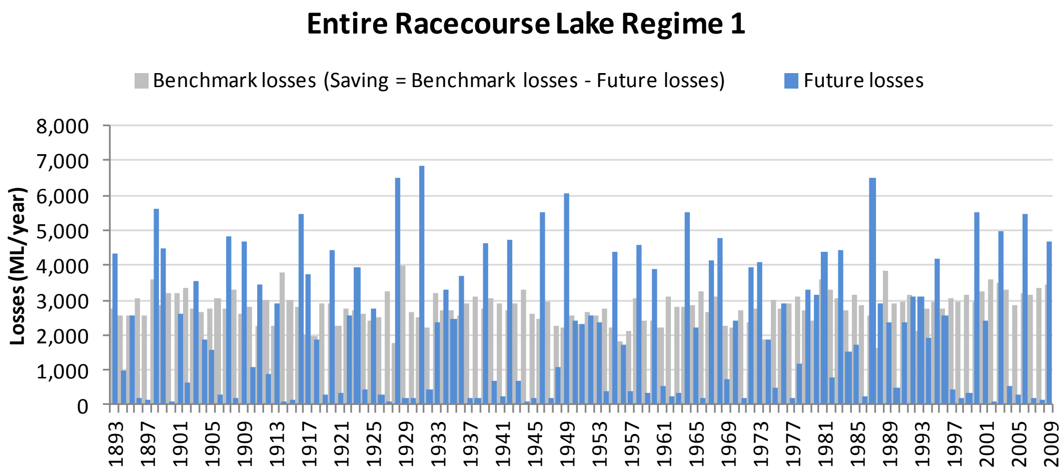

Figure 42. Entire Racecourse Lake time series of losses under Benchmark scenario and Future scenario Regime No. 1, with the difference representing savings.

Table 23. Mean annual losses and savings, entire Racecourse Lake, Regime No. 1.

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Entire Racecourse Lake, Regime No. 1	2,782.1	2,196.9	585.2

4.5.6 Future scenario Regime No. 2

The future scenario Regime No. 2 for Racecourse Lake involved maintaining the lake level between 73.5 and 72.4 m AHD for 3 in 5 years, reaching higher to 73.93 m 1 in 5 years, and fully drawdown at the natural rate determined by net evapotranspiration 1 in 6 years (Table 24).

It was intended for the lake to fully draw down 1 in every 5 years, but the drawdown cycle was often interrupted by unregulated inflows (Figure 43).

Table 24. SWET model parameter settings for Racecourse Lake, Future scenario, Regime No. 2.

Model parameter	Model setting
Supply of inflows	Assumed unlimited capacity to supply, and SWET modelled outflows from Little Lake Charm
Controlled filling frequency and levels	Year 1: Fill to 73.50 m AHD in late winter/spring Year 2: Fluctuate over the range 73.50 - 72.40 m AHD Year 3: Fluctuate over the range 73.50 - 72.40 m AHD Year 4: Fill to 73.93 m AHD in late winter/spring Year 5: Drawdown naturally to the bed
Durations of filling phases	3 months (includes filling phase) for high filling phase; 2 months (includes filling phase) for mid-filling phase; allow to recede naturally over the remainder of the year
Assumed maximum rate of rise	50 mm/day
Start of filling	1 September
Drawdown rule	72.4 m lowest level in Years 1 to 3, and Year 5
Assumed local contributing area	None
Water use calculation period	From 1 September

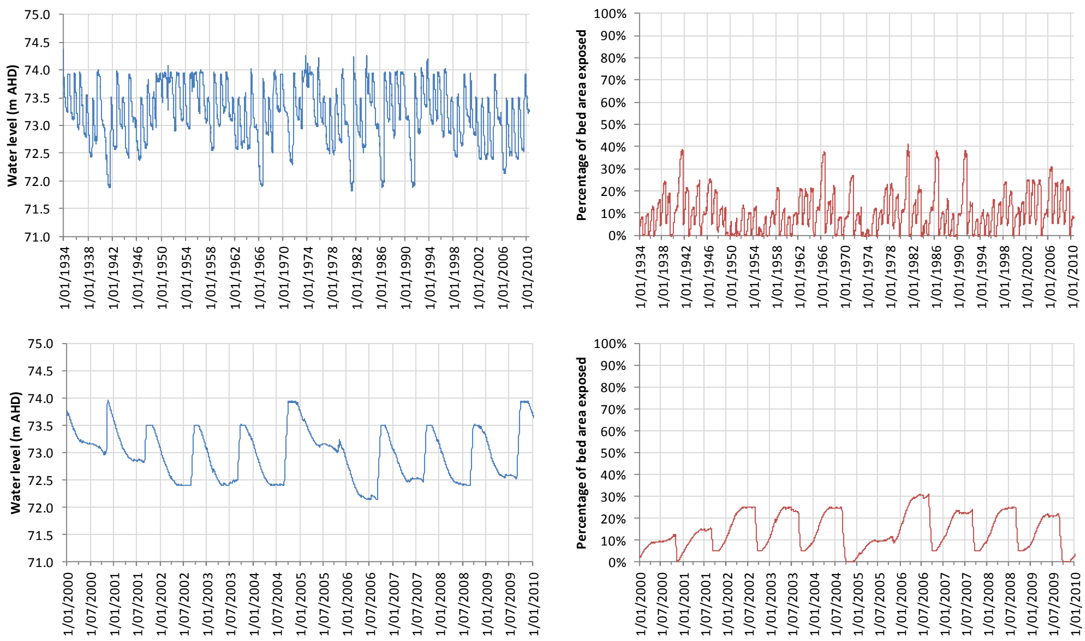

Figure 43. Predicted water levels and percentage of bed dry for Future scenario, Regime No. 2, entire Racecourse Lake.

4.5.7 Filling and drawdown

The target filling levels for Racecourse Lake of 73.93±0.01 m and 73.50±0.01 m were achieved in 100% of intended filling years. It was intended for the lake to fully draw down every 1 in 5 years, but this never occurred because the drying cycle was not long enough (two years would be required). In the other years, the cycle of fluctuating water levels was interrupted by unregulated inflows, such that the target level of 72.40 m±0.05 m was achieved in only 30% of intended years.

4.5.8 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Racecourse Lake future scenario was 1,236 ML (Table 25), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 41) assumed automatic daily adjustments as required to maintain the target levels.

Table 25. Entire Racecourse Lake annual inflow and outflow statistics for the future scenario, Regime No. 2. P95 is 95th percentile.

	Inflows (ML/yr)			Outflows (-ML/yr)		
Lake	Mean	P95	Max.	Mean	P95	Max.
Racecourse Lake (all inflows)	22,024	81,494	172,959	19,472	77,800	171,101
Racecourse Lake (unregulated inflows)	20,788	80,356	172,959	-	-	-
Racecourse Lake (additional inflows required)	1,236	3,397	4,263	-	-	-

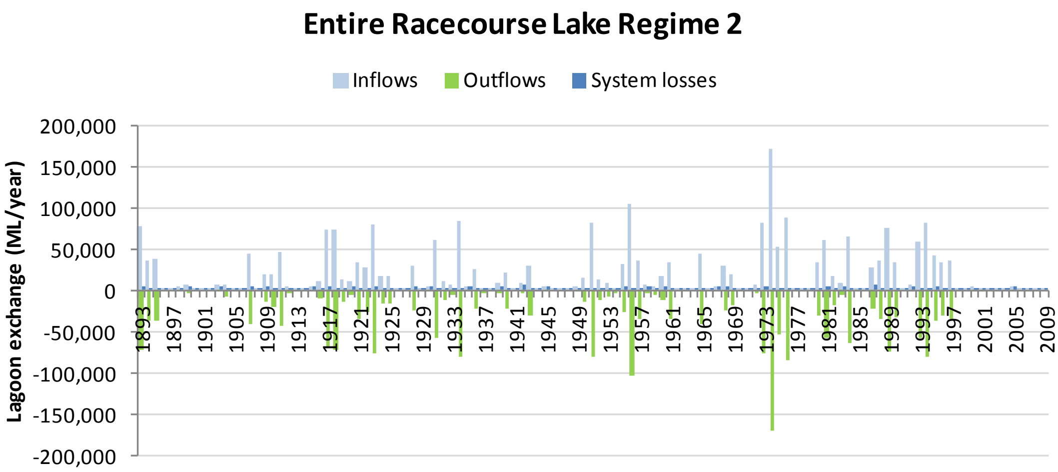

Figure 44. Entire Racecourse Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 2. Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.5.9 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 45). Under the Future scenario Regime No. 2, the mean annual saving was 267.5 ML (Table 26).

