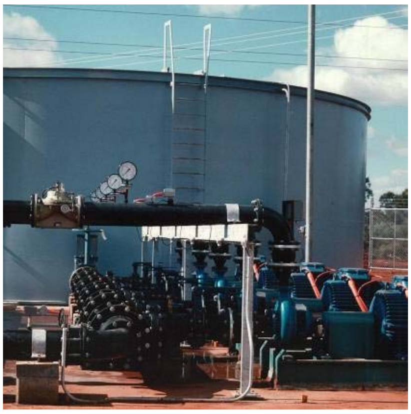
ASSESSING THE SALINITY IMPACTS ON CHANGES TO IRRIGATION ON THE RIVERINE PLAINS - PHASE 3 AND 4 REPORT




ASSESSING THE SALINITY IMPACTS ON CHANGES TO IRRIGATION ON THE RIVERINE PLAINS - PHASE 3 AND 4 REPORT

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EXECUTIVE SUMMARY

This report covers phase 3 and phase 4 of the project 'Assessing the Salinity Impacts on Changes to Irrigation on the Riverine Plains.

The objective of the risk assessment in phase 3 is to develop recommendations with regard to:

- Geographical priority areas/zones/irrigation districts within the Riverine Plains
- Wet climatic sequence versus dry climatic sequence.

This is undertaken as a precursor to drafting a framework to determine the most suitable tools/models that should be employed in the Irrigation salinity assessment framework of Phase 4 of the study.

The development and testing of the proposed ISAF was based on two broad risk parameters:

Spatial variability risks for ISAF

The spatial variability in the salinity impact of irrigation is well known across the Riverine Plains. The key spatial risk is that the ISAF does not adequately identify the spatial variability in salinity processes that create irrigation induced salinity and potential salinity impacts are missed. To assess this risk the salt loads generated by different parts of the Riverine Plains are examined to identify different salinity risk zones. These have been called salinity hazard zones, which is consistent with the terms used in the Victorian Mallee.

Barr Creek justifies a more detailed assessment of the salinity impacts. The later SKM 2008 Barr Creek modelling for CSIRO provides the basis to determine the impacts and shows these impacts are very significant (as much as the Mallee per GL). Given the scale of the potential credit further work would be required in order to justify a full claim.

Alternatively, the model could suggest a low estimate (say 50%) could be conservatively claimed now and the size of the remaining 50% could inform the scale of the additional investigation for this additional claim.

All other areas within the Riverine Plan are low impact and a large change in irrigation volumes is required in order to trigger an accountable action of 0.1 EC.

Temporal variability risks for ISAF

The second risk is related to the temporal variability related to the large influence of climate sequencing on salt generation. The risk here is that the model is developed upon salinity impacts related to a sequence of years that do not represent actual impacts over the longer term. In one sense the operational protocols specify the climatic sequence in the baseline and it is this impact that is used to assess the salinity impacts of irrigation change

Any claims for EC credits arising from changes to water use on the Riverine Plains would require an analysis of the changes in irrigation to define the change. It would also require some certainty that those changes would endure over the long term.

This is problematic. Water entitlements held in association with land holdings no longer reflect usage since people can now hold water separate to land, and usage varies according to climatic sequences and other factors. Therefore it is difficult to differentiate underlying changes in long-term water use from short-term variable changes associated with policy, weather or commercial imperatives.

In Victoria, the total volume of annual use limits on water-use licences in any given irrigation area are very high relative to usage, they are also high relative to potential allocations against water entitlements. Consequently, they are conservative in the sense that if they were to be used as a surrogate for irrigation water usage they would overestimate salinity impacts – unless over time they were somehow reduced to reflect actual usage.

Both Victoria and NSW operate under the Murray Darling Basin Cap on Diversions, and there are agreed and consistent, audited, processes used to define the cap volume and adjustments to it. For example the adjusted cap volume diminishes as environmental water holders acquire water entitlements. This existing process could potentially be used to define changes to water use on the Riverine Plains.

In NSW the issue is much simpler; virtually all general security water is associated with usage in the Riverine Plains (as defined in the brief for this project) – consequently the cap-adjusted volume for NSW Murray general security water reflects more closely the maximum water available for use in the Riverine Plains. The exception will be wetter years when demand is low relative to the irrigation footprint. In NSW, changes in the cap-adjusted volume to NSW Murray reflect real changes in the maximum potential use and have the advantage of being audited and accepted by jurisdictions. The accumulated cap adjustments are a real indicator of change in the volume available for irrigation. The NSW cap falls as water is removed from the consumptive pool to be used, instead, for environmental flows.

In Victoria the changes to the cap-adjusted volume in the Goulburn/Broken/Loddon also reflect real change and could be used in a similar manner to that discussed for NSW. It may be worth disaggregating that change down to individual districts, but this may not be a priority given that irrigation salinity impacts in those districts are all comparably low and the extent of change to date (for example, buybacks and water trade to the Mallee) is relatively evenly spread across the GMID. However, there would need to be consideration of disaggregation for any Goulburn entitlements that are used outside the Riverine Plains e.g. Goulburn entitlement that is used in the Mallee.

In terms of the Victorian Murray, change in the cap-adjusted volume is more difficult to apply meaningfully as a surrogate for actual annual use in the Riverine Plains. The Victorian Murray cap-adjusted volume includes the relatively large volume used for irrigated horticulture in the Mallee and a smaller volume delivered to the Wimmera-Mallee domestic and stock system. Moreover, the total volume used in the Victorian Murray has increased as Goulburn entitlements started to be used in the Mallee. Therefore, this volume needs to be disaggregated between the Victorian Mallee and the Victorian Riverine Plains. The Victorian Riverine Plains needs to be further disaggregated to distinguish between Torrumbarry (both Barr Creek and the rest of Torrumbarry) and the Murray Valley irrigation areas. This process need not be complicated; it could be based on a five-year moving average of usage in each of these areas - as reported in the annual reports from the relevant water authorities. However, defining the baseline conditions for historic usage in each of these areas for the benchmark period would require some examination of historical usage in order to determine the change. If done, this would then be part of the five-year review cycle for register entries. DPI Victoria maintains a GIS database of water use for the GMID that could inform this.

Once the SDLs are fully incorporated into the cap adjustments then there will be lower diversions and a credit claim is potentially possible as the diversions (in Victoria) might be broadly similar to the 2002/3-2008/9 drought sequence when salt exports were very low relative to 'average' climatic years

Draft ISAF

A range of guiding principles were developed in a workshop with the Project Advisory Group. The Draft ISAF was developed from these.

The proposed ISAF is simple, but is based on decades of salinity assessment, modelling and calibration with data across the Riverine Plains. It is:

$$\Delta \text{EC Morgan} = \Delta \text{EC Morgan/GL in zone} \times \Delta \text{GL in zone}$$

Its application involves 3 basic steps:

1) Determine salinity zone and its salinity coefficient ΔEC Morgan/GL
2) Determine irrigation water use change ΔGL for the zone
3) Apply formula.

As previously discussed this provides an assessment of the salinity impact from water departure, but not arrival or transit.

Case studies

The proposed coefficients for evaluating change were then applied to three scenarios that involve a 30% reduction in water use. This being a constant 1,400 GL to meet the Basin Plan SDL from the 2008 cap model run applied to:

1) A 30% reduction involving all of the water coming out of the highest impact zones. (This would involve no irrigation in Barr Creek or Torrumbarry and a significant reduction in outflows from NSW drains.)
2) A 30% reduction spread uniformly across the entire Riverine Plains.
3) All of the 30% reduction coming out of the lowest impact zones.

As a test of the coefficients a further scenario was developed to test an extreme case of nil irrigation (scenario 4) to see how this compared with the total EC impacts of irrigation from BigMod.

The summary of the low and high estimates across the whole of the Riverine Plains is shown in Table 1.1 below.

Table 1.1: Summary of Scenarios

Scenario – GL reductions	Low Estimate & % reduction from BigMod total of 40.8 EC for irrigation drains		High Estimate & % reduction from BigMod total of 63.3 EC (irrig drains+Torrumbarry gwater)	
1) Highest Impacts zones -1400GL	-18.6 EC	-41%	-59.0 EC	-93%
2) Uniformly spread -1400GL	-7.6 EC	-19%	-30.8 EC	-49%
3) All from lowest impact zones -1400 GL	-2.8 EC	-7%	-16.7 EC	-26%
4) All irrigation ceases -4519 GL	-24.5 EC	-60%	-99.4 EC	-157%

The results from the fourth scenario suggests that across the Riverine Plains the low estimate coefficients underestimate impacts as they are only 60% of the irrigation drainage flows from BIgMod. Mostly because of needing to avoid the risk of double counting the Barr Creek Drainage Diversion Scheme.

On the other hand, the high estimate suggests the coefficients may overestimate impacts by 157%. In this case it is likely all areas except for Barr Creek is over estimated.

These potential changes need to be contemplated in the context of the dilution flows associated with the increase of entitlements for environmental flows. Assuming the return of 1400 GL to the environment, the salinity impact of these return flows could involve a potential salinity credit as high as 70 EC. This is significantly higher than the potential benefits of a reduction in irrigation water use in different irrigation districts from a uniform spread (Scenario 2).

There would also need to be some consideration of a policy mechanism in order to 'lock in' the reductions for any potential claim. For example, there is potential to cap the total volume of annual use limits in different parts of the Riverine Plains as has already happened in parts of the Victorian Mallee. This could prevent subsequent back-trade undermining any EC credits claimed against reduced water use in different parts of the Riverine Plains. However, given the significant change currently in train in the Victorian part of the Riverine Plains as a result of the modernisation of the irrigation delivery system it may be prudent to evaluate that potential in say five year's time after the modernisation is complete.

Recommended Decision Framework

The ISAF has been developed to manage risks associated with changes in water use on the RIverine Plains. It is recommended that the decision process shown in Figure E1 be adopted to continuously assess district scale water use changes and to determine what actions are reasonable for partner governments to take to ensure ongoing compliance with the accountabilities set out under the BSMS.

A number of tools are also available to support the decision process including:

- Salinity Impact Coefficients – Figure E1 and Table 1.2
- Cap water use, diversion and trading data – See Phase 2 report for analysis of changes in actual and modeled data.
- BigMod data files and model runs – Phase 1 and Phase 2 reports describe the context for assessing seasonal variability.

Implementation

A number of implementation steps are covered in the Project overview and Summary Report.

Figure E1: Decision process

Table 1.2: Suggested ISAF coefficients for evaluating long-term changes in total water use in the Riverine Plains (assuming no climate change)

Zone	Description	Recommended by SKM in 2006 ∆EC Morgan/GL ∆EC Morgan/GL	Drainage system	Proposed for ISAF in this report for use in calculating changes in irrigation ∆EC Morgan/GL Low estimate (excludes unaccounted salt loads)	∆EC Morgan/GL High estimate (includes part of the unaccounted salt loads)
Green	All areas outside Torrumbarry	0.0 to 0.05. Use 0.0	NSW drains.	0.003 Based on 4.5 EC from BIgMOD NSW drains	0.024 from SKM 2006.
			Murray Valley	0.002 from BigMod (average of 9.8 EC over 4,200 GL)	0.008 from SKM 2006
			Shepparton / Goulburn System	0.002 (average of 9.8 EC over 4,200 GL) from BigMod	0.015 from SKM 2006
Blue	Torrumbarry outside of Barr Creek	- 0.1 EC/GL. Water use reductions increase river salinity	Kerang Lakes area and other parts of Torrumbarry outside of Barr Creek	Could be negative. But changes to the Torrumbarry system make SKM 2006 coefficient of -0.1 EC/GL less certain. **More detailed investigation required.**	Parts of this could be as high as Barr Creek given similar highly saline groundwater & drainage (e.g. irrigation adjacent to Lower Loddon & Pental Island). **More detailed investigation required.**
Red	Barr Creek	0.15 +. Use 0.25	Barr Creek as defined by zones in SKM 2008	0.08 to guard against risk of double counting with Barr Creek Strategy (see next section). This represents the upper bound of the lowest impact zone within Barr Creek.	0.16 from SKM 2008 (see next section. A higher coefficient may be warranted in certain parts of Barr Creek and for increases in irrigation above the baseline.)

