South Australian Salinity Mapping and Management Support Project

Groundwater Modelling of Salinity Impacts on the River Murray due to Vegetation Clearance in the Riverland area of SA

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ABSTRACT

As part of the South Australian Salinity Mapping and Management Support Project (SA SMMSP), a groundwater model was constructed to predict the impacts of increased recharge following clearing on salt inflows to the river and floodplain in the Riverland area. Associated SMMSP projects provided much improved estimates for recharge and lag times between clearing and impact on the watertable, as well as a more accurate map of the extent and thickness of the Blanchetown Clay (of importance in impeding recharge).

For the purposes of this SMMSP project, the following scenarios were run.
Scenario 1: No intervention – this scenario takes into account the impacts of clearing only. Irrigation induced watertable mounds are not included, nor are any mitigation strategies.
Scenario 2: Revegetation over holes in Blanchetown Clay – this scenario assumes revegetation over holes in the Blanchetown Clay determined by aerial geophysics.
Scenario 3: Revegetation in priority areas determined by the River Murray Dryland Corridor Project (RMDCP) which used the Simpact GIS model.
Scenarios 4 - 6: Revegetation in corridors 5, 10 and 20km wide adjacent to the river valley to compare with results from previous modelling exercises (Barnett et al, 2001).

The model results indicate that the no intervention scenario shows an increase of 30 EC by 2100 with no evidence of a decrease in the linear trend of about 0.35 EC/year increase. Intervention options such as revegetating priority areas and holes in the Blanchetown Clay both have a reduction of about 2 EC by 2050, with very little or no real increase in benefit after that.

Revegetation of the 5 km zone has a reduction of 6 EC from the no intervention scenario by 2050 and has an ongoing benefit by reducing the rate of increase to 0.13 EC/year. Similarly, revegetation of the 10 km zone has a reduction of 7.5 EC by 2050, and will maintain EC levels at those reached by 2025. The 20 km zone will have reduction of 7.8 EC by 2050 and will reduce the increases due to clearing to only 1 EC by 2100.

When the saltload reductions per unit area of revegetation were considered, the surprising result shows that although the total saltload reduction of planting the RMDCP priority areas is small, it has by far the most effective result for the area planted. This is because the areas are located close to the river and are underlain by sandy soils with high recharge rates.

For the no intervention scenario, the current modelling shows a 70 % reduction from the previous modelled prediction in 2001. This is due to several factors, with the most significant being improved recharge estimates and a more detailed and better calibrated groundwater model.

Further investigations are needed to quantify the amount of salt intercepted by the floodplain, and how it is later mobilised during high flow events.

INTRODUCTION

The area of the Riverland surveyed under the SA SMMSP (Border to Lock 3) is a priority for intervention under the National Action Plan, as 30% of the salt load of the River Murray at Morgan is sourced from this reach of the river. Drainage from irrigation developments and increased recharge from dryland agriculture, both lead to a rise in watertables and increased discharge of naturally occurring saline groundwater to the river and floodplain.

Time lags between changing land use and the resultant impact on the river can be long, often over 50 years. Determining the magnitude and timing of these impacts is essential in formulating effective and cost-efficient mitigation strategies.

Previous modelling exercises to predict the impacts of vegetation clearance on the river (Barnett 1990, Barnett et al 2001), were carried out with the best recharge information available at the time (Cook, 1989), but were ultimately hampered by the use of broad landscape units and recharge rates derived from measurements carried out in other wetter areas of the Murray Basin.

An associated SMMSP project (Cook et al., 2004) has provided much improved recharge estimates and lag times. This work obtained point estimates within the study area and derived improved drainage equations that take into account the presence of the Blanchetown Clay. The SA SMMSP used airborne geophysical techniques, described in a separate project report (Munday, 2004), to produce a more accurate map of the extent and thickness of the Blanchetown Clay. More detailed soil landscape mapping has also been carried out at a finer resolution than used previously.

This report details the construction of a groundwater model, which has a smaller grid size and better calibration than the models used previously in the study area. Using the improved recharge estimates and lag times described above, this model was used to predict the impacts of increased recharge following clearing on salt inflows to the river and floodplain from the southern side of the river. The northern side of the river was not included in this exercise because of the low amount of clearing and annual cropping. The model also examines the efficiency of various management strategies to minimise the impacts.

The area modelled is considerably larger than the airborne geophysics survey area as shown (in red) in Figure 1. This was done to avoid boundary condition problems and because the model will be used for other larger scale projects.

In parallel with this modelling exercise, a DWLBC / SA MDB INRM / NAP project entitled Development of Market Based Incentive Programs for NRM along the River / Murray Mallee Dryland Corridor was carried out (Schultz, in prep). This project employed a GIS modelling package to determine priority areas for revegetation to reduce salinity impacts due to clearing. It is referred to in this report as the River Murray Dryland Corridor Project (RMDCP).

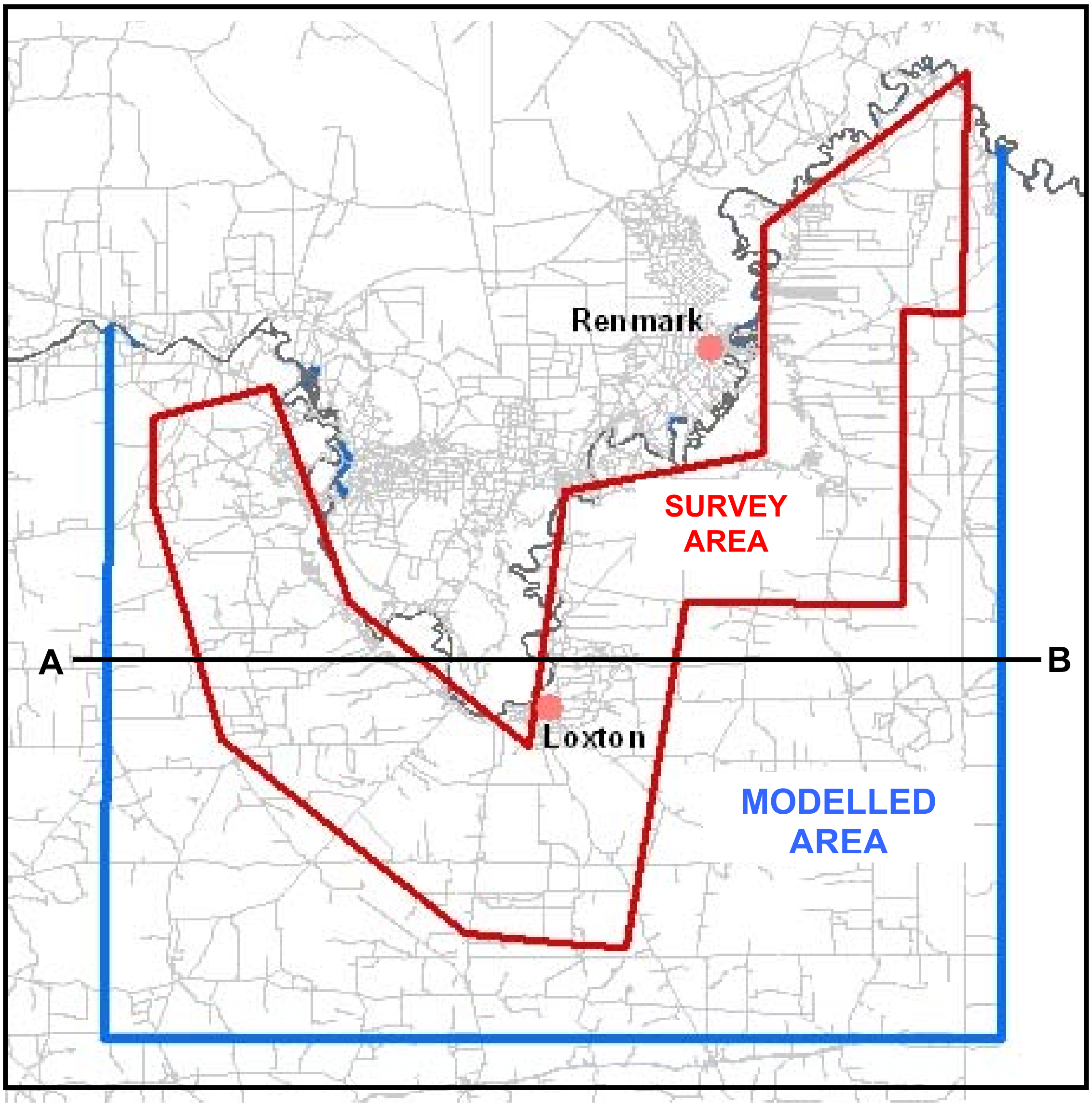

Figure 1 Model extent and survey area

HYDROGEOLOGY

Beneath the modelled area, there are four main aquifers separated by three confining layers. Figure 2 shows the regional hydrogeology along an east-west section through the model located in Figure 1. The geological units are, in order of increasing depth below the surface :