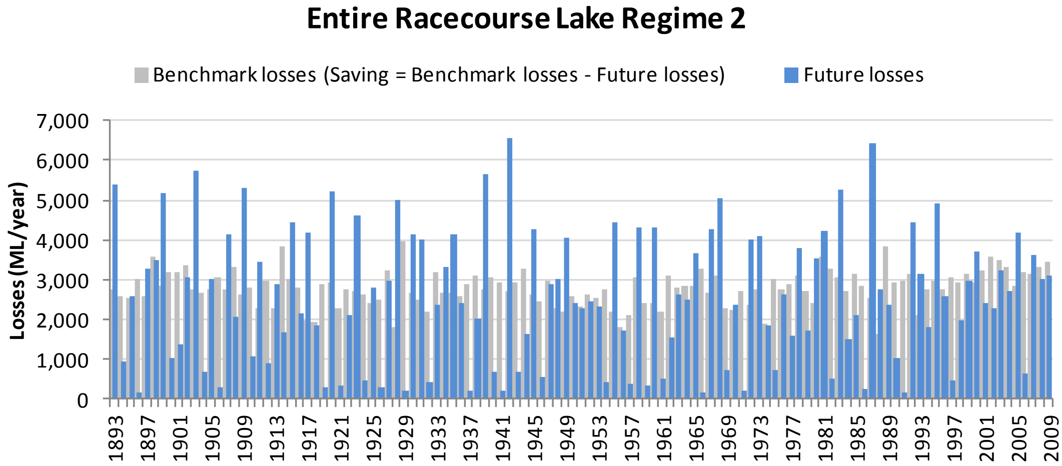

Figure 45. Entire Racecourse Lake time series of losses under Benchmark scenario and Future scenario Regime No. 2, with the difference representing savings.

Table 26. Mean annual losses and savings, entire Racecourse Lake, Regime No. 2.

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Entire Racecourse Lake, Regime No. 2	2,785.9*	2,518.5	267.5

* This value differs slightly from that for Regime No. 1 (Table 23), because the two regimes had different cycle lengths (6 years for Regime 1; 5 years for Regime 2), so the annualisation was calculated over different periods for each regime option.

4.6 Racecourse Lake - Bertram's Lake (western) partition only

4.6.1 Benchmark scenario

The Benchmark scenario for the Bertram's Lake partition of Racecourse Lake was the same as that for the entire lake (Table 20). At FSL the Bertram's partition comprised 42.2% of the total lake area. There was little difference in the proportion of the total lake area in the Bertram's partition at other elevations. Thus, the Benchmark losses were split between the Bertram's and Racecourse partitions according to this ratio.

4.6.2 Future scenario regimes inflows to Racecourse Lake and spills to Bertram's Lake

The inflows to Racecourse Lake were SWET modelled outflows from Little Lake Charm. Outflow peaks exceeding the capacity of the interconnecting channel between Racecourse Lake and Kangaroo Lake occurred for 0.626% of the time in the case of 800 ML/d capacity and 0.415% in the case of 1000 ML/d capacity. When the capacity of the interconnecting channel was exceeded, the excess flow was spilled into Bertram's Lake, potentially interrupting a drying cycle. Although lake outflows exceeded the capacity of the interconnecting channel for less than 1% of the time, these events were reasonably common, such that spills to Bertram's Lake occurred in 51% of years in the case of 800 ML/d capacity and 44% of years in the case of 1000 ML/d capacity. Thus, the frequency of spill events was not strongly dependent on the capacity of the interconnecting channel within the range 800 – 1000 ML/d. The SWET model calculation of outflows from Little Lake Charm did not include a function to describe flow attenuation (damping of the peak) during passage through Little Lake Charm, so while the estimate of total volume of flow to Racecourse Lake would be realistic, the peaks would have been lower than predicted. Therefore, the frequency of spills to Bertram's Lake would likely be slightly lower than predicted here, which means that the savings estimates are conservative (i.e., if anything, a slight under-estimate).

4.6.3 Future scenario Regime No. 1(800) and Regime No. 1(1000)

The future scenario Regime No. 1 for Bertram's Lake was the same as that for the entire lake (Table 21), except that it was assumed that all unregulated inflows less than 800 ML/d [Regime No. 1(800)] and less than 1,000 ML/d [Regime No. 1(1000)] would be diverted to the Racecourse (eastern) partition of Racecourse Lake.

Exclusion of the unregulated inflows during relatively dry periods allowed Bertram's Lake to fully (or near to fully) draw down two years in each 6-year cycle, but spills into Bertram's Lake occurred during wet periods, interrupting the drying cycle, slightly less so for an interconnecting channel with a capacity of 1000 ML/d (Figure 46 and Figure 47).

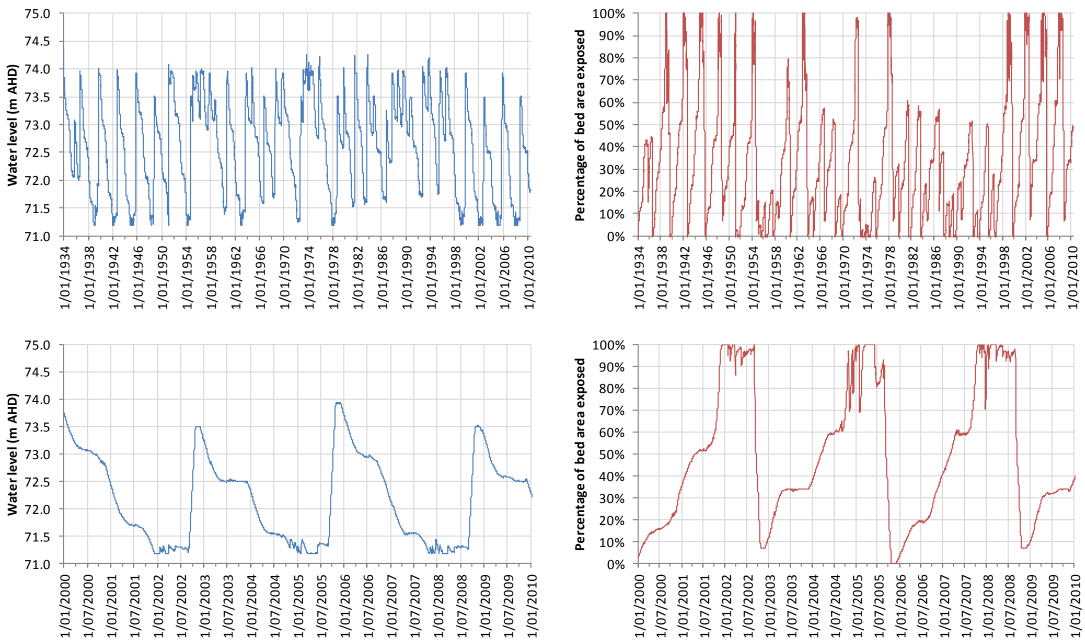

Figure 46. Predicted water levels and percentage of bed dry for Future scenario Regime No. 1(800), Bertram's Lake.