There may also be a lag effect between irrigation reductions and EC reductions at Morgan; this could be influenced by the climatic sequence at the time. Although it is expected that the lag effect will be much smaller in the Riverine Plains than the Mallee.

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1. INTRODUCTION

1.1 Project context

RPS Aquaterra and RMCG were engaged by the Murray Darling Basin Authority to undertake and '*Assessment of the Salinity Impacts on Changes to Irrigation in the Riverine Plains'*. The Riverine Plains is defined as the areas upstream of the Murray River at Swan Hill and upstream of the Wakool River at Kyalite. The projects main objectives are to determine how best to identify, characterise and account for irrigation changes on the Riverine Plains in the context of the BSMS and the post 2015 operational plan.

A framework, developed and tested in this report, is to assess the salinity impacts of changes to irrigation water use on the Riverine Plains. This report covers the project phases shown in **BOLD** below:

1. Provide a detailed understanding of Riverine Plains salt loads from the MSM BigMod Model (Phase 1).
2. Gap analysis to codify changes in water use, past and future and how these relate to salinity loads and how they are treated on the registers (Phase 2).
3. **Risk analysis (Phase 3).**
4. **Develop and test the Irrigation salinity assessment framework (Phase 4)**.

The objective of the risk assessment in phase 3 is to develop recommendations with regard to:

- Geographical priority areas/zones/irrigation districts within the Riverine Plains
- Wet climatic sequence versus dry climatic sequence.

This is undertaken as a precursor to drafting a framework to determine the most suitable tools/models that should be employed in the Irrigation salinity assessment framework of Phase 4.

1.2 Description of key riverine plains salinity risks

The tool developed in Phase 4 will be required to account for the change in salt load as a result of change in irrigation. There are two key risks that Phase 3 examines.

Spatial risks

Spatial variability is evident in the salinity impact of irrigation across the Riverine Plains from the Phase 2 report. The risk here is that the framework does not adequately identify the spatial variability in salinity processes that create irrigation induced salinity and potential salinity impacts are missed. To assess this risk the salt loads generated from different parts of the Riverine Plains are examined to identify different salinity risk zones. These have been called salinity hazard zones, which is consistent with the terms used in the Victorian Mallee.

Temporal risks

The second risk is related to the temporal variability related to the large influence of climate sequencing on salt generation. There is significant evidence of seasonal variability as well as longer run trends as shown in the Phase 2 report. The risk here is that the framework is developed upon salinity impacts related to a sequence of years that do not represent actual impacts over the longer term. In one sense the operational protocols specify the climatic sequence in the baseline and it is this impact that is used to assess the salinity impacts of irrigation change.

However, it is clear from the previous Phase 2 analysis that the benchmark sequence did not necessarily represent salt loads from the last decade and current salt generation appears to be much lower post-benchmark. In other words there is a potential risk that salinity impacts could be overstated when relying upon the benchmark sequence.

Therefore, this risk analysis examines salinity impacts for more recent conditions (last ten years) in order to provide some sensitivity around the climatic impacts/temporal variability. On the other hand, we also need to be careful that we do not assume that the last ten years is more representative of the future than the benchmark sequence. It is a source of information that confirms that some flexibility is required for an ISAF that accounts for impacts of water use change.

2. SPATIAL VARIABILITY ASSESSMENT

2.1 Variability identified in BigMod

The spatial variability was identified in the Phase 1 report where the BigMod inputs were unpacked. This identified that of the average salinity at Morgan at 592.6 EC the Riverine Plains contributes 26.1% (154.7 EC). This is shown in Table 2.1 below which is reproduced from the Phase 2 report.

Table 2.1: Relative contributions to Morgan Salinity

Sources for the relative contributions to Morgan salinity	Flow (ML/d)	Salinity (µs/cm)	Salt load (t/d) average over benchmark	Relative contribution @ Morgan (EC)	Relative contribution @ Morgan (%)
TRIBUTARIES (SUBTOTAL)				**59**	**10%**
Goulburn River	4,281	210	465	+16.5	2.8%
Broken Creek	493	178	51	+2.9	0.5%
Campaspe @ Rochester	624	865	253	+7.3	1.2%
Campaspe Rochester to Echuca	-	-	-	+0.9	0.2%
Loddon	714	799	207	+23	3.9%
Billabong Creek and Box Creek	979	352	137	+8.4	1.4%
DRAINS				**50**	**8.4%**
Shepparton drains	243	347 – 929	74	+3.8	0.6%
Campaspe Drains				+1.5	0.3%
Koondrook spillway	-	-	29	+3	0.5%
Barr Creek	160	8,404	763	+31	5.2%
Torrumbarry 6/7 outfall and Lake Boga outfall	284	~2,000	78 + 31.6	+6.2	1.0%
NSW LWMP	65	222 – 3,271	~50	+4.5	0.8%
GROUNDWATER				**45.7**	**7.7%**
Yarrawonga to Torrumbarry	-	-	48	+2.9	0.5%
Yarrawonga to Kyalite	-	-	187	+20.3	3.4%
Torrumbarry to Swan Hill	-	-	282	+22.5	3.8%
TOTAL FOR RIVERINE PLAINS				**154.7**	**26.1%**
TOTAL @ MORGAN				**592.6**	**100%**

The overall impact of 154.7 EC from the Riverine Plains is 26.1% of the total salt impact at Morgan. Impacts from changed irrigation are the focus of this study and so non-tributary items above are where the relationship between irrigation and salinity are important.

The salinity (EC) impacts of drains, tributaries and unaccounted loads (groundwater) from the Riverine are shown in Figure 1 of the Morgan Exeedance Study Report (MDBC 2003), which is reproduced below. A summation on the relative impacts of each of the sources of salinity impact from BigMod is discussed below.

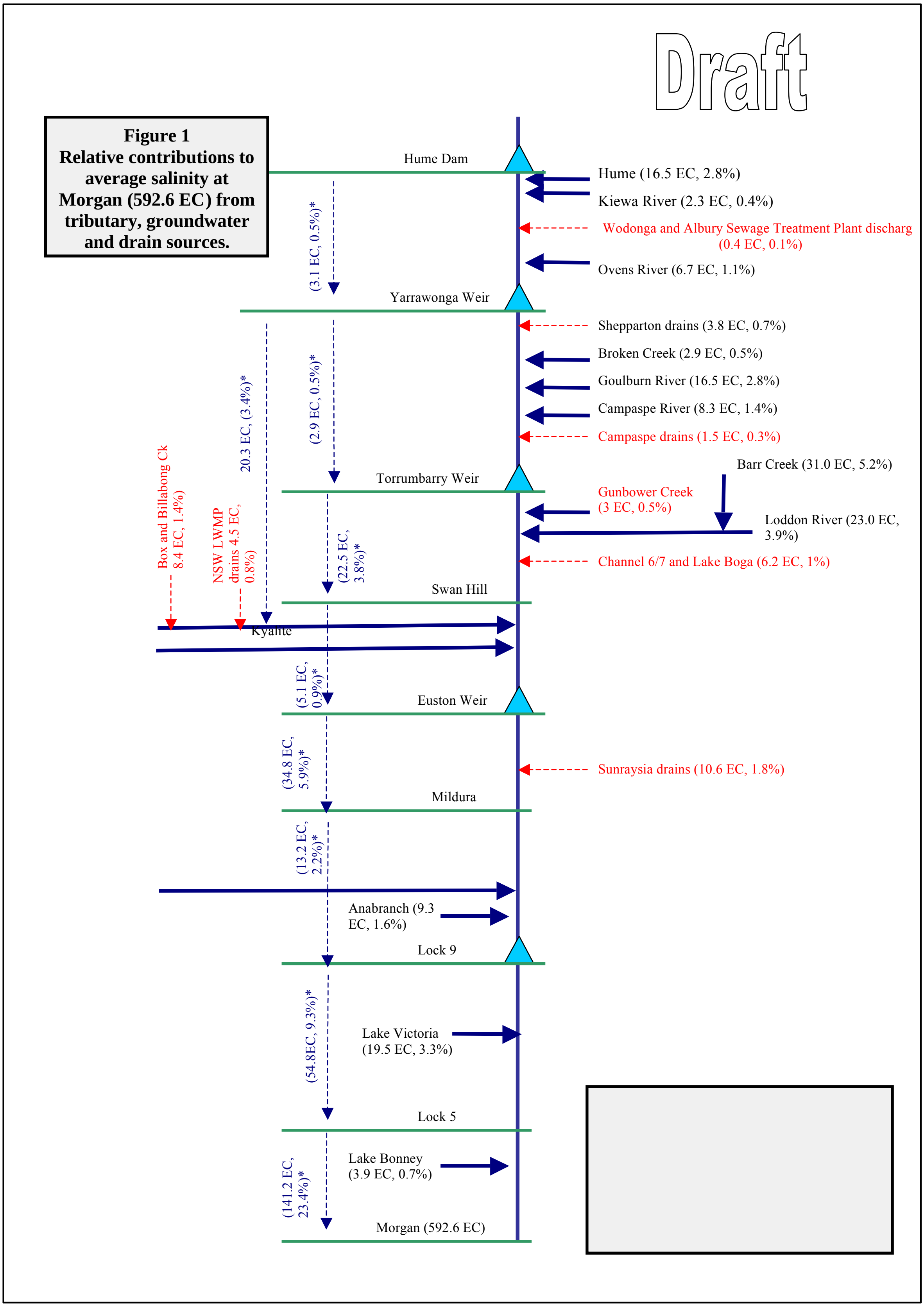

Figure 1: BigMod Schematic

2.1.1 Drains – EC impact by irrigation drain

The total within the Riverine plains for irrigation drains including Barr Creek is 50 EC. Barr Creek represents a significant component of the irrigation salinity impacts at 31 EC.

However, the return flows from Koondrook (3EC) and the 6/7 channel-Lake Boga outfall (6.2 EC) are associated with the management of the Torrumbarry irrigation supply system rather than collected irrigation drainage.

Once these figures are deducted, the irrigation drainage impacts are 40.8 EC of which Barr Creek is 76%.

2.1.2 Unaccounted salt loads/Groundwater – EC impact by irrigation induced ground water

Unaccounted for salt loads are attributed to groundwater. They represent 45.7 EC.

A key river reach is Torrumbarry to Swan Hill, which contributes 22.5 EC. The contribution from the Yarrawonga to Torrumbarry is minor at 2.9 EC and the NSW reach from Yarrawonga to Kyalite contributes 20.3 EC.