Monoman Formation aquifer (Alluvium):- consists of medium to coarse alluvial sand overlain by thin silts and clay of the Coonambidgal Formation. It is restricted to the river valley and is in direct hydraulic contact both with the River Murray and the surrounding unconfined aquifer (Loxton Sands or Murray Group Limestone). It is a semi-unconfined aquifer commonly 4 - 10 m thick, with highly variable groundwater salinities in the range from 5,000 – 60,000 mg/L.

Loxton Sands aquifer:- an unconfined aquifer which is saturated only upstream of Overland Corner. The unit comprises unconsolidated to weakly cemented fine to coarse sand. It is an inverted aquifer, with the most permeable coarse grained and frequently unsaturated sands occurring at the top of the sequence with the least permeable fine sands at the base. The groundwater flow is generally towards the river under low gradients, except where watertable mounds exist beneath irrigation areas. Groundwater salinity values in the Loxton Sands vary dramatically across the model area (from 5,000 - 30,000 mg/L), reflecting the impact of low salinity irrigation drainage on the saline native groundwater.

Bookpurnong Formation (confining layer):- this unit occurs only upstream of Overland Corner where it dips down gradually to the east and increases in thickness to a maximum of about 30 m. It consists of poorly consolidated plastic silts and shelly clays, which confines the underlying limestone aquifer.

Murray Group Limestone aquifer:- Although regionally considered to be one aquifer, detailed drilling in the Loxton – Bookpurnong area has enabled a finer subdivision of the aquifer as proposed by Luksik and James (1998). In order of increasing depth, the units are;

The **Pata Formation** semi-confined aquifer is a poorly consolidated bryozoal limestone (with interbedded sand layers) that occurs throughout the model area. It is typically in the range of 10 - 15 m in thickness. The unit is a poor aquifer due to the presence of low permeability marls. Groundwater salinities are uniformly high, up to 30,000 mg/L on average, with lower salinities beneath the floodplain (~10,000 mg/L).

The **Winnambool Formation** aquitard comprises grey to pale green marl and silty clay, which varies in thickness from 3 to 5 m regionally, and provides an effective aquitard between the Pata Formation and Glenforslan Formation.

The **Glenforslan Formation** semi-confined aquifer is a grey sandy limestone that closely resembles the Pata Formation, with the exception that it contains occasional fine-grained cemented layers. Its thickness is consistently in the range 20 - 30 m in with the unit dipping to the east. Groundwater salinities in the Glenforslan Formation range from 5,000 – 30,000 mg/L.

The **Finniss Formation** aquitard is a thin but persistent grey to dark grey clay with thin sand layers which separates the Glenforslan Formation and Mannum Formation. It has a maximum thickness of 4.5 m but is commonly 1 - 2 m in thickness.

The **Mannum Formation** confined aquifer is around 80 m thick and consists of a highly fossiliferous calcarenitic and sandy limestone. The unit thickens and deepens to the east. Groundwater salinities in the Mannum Formation range from 3,000 - 25,000 mg/L.

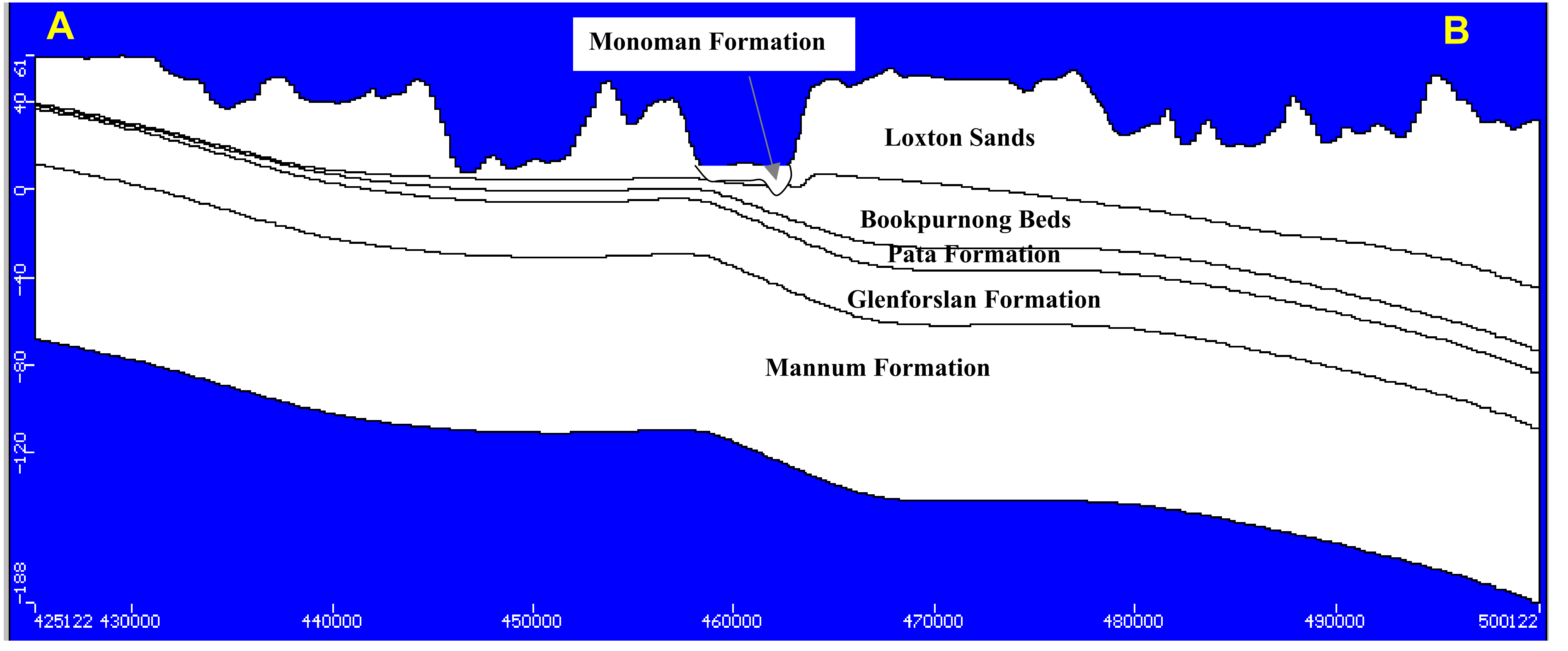

Figure 2 Hydrogeological cross section

MODEL CONSTRUCTION

The model domain simulates an area 75 km (east west) by 78 km (north south). The bounding AMG coordinates of the model domain are southwest (easting 425122 northing 6160180) and northeast (easting 500122 northing 6238500) (Figure 1). The rectangular model grid was divided into 359 rows and 398 columns. The minimum grid size is 125 x 125 m in the Loxton area. The maximum grid size is 250 x 250 m in the remaining model area.

Vertically, the five layers were conceptualised in the model as follows ;

Layer 1: Loxton Sands and Monoman Formation

Layer 1 simulates the Loxton Sands unconfined - semi-unconfined aquifer over most of the model area, and the Monoman Formation semi-unconfined aquifer in the river floodplain. The Blanchetown Clay has not been modelled as the effect of this aquitard in perching water is accounted for by controlling the recharge rate to the Loxton Sands, where the true watertable occurs.