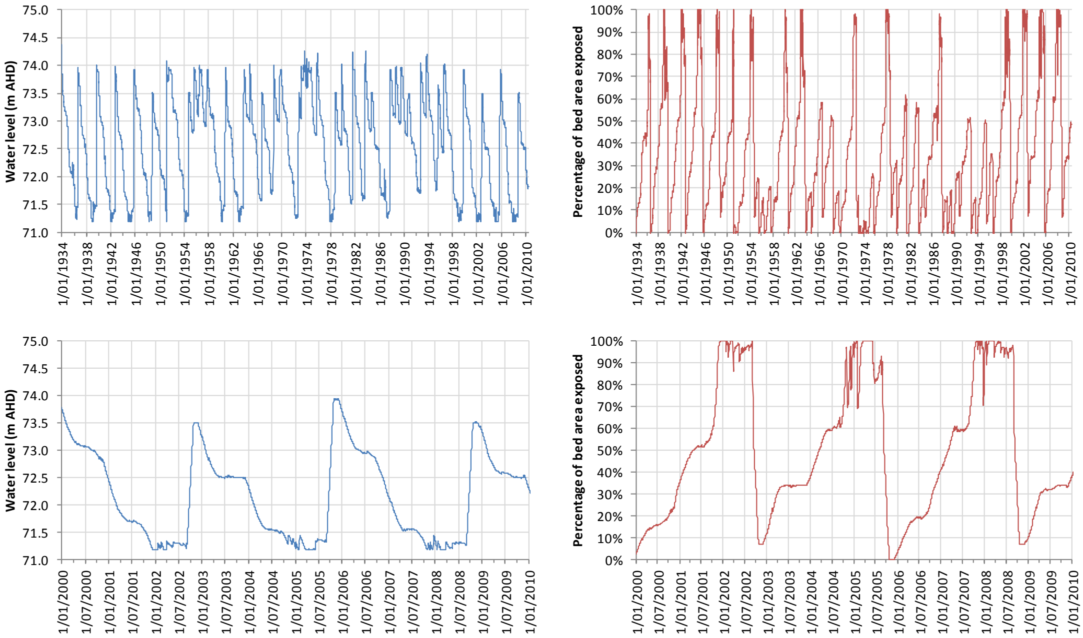

Figure 47. Predicted water levels and percentage of bed dry for Future scenario Regime No. 1(1000), Bertram's Lake.

4.6.4 Filling and drawdown

The target filling level for Bertram's Lake of 73.93±0.01 m was achieved in 100% of intended filling years for both Regime No. 1(800) and Regime No. 1(1000). It was intended for the lake to fully draw down every 2 years in 6; this occurred in 49% of intended years for Regime No. 1(800) and 51% of intended years for Regime No. 1(1000).

4.6.5 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Bertram's Lake future scenario Regime No. 1(800) was 405 ML and Regime No. 1(1000) was 418 ML (Table 27), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 48 and Figure 49) assumed automatic daily adjustments as required to maintain the target levels.

Table 27. Bertram's Lake partition of Racecourse Lake annual inflow and outflow statistics for the future scenarios, Regime No. 1(800) and Regime No. 1(1000). P95 is 95th percentile.

Lake (regime)	Inflows (ML/yr) Mean	P95	Max.	Outflows (-ML/yr) Mean	P95	Max.
Bertram's Lake Regime No. 1(800) (all inflows)	5,921	29,084	64,886	5,105	27,459	64,097
Bertram's Lake Regime No. 1(800) (unregulated inflows)	5,516	29,084	64,886	-	-	-
Bertram's Lake Regime No. 1(800) (additional inflows required)	405	1,922	2,239	-	-	-
Bertram's Lake Regime No. 1(1000) (all inflows)	4,078	22,670	47,508	3,278	20,907	46,798
Bertram's Lake Regime No. 1(1000) (unregulated inflows)	3,660	22,554	47,508	-	-	-
Bertram's Lake Regime No. 1(1000) (additional inflows required)	418	2,179	2,271	-	-	-

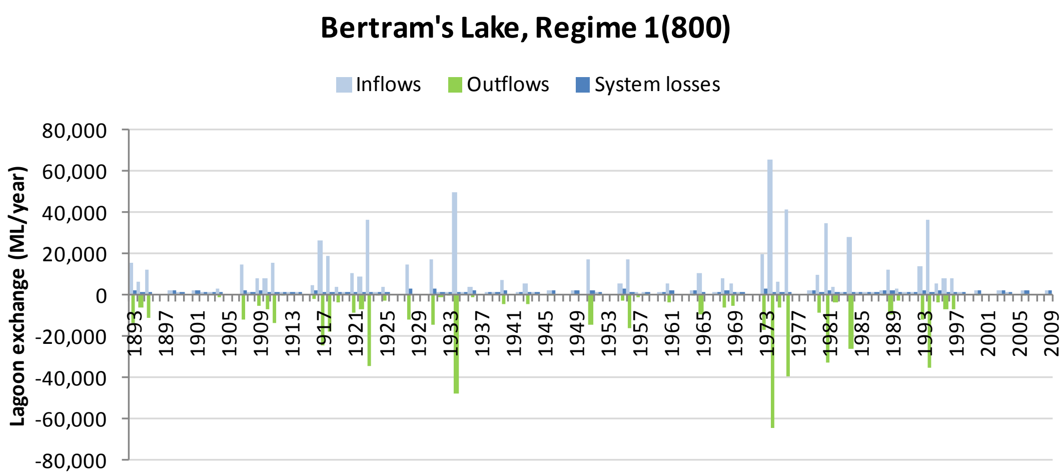

Figure 48. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 1(800). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

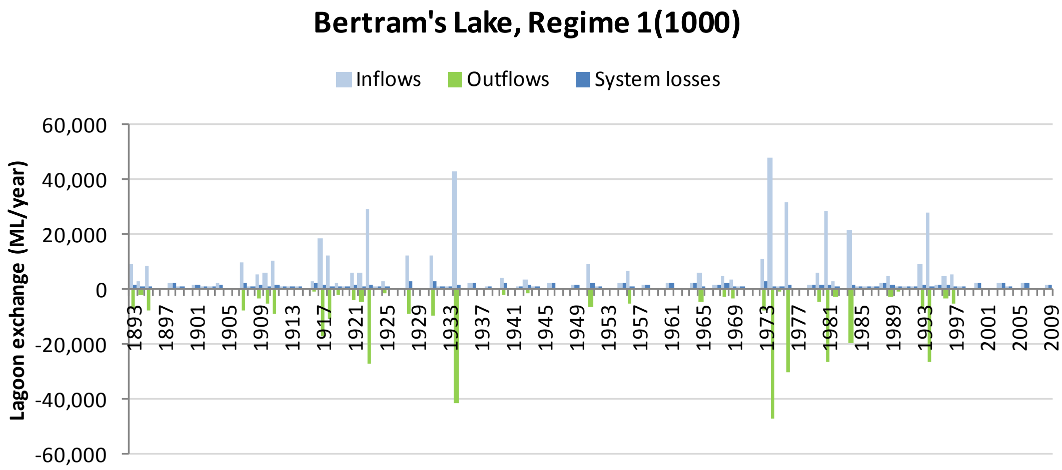

Figure 49. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 1(1000). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.6.6 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 50 and Figure 51). The losses for the Future scenario were somewhat lower than those of the Benchmark scenario. Under the Future scenario, the mean annual saving was 369.3 ML for Regime No. 1(800) and 384.6 ML for Regime No. 1(1000) (Table 28).