Locks and weirs, regional groundwater systems and irrigation recharge can each influence these salt loads. The reach most likely to be influenced by changes in irrigation is the Torrumbarry Reach. This is because the Torrumbarry irrigation district is located in closer proximity to the River and has higher salt loads per kilometre than the reaches in the other areas; being close to the river irrigation is more likely to be able to create a significant driving head of groundwater.

2.1.3 Irrigation supply systems EC impact by system

The salinity impacts from tributaries in the Riverine Plains amount to 59 EC. The Goulburn and Loddon River provide the two largest contributions to this impact.

In the baseline period tributary salt loads and salinities are generally not be influenced by changes in irrigation - except in the Kerang Lakes area where changes in irrigation influence how much salt is intercepted from the Loddon. Somewhat paradoxically reductions in irrigation from the Kerang Lakes area may create a salinity debit, while increases may create a salinity credit.

2.1.4 Impacts of Irrigation

From the above it can be deduced that BigMod treats the impact of irrigation as lying between between:

- Minimum of 40.8 EC for irrigation drains
- An indicative maximum of 63.3 EC for the combination of irrigation drains (40.8 EC) and groundwater from Torrumbarry (22.5 EC). There may be some additional groundwater salinity contributions associated with irrigation in NSW, which would further increase this number. For the purposes of this report the NSW districts have been assumed to have a less of a significant groundwater impact, because the drainage intensity is lower and the NSW districts are further from the river.

This report therefore uses these figures as the upper and lower limits for the salinity impacts of irrigation in the Riverine Plains.

Torrumbarry Irrigation Impacts

Torrumbarry impacts are 31 EC from Barr Creek drains plus up to an additional 22.5 EC from groundwater. The total impact from Torrumbarry therefore is 53.5 EC or 85% of the total 63.3 EC irrigation salt load from the Riverine Plains.

There is also the 6.2 EC associated with Lake Boga and the 6/7 channel and 3 EC from the Koondrook spillway that returns water from the Torrumbarry system, but these impacts may be more associated with the irrigation supply system than irrigation of land and have not been counted as irrigation ‘footprint’ impacts.

Non-Torrumbarry Impacts

According to BigMod irrigation outside of Torrumbarry only generates 9.8 EC from irrigation drainage. This is despite this area using more than 90% of the total water used for irrigation on the Riverine Plains[1]. Therefore, the irrigation areas outside Torrumbarry can be classified as having a very low salinity impact.

The water use in these lower impact areas is around 4,100 GL of gross diversions from MDBA model run of 114 year climate sequence with current cap rules as per Table 2.3 (4,700 GL less 600 GL for Torrumbarry diversions including system losses).

This would suggest a salinity impact of 9.8 EC per 4,100 GL or 0.002 EC per GL, assuming a linear relationship. In other words it would take 50 GL of water use change to trigger an accountable action of 0.1 EC.

Therefore, reduction in irrigation outside of Torrumbarry will have very low impact under the baseline river flow conditions.

BigMod treats Victoria outside of Torrumbarry as having salinity impacts ranging from:-

- 5.3 EC (Shepparton Drains + Campaspe Drains); to
- 8.2 EC (Shepparton drains + Campaspe drains + Broken Creek)

This results from water use of 1,579 GL (Goulburn) + 430 GL (Murray Valley) + 112 GL (Campaspe) +118 GL (Loddon) = 2,239 GL. This is 0.002 to 0.004 EC per GL, but much of the Broken Creek EC impact is from flooding flows rather than irrigation drainage, so the 0.002 EC average is still applicable.

In reality, reductions in irrigation will be accompanied by increased river flows and these river flows will have a significant dilution EC benefit. However, as the destination for this water is unknown, in the current accounting framework these dilution impacts are treated as a separate accountable action. They will generate separate credits that cannot be claimed as being a result of changes to irrigation.

Table 2.2: Potential changes under 2,800GL SDL

Catchment	Baseline diversion (close to Cap)	2,800GL scenario	Reduction in diversion	% reduction
NSW Murray Diversions (GL/yr)	1,696,165	1,179,884	516,281	30%
Vic. Murray	1,654,092	1,160,519	493,572	30%
Vic Murray less LMW/Sunraysia.	1,240,569	870,390	370,179	
Goulburn private (ML/yr)	34,003	21,122	12,880	38%
Goulburn Districts (via EGM)	303,471	205,292	98,179	32%
Goulburn Districts (via WWC)	1,209,680	862,460	347,220	29%
Goulburn urban	18,856	18,210	647	3%
Goulburn Total	1,566,010	1,107,084	458,926	29%

[1] Total use of water applied to land inTorrumbarry is 300-500 GL compared to 3,000-5,000 GL from the Riverine Plains (note the latter figure is total diversions usage would be around 75-80% of this)

Catchment	Baseline diversion (close to Cap)	2,800GL scenario	Reduction in diversion	% reduction
Broken diverters	10,734	10,734	-	0%
Broken urbans	130	130	-	0%
Total Broken	13,172	13,172	-	0%
Goulb-Broken diverters	44,737	31,857	12,880	29%
Goulb-Broken Districts	1,513,151	1,067,752	445,399	29%
Total Goulb-Broken diversions	1,579,182	1,120,256	458,926	29%
Loddon diverters (ML/yr)	13,062	8,491	4,571	35%
Loddon Districts	5,520	5,520	-	0%
Loddon to WWC	97,310	65,875	31,435	32%
Loddon Total	118,560	82,561	35,999	30%
Campaspe diverters	22,638	14,531	8,107	36%
Campaspe diverters	31,163	20,041	11,122	36%
Campaspe to WWC	14,341	7,449	6,892	48%
Campaspe urban	2,112	2,137	-25	-1%
Campaspe to Colban	42,074	35,906	6,169	15%
Campaspe Total	112,329	80,064	32,265	29%
Total Riv.Plains (ML)	4,746,805	3,333,154	1,413,650	30%

2.2 Linking spatial variability with salinity processes

URS *et al* report

URS *et al* 2004[2] working for the Murray Darling Basin Commission examined extending the use of a SIMRAT type model, which had been developed for the Mallee zone, into the Riverine Plains

There are some key lessons from this study that can inform the proposed ISAF. These are:-

- Rapid assessment approach. When several parts of the analysis are equally important there is no point in improving the accuracy of any part of the analysis beyond the accuracy afforded to the least accurate part.
- Salinity impacts are based on departure and arrival of water. But arrival impacts are separately assessed e.g. by the Mallee for new development, or by the environmental water manager when water is purchased for environmental use.
- In the ISAF we are interested in the departure impacts, but cannot assess transit or arrival impacts, because they are unknown.
- Due to relatively similar geology, property scale and land use it is believed that it is possible develop salinity impact indices in the form of ΔEC Morgan per GL change in or out, to whole drainage catchments, or large parts thereof.
- On the input side of the hydrologic system, the key component is applied irrigation water. Irrigation and rainfall that does not runoff infiltrates to the root zone and is removed by

[2] Tools for assessing salinity impacts of interstate water trade in the Southern Murray Darling basin- SIMRAT a spatially distributed rapid assessment tool for Nyah to Lake Alexandrina -Scoping of a rapid assessment tool for the Riverine Plains. Prepared for the Murray Darling basin Commission. June 2004 by URS, AWE, DEH, SKM.

evapotranspiration. The head of the watertable above the drain invert determines groundwater inflow into the drain. This model was used to develop salinity impacts in the form of ∆EC Morgan per GL change for Shepparton and Barr Creek.

- Barr Creek is the main arterial drain in a surface drainage system that comprises 650 km of constructed drains, and serves some 65,000 ha of irrigated land, in the vicinity of Kerang, Koondrook and Cohuna. The catchment had a high watertable for 80 years. Groundwater salinities are high at 15,000 to 30,000 mg/L. Available data includes more than 40 years of continuous flow and salinity records at the outflow point and monthly groundwater data. Modelling has shown that the major proportion (about 85%) of the salt load exported via the Creek comes from direct groundwater intrusion into the drains, and most of the remainder from rainfall wash-off of salt accumulated in discharge zones.
- The salinity of shallow groundwater, therefore, is a major determinant of the salinity risk from irrigation.
- There is likely to be a lag effect for ground water to respond to changes in irrigation.
- There is great variation in groundwater salinities (2,000 mg/L for Shepparton, 22,000 mg/L for Barr Creek), but despite this the processes are similar:-.
    - The calibrated Shepparton model concluded that tailwater was 240 to 390 EC (3x applied water salinity). Barr Creek irrigation tailwater at 400 EC, is also 3x applied water EC. Except for the first irrigations in autumn, which are higher salinity due to salt accumulation from discharge zones. The generally very low tailwater salinities suggest that tailwater is not a significant factor in salt load export from drained catchments.
    - That salinity of rainfall runoff is a function of groundwater salinity. Rainfall Runoff Salinity is 10% to 15% of groundwater salinity. For example, in the Lockington Catchment groundwater salinity is 5,000 EC, while the rainfall runoff salinity is 750 EC. This means that one of the more significant sources of salt export (rainfall runoff) is directly related to groundwater salinity.
    - The "head versus direct groundwater discharge relationship" is a linear relationship. Both Barr Creek drainage and Shepparton drains have unit groundwater discharges of the same order of magnitude, especially in the region of heads of 1.0 to 1.5 metres.
- Possible drivers of salinity impact are irrigation intensity, groundwater salinity, drain depth, water use ML/ha of pasture (or crop), discharge to or from a deeper aquifer system, soil permeability and standard of irrigation management.
- The report concluded that groundwater salinity is the biggest determinant of salt export changes following water trades in the Riverine Plains, and that an index of River salinity impact can be related to groundwater salinity.
- The report derived a relationship simply by plotting the Barr Creek total impact per 1,000 ML/year of irrigation usage (0.145 EC per 1,000 ML), and running a straight line back to near the zero point (but allowing for the salt load in irrigation tailwater).
- When the other factors are taken into account the result might be a family of curves/lines.
- URS et al 2004 also identified that:
    - For areas with average groundwater salinities less than 2,000 mg/L the salinity effects of transfers can probably be ignored.
    - Where the average groundwater salinity is between 2,000 mg/L and (say) 10,000 mg/L, a simple index of ΔEC Morgan per 1,000 ML/year can probably be used safely.
    - For average groundwater salinities higher than around 10,000 mg/L then a more specific model should be considered. The advantage of modelling is that it could help determine

the time lag effects[3].

- The salinity impact of drainage is different in the Victorian Tragowel Plains Irrigation Area. High salt loads existed prior to drainage and are mobilised by flooding and this is a special case.
- The impacts of water trade out of the Kerang Lakes Area can create salinity credits as irrigation acts as salt interception of saltier Loddon flows that would otherwise reach the Murray. This is also a special case.

2.3 Geographic hotspots

In 2010 The Victorian Department of Sustainability and Environment, commissioned Tim Cummins & Associates to review salinity costs associated with irrigation across northern Victoria. The study reviewed recent reports and from these estimated the indicative salinity impacts for different geographical zones. The summary table is reproduced Table 2.3 below.