This layer only exists in the eastern half of the model area, because to the west, the Loxton Sands is structurally elevated above the watertable and is unsaturated. To simulate this situation, the model cells in the western half for Layer 1 are inactive cells.

The regional groundwater flow within the model domain is toward the River Murray from the east, south and west. Discharge occurs directly from the Loxton Sands to the river at cliff sections, or via the Monoman Formation beneath the floodplain.

The following boundary conditions were applied (also shown in Fig. 4)

- No-flow boundaries where groundwater flow is parallel to the model boundary.
- General head boundaries to simulate groundwater flow on the model boundaries where flow occurs into and out of the model.
- Constant head boundaries to simulate hydraulic communication between the Noora Disposal Basin and the unconfined aquifer.
- Constant head boundary cells to simulate the River Murray.
- River cells to simulate anabranch creek systems on the floodplain.
- Drainage cells to simulate groundwater seepage from the highland to the floodplain in the Loxton area.

Layer 2: Lower Loxton Sands, Bookpurnong Formation and Part Pata Formation

Layer 2 simulates the impermeable clays at the base of the Loxton Sands (Lower Loxton Clay and Shells) and the Bookpurnong Formation aquitards. This layer only exists in the eastern half of the model area as the Bookpurnong Beds confining layer is absent in the west, and is represented by inactive cells. Very small volumes of water move laterally into and out of this layer due to its low permeability.

The following boundary conditions were applied to Layer 2.

- No-flow boundaries were used at the model boundaries.
- Some constant head boundaries were used along the River Murray in areas where the river is in hydraulic communication with the Pata Formation.
- River cells were used to simulate Lake Bonney.

Layer 3: Pata Formation

Layer 3 simulates the regionally distributed Pata Formation semi-confined low permeability aquifer. This layer is only saturated in the eastern half of the model area, and is represented by inactive cells to the west. Regional groundwater flow is from the northeast to southwest within the model domain.

The following boundary conditions were applied to Layer 3.

- No-flow boundaries where groundwater flow is parallel to the model boundaries.
- General head boundaries were used at the model boundaries to simulate groundwater flow into and out of the model.
- Constant head boundaries were used in the western area of the model where the River Murray is in hydraulic communication with the Pata Formation.
- Constant head boundary cells to simulate the River Murray.

Layer 4: Glenforslan Formation

Layer 4 simulates the regionally distributed Glenforslan Formation confined aquifer, which averages 25 m in thickness. The Winnambool Formation aquitard averages around 3 m in thickness and lies between the Glenforslan Formation and the overlying Pata Formation. This aquitard was simulated in the model by using vertical leakage, which is controlled by the vertical hydraulic conductivity in Layers 3 and 4.

The regional groundwater flow in this aquifer is from the northeast to the southwest within the model domain. The following boundary conditions were applied to Layer 4.

- Constant head boundaries were used at the model boundaries to simulate groundwater flow into and out of the model
- No-flow boundaries where groundwater flow is parallel to the model boundaries.
- General head boundaries were used at the model edges to simulate groundwater flow into and out of the model.
- General head boundaries were used at part of the western model edge to simulate upward leakage from deeper Renmark Group confined aquifer into the Murray Group Limestone aquifer.
- Constant head boundaries were used in the western area of the model where the River Murray is in hydraulic communication with the Glenforslan and Mannum Formation.
- Constant head boundary cells to simulate the River Murray.

Layer 5: Mannum Formation

This layer simulates the regionally distributed Mannum Formation confined limestone aquifer, which has a moderate permeability and a thickness of 80 m. It is directly overlain by the Finnis Formation, a three metre thick aquitard which was simulated using vertical hydraulic conductivities in both Layers 4 and 5. The same boundary conditions as Layer 4 apply, which are shown in Figure 4.

Table 1 displays the initial hydraulic parameters applied to the various layers in the model.

Table 1 Initial hydraulic parameters

Aquifer / Aquitard	**Layer**	**Hydraulic conductivity**		**Storage**	
		Kh (m/day)	**Kv (m/day)**	**Sy**	**Ss(/m)**
Loxton Sands	1	0.5 – 10	0.05 - 0.1	0.15	
Monoman Formation	1	15	0.15	0.15	
Lower Loxton Clay Bookpurnong Formation	2	0.006	0.0005 - 0.0006		$1x10^{-4}$
Pata Formation	3	0.5	0.01		$1x10^{-4}$
Glenforslan Formation	4	1-1.5	0.0003 - 0.0005		$1x10^{-4}$
Mannum Formation	5	2	0.2 - 0.0002		$1x10^{-5}$

RECHARGE RATES

The increase in recharge rates following clearing is the key process driving the increase in salt loads to the river. These rates are dependent on several factors:

- time since clearing,
- the depth to the water table,
- soil type, and
- thickness of Blanchetown Clay.

The recharge was applied in areas cleared of mallee (and outside irrigation areas), with values based on Cook et al., (2004). Forty recharge zones were delineated in this investigation, but in order to make the modelling process workable, these zones were aggregated down to a total of seven (Fig. 3). Table 2 shows how the rate (in mm/year) varies over time in these simplified recharge zones.

CALIBRATION

The groundwater model was designed to simulate the various impacts made on groundwater levels over time by the processes of land clearing, river regulation (locking) and irrigation development.