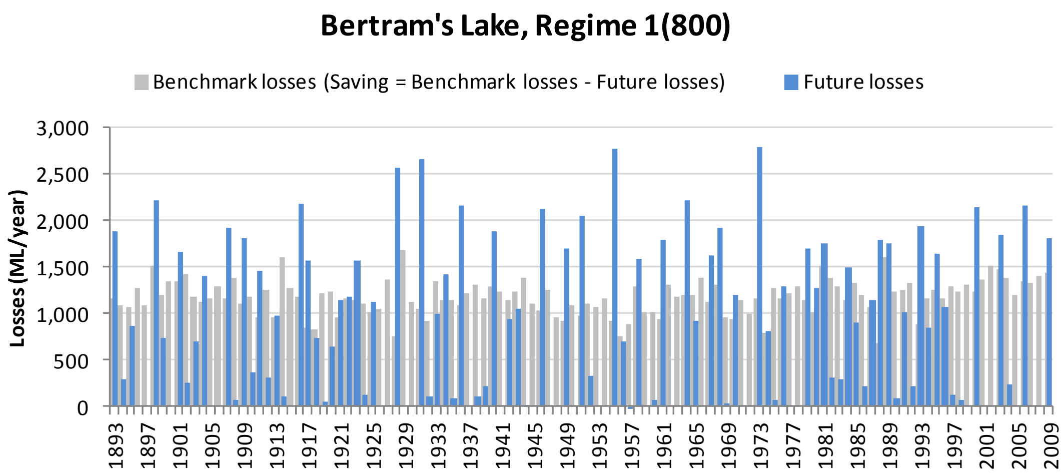

Figure 50. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 1(800), with the difference representing savings.

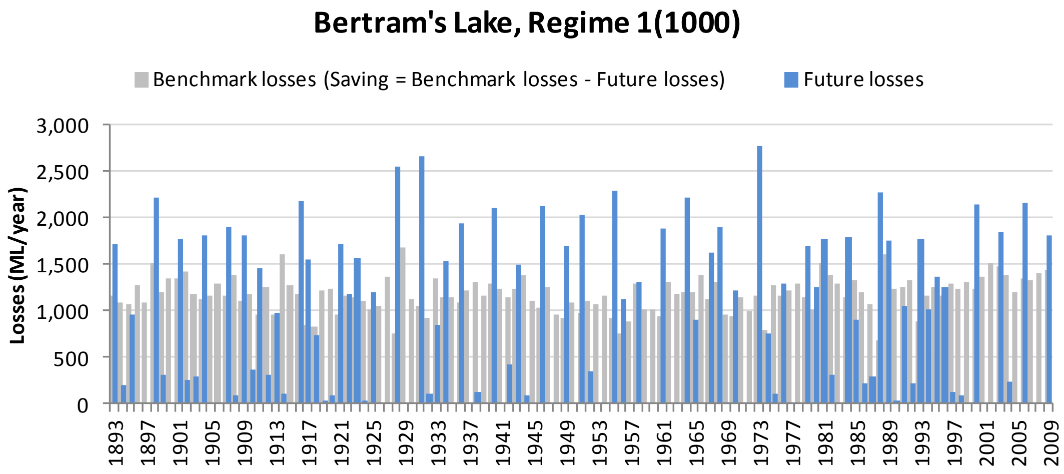

Figure 51. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 1(1000), with the difference representing savings.

Table 28. Mean annual losses and savings, Bertram's Lake, Regime No. 1(800) and Regime No. 1(1000).

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Bertram's Lake, Regime No. 1(800)	1,174.0	804.8	369.3
Bertram's Lake, Regime No. 1(1000)	1,174.0	789.4	384.6

4.6.7 Future scenario Regime No. 2(800) and Regime No. 2(1000)

The future scenario Regime No. 2 for Bertram's Lake was the same as that for the entire lake (Table 24), except that it was assumed that all unregulated inflows less than 800 ML/d [Regime No. 2(800)] and less than 1,000 ML/d [Regime No. 2(1000)] would be diverted to the Racecourse (eastern) partition of Racecourse Lake.

Exclusion of the unregulated inflows during relatively dry periods allowed Bertram's Lake to draw down further than for the entire lake option, but spills into Bertram's Lake occurred during wet periods, interrupting the drying cycle, slightly less so for an interconnecting channel with a capacity of 1000 ML/d (Figure 52 and Figure 53).

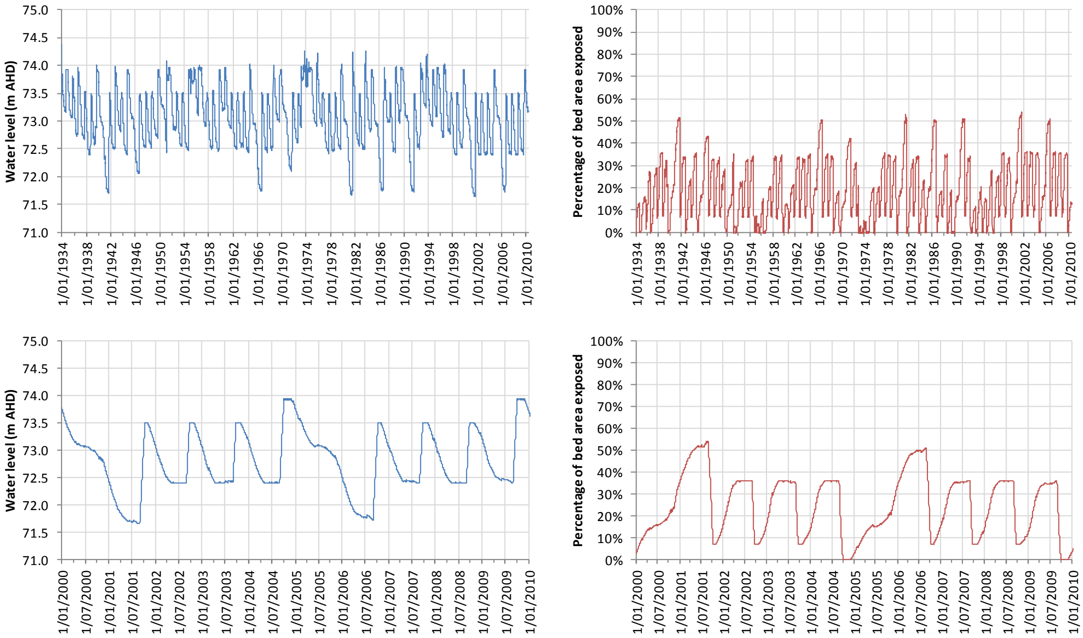

Figure 52. Predicted water levels and percentage of bed dry for Future scenario Regime No. 2(800), Bertram's Lake.