Table 2.3: Indicative salinity ranking across Northern Victoria

Reviewed zones	Salinity Impact (EC) per 1,000ML of water used [1]	Reduction in water use volume required to trigger BSMW accountable action (0.1EC credit)
Mallee LI1	0.0	N/A
Shepparton Drainage	0.0005	200,000
Loddon Drainage	0.0005	200,000
Pyramid Creek Drainage	0.002	50,000
Calivil Creek Drainage	0.003	33,333
Shepparton Groundwater Pumps	0.014	7,143
Mallee LI2	0.02	5,000
Tragowel Plains	0.02	3,571
Mallee LI3	0.05	2,000
Sunraysia Drains to the River only	0.053	1,887
Mallee LI4	0.07	1,429
Barr Creek Deep Green	0 – 0.08	1250
Mallee LI5	0.10	1000
Barr Creek Light Green	0.09 – 0.15	667
Mallee LI6	0.15	667
Mallee LI7	0.20	500
Barr Creek Amber	0.16 – 0.27	370
Mallee HI1	0.30	333
Mallee HI2	0.35	286
Mallee HI3	0.40	250
Mallee HI4	0.45	222
Mallee HI5	0.50	200
Barr Creek Orange	0.28 – 1.21[2]	82

[3] a model of removal of irrigation can re-balance the groundwater discharges between drain discharge, and surface discharge, which is washed off by rainfall. Groundwater that is drain discharged adjust relatively quickly to change, while surface discharge can take years.

[1](Note: Barr Creek figures may double count catchment strategy and channel seepage EC benefit)

[2]Keith Collett, pers. comm..advises that there was only one cell at the upper end of this range.

This table represents the maximum impact as it assumes that groundwater and drain flow response from ceasing irrigation is instant and linear. In reality, there may be a lag (hysteris) period between ceasing irrigation and groundwater responding and there may be threshold points that result in a non-linear response between change in irrigation and salt exported. For example, groundwater levels beneath drains.

Nevertheless, they do provide a strong indication that the impacts outside of Torrumbarry, and Barr Creek in particular, are small while within Barr Creek there are areas where salt impacts are as significant as parts of the Mallee zone.

The Kerang Lakes parts of Torrumbarry are a salt sink for salt imports from other areas, specifically the Loddon Catchment and Pyramid Creek. That means it serves the function of absorbing other areas' salt and effectively immobilising it in natural waterbodies (and evaporation basins) or in the groundwater system of the undrained areas. If irrigation reduces in the Kerang Lakes due to water trade, that means the area performs less as a sink, and extra salt may finds its way to the Murray. This phenomenon has been modelled in the REALM model of the Kerang Lakes, including for the case where a through flow and outfall to the river is maintained in the Lakes to control their salinity for users. See "Future Land Use in the Kerang Swan Hill Area", Rendell McGuckian et al, January 2003.

The Kerang Lakes modelling shows that for the case of maintained through flow, and water trading down river to Sunraysia, the adverse impact at Morgan would be 0.04 EC per 1,000 ML/year of usage traded. However, the Pyramid Creek salt interception scheme was implemented after this modelling was completed. The current impact would, therefore, be expected to be significantly lower. Nevertheless, declining irrigation usage in the Kerang Lakes area would still be expected to increase river salinity. What this suggests is that In other words Torrumbarry's main salinity impact comes from the Barr Creek catchment (which is <<0.04EC/ 1,000ML).

SKM 2008[4] mapped and modelled Barr Creek salinity impacts from water trade as part of the CSIRO 2008[5]. The four zones were:-

- Deep green 0 to 0.08 ΔEC Morgan per 1,000 ML/year
- Light green 0.09 to 0.15 ΔEC Morgan per 1,000 ML/year
- Amber 0.16 to 0.27 ΔEC Morgan per 1,000 ML/year
- Orange 0.28 to 1.21 ΔEC Morgan per 1,000 ML/year

The outputs of the study provided zoning on a pod and property basis.

DPI Victoria, as part of the work by Tim Cummins and Associates in 2010, calculated estimates of water use in a 100% allocation year (2004/5) by zone in 2008 from their GIS system for each of the above zones and this is produced below in Table 2.4. This estimate was based on water entitlements held.

[4] Torrumbarry System Salt Export Mechanisms from the Barr Creek Catchment – SKM Final 17 January 2008.

[5] 'Targeting Environmental Flow Sourcing for Multiple Benefits R2-14' Jeffery Connor, Neville Crossman, John Ward, Andrea Cast, and David Summers Water for a healthy Country Flagship Report, June 2008.

Table 2.4: Water use estimates for the Barr Creek catchment

Barr Creek zone	Water use	
	High estimate for 2004/05	Low estimate for 2004/05
1 green	101,097	82,962
2 light green	84,085	69,077
3 amber	58,184	45,481
4 orange	31,278	20,613
Total	**274,644**	**218,133**

This data indicates that if water use were to halve (from the average of the values above) the EC benefits would be as shown in Table 2.5:

Table 2.5: Indicative changes to benefits in Barr Creek with reduced water

Barr Creek zone	Reduction in water use (ML)	Average EC reduction per GL	EC reduction
1 green	46,015	0.04 (mid value)	1.8
2 light green	38,291	0.12 (mid value)	4.6
3 amber	25,916	0.215 (mid value)	5.6
4 orange	12,973	0.27 & 0.75 (done at minimum and mid values as only a few cells at max level of 1.21)	3.6 to 9.7
Total	**123,194**		**15.6 to 21.7**

These numbers are broadly consistent with the 31 EC total impact apportioned to the Barr Creek drainage from the unpacking of BigMod. Therefore, this along with the other studies reinforces the view that Barr Creek remains the only high salinity impact area on the Victorian side of the Riverine Plains.

2.4 Variability in the NSW Murray Riverine Plains

Murray Irrigation produce annual compliance reports to meet their licence requirements with the NSW Office of Water (NOW) and the NSW Office of Environment and Heritage. These annual reports provide salinities flows and salt loads for monitored drains and outfalls. However, the reported drains do not necessarily relate to the salt exports that impact upon river salinity. They also do not compare this against the salinity loads during the benchmark period of 1975 to 2000.

Therefore, we have relied upon the NSW Office of Water, 2009[6] . The objective of this report was to model salt exports from the NSW Murray Irrigation Districts to determine the impact of the Land and Water Management Plans (LWMPS) on the river EC at Morgan under the BSMS protocols.

Under the protocols each State is responsible for actions taken after 1 January 1988 that significantly affect river salinity. The change in salt loads from 1988 was modelled for this region, for a range of 'No Plan' and 'With Plan' scenarios.

The model runs indicate there is a B register debit. In other words, there is expected to be increasing salinity impacts arising from pre 1988 conditions not yet expressed in the river.

Instead, the A register item for the implementation of the LWMPS, which include additional drainage and a package of other actions, was calculated as the reduction in the B register item as a result of the LWMPs.

The B register item was not considered satisfactorily resolved to list on the Register. This was described in section 3.3.2 of the Report and is reproduced below:

> *"The salinity assessment for the BSMS is based on the differences in flows and salt loads between two different scenarios. Entries to Register A are based on the differences of an action (e.g., the Plans) relative to a baseline. The BSMS baseline is a continuation of the assessment from the Salinity and Drainage Strategy that is compared with the physical conditions that existed on 1 January 1988. Register B records the 'legacy of history', which describes the post 2000 impacts of pre 1988 actions.*
>
> *The eight scenarios simulated here are designed to provide information to calculate the salinity changes for an entry onto Register A. At this point, there has been no consideration of the potential use of this methodology for use in assessing legacy of history impacts (Register B.) This is consistent with the approach to develop relevant methodology for the Mallee (both A and B Register) prior to considering the more complex irrigation settings, which characterise the Riverine Plains. To date the B Register Mallee entry has not been satisfactorily resolved."*

The 'with plan' scenarios were modelled by reducing recharge to the shallow aquifer, which resulted in lower groundwater levels and reduced salinity exported into drains. The 'with plan' scenarios also had a higher percentage of the Berriquin and Wakool catchments draining, and as a result, much larger volumes of water flowed from these catchments.

Overall the 'with plan' produced additional salt loads compared to the 'no plan' scenario, mainly because additional runoff drained from the areas. However, the flow increased significantly, and as it was of lower average salinity than the other flow components, the net effect was a reduction of 4.01 EC units at Morgan. This is detailed below:

- 'No Plan" has an EC increase of 4.92 EC above 1988 levels (in effect the potential B Register item)
- 'With Plan' has an EC increase of 0.91 EC above 1988 levels
- EC benefit of Plan = 4.92-0.91 = 4.01 EC (listed A register item)

6 NSW Murray Irrigation Limited Land and Water Management Plans Salinity Assessment. Prepared by Richard Beecham and Perlita Arranz Water Management Division NSW Office of Water.

Using this interpretation of the modelling results, this approach appears to be different to other riverine plains register entries, such as that for Shepparton drainage, which examines the salinity impact of an action based on the salinity and flow mobilized by the construction of the drain post 1/1/1988.

Instead the NSW approach attributes some of the post 1988 increase in salt load to irrigation works prior to 1st January 1988 and this has not yet been expressed by the year 2000 (Register B debit). The impact of the post 1988 actions under the LWMPS ('With Plan') is that this salt load will be reduced by the amount listed in the Register A item.

More detail of the modelling scenarios run by NSW Office of Water, 2009 is produced below.

Table 2.6: Scenarios modelled for NSW Impacts

Scenario		Physical conditions modelled		
		Starting GWL	Drainage development	Management Practices
1	Baseline BSMS	1988	1988	1988
2	Land and Water Management Plan baseline	1995	1995	1995
3	1995 without plan	1995	1988	1988
4	1995 without plan drains	1995	1988	2000
5	1995 with plan	1995	2000	2000
6	Impact of 1995 drains with 1988 starting groundwater water level	1988	1995	1988
7	Impact of 1988 drains with 2000 starting groundwater water level	2000	1988	1988
8	2000 with plan	2000	2000	2000

The various modelling scenarios can be compared for the effect of either:

- Starting groundwater levels (S1 v S3 v S7);
- Other plan elements not including drainage (S3 v S4);
- Extent of drainage alone (S2 v S3 v S5, or S6 v S1); and
- Full plan (S7 v S8, or S5 v S1).

Depth to water table maps show that the modelled scenarios consistently produced more areas of high water table than was observed (except for Wakool). This suggests the EC impacts may be overstated. The modelled EC impacts for each scenario are reproduced below in Table 2.7.

Table 2.7: NSW impact scenarios

Scenario No.	1	2	3	4	5	6	7	8
Water table condition	1988	1995	1995	1995	1995	1988	2000	2000
Plan in place (Y/N)	N	N	N	Y	Y	N	N	Y
Drainage conditions	1988	1995	1988	1988	2000	1995	1988	2000
		∆ EC relative to Scenario 1						
Berriquin	-	0.79	2.17	3.01	-0.01	-1.32	1.94	-0.53
Denimein	-	0.47	0.47	0.14	0.14	0.00	0.67	0.12
Cadell	-	2.48	2.48	1.53	1.53	0.00	2.79	1.45
Wakool	-	0.66	0.66	0.79	0.47	0.00	-0.27	-0.19
Combined	**-**	**4.35**	**5.59**	**5.37**	**2.19**	**-1.20**	**4.92**	**0.91**

The A register entry of 4.01 EC for the LWMPs is based on s7 – s8, which is an impact of 4.92 EC (no plan addition to the 1988 baseline, in effect the unlisted B register item) less 0.91 EC (with plan addition to the 1988 baseline).