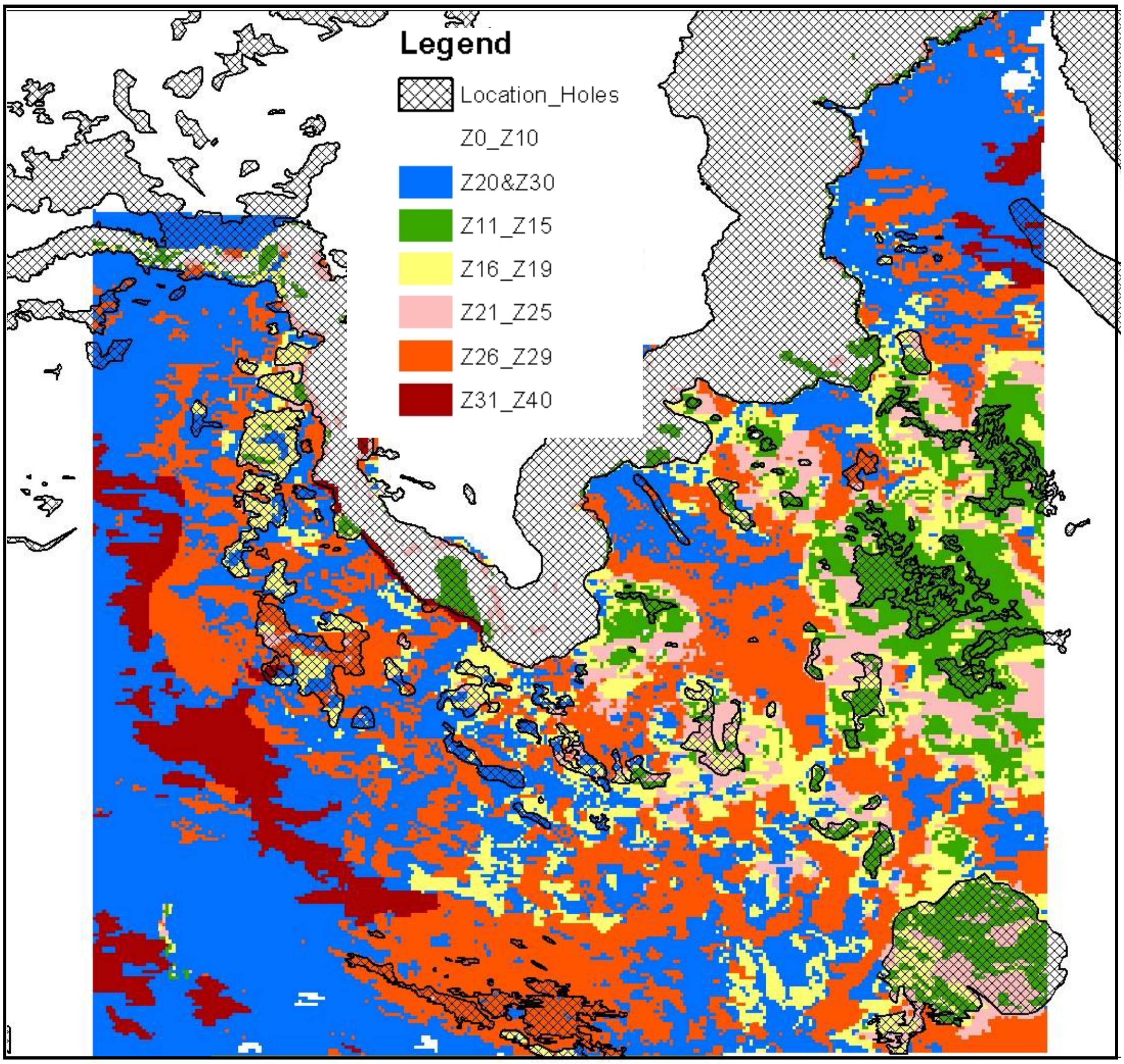

Figure 3 Location of simplified recharge zones

Steady State Calibration

The first model is the steady-state pre-irrigation model, which aimed to reproduce the groundwater levels and estimated salt loads to the river thought to occur before irrigation commenced and after the river was regulated by locks. Pre-clearing recharge rates of 0.1 mm/year were applied throughout the model area. Figures 4 and 5 show the simulated steady-state potentiometric heads in Layer 1 (Loxton Sands) and Layer 5 (Mannum Formation) respectively, and the reasonable agreement obtained with the estimated pre-European regional potentiometric head away from the locks.

Table 2 Variation in recharge rates following clearing within the modelled recharge zones (mm/year).

Year	Z0-Z10	Z20 & Z30	Z11-Z15	Z16-Z19	Z21-Z25	Z26-Z29)	Z31-Z40)
1920	0.00	0.10	0.14	0.10	0.10	0.10	0.10
1930	0.00	0.10	0.53	0.10	0.10	0.10	0.10
1940	0.00	0.10	0.80	0.10	0.10	0.10	0.10
1950	0.00	0.10	1.08	0.10	0.39	0.10	0.10
1960	0.00	0.10	1.38	0.10	1.32	0.10	0.10
1970	0.00	0.10	1.66	0.11	2.58	0.11	0.10
1980	0.00	0.10	1.99	0.13	3.84	0.12	0.10
1990	0.00	0.10	2.32	0.17	5.00	0.17	0.10
2000	0.00	0.11	2.58	0.29	5.96	0.36	0.13
2010	0.00	0.11	2.73	0.49	6.61	0.82	0.29
2020	0.00	0.13	2.81	0.80	6.95	1.53	0.76
2030	0.00	0.17	2.84	1.15	7.10	2.40	1.66
2040	0.00	0.22	2.85	1.52	7.16	3.34	2.94
2050	0.00	0.31	2.85	1.90	7.18	4.27	4.45
2060	0.00	0.46	2.85	2.25	7.19	5.13	5.98
2070	0.00	0.68	2.85	2.57	7.20	5.86	7.36
2080	0.00	0.99	2.85	2.83	7.20	6.45	8.46
2090	0.00	1.37	2.86	3.02	7.20	6.87	9.26
2100	0.00	1.81	2.86	3.16	7.20	7.15	9.78
2110	0.00	2.28	2.86	3.24	7.20	7.32	10.10
2120	0.00	2.28	2.86	3.24	7.20	7.32	10.10

In order to convert the groundwater discharge volumes calculated by the model into salt loads to the river, salinities were assigned to the groundwater in the various reaches.

It must be pointed out that the model calculates the discharge from the regional unconfined aquifers to the edge of the river valley. The rate and timing of salt loads entering the main river channel are determined by a range of complex processes within the river floodplain, including fluctuations in river flow and level, storage of saline groundwater discharge in floodplain aquifers and evapotranspiration from the floodplain.

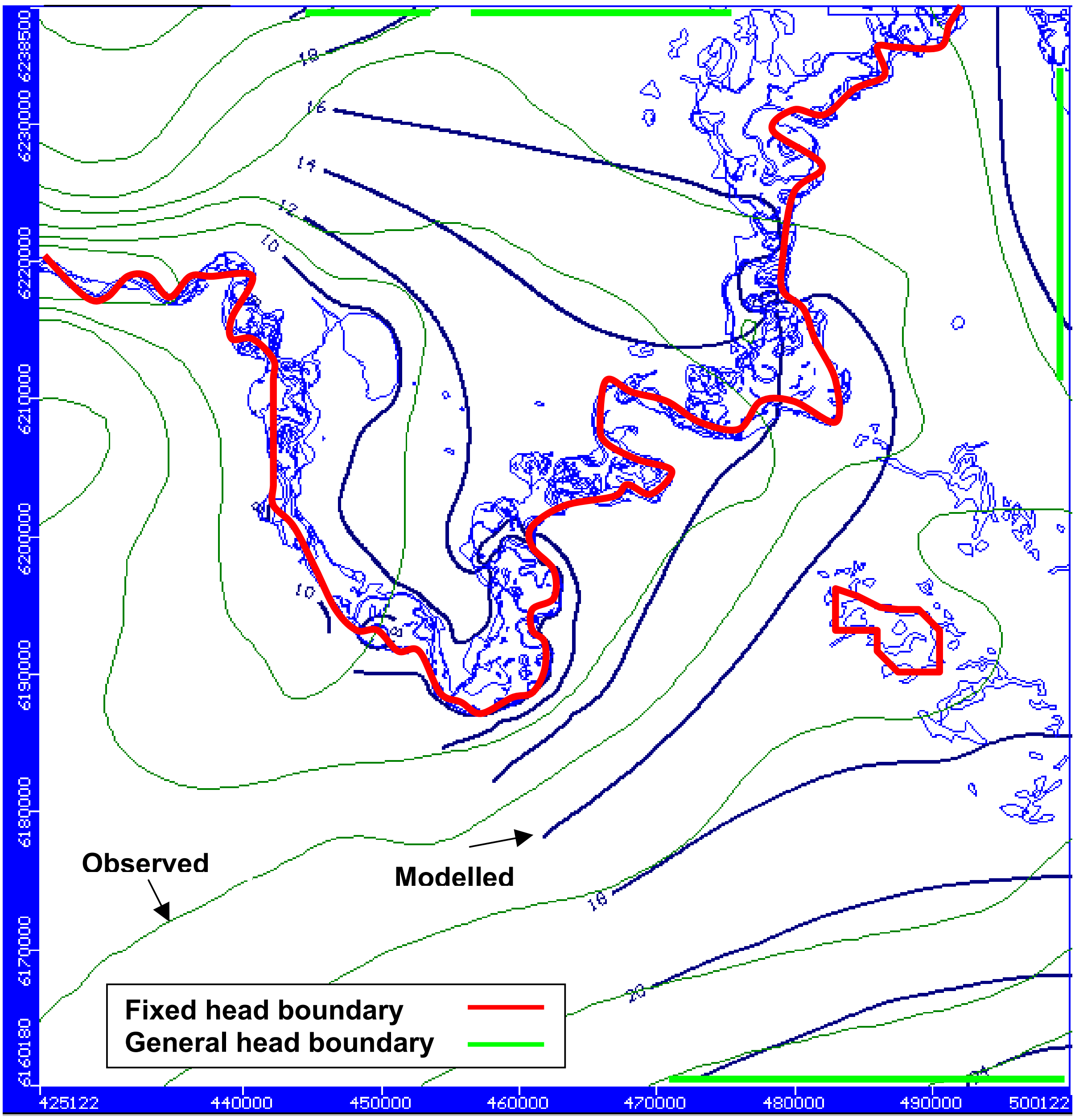

Figure 4 Steady state calibration and boundary conditions – Loxton Sands aquifer

Where the river flows adjacent to the side of the valley, it is assumed that all of the groundwater discharge directly enters the river. However where the river flows mid-valley, the discharge would have to travel beneath the floodplain at shallow depth before entering the river. In doing so, losses due to evaporative discharge and interception by lagoons could occur. While the discharge volumes to the river at low flows may be reduced by these processes that effectively store salt in the floodplain, high flow events will eventually mobilise this stored salt into the river.