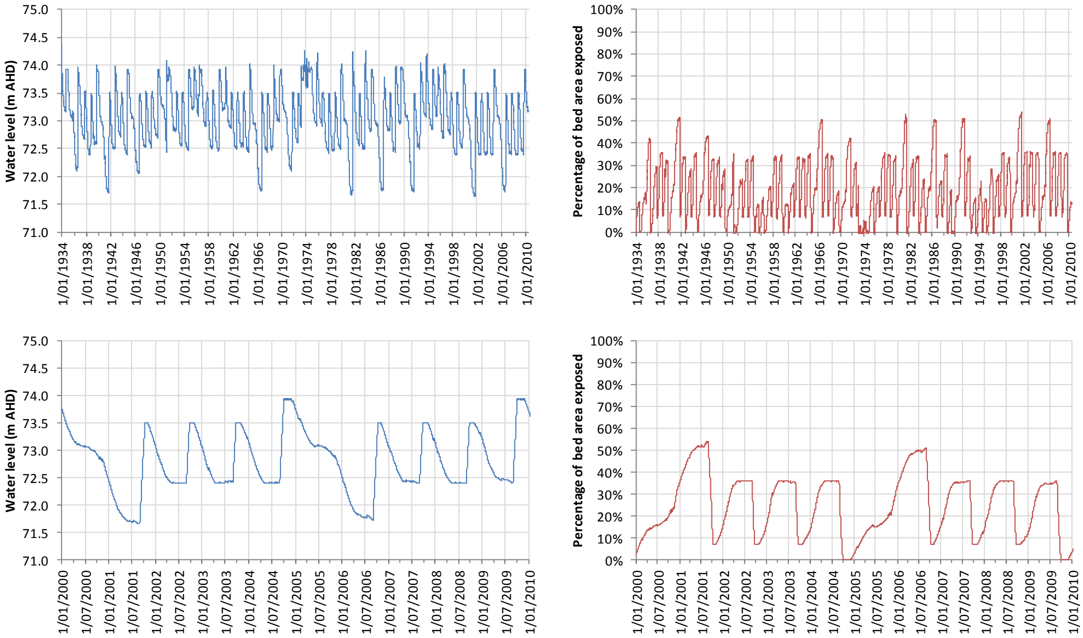

Figure 53. Predicted water levels and percentage of bed dry for Future scenario Regime No. 2(1000), Bertram's Lake.

4.6.8 Filling and drawdown

The target filling levels for Bertram's Lake of 73.93±0.01 m and 73.50±0.01 m were achieved in 100% of intended filling years for both Regime No. 2(800) and Regime No. 2(1000). It was intended for the lake to fully draw down every 1 in 5 years, but this never occurred because the drying cycle was not long enough (two years would be required). In the other years the target level of 72.40 m±0.05 m was achieved in

48% of intended years for Regime No. 2(800) and Regime No. 2(1000), with 72.40 m±0.15 m achieved in 68% of intended years for Regime No. 2(800) and 69% of intended years for Regime No. 2(1000).

4.6.9 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Bertram's Lake future scenario was 684 ML for Regime No. 2(800) and 714 ML for Regime No. 2(1000) (Table 29), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 54 and Figure 55) assumed automatic daily adjustments as required to maintain the target levels.

Table 29. Western partition of Racecourse Lake annual inflow and outflow statistics for the future scenario, Regime No. 2(800) and Regime No. 2(1000). P95 is 95th percentile.

	Inflows (ML/yr)			Outflows (-ML/yr)		
Lake	Mean	P95	Max.	Mean	P95	Max.
Bertram's Lake Regime No. 2(800) (all inflows)	6,200	29,116	64,886	5,182	27,891	64,097
Bertram's Lake Regime No. 2(800) (unregulated inflows)	5,516	29,084	64,886	-	-	-
Bertram's Lake Regime No. 2(800) (additional inflows required)	684	1,599	1,732	-	-	-
Bertram's Lake Regime No. 2(1000) (all inflows)	4,375	22,709	47,508	3,360	21,380	46,798
Bertram's Lake Regime No. 2(1000) (unregulated inflows)	3,660	22,554	47,508	-	-	-
Bertram's Lake Regime No. 2(1000) (additional inflows required)	714	1,599	1,732	-	-	-

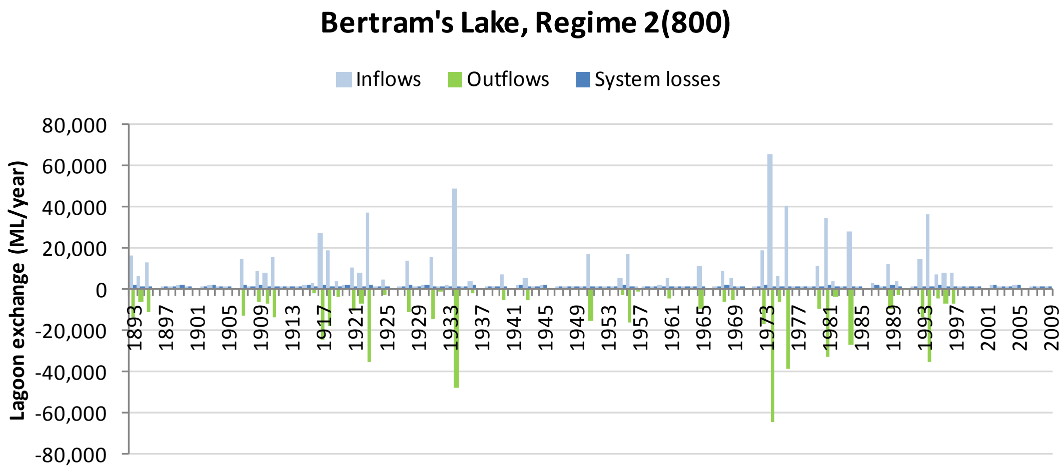

Figure 54. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 2(800). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

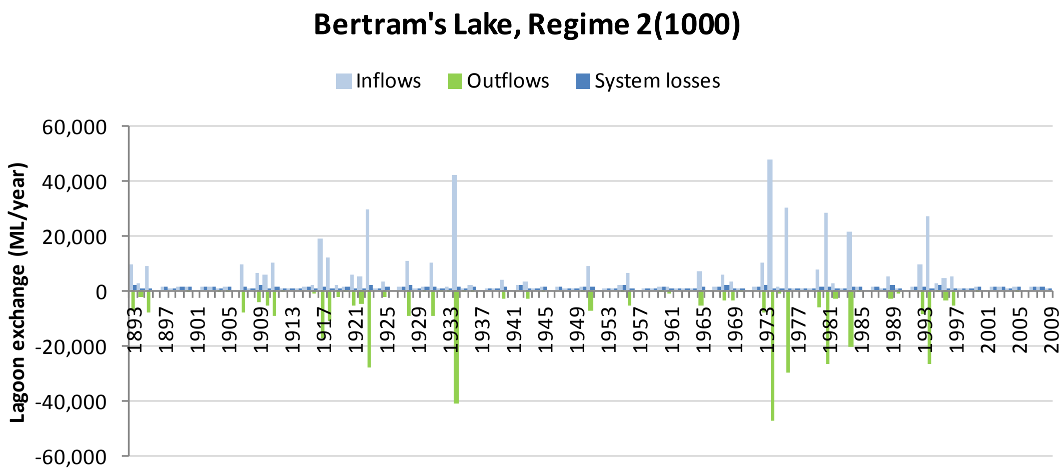

Figure 55. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 2(1000). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.6.10 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 56, and Figure 57). The losses for the Future scenario were somewhat lower than those of the Benchmark scenario. Under the Future scenario, the mean annual saving was 173.0 ML for Regime No. 2(800) and 176.1 ML for Regime No. 2(1000) (Table 30).