The reduction in the B register item is due to the mechanics of the LWMP, in targeting reduced groundwater accessions from waterlogged areas. This results in relatively low salinity water partly from catchment runoff bypassing the previous landlocked areas, which contributed to the groundwater accessions and shallow watertables.

The EC impact of the 1988 baseline (Scenario1) in Table 6.3 of NSW Office of Water 2009 is not calculated in the report, but Table 6.2 in the report does provide the salt loads. The combined total salt load for Scenario 1 (1988 BSMS baseline) is 44,600 t/y.

Extrapolating the change in salt loads with change in EC used in the Reports modelling suggests an impact using specific catchment ΔEC/GL relationships of 16.7 EC. This is calculated in Table 2.8 below.

Another way to estimate the EC impact of 44, 600t/y is to use the Morgan Salinity Impact Ready Reckoner (Figure 2). 44,600/t/y is 122 t/d or around 14.7 EC (see chart below for 12 EC per 100t/d at Swan Hill) assuming a uniform distribution.

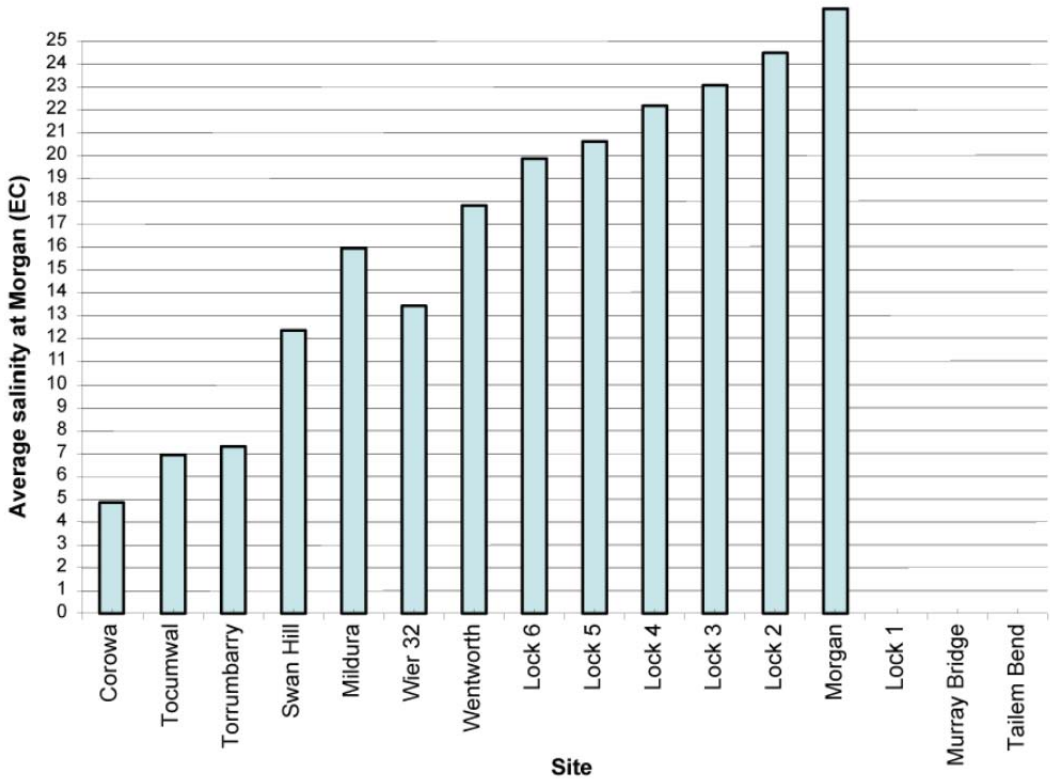

Figure 2: Morgan salinity impact Ready Reckoner

Both the 16.7 EC and 14.7 EC are higher than the BigMod number of 4.5 EC for NSW drains, which has a salt load of around 18.25kt/y (based on 50t/d in Table 2.1).

Therefore it is suggested that the EC impact of irrigation for the baseline period is 4.5 to 16.7 EC. The average annual diversion for this period is 1,531 GL (range 900-2,000 GL), of which an average 81% (range 72-85%) is delivered to irrigation farms.

The indicative EC impact per GL is therefore:

- 4.5/1,531 = 0.003 EC/GL; to
- 16.7/1,531 =0.011 EC/GL.

SKM (2006) derived a factor of 0.012 EC/GL for NSW drains, but also said that due to the large unaccounted salt load that is unmonitored this could be doubled to 0.024 EC/GL.

Some of the individual catchments vary by quite large factors and across scenarios depending on the amount of dilution of drainage flows. This is shown in Table 2.8 that calculates ΔEC versus change in Kt/y of additional salt across all scenarios and drains. The data from the model runs have been derived from NSW Office of Water, 2009.

Table 2.8: EC impacts from annual salt loads derived from NSW Office of Water, 2009

		Model run kt	EC impact of scenario 1	EC Impact of scenario 1	Determination of EC impact from specific catchment factors		
					Model run additional salt load	Model run additional EC impact	Derived EC impact per Kt
scenario		annual salt load	using average of 12 EC/100t/d ready reckoner	EC impact using specific catchment factors listed from far right column for Scenario 1	above scenario 1	above scenario 1	
1	Berriquin	25.5	8.4	4.29 using 0.168	0	0	
2	Berriquin	40.9			15.4	0.79	0.051
3	Berriquin	38.4			12.9	2.17	0.168
4	Berriquin	35.5			10	3.01	0.301
5	Berriquin	48.9			23.4	-0.01	0.000
6	Berriquin	28.1			2.6	-1.32	-0.508
7	Berriquin	36.4			10.9	1.94	0.178
8	Berriquin	44.7			19.2	-0.53	-0.028
1	Cadell	5.7	1.9	2.02 using 0.354	0	0	
2	Cadell	12.7			7	2.48	0.354
3	Cadell	12.7			7	2.48	0.354
4	Cadell	9.6			3.9	1.53	0.392
5	Cadell	9.6			3.9	1.53	0.392
6	Cadell	5.7			0	0	
7	Cadell	13.4			7.7	2.79	0.362
8	Cadell	9.3			3.6	1.45	0.403
1	Denimien	2.9	1.0	0.52 using 0.181	0	0	
2	Denimien	5.5			2.6	0.47	0.181
3	Denimien	5.5			2.6	0.47	0.181
4	Denimien	2.4			-0.5	0.14	-0.280
5	Denimien	2.4			-0.5	0.14	-0.280
6	Denimien	2.9			0	0	
7	Denimien	6.8			3.9	0.67	0.172
8	Denimien	2.3			-0.6	0.12	-0.200
1	Wakool	10.5	3.5	9.90 using 0.943	0	0	
2	Wakool	11.2			0.7	0.66	0.943
3	Wakool	11.2			0.7	0.66	0.943
4	Wakool	8.1			-2.4	0.79	-0.329
5	Wakool	10.1			-0.4	0.47	-1.175
6	Wakool	10.5			0	0	
7	Wakool	7.9			-2.6	-0.27	0.104
8	Wakool	7			-3.5	-0.19	0.054
Total baseline 1988 scenario 1 impact		44.6	**14.66**	**16.73 (sum of above)**			

Table 2.9 shows the impact of the baseline for each of the LWMP areas.

Table 2.9: Salinity impacts associated with Annual Salt Loads derived from NOW 2009

District	Modelled water use (ML)	Baseline ready reckoner	EC/GL	EC for Catchment specific model	EC/GL
Berriquin	787	8.4	0.011	4.3	0.005
Denimein	92	1.9	0.020	2.0	0.022
Cadell	165	1.0	0.006	0.5	0.003
Wakool	311	3.5	0.011	9.9	0.032
TOTAL	1,355	14.7	0.011	16.7	0.012

The large variation in EC/GL does not give confidence to separate the combined figure for NSW drains down to a coefficient on a per catchment basis. Overall though, it is a similar order of magnitude as the 0.012 EC/GL to 0.024 EC/GL proposed in SKM 2006 (see following section).

It would be expected that there would be higher EC/GL coefficients numbers for Wakool in the western region. This is because the groundwater salinity is much higher in the western end of the region.

2.5 Existing spatial variability modeling

In 2006 SKM undertook a detailed analysis of salt loads from the Riverine Plains for the Murray Darling Basin Commission. The report was called Riverine Plains Drain Salt Loads- Analysis of Modelling Results to Estimate Salinity Impacts.

It established the scale of unaccounted salt loads as per Table 2.10 below

Table 2.10: BigMod unaccounted salt loads

River Reach	Unaccounted salt load (t/yr average)	Approximate reach length (km)	Average salt load (t/km/yr)
Hume to Yarrawonga	24,900	237	105
Yarrawonga to Torrumbarry	17,600	358	49
Torrumbarry to Swan Hill	101,600	220	462
Edward / Wakool	65,700	339	194
TOTAL	209,800	1,154	182

Note:

1) The distance for each reach was calculated based on the information contained within MSM-BigMOd.

2) The length of the Edward/Wakool reach (Yarrawonga – Kyalite) was calculated based on the Edward River between Edward Escape and Kyalite. However, it is likely that some salt would also be sourced from Wakool River in this area, which has not been incorporated in this calculation of river length

The study used BigMod and other sources to establish the EC impacts per GL for the purpose of assessing the impact of trade. It is an important report that was based on decades of studies and key results and conclusions are reproduced below including the salt loads from individual systems:

Table 2.11: Salt Load Discharge from Irrigation Areas

Time Period	Torrumbarry						Murray Valley				Shepparton							NSW					
	Barr Creek (@ Capels)	Koondrook	Loddon River (Kerang Weir)	Lake Boga outfall	6/7 channel outfall	TOTAL	MV Drain 3	MV Drain 6	Broken Creek (@ Rice's Weir)	TOTAL	Yambuna Drain	Warrigal Creek	Deakin Drain	Lockington / Bamawm Drain	Mullers Creek	Goulburn River (@McCoys)	TOTAL	Box Creek (Conargo Rd)	Lalalty Drain	DC 100 Drain	Nlemur Outfall	Deniboota EScape	TOTAL
Benchmark Period (1975 – 2000)	192,011	11,951	74,704	33,248	34,232	346,146	983	3,801	17,471	22,255	47	4,844	8,730	6,844	889	61,456	82,810	5,656	8,887	748	8,303	1,735	25,329
Average (1975 – 1984)	167,536	10,150	78,505	36,164	33,187	325,542	548	2,454	13,695	16,697	55	3,989	4,897	5,341	888	62,469	77,639	1,359	10,412	843	11,843	1,674	26,131
Average (1975 – 1984)	224,248	15,265	95,316	38,982	38,174	411,985	1,372	4,877	23,131	29,380	69	5,570	12,188	8,965	1,086	73,324	101,202	4,502	10,135	923	9,443	1,949	26,952
Average (1975 – 1984)	174,996	9,131	34,647	19,317	29,231	267,322	988	4,028	13,701	18,717	0	4,917	8,718	5,562	560	40,157	59,914	14,027	4,520	316	1,091	1,469	21,423
% missing data	0	0	0	0	0	0	62	15	0	-	0	49	7	2	64	0	-	0	60	84	63	77	-

A year earlier SKM 2005[7] calculated ΔEC per GL/year of trade for the Riverine Plains districts using (primarily) process modelling compares the results of SKM 2005 with SKM 2006

Table 2.12: Salt generation rates from existing work

District catchment	Δ EC per GL/yr (1)	Subcatchment	Δ EC per GL/yr (2)	Crop / pasture mix
Torrumbarry	0.147	Barr Creek	0.24	Annual pasture
		Barr Creek	0.13	Perr. Pasture
Murray Valley	0.008	MV Drain 3	0.00	Pasture
		MV Drain 6	0.00	Pasture
SIR	0.015	Bamawm	0.01	Pasture
		Deakin	0.00 to 0.04	Pasture
		Rodney	0.00	Pasture
		Lockington	0.00	Pasture
NSW Murray	0.012	Denimein	0.38 to 0.76	Pasture
		Berriquin	0.05 to 0.18	Pasture
		Deniboota	0.06 to 0.09	Rice
		Wakool	0.02 to 0.06	Rice

Overall the results between SKM 2005 and SKM 2006 are similar, except for the NSW Murray Districts. They explain that there are two reasons for this:

- Firstly in SKM 2005, the drain catchment areas were taken only to be 1.0km on both sides for the drains. By contract SKM 2006 revised this to be the supply volume GL/year over the whole of the districts including undrained parts.
- Secondly, some of the unaccounted salt load coming out of the NSW districts is attributed to unmonitored surface drainage. SKM 2006 also go onto say that the figure of 0.012 could be doubled to 0.024EC per GL/year to account for more of the unaccounted salt loads.