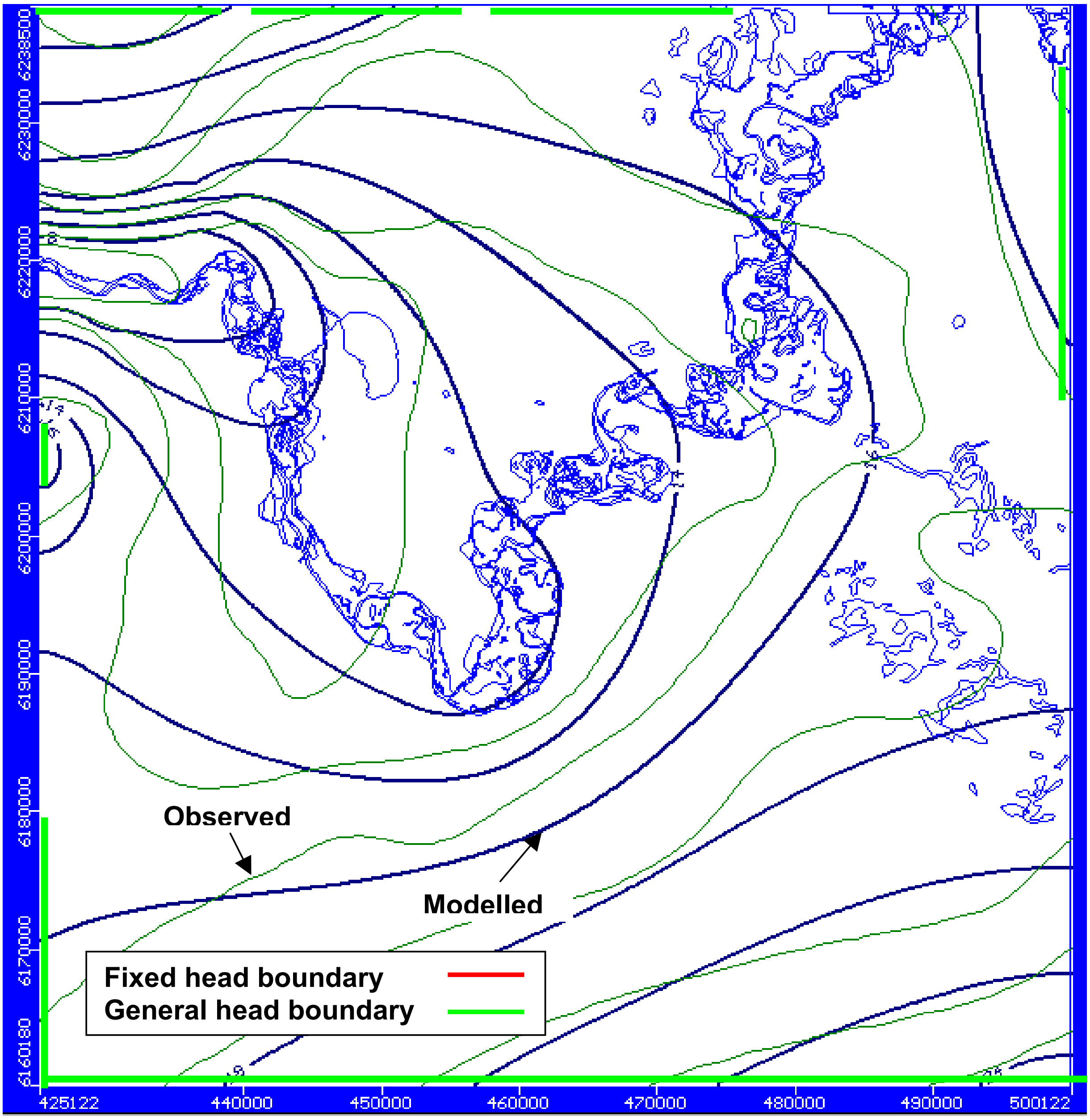

Figure 5 Steady state calibration and boundary conditions – Mannum Formation aquifer

Transient Calibration

The model was calibrated in some areas where there is data available from intensive investigations. A recent investigation by DWLBC and Australian Water Environments (AWE, 2003) has detailed the pre-irrigation and current salt loads to the river in Loxton and Bookpurnong areas. The calibration was based on the observed groundwater levels and the measured salt load from 'Run the River' surveys. The final aquifer parameters chosen are shown in Figures 6 and 7.