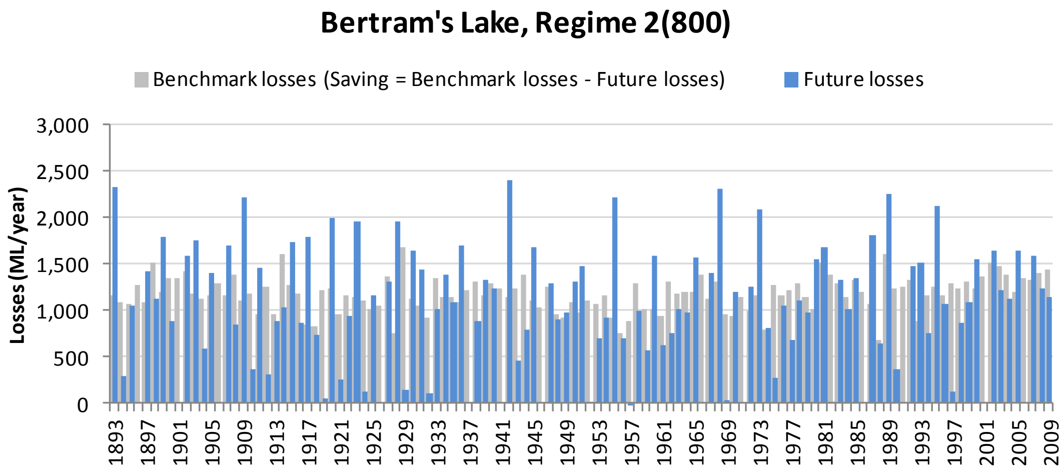

Figure 56. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 2(800), with the difference representing savings.

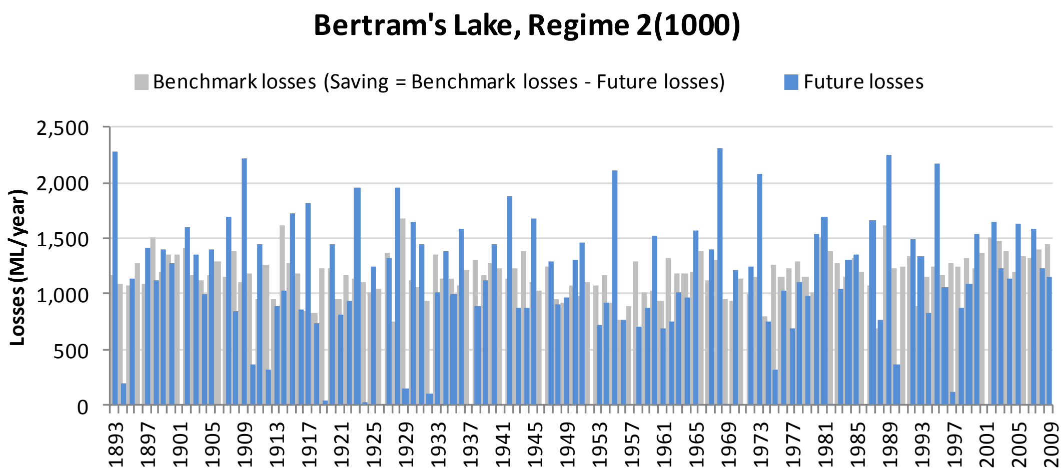

Figure 57. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 2(1000), with the difference representing savings.

Table 30. Mean annual losses and savings, Bertram's Lake, Regime No. 2(800) and Regime No. 2(1000).

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Bertram's Lake, Regime No. 2(800)	1,175.7*	1,002.7	173.0
Bertram's Lake, Regime No. 2(1000)	1,175.7*	999.5	176.1

* This value differs slightly from that for Regime No. 1 (Table 28), because the two regimes had different cycle lengths (6 years for Regime 1; 5 years for Regime 2), so the annualisation was calculated over different periods for each regime option.

4.6.11 Future scenario Regime No. 3(800) and Regime No. 3(1000)

The future scenario Regime No. 3 for Bertram's Lake was the same as Regime No. 1 for the entire lake (Table 21), except that: (i) in Year 1, the target water level was 73.5 m instead of 73.93 m, and (ii) it was assumed that all unregulated inflows less than 800 ML/d [Regime No. 1(800)] and less than 1,000 ML/d [Regime No. 1(1000)] would be diverted to the Racecourse (eastern) partition of Racecourse Lake.

Exclusion of the unregulated inflows during relatively dry periods allowed Bertram's Lake to fully (or near to fully) draw down two years in each 6-year cycle, but spills into Bertram's Lake occurred during wet periods, interrupting the drying cycle, slightly less so for an interconnecting channel with a capacity of 1000 ML/d (Figure 58 and Figure 59).

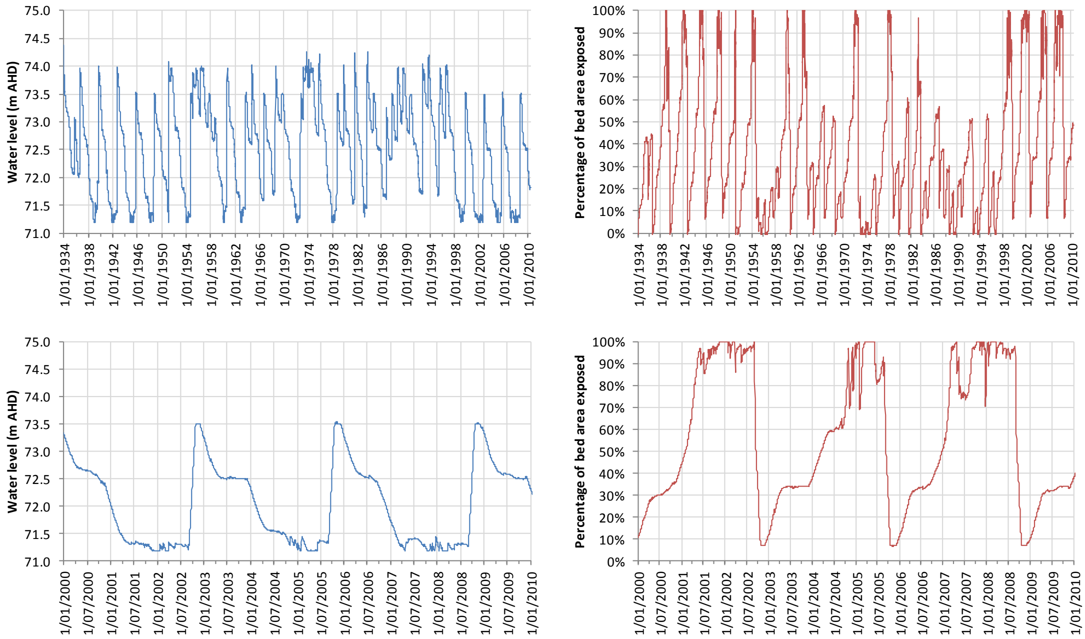

Figure 58. Predicted water levels and percentage of bed dry for Future scenario Regime No. 3(800), Bertram's Lake.