SKM 2006 conclusions confirm Barr Creek as the only high impact zone in the Riverine Plains. They also highlight the large unaccounted salt loads in BigMod.

2.6 Spatial variability conclusions

Barr Creek justifies a more detailed assessment of the salinity impacts. The later SKM 2008 Barr Creek modelling for CSIRO provides the basis to determine the impacts and shows these impacts are very significant (as much as the Mallee per GL). Given the scale of the potential credit further work would be required in order to justify a full claim.

Alternatively, the model could suggest a low estimate (say 50%) could be conservatively claimed now and the size of the remaining 50% could inform the scale of the additional investigation for this additional claim.

All other areas within the Riverine Plan are low impact and a large change in irrigation volumes is required in order to trigger an accountable action of 0.1 EC.

[7] "Salinity Effects of Interstate Water Trade – Preliminary Assessment of Impacts Arising from Riverine Plains Trades".

3. TEMPORAL VARIABILITY ASSESSMENT

The following sections summarise the current understanding of wet and dry sequences.

3.1 Assessment of wet sequence

Table 3.1 below (from SKM, 2006) shows the variability in wet sequences and dry sequences within the benchmark period.

Table 3.1: Irrigation district salt export summary

Average annual salt load (t/y) Time period (irrigation seasons)	Torrumbarry	Murray Valley Vic	Shepparton Irrigation Region (excl Murray Valley)	NSW Murray
1975-2000	346,100	22,300	82,800	100,200
1975-1984	325,500	16,700*	77,600	99,900
1985-1994	412,000	29,400	101,200	112,300
1995-2000	267,300	18,700	59,900	80,700

* corrected from 167,000 in report by graphed result

Wet sequences have a large impact and are related to flooding events and high rainfall periods. These are particularly pronounced in Torrumbarry, where salt loads increase from the benchmark period salt load of 346,100 t/y to 412,000 t/y in the wetter period of 1985 to 1994 or around a 20% increase.

Climate change scenarios developed by CSIRO in the Murray Darling Basin Sustainable Yields Project (CSIRO 2008[8]) indicates that relative to historic climate: -

- **Scenario B Recent climate and current development**. This results in surface water availability declining by 30% with NSW diversions declining by 21% and Victorian diversions by 7%.
- **Scenario C Future climate and current development.** Provides a range in modelled results ranging from -37% to +7% in average annual runoff. Around 75% of the results showed a reduction in water availability. Under the best estimate 2030 climate average surface water availability for the Murray region falls 14 %. New South Wales and Victorian diversions in the region would, on average, decrease by 8% and 1% respectively.

If it is accepted that the benchmark period represents historic flows then a similar probability could be inferred. i.e. the probability of higher than historic flows occurring in 2030 are in the order 25%, while the probability of a drier sequence is 75%.

During a wet sequence, assuming a similar response to the 1985-95 sequence, the riverine plains salt loads may increase by around 20%, that is based on the response in Torrumbarry. The impact on River EC may be less of an issue though as river flows will be higher in this case.

[8] CSIRO (2008). Water availability in the Murray. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia.

3.2 Assessment of dry sequence

Phase 2 has shown that dry sequences show significantly declining salt loads. Salt loads from the Riverine Plains as a whole fell by around 60% of the benchmark period and irrigation drainage salt loads fell by 80% of the baseline loads.

This reduction also includes the impact of Register A items, which are a mixture of positive and negative items, (See Phase 1 Table 1.2). However, the combined total credit of 5 EC is minor compared to the baseline BIgMod impact of 154.7 EC from the Riverine Plains (see Table 2.1) and has been ignored.

It has been observed that in the recent drought the flow in Barr Creek was so low that there were some periods where the entire flow and salt load from the Barr was diverted to the Tutchewop Lakes. In similar years there will be very low or no EC impact from irrigation in Barr Creek.

On the other hand, these low salinity impact periods were much more persistent in the post 2000 drought compared, to dry periods in the benchmark sequence.

It is suggested that salt loads may reduce by up to 80% during extended drought sequences, as has occurred in the millenium drought and outlined in the Phase 2 report. However, short term dry spells would have a much lower reduction in salt loads.

The EC impact of these reductions would also need to consider the river flows at the time.

3.3 Changes in water use compared with historic use

An examination of the actual diversions in each valley (net of trade) for each year since 1997/98 to 08/09 provides data on what happened in the 5 years pre drought period (i.e. before 02/03) and the 7 years of drought. This can be compared with SDL volumes.

The table below was compiled from data provided by the MDBA. See Appendix for source data.

Table 3.2: Diversions Vs SDLs

Cap Valley **Background data for each catchment**	**run 847** **114 year averages** **Current Diversion Limit**	**run 847** **114 year averages** **2,800 GL scenario**	**7 Year Drought comparison** **Average GL actual diversions**	**12 years - comparison** **average GL actual diversions**	**5 years pre drought comparison** **average GL actual diversions**
			2002/03 to 2008/09	1997/98 to 2008/09	1997/08 to 2001/02
Murray (NSW)	1,696	1,180	898	1,299	1,861
Goulburn	1,566	1,107	1,057	1,277	1,584
Victorian Murray	1,654	1,161	1,304	1,469	1,700
Victorian Murray Riverine Plains (75% of Vic Murray) c. 400 GL to Sunraysia[9] with current plantings	1,240	870	873	1,018	1,243

[9] LMW diverted 417 GL in 2011/12

From this table it can be seen that:

- For the Goulburn the 7-year drought period represents a similar amount of water as is proposed for the 2,800 SDL. What happened during the drought is therefore a very good comparison for the outlook under the Basin Plan. In other words the summer salt loads under the SDL are expected to be similar to the summer salt loads that were experienced during the drought. Winter salt loads are likely to be higher given, a normal climatic sequence, as this tends to be more influenced by rainfall, which was low during the drought.
- However, NSW Murray used 898 GL compared to 1180 GL from a 2,800 GL SDL. This is 76% of what is predicted to happen. In other words, the drought period does not represent a reasonable picture of what may happen in NSW in the future.
- Total water use in the Victorian Murray was higher during the drought than might be expected under the SDL. This is a result of water being purchased for horticulture in Sunraysia during the drought.
- Water use on the Victorian Murray parts of the Riverine Plains shows the pattern there to be the same as the Goulburn part. In other words the 7-year drought period is probably a good representation of summer salt exports from the Riverine Plains in Victoria.

The implication of this will be that summer salt exports may be permanently reduced up to that experienced in the recent drought, which as described in the Phase 2 report is in the order of an 80% reduction of baseline loads. This would mean the salt impacts EC Morgan/GL of water use would be reduced to very low values for all zones

3.4 Water trading and policy controls

Water trade is an integral management tool of irrigators and water will move according to fluctuations in commodity prices, water availability and seasonal climate.

The price of milk, rice, almonds, grape vines, grain and hay will all influence demand for water and usage in each area will change.

In dry years water tends to trade from NSW rice-growing areas to Victorian dairying areas and horticultural areas in the three southern states. By contrast, in wet years, the trade tends to go the other way. These generalised trends are of course moderated by the short-term relativities between commodity prices.

Since water is now unbundled from land there are few policy instruments that can prevent water moving and held water entitlements do not accurately reflect potential usage. In Victoria, annual use limits determine maximum application rates for individuals, but these generally do not change when water is sold (temporary and permanent) and a property becomes dryland.

For example, in the Barr Creek catchment long term average use (pre drought) are 60-70% of the annual use limits (AUL) held. During this time usage in drought years was only around 30% of AULs.

3.5 Temporal variability conclusions

Any claims for EC credits arising from changes to water use on the Riverine Plains would require an analysis of the changes in irrigation to define the change. It would also require some certainty that those changes would endure over the long term. This is problematic.

Water entitlements held in association with land holdings no longer reflect usage since landholders can now hold water separate to land, and usage varies according to climatic sequences and other factors. Therefore it is difficult to differentiate underlying changes in long-term water use from short-term variable changes associated with policy, weather or commercial imperatives.

In Victoria, the total volume of annual use limits on water-use licenses in the Riverine Plains irrigation districts are very high relative to normal usage which reflects the land-use being dominated by flood irrigation of pasture. They are also high relative to potential seasonal allocations against water entitlements. Consequently, they are conservative in the sense that if they were to be used as a surrogate for irrigation water usage they would overestimate salinity impacts – unless over time they were somehow reduced to reflect actual usage and/or land-use.

Both Victoria and NSW operate under the Murray Darling Basin Cap on Diversions, and there are agreed and consistent, audited, processes used to define the cap volume and adjustments to it. For example the adjusted cap volume diminishes as environmental water holders acquire water entitlements. This existing process could potentially be used to define changes to water use on the Riverine Plains.

In NSW the issue is much simpler; virtually all general security water is associated with usage in the Riverine Plains (as defined in the brief for this project) – consequently the cap-adjusted volume for NSW Murray general security water reflects more closely the maximum water available for use in the Riverine Plains. The exception will be wetter years when demand is low relative to the irrigation footprint.

In NSW, changes in the cap-adjusted volume to NSW Murray reflect real changes in the maximum potential use and have the advantage of being audited and accepted by jurisdictions. The accumulated cap adjustments are a real indicator of change in the volume available for irrigation. The NSW cap falls as water is removed from the consumptive pool to be used, instead, for environmental flows.

In Victoria the changes to the cap-adjusted volume in the Goulburn/Broken/Loddon also reflect real change and could be used in a similar manner to that discussed for NSW. It may be worth disaggregating that change down to individual districts, but this may not be a priority given that irrigation salinity impacts in those districts are all comparably low and the extent of change to date (for example, buybacks and water trade to the Mallee) is relatively evenly spread across the GMID. However, there would need to be consideration of disaggregation for any Goulburn entitlements that are used outside the Riverine Plains e.g. Goulburn entitlement that is used in the Mallee.