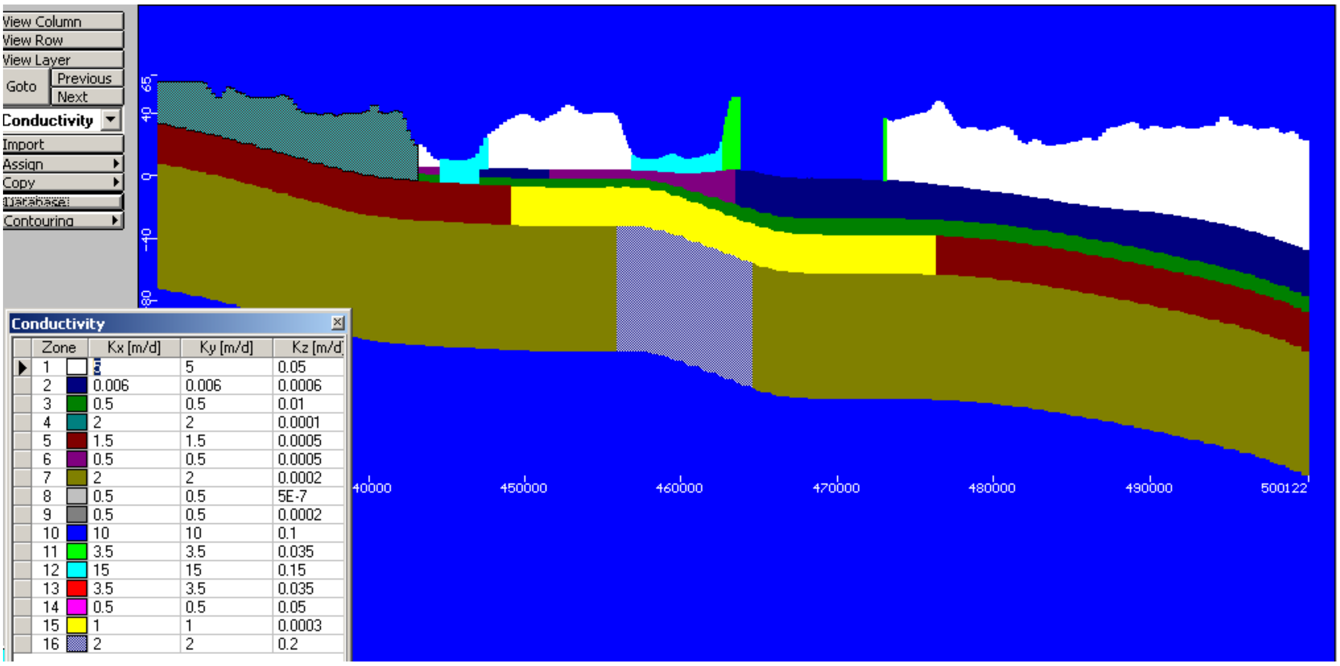

Figure 6 Conductivities applied in model

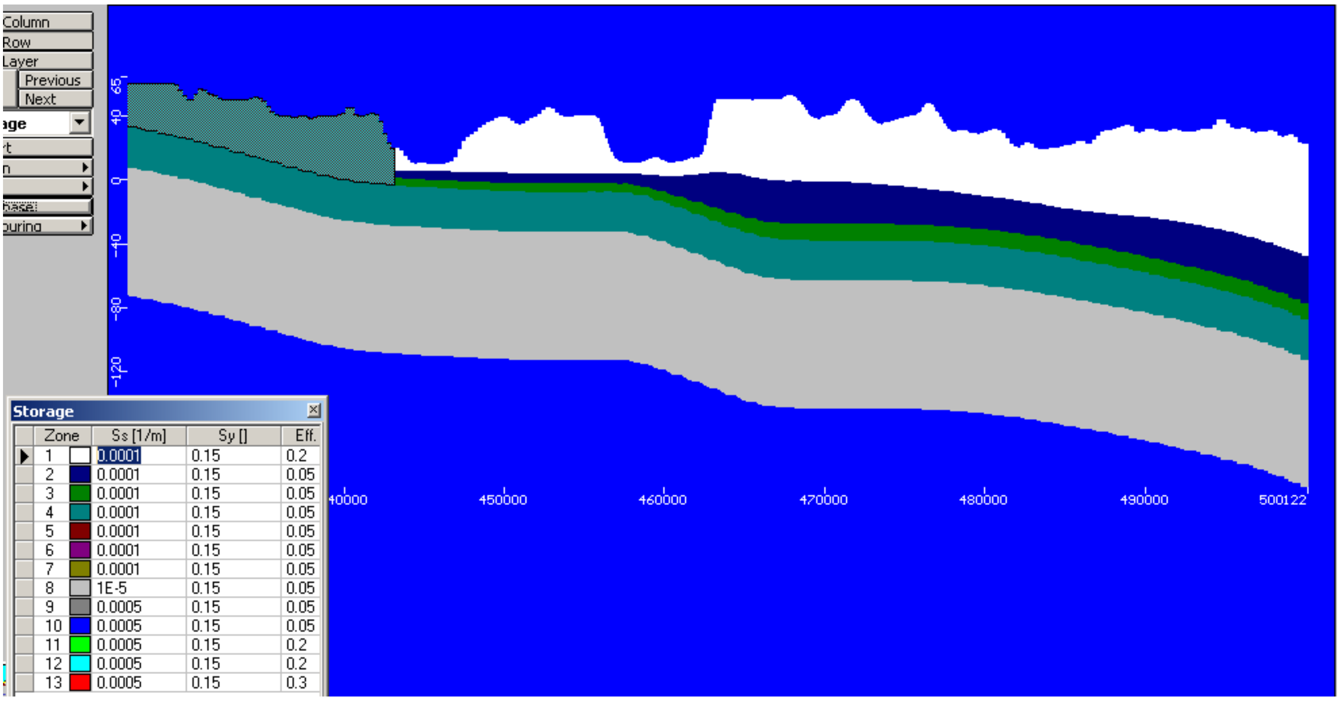

Figure 7 Storage values applied in model

MODELLING RESULTS

For the purposes of this SMMSP project, irrigation induced watertable mounds were not included. The following scenarios were run.

Scenario 1: No intervention – this scenario takes into account the impacts of clearing only, with no mitigation strategies included.

Scenario 2: Revegetation over holes in Blanchetown Clay – this scenario assumes revegetation over holes in the Blanchetown Clay determined by aerial geophysics.

Scenario 3: Revegetation in priority areas determined by the River Murray Dryland Corridor Project (RMDCP) which used the Simpact GIS model.

Scenarios 4 - 6: Revegetation in corridors 5, 10 and 20km wide adjacent to the river valley to compare with results from previous modelling exercises (Barnett et al, 2001).

Figure 8 shows the areas under each scenario.

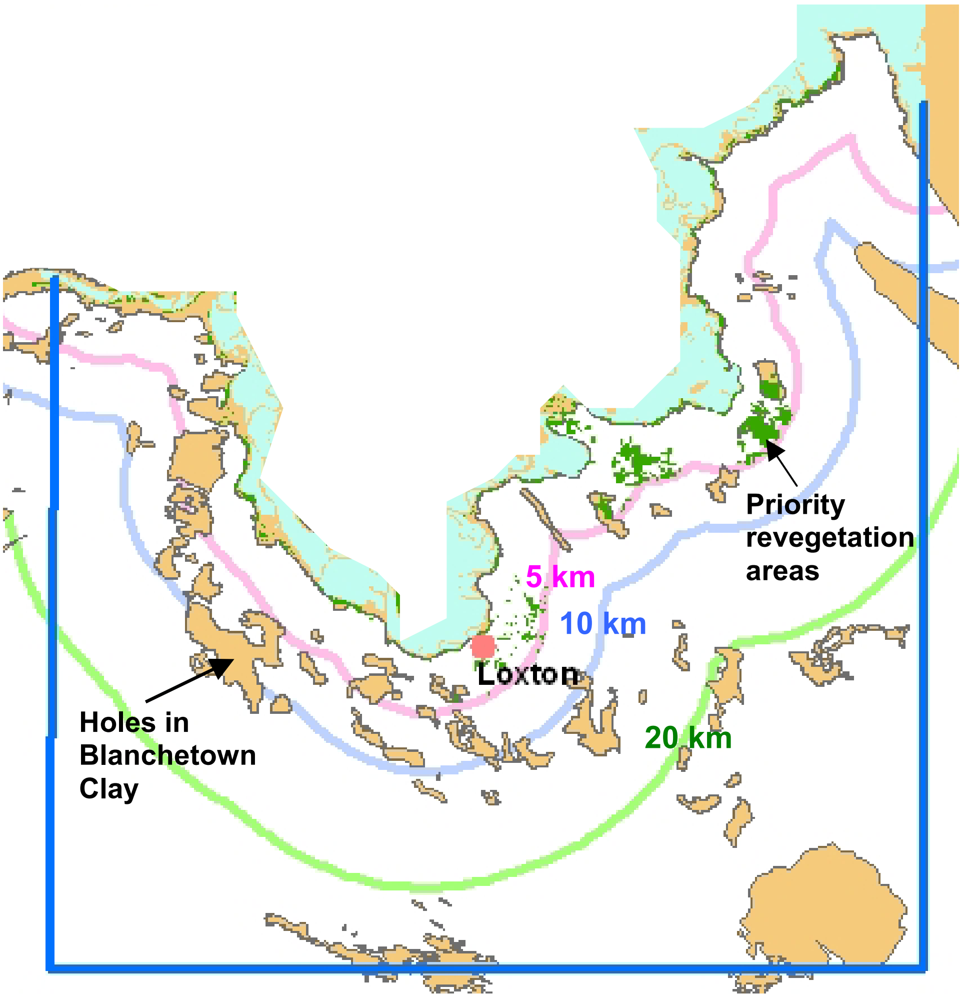

Figure 8 Extent of modelled scenarios

These scenarios have included an assumed time lag between revegetation (which is assumed to have occurred in 2000), and the reduction of recharge rates as seen at the watertable in 2010. The decrease in recharge rates over time following revegetation were estimated using the SIMPACT model. Table 3 shows how the recharge rates reduce over time in these simplified recharge zones.

Table 3 Reduced recharge rates due to revegetation (mm/year)

Year	Z0-Z10	Z20 & Z30	Z11-Z15	Z16-Z19	Z21-Z25	Z26-Z29	Z31-Z40
2010	0.000	0.100	2.205	0.122	5.531	0.170	0.100
2020	0.000	0.100	1.818	0.122	5.531	0.170	0.100
2030	0.000	0.100	1.462	0.122	4.979	0.170	0.100
2040	0.000	0.100	1.126	0.122	3.705	0.170	0.100
2050	0.000	0.100	0.861	0.122	2.783	0.170	0.100
2060	0.000	0.100	0.671	0.122	2.169	0.170	0.100
2070	0.000	0.100	0.539	0.122	1.735	0.170	0.100
2080	0.000	0.100	0.440	0.122	1.412	0.170	0.100
2090	0.000	0.100	0.369	0.122	1.166	0.170	0.100
2100	0.000	0.100	0.316	0.122	0.979	0.170	0.100
2110	0.000	0.100	0.296	0.122	0.909	0.170	0.100
2120	0.000	0.100	0.276	0.122	0.839	0.170	0.100

The modelled total salt loads to the edge of the river valley from the south are presented in Table 4 and Figure 9. As expected, the large scale revegetation would have most impact. Of the more targeted options, revegetation of the holes in Blanchetown Clay would reduce inflows by 14 tonnes/day after 100 years, whereas treating the priority areas delineated by the RMDCP would realize a reduction of 11 tonnes/day. The highest priority areas determined by that project were not within the model extent.