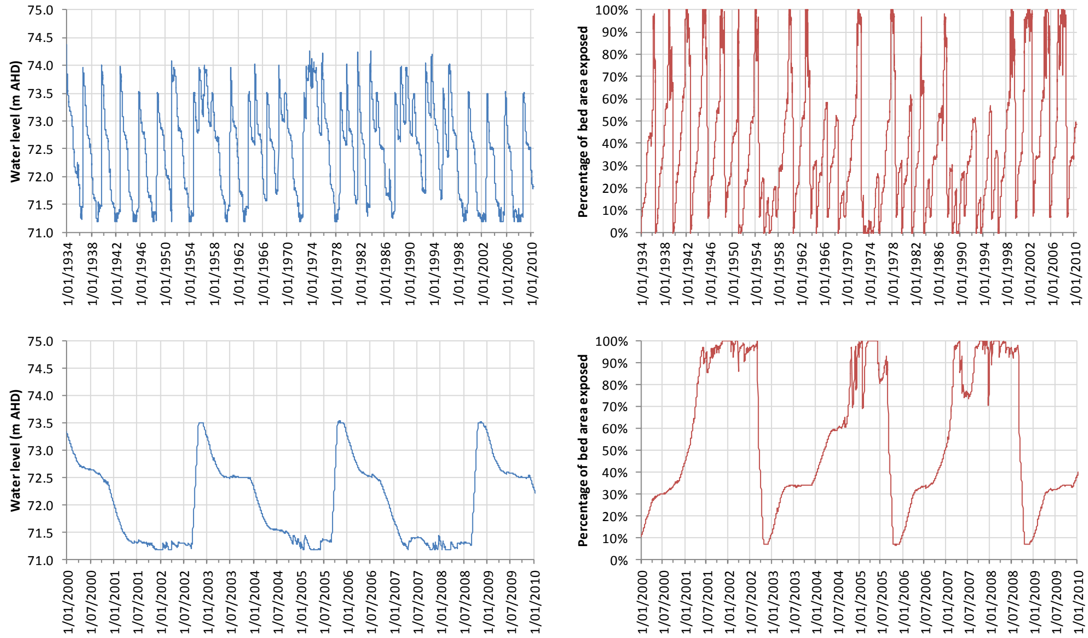

Figure 59. Predicted water levels and percentage of bed dry for Future scenario Regime No. 3(1000), Bertram's Lake.

4.6.12 Filling and drawdown

The target filling level for Bertram's Lake of 73.5±0.01 m was achieved in 100% of intended filling years for both Regime No. 3(800) and Regime No. 3(1000). It was intended for the lake to fully draw down every 2 years in 6; this occurred in 54% of intended years for Regime No. 3(800) and 56% of intended years for Regime No. 3(1000).

4.6.13 Inflows and outflows

The mean annual inflow, additional to unregulated inflows, required to maintain the Bertram's Lake future scenario Regime No. 3(800) was 334 ML and Regime No. 3(1000) was 351 ML (Table 31), which includes filling in September, and maintaining the target upper and lower levels. The modelled inflows and outflows (Figure 60 and Figure 61) assumed automatic daily adjustments as required to maintain the target levels.

Table 31. Bertram's Lake partition of Racecourse Lake annual inflow and outflow statistics for the future scenarios, Regime No. 3(800) and Regime No. 3(1000). P95 is 95th percentile.

Lake (regime)	Inflows (ML/yr) Mean	Inflows (ML/yr) P95	Inflows (ML/yr) Max.	Outflows (-ML/yr) Mean	Outflows (-ML/yr) P95	Outflows (-ML/yr) Max.
Bertram's Lake Regime No. 3(800) (all inflows)	5,850	29,084	64,886	5,068	27,407	64,097
Bertram's Lake Regime No. 3(800) (unregulated inflows)	5,516	29,084	64,886	-	-	-
Bertram's Lake Regime No. 3(800) (additional inflows required)	334	1,764	1,858	-	-	-
Bertram's Lake Regime No. 3(1000) (all inflows)	4,012	22,632	47,508	3,247	20,857	46,798
Bertram's Lake Regime No. 3(1000) (unregulated inflows)	3,660	22,554	47,508	-	-	-
Bertram's Lake Regime No. 3(1000) (additional inflows required)	351	1,781	1,858	-	-	-

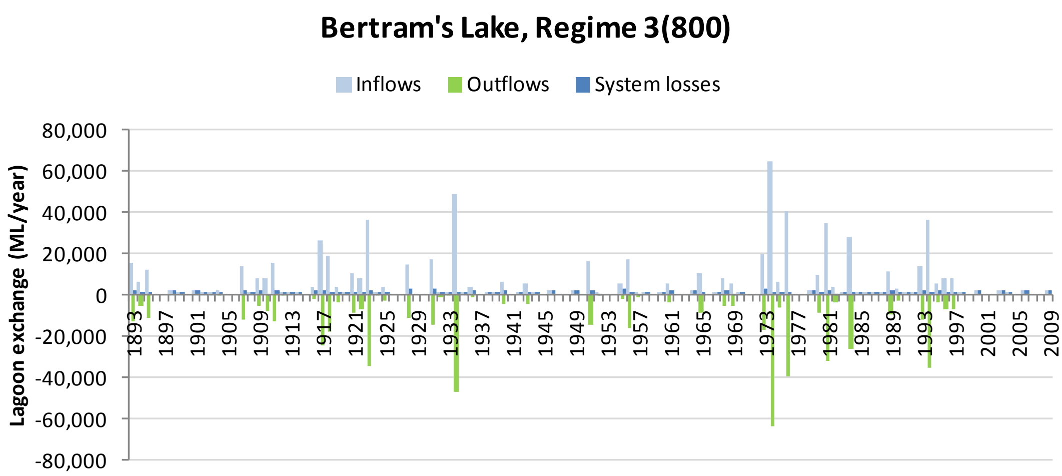

Figure 60. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 3(800). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

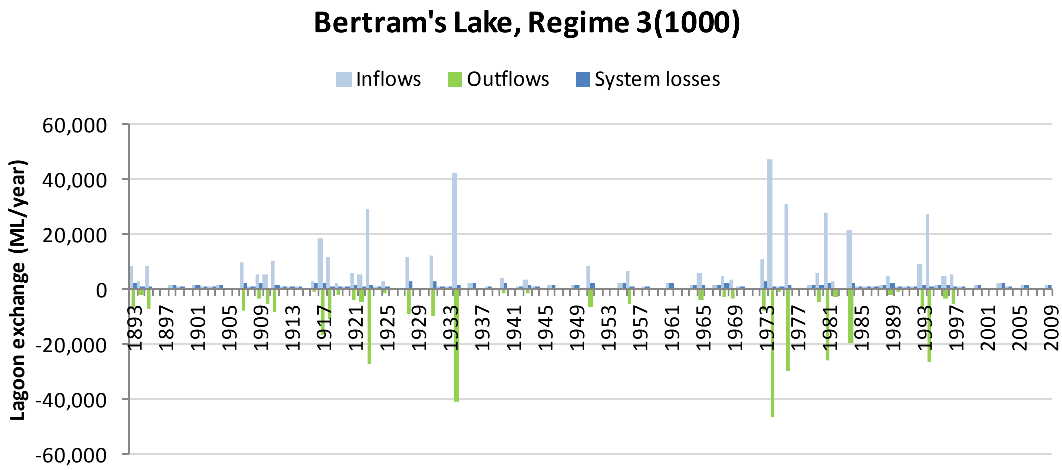

Figure 61. Bertram's Lake time series of annual inflows and outflows from the lagoon, and system losses, for the Future scenario Regime No 3(1000). Outflows are denoted with a negative sign. System losses are inflows minus outflows.

4.6.14 Water losses and savings

The annual losses and savings varied throughout the modelled time series (Figure 62 and Figure 63). The losses for the Future scenario were somewhat lower than those of the Benchmark scenario. Under the Future scenario, the mean annual saving was 399.8 ML for Regime No. 3(800) and 417.6 ML for Regime No. 3(1000) (Table 32).