In terms of the Victorian Murray, change in the cap-adjusted volume is more difficult to apply meaningfully as a surrogate for actual annual use in the Riverine Plains. Apart from covering a long length of River with multiple irrigation districts, the Victorian Murray cap-adjusted volume includes the relatively large volume used for irrigated horticulture in the Mallee and a smaller volume delivered to the Wimmera-Mallee domestic and stock system. Moreover, the total volume used in the Victorian Murray has increased as Goulburn entitlements started to be used in the Mallee. Therefore, this volume needs to be disaggregated between the Victorian Mallee[10] and the Victorian Riverine Plains.

The Victorian Riverine Plains needs to be further disaggregated to distinguish between Torrumbarry (both Barr Creek and the rest of Torrumbarry) and the Murray Valley irrigation areas. This process need not be complicated; it could be based on a five-year moving average of usage in each of these areas - as reported in the annual reports from the relevant water authorities. However, defining the baseline conditions for historic usage in each of these areas for the benchmark period would require some examination of historical usage in order to determine the change.[11] If done, this would then be part of the five-year review cycle for register entries. DPI Victoria maintains a GIS database of water use for the GMID that could inform this.

Once the SDLs are fully incorporated into the cap adjustments then there will be lower diversions and a credit claim is potentially possible as the diversions (in Victoria) might be broadly similar to the 2002/3-2008/9 drought sequence when salt exports were very low relative to ’average’ climatic years. The actual accountability for any Register claim for SDL adjustments will need to be worked through between the Commonwealth and the relevant accountable jurisdiction.

[10] Lower Murray Water and Grampians Wimmera-Mallee Water also deliver to water to users in the Victorian Mallee

[11] As used in the BSMS, the ‘Benchmark period’ defines a climatic sequence that is used consistently in models to predict the effects of various combinations of actions at specified times. The period initially selected was from 1 May 1975 to 30 April 2000.

3.5.1 Dilution Impacts

It is understood that the implementation of environmental flows under the Basin Plan and The Living Murray initiatives could potentially provide 50-100 of EC credits, depending upon the flow regimes sites watered etc.

This has the potential affect of diluting (diminish) all credits and debits on the registers and may become an accounting issue. The the actual flow regime will be quite different to the Benchmark sequence of flows and registers under this new sequence may no longer reflect the change in EC at Morgan.

As actual EC impacts will be much lower than the register items report it will become harder to explain the difference to the broader community. It will become harder to justify the economic rationale for salt interception works, salinity levies etc. as they relate to salinity accounting for a hydrology regime that no longer exists.

Under the current protocols the dilution impacts are separately accounted for as their own credits in environmental flow actions. Therefore, the Irrigation Salinity Assessment Framework (ISAF) proposed in this report cannot deal with the dilution credit it must use the benchmark sequence. It is uncertain what the new flow regime will be. But the BSMS will need to have a clear position on this. For example, who will own the dilution credits?

The following section explores the potential scale of the dilution impacts as they relate to the Riverine Plains. The table below is taken from the Ready Reckoner of the Operational protocols for the impact of 100t/d of salt at different locations and river flows. They are indicative only and two methods are examined. Method 1 uses the ready reckoner to identify EC impacts for a given salt load at increasing river flows. Method 2 uses the table for transit impacts of water movement in the system referred to for use with SIMRAT by URS 2004.

Method 1

Table 3.3 below is derived from the Operational Protocols and shows the salinity impacts of 100t/d at different locations and river flows. This can be used to scope the changes in EC impact for the same salt load at different flow regimes, as per the table below, which calculates the % of the original EC impact at a flow of less than 10,00 ML/d for higher flow events. This has been used to calculate the reduction in EC for 100t/d at different river locations as flow increases from less than 10,000 ML/d to 10-20,000 ML/d and then to > 20,000 ML/d.

The additional environmental water as a result of the SDL is 1,400 GL as outlined in the model run Table 2.2 (earlier in report). This would provide an average daily flow of 3,800 ML/d if distributed evenly (which is unlikely). This does indicate that the salt loads from irrigation (and all other sources) will be substantially diluted and EC impacts could feasibly be around 20% to 50% of current baseline EC impacts[12] depending upon the regime.

This means that the EC impacts of actions against the currently adopted baseline period is likely to be unrepresentative of future EC impacts at Morgan

[12] Assuming 4,000/10,000 = 40% of the reduction associated with 10,000 ML/d increase at Torrumbarry. i.e. 15%/.40= 38%. Say +/- 15%is c.20-50%

Table 3.3: Changes in salinity with river flow changes

River Reach	River Distance	Salt Load in flow range (t/d)			Salinity (EC) impact @ Morgan for flow range				
		< 10,000	10,000 - 20,000	<20,000	< 10,000	10,000 - 20,000	EC impact reduction in change flow <10GL/m	<20,000	EC impact reduction in change flow <10GL/m
Corowa	2,208	100	100	100	2.2	1.3	59%	1.3	59%
Tocumwal	1,886	100	100	100	3.6	2.7	75%	0.58	16%
Torrumarry	1,678	100	100	100	5.8	0.89	15%	0.61	11%
Swan Hill	1,409	100	100	100	11	1	9%	0.69	6%
Kyalite	N/A	100	100	100	12	0.47	4%	0	0%
Mildura	910	100	100	100	13	1.9	15%	1.3	10%
Weir 32	N/A	100	100	100	13	0.58	4%	0.31	2%
Wentworth	825	100	100	100	13	3.2	25%	1.8	14%
Lock 6	654	100	100	100	17	2.3	14%	1.2	7%
Lock 5	620	100	100	100	18	1.8	10%	1.2	7%
Lock 4	516	100	100	100	20	1.6	8%	1.1	6%
Lock 3	496	100	100	100	21	1.4	7%	1.1	5%
Lock 2	383	100	100	100	22	1.3	6%	1.1	5%
Morgan	315	100	100	100	22	3	14%	1.5	7%
Lock 1	274	100	100	100	0	0	-	0	-
Murray Bridge	150	100	100	100	0	0	-	0	-

Method 2

Another way of assessing dilution impacts is to use the process accompanying SIMRAT to assess the transit impacts of water movement. URS, 2004 identified the following dilution factors for assessing the impact of transit water.

Table 3.4: Dilution effects matrix for 1,000ML transfer

Δ EC per 1,000ML		**FROM**									
		Hume to Torr.	Torr to S. Hill	S.Hill to Eust	Eust. to Merb	Merb to Lock 9	Lock 9 to Renm.	Renm. to Lock 4	Lock 4 to Lock 3	Lock 3 to Morg	Morg to Mouth
TO	Hume to Torr.	**0.00**	+0.02	+0.02	+0.3	+0.3	+0.4	+0.4	+0.4	+0.4	+0.5
	Torr to S. Hill	-0.02	**0.0**	+0.02	+0.3	+0.3	+0.4	+0.4	+0.4	+0.4	+0.5
	S.Hill to Eust	-0.02	-0.2	**0.0**	+0.3	+0.3	+0.4	+0.4	+0.4	+0.4	+0.5
	Eust. to Merb	-0.03	-0.03	-0.03	**0.0**	0.0	+0.2	+0.2	+0.2	+0.2	+0.5
	Merb to Lock 9	-0.03	-0.03	-0.03	0.0	**0.0**	+0.2	+0.2	+0.2	+0.2	+0.5
	Lock 9 to Renm.	-0.04	-0.04	-0.04	-0.2	-0.2	**0.0**	0.0	0.0	0.0	+0.8
	Renm. to Lock 4	-0.04	-0.04	-0.04	-0.2	-0.2	0.0	**0.0**	0.0	0.0	+0.8
	Lock 4 to Lock 3	-0.04	-0.04	-0.04	-0.2	-0.2	0.0	0.0	**0.0**	0.0	+0.8
	Lock 3 to Morg	-0.04	-0.04	-0.04	-0.02	-0.02	0.0	0.0	0.0	**0.0**	+0.8
	Morg to Mouth	-0.05	-0.05	-0.05	-0.05	-0.05	-0.08	-0.08	-0.08	-0.08	**0.00**

If this were applied to the 1400 GL of SDL reduction across the Riverine Plains and if it were used downstream of Morgan, it would provide a dilution credit of around 1400 x 0.05 =70 EC. This is more than the salinity impact of irrigation in the Riverine Plains.

It is understood that the interstate trading rules specify how the salinity effects[13] of interstate trades are to be accounted (though it is unclear to the present authors if these rules apply to areas outside the original interstate pilot project – Nyah to Goolwa – or indeed if they are still current). These are as follows (URS et al 2004 for the MDBC):

- Any salinity debits or credits arising from the dilution effects of a trade into (or out of) South Australia are to be assigned to the upstream State involved in the transfer.

[13] Noting that it is the change in the application of water to land or the change in the patterns of river flows that are the accountable action, rather than trade per se.

- Any salinity debits or credits arising from the dilution effects of a trade between NSW and Victoria are to be shared equally between those two States.
- Any salinity debits or credits arising from changes to salt accessions are: (a) to be assigned in NSW and Victoria to the state in which the change occurs; and (b) to be treated as a requirement in SA for zero salinity impact.

4. IRRIGATION SALINITY ASSESSMENT FRAMEWORK (PHASE 4)

4.1 Objective

The objective of Phase 4 was to develop a draft Irrigation Salinity Assessment Framework (ISAF) based around management of the above risks.

The requirement of the proposed ISAF was to acknowledge the risks and seek to minimise them by building cost-effective risk management into the proposed framework.

4.2 Operational protocols

The existing methods for assessing the impacts of water trade are detailed in the operational protocols (included in Appendix B).

It is important that the framework be consistent with the intent of these protocols, however, it is noted that many of the tools and protocols, such as SIMRAT, have been designed for higher risk areas in the Mallee where hydrogeology is significant factor in salt mobilisation.

The protocols are more difficult to apply to the Riverine Plains for the reasons discussed in Chapters 2 and 3 above. The biggest difference is that compared to the Mallee, the Riverine Plains salinity risk is related to much more variable irrigation usage and a hydrogeological system that changes dramatically in response to wet and dry sequences. The draft ISAF, therefore, is structured around the irrigation districts with a regional focus.

4.3 Guiding principles for ISAF development

The following section was developed at a workshop of the Project Advisory Group to discuss the application of the proposed ISAF.

Underlying BSMS principles

1) Jurisdictions continue to be required to register individual actions, and cumulative actions, that increase Morgan salinity by 0.1 EC or more.

2) Jurisdictions are responsible for deciding whether or not to register actions that decrease salinity at Morgan by 0.1 EC or more.

3) Unless and until decreases in Morgan salinity are claimed as credits the benefits accrue to the River

4) All register entries must satisfy the BSMS operational protocol; they must be evidence based and peer reviewed.

5) The effort involved in quantifying register entries must be commensurate with the risk and the relative impact of the defined change.

A framework for assessing water trade within the Riverine Plains outside Torrumbarry

6) Investigations have confirmed that, other than the Torrumbarry Irrigation Area, the risk of salt being mobilised by irrigation is relatively consistent across the Riverine Plains. See See Table 4.3..

7) Given the relative consistency of irrigation impacts across the Riverine Plains, and the dynamic nature of actual water use on the Plains, it is unlikely that a complex ISAF requiring extensive monitoring and evaluation could be justified as being commensurate with the risk.

8) Water trade within the Riverine Plains outside Torrumbarry should be treated as salinity neutral.