Table 4 Total modelled salt loads to edge of river valley from the south (tonnes/day)

Scenarios	Before Clearance	1995	2020	2050	2100
1. No intervention	154	160	171	193	254
2. Reveg clay holes	154	160	169	187	240
3. Reveg priority areas	154	160	170	188	243
4. Reveg 5 km	154	160	167	172	190
5. Reveg 10 km	154	160	167	168	170
6. Reveg 20 km	154	160	167	167	163

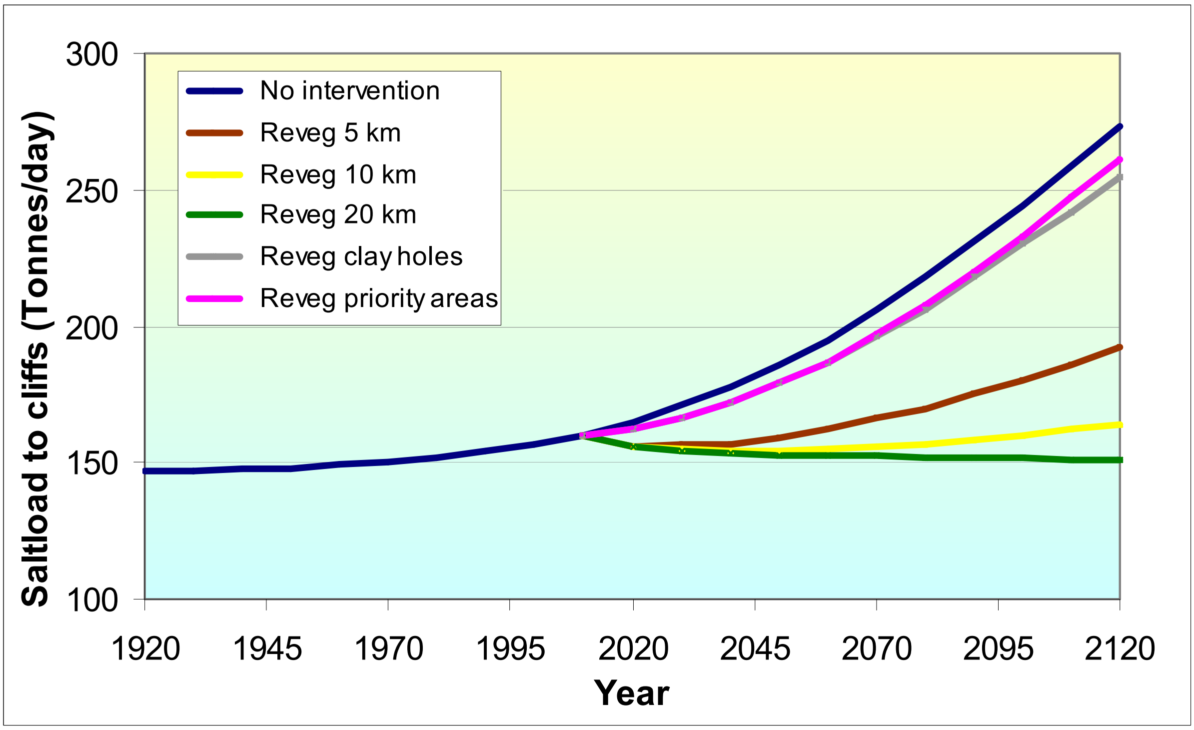

Figure 9 Modelled scenario results

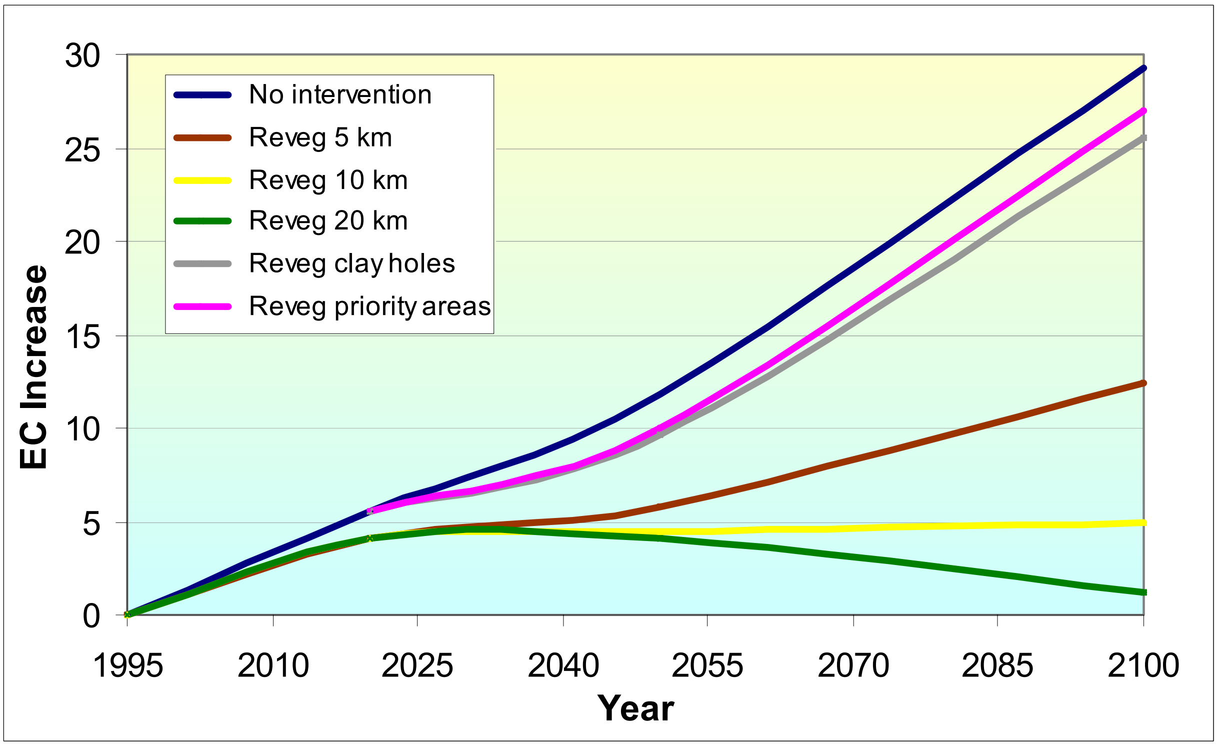

Figure 10 Increase in EC at Morgan for modelled scenarios

Figure 10 depicts the EC increase at Morgan from 1995 as modelled by the MDBC, assuming a 30 % floodplain attenuation factor for the saltloads shown in Figure 9. The no intervention scenario shows an increase of 30 EC by 2100 with no evidence of a decrease in the linear trend of about 0.35 EC/year increase. Intervention options such as revegetating priority areas and holes in the Blanchetown Clay both have a reduction of about 2 EC by 2050, with very little or no real increase in benefit after that.

Revegetation of the 5 km zone has a reduction of 6 EC from the no intervention scenario by 2050 and has an ongoing benefit by reducing the rate of increase to 0.13 EC/year. Similarly, revegetation of the 10 km zone has a reduction of 7.5 EC by 2050, and will maintain EC levels at those reached by 2025. The 20 km zone will have reduction of 7.8 EC by 2050 and will reduce the increases due to clearing to only 1 EC by 2100.

While Figures 9 and 10 depict the overall saltload reductions and EC responses for the various revegetation scenarios, in order to determine the relative efficiency of the scenarios, the saltload reductions per unit area of revegetation were plotted in Figure 11. The surprising result shows that although the total saltload reduction of planting the RMDCP priority areas is small, it has by far the most effective result for the area planted. This is because the areas are located close to the river and are underlain by sandy soils with high recharge rates. Within the model boundary, the main RMDCP priority areas lie behind the Lower Pike irrigation areas which are being investigated for the feasibility of constructing an interception scheme in the near future.