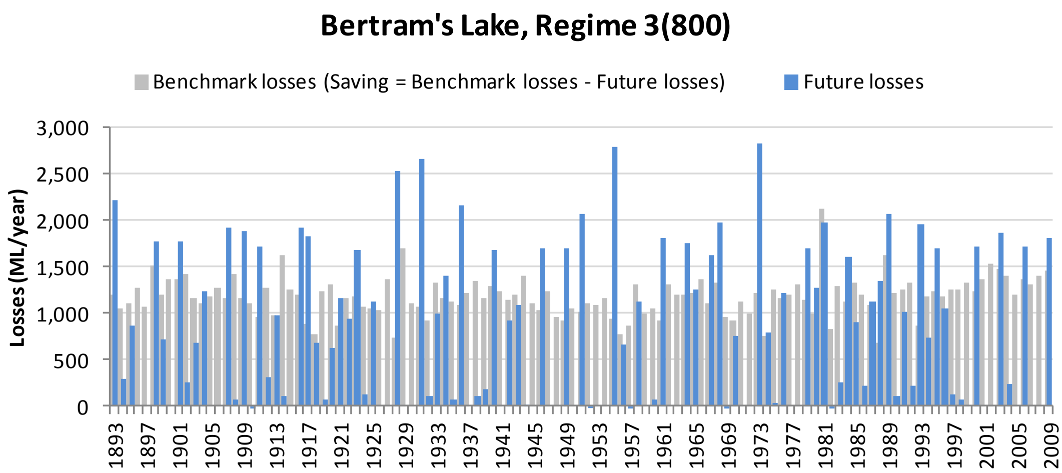

Figure 62. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 3(800), with the difference representing savings.

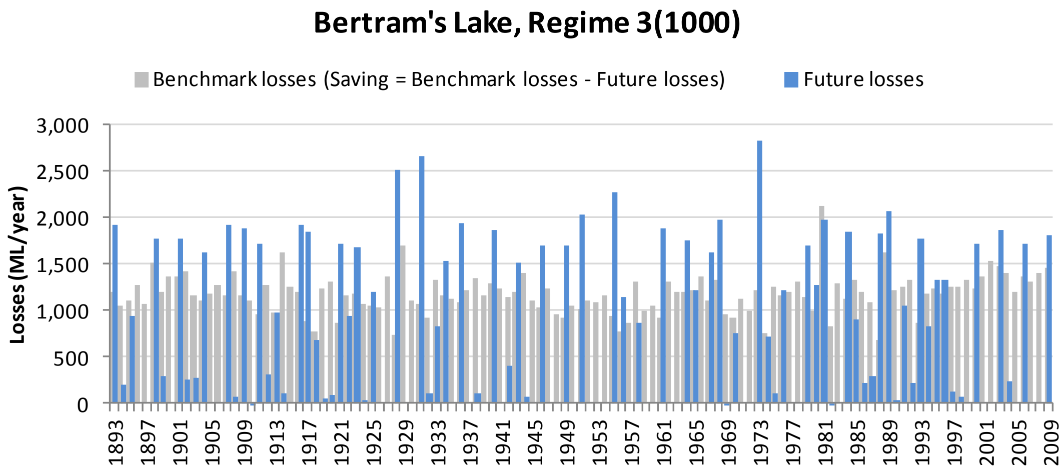

Figure 63. Bertram's Lake time series of losses under Benchmark scenario and Future scenario Regime No. 3(1000), with the difference representing savings.

Table 32. Mean annual losses and savings, Bertram's Lake, Regime No. 3(800) and Regime No. 3(1000).

Lake	Annualised mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
Bertram's Lake, Regime No. 3(800)	1,174.0	774.3	399.8
Bertram's Lake, Regime No. 3(1000)	1,174.0	756.5	417.6

5 Summary of losses and potential savings

The estimated losses and potential for savings provided in this report are preliminary, subject to refinement of the models, and refinement of the modelled scenarios (Table 33).

Table 33. Mean (1893 – 2009) annual losses and savings, Kerang Lakes.

Lagoon [scenario]	Mean loss		Mean saving
	Benchmark (ML/yr)	Future (ML/yr)	Future (ML/yr)
First Reedy Lake	2,233.2	2,179.2	54.0
Middle Reedy Lake	2,202.4	2,153.1	49.2
Third Reedy Lake [establishment]	2,637.3	1,995.9	641.5
Third Reedy Lake [long-term]	2,637.4	1,721.7	915.7
Little Lake Charm	1,513.3	1,504.6	8.7
Entire Racecourse Lake [Regime No. 1]	2,782.1	2,196.9	585.2
Entire Racecourse Lake [Regime No. 2]	2,785.9	2,518.5	267.5
Bertram's Lake [Regime No. 1(800)]	1,174.0	804.8†	369.3
Bertram's Lake [Regime No. 1(1000)]	1,174.0	789.4†	384.6
Bertram's Lake [Regime No. 2(800)]	1,175.7	1,002.7†	173.0
Bertram's Lake [Regime No. 2(1000)]	1,175.7	999.5†	176.1
Bertram's Lake [Regime No. 3(800)]	1,174.0	774.3†	399.8
Bertram's Lake [Regime No. 3(1000)]	1,174.0	756.5†	417.6

† assumes unregulated inflows from Little Lake Charm diverted to the eastern partition of the lake (Racecourse) up to the capacity of the interconnecting (outflow) channel, indicated as 800 ML/d or 1000 ML/d by the scenario name, with excess spilled to Bertram's Lake.

6 References

DSE 2004. Kerang Wetlands Ramsar Site, Strategic Management Plan. Parks Victoria. The State of Victoria, Department of Sustainability and Environment, East Melbourne. URL:

http://www.dse.vic.gov.au/__data/assets/pdf_file/0010/100135/Kerang_Wetlands_Ramsar_Site_Strategic_Management_Plan.pdf (accessed 9 September 2012).

DSE 2010. Kerang Wetlands Ramsar Site, ecological character description. Arthur Rylah Institute for Environmental Research, Heidelberg. The State of Victoria, Department of Sustainability and Environment, East Melbourne.

Ecological Associates. 2008. Determination of environmental water requirements for Mosquito Creek Catchment and Bool and Hacks Lagoon. Final Report. South East Natural Resources Management Board, Mount Gambier, South Australia, August.

Gippel, C.J. 2012. Preliminary hydrological modelling for Kerang Lakes bypass investigation project. Fluvial Systems Pty Ltd, Stockton. Goulburn-Murray Water, Shepparton, September.

North Central CMA 2007. Loddon Campaspe Irrigation Region Land and Water Management Plan Summary. The State of Victoria. North Central Catchment Management Authority, Huntly.

North Central CMA 2010. Lake Meran Environmental Watering Plan, Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly.

North Central CMA 2012. Environmental Watering Scenarios for Kerang Lakes Bypass Investigation Project - Phase 1. Prepared for the Goulburn-Murray Water Connections Project, North Central Catchment Management Authority, Huntly.

North Central CMA 2013a. Kerang Lakes Bypass Investigation Project Technical Report - Third Reedy Lake, North Central Catchment Management Authority, Huntly.

North Central CMA 2013a. Kerang Lakes Bypass Investigation Project Technical Report - Racecourse Lake, North Central Catchment Management Authority, Huntly.

NVIRP 2012. Kerang lakes bypass investigation project. Newsletter No. 1, May. Northern Victoria Irrigation Renewal Project. URL: http://www.g-mwater.com.au/downloads/connections/Kerang_Lakes_bypass_project_May_2012.pdf (accessed 1/11/2013).

SKM 2007. Kerang Lakes REALM modelling for refinement of the MDBC BSMS register. Sinclair Knight Merz, Armadale. Goulburn-Murray Water, Shepparton.

SKM 2012. Kerang Lakes Model - data extension. Sinclair Knight Merz, Armadale. Department of Sustainability and Environment, April.

Tucker, P. Harper, M., Dominelli, S., van der Wielen, M. and Siebentritt, M. 2002. Your Wetland: Hydrology Guidelines. Department of Environmental Biology, University of Adelaide, Adelaide.