9) Monitoring of other changes in water use should involve low-cost assessments of the irrigation footprint and trends in actual water use.

10) Departure credits can be claimed if a policy is in place to prevent the return of water to land.

A framework for assessing water trade into, out of, and within the Torrumbarry Irrigation Area

11) The risk of salt being mobilised by irrigation in the Barr Creek subsystem of the Torrumbarry Irrigation Area is an order of magnitude greater than the other parts of the Riverine Plains. See Table 4.3.

12) The Kerang Lakes subsystem of the Torrumbarry Irrigation Area may be acting as a significant salt sink. See Table 4.3.

13) The salinity risks associated with changes in water use within the Torrumbarry system make it a priority area for future investigations.

14) Water reforms since 1988 have on balance tended to reduce the total volume of water used for irrigation in Torrumbarry.

    a. The BSMS accountable actions associated with increased irrigation in the Mallee largely depended on the trade of entitlements out of Torrumbarry. In other words, there has been a net trade of water entitlement out of Torrumbarry, mostly to Victorian Mallee.

    b. Modernisation of the irrigation delivery system in Torrumbarry involves a rationalisation in the total area being serviced by the delivery system. The total irrigated area is being decreased.

    c. The CEWH has purchased entitlements from irrigators in Torrumbarry.

15) On the balance of probabilities, accountable actions in Torrumbarry to date are likely to involve salinity credits rather than salinity debits.

16) System modernisation will be completed sometime in the next five years; detailed investigations after modernisation is complete would reveal more certainty than investigations before it is complete.

17) Changes in water use in Torrumbarry should be brought into the five-year review process. The first review should commence when modernisation is complete.

18) The review process should be kept simple in the first instance. More detailed investigations could only be justified if the balance of probabilities suggested an increase in salinity impacts – or if Victoria wished to claim a credit.

19) Monitoring should involve an assessment of the irrigation footprint and trends in actual water use.

20) Departure credits can be claimed if a policy is in place to prevent the return of water to land.

A framework for assessing the dilution effects of environmental water purchases

21) Preliminary analysis suggests that the dilution flows arising from environmental water purchases are more important than departure credits.

22) Dilution credits will need to find their own way onto the register. No action required in this study and is not considered further.

4.4 Irrigation salinity assessment framework

4.4.1 Calculation

The proposed ISAF is simple, but is based on decades of salinity assessment, modelling and calibration with data across the Riverine Plains. It is:

ΔEC Morgan = ΔEC Morgan/GL in zone x ΔGL in zone

Its application involves 3 basic steps:-

1) Determine salinity zone and its salinity coefficient ΔEC Morgan/GL
2) Determine irrigation water use change ΔGL for the zone
3) Apply formula.

As previously discussed this provides an assessment of the salinity impact from water departure, but not arrival or transit.

Risk management

This simple approach requires conservatism to ensure that the EC impacts of water reductions do not overstate the salinity benefit from using such a generalised approach. Therefore, the low end of the range of values for the salinity coefficient is recommended for use when developing a credit claim. The difference between the under-estimate and the actual is a credit that accrues to the River.

Similarly the impacts of additional water use in the zone should be assumed to be at the high end of the range (so salinity costs are not understated). In this case the difference between the over-estimate and the actual is a debit that is borne by the jurisdiction. However, additional water use in the Riverine Plains is considered unlikely, as the total water use in the future is likely to be under the 1988 benchmark for every salinity zone in the Riverine Plains.

The MDBA cap also ensures no expansion as a total for the system, but it may be possible for total water use to increase in one or more of the different parts of the Riverine Plains – but not all parts. In effect this is what has happened with regard to the increased water use in the Mallee.

When is detailed analysis required?

The proposed ISAF is really a first cut to determine whether the scope of a larger investigation for a claim is justified. The improved understanding of the differences between Torrumbarry and the rest of the Riverine Plains is useful in this regard. For example, reductions in salinity from change in the Murray Valley area is likely to have a very low salinity impact and is unlikely to be worth pursuing compared to the cost of the exercise. Barr Creek, on the other hand, provides a more compelling justification.

It is also noted that whilst out of scope for this study, dilution impacts are also very significant and need further analysis.

The decision to pursue a more detailed investigation and a potential credit claim will need to be based on size of potential claim (guided by the ISAF), demand for salinity credits, the complexity and cost of that investigation. The Phase 1 report provides some guidance to the scale of the investigation warranted.

4.4.2 Zones

Table 4.2 proposes the zones based on the spatial analysis in Phase 3 and compares it with the zones considered in SKM 2006.

Torrumbarry Outside of Barr Creek

The results for the Torrumbarry outside of Barr Creek, the Blue zone, in SKM 2006, were based on a report done in 2003 (*2003 Kerang lakes Future Land Use Study*, Rendell McGuckian with SKM et al.) for GMW. This was quoted in the SKM 2005 report *Salinity Effects of RP water trades calibration and sensitivity testing*. It showed that irrigation had a positive impact on salinity at Morgan, so a negative -0.1ΔEC Morgan/GL was developed.

There have been significant changes in the management of water in this zone since 2003 that may have changed the impacts, but this would need to be confirmed. These changes include the implementation of the Pyramid Creek salt interception scheme, the new mid river storage in Lake Charm, Lake Kangaroo and Lake Boga; and there is also a Lakes bypass being investigated. This means that the SKM 2006 coefficient of -0.1 EC/GL may no longer be relevant. The sequencing of these changes/actions may also affect the EC/GL coefficient.

The area is underlain by highly saline groundwater and there is a high unaccounted salt load in BigMod. It is known that there are high loads from the 6/7 channel and there may be high impacts associated with the irrigation near the Kerang Weir and lower Loddon. On the other hand there are some undrained areas away from the river that may have lesser impacts.

There are potentially several zones within Torrumbarry outside of Barr Creek that could be investigated:-

- One area is the Kerang Lakes, which diverts water from the Loddon and Pyramid Creek, where irrigation could be reducing the salinity at Morgan, because it is intercepting saline flows.
- Another is the area that uses Murray water without being mixed with flows from the Loddon and Pyramid Creek, and so irrigation does not intercept the more saline inflows. These areas include some irrigation from the Macorna Main Channel and also on Gunbower Island.
- A third zone could be areas of irrigation close to and influencing groundwater near the Little Murray, Lower Loddon and the Murray (e.g. Tyntynder Flats).

In short, more investigation is needed for this blue zone to make a determination with more confidence.

Within Barr Creek

As mention in Section 2.3 more detailed zoning within Barr Creek was completed by SKM in 2008[14] for CSIRO and this is recommended for more detailed analysis within Barr Creek.

The SKM 2008 coefficients for within Barr Creek are shown below. The report also includes maps at a pod and property level.

Table 4.1: Barr Creek salinity impacts at Morgan

Zones	Salinity (EC) impact per 1,000ML of water used[1]
Barr Creek – Deep Green	0.0 – 0.08
Barr Creek – Light Green	0.09 – 0.15
Barr Creek Amber	0.16 – 0.27
Barr Creek - Orange	0.28 – 1.21[2]

[14] Torrumbarry System Salt Export Mechanisms from the Barr Creek Catchment - Final 17 January 2008.

[1](Note: Barr Creek figures may double count catchment strategy and channel seepage EC benefit)

[2]Keith Collett, pers. comm. advises that there was only one cell at the upper end of this range.

Those cells with the highest (orange) salt exports typically follow the course of the Creek itself and have high driving groundwater heads.

There needs to be some caution in accounting for possible double counting and uncertainty. Once uncertainty that SKM 2008 advise in the above report is the issue of soil permeability; that may mean that the coefficients used for cells in light soils might be underestimates and those for the cells in heavy soils may be over estimates. However the average is expected to be correct.

SKM, 2008 advise the average across the whole of the Barr Creek of 0.16 EC/GL. Reducing this would guard against the risk of double counting with the Barr Creek Catchment Strategy and channel seepage EC benefit. It is expected that reducing this value to 0.1 EC/GL would be a conservative approach (previously an average of 0.25 was recommended in SKM 2006).

Therefore, it is recommended that 0.08 EC/GL is used across the Barr Creek catchment area defined above for the low estimate and 0.16 EC/GL for the high estimate. This low estimate is also equivalent to the coefficient for the upper end of the Barr Creek lowest impact zone in the table above (Deep Green).

However, it should be noted that the high estimate may underestimate impacts, particularly for water changes in the amber and orange zones. This is not likely to be a problem for water departures (the underestimate accrues a credit to the River), but would be a problem for irrigation arrivals/expansion.

In the case of irrigation expansion above the 1988 baseline then higher coefficients (more than 0.16) may be justified. However, this scenario is considered unlikely, as most changes to date have been reductions in water use.

Defining change in irrigation use in Barr Creek

However, there is no guarantee that water would not be traded back to these zones, so a claim can only be “locked in” if a salinity impacts zone is declared and annual use limits (AUL) are capped as per the Mallee zone in Victoria. Credit claims can only be permanently achieved when there is a reduction in AUL in the zone.

Currently there is much more AUL than usage so the coefficients for reducing salinity as a result of a reduction in AUL will need to be adjusted for this.

An alternative approach is to use a 5-year rolling average for use per property and develop credit claims based on changes in this every 5 years. The claim would be made on retrospective performance for each 5 year review period and adjusted upwards or downwards relative to the 1988 baseline at that interval.

However, defining the baseline conditions for historic usage in each of these areas for the benchmark period[15] would require some examination of historical usage in order to determine the change. If done, this would then be part of the five-year review cycle for register entries. DPI Victoria maintains a GIS database of water use for the GMID that could inform this.

There are issues of resourcing this, which would be quite expensive, but current and future data is already collected in the Victorian Water Register.

[15] As used in the BSMS, the ‘Benchmark period’ defines a climatic sequence that is used consistently in models to predict the effects of various combinations of actions at specified times. The period initially selected was from 1 May 1975 to 30 April 2000.

Table 4.2: Suggested ISAF coefficients for evaluating long-term changes in total water use in the Riverine Plains (assuming no climate change)

Zone	Description	Recommended by SKM in 2006 ∆EC Morgan/GL ∆EC Morgan/GL	Drainage system	Proposed for ISAF in this report for use in calculating changes in irrigation ∆EC Morgan/GL Low estimate (excludes unaccounted salt loads)	∆EC Morgan/GL High estimate (includes part of the unaccounted salt loads)
Green	All areas outside Torrumbarry	0.0 to 0.05. Use 0.0	NSW drains.	0.003 Based on 4.5 EC from BIgMOD NSW drains	0.024 from SKM 2006.
			Murray Valley	0.002 from BigMod (average of 9.8 EC over 4,200 GL)	0.008 from SKM 2006
			Shepparton / Goulburn System	0.002 (average of 9.8 EC over 4,200 GL) from BigMod	0.015 from SKM 2006
Blue	Torrumbarry outside of Barr Creek	- 0.1 EC/GL. Water use reductions increase river salinity	Kerang Lakes area and other parts of Torrumbarry outside of Barr Creek	Could be negative. But changes to the Torrumbarry system make SKM 2006 coefficient of -0.1 EC/GL less certain. **More detailed investigation required.**	Parts of this could be as high as Barr Creek given similar highly saline groundwater & drainage (e.g. irrigation adjacent to Lower Loddon & Pental Island). **More