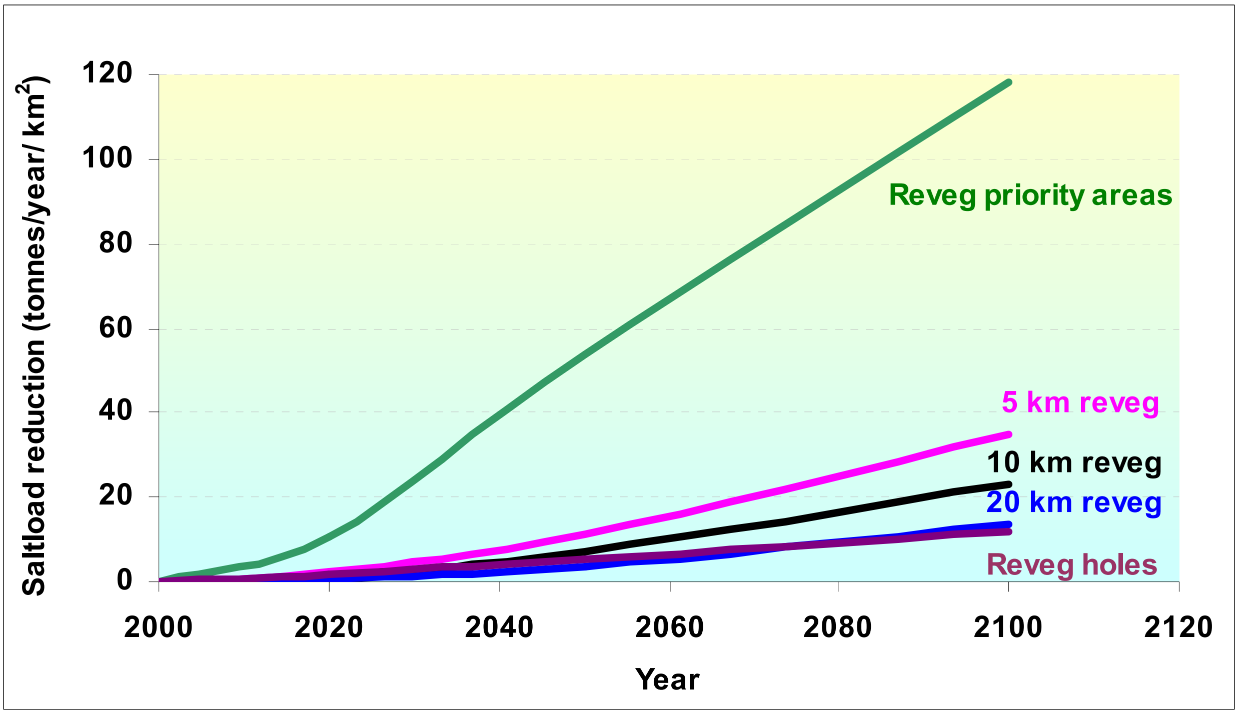

Figure 11 Efficiency of revegetation options

The priority areas used in this exercise where those calculated to give a maximum EC benefit to the river by 2050. The larger areas which would have maximum EC benefit by 2100 were not available at the time for this project.

The treatment of holes in the Blanchetown Clay is less effective because they are further from the river and may not always have sandy soils above them. The presence or absence of Blanchetown Clay is not as critical in determining recharge rates as the presence of sandy soils in the top two metres of the profile.

COMPARISON WITH PREVIOUS MODELLING

Of interest is a comparison with the previous exercise (Barnett et al, 2001), where modelling was carried out by Australian Water Environments between Morgan and the SA Border, using recharge estimates from Cook (1989).

For the no intervention scenario, the current modeling shows a 70 % reduction in salt loads to the edge of the floodplain from the previous modelled prediction. This is due to several factors, with the most significant being improved recharge estimates and a more detailed and better calibrated groundwater model. Figure 12 compares graphically the two model results.

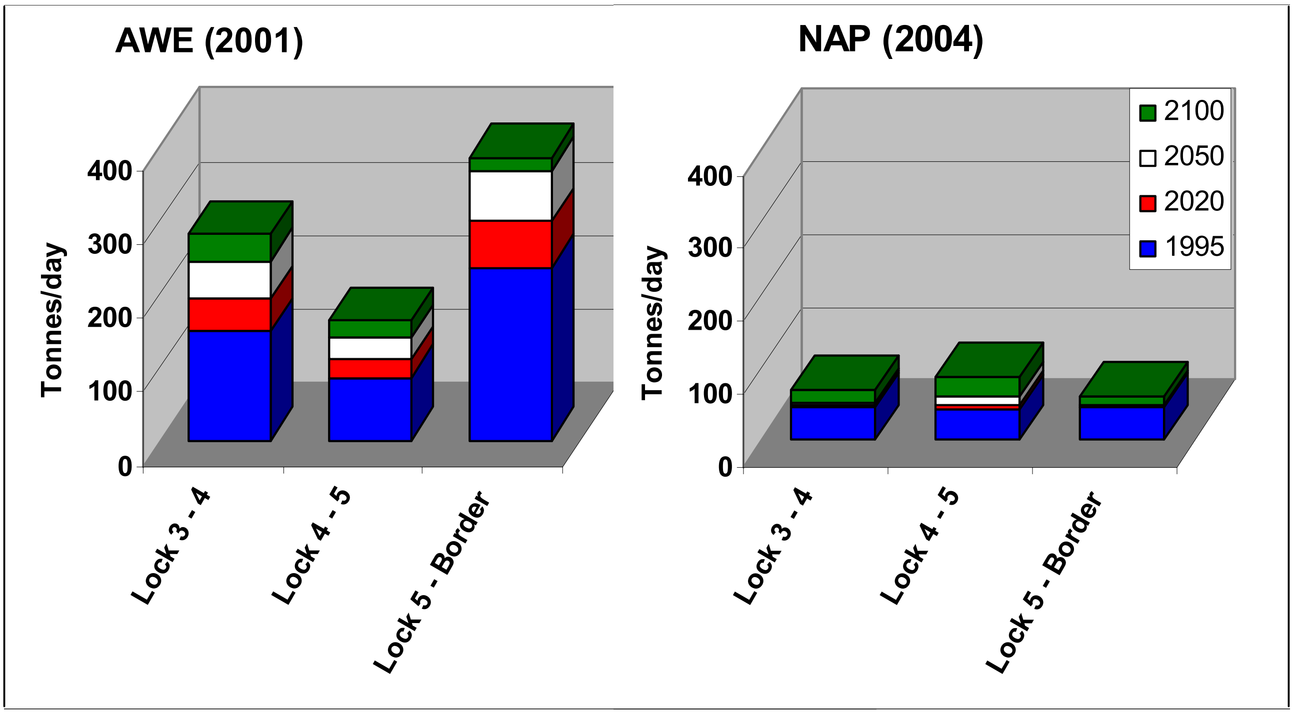

Figure 12 Comparison of no intervention scenario results from AWE and NAP models

MODEL SENSITIVITY ANALYSIS

As mentioned earlier, a steady-state solution was obtained by adjusting hydraulic parameters (hydraulic conductivities, recharge to the top layer, inter-aquifer leakage) and boundary conditions. In this model, the water levels in the unconfined aquifers (Pliocene Sands or Murray Group Limestone), were found to be very sensitive to the recharge rate and hydraulic conductivities in that layer.

The water level calibration for the confined aquifers in the model was found to be sensitive to vertical hydraulic conductivity, which controls rates of leakage between layers.

The sensitivity analysis was also undertaken during the transient calibration processes. The water level changes are more likely dominated by increased recharge and are quite sensitive to specific yield and storativity values.

LIMITATIONS OF THE MODEL

The main limitation appears to be the inability to model the floodplain processes that reduce the final saltload that enters the river from that calculated to enter the edge of the floodplain. Further investigations are needed to quantify the amount of salt intercepted by the floodplain, and how it is later mobilised during high flow events.

It is also recognised that in the model, the calculated inflows to the river valley are very sensitive to the chosen values of hydraulic conductivity for the unconfined aquifer close to the river. For instance, an increase of only 1 m/day in the Loxton Sands aquifer hydraulic conductivity from 1 to 2 m/day, would result in a doubling of the inflows. However, it is considered that the values chosen are consistent with current knowledge.

Given the above uncertainties, it is considered the models' accuracy to be within +/- 50 % at the current level of knowledge. Although this seems at first to be a large error band, it is still sufficient to draw conclusions about priority areas and actions.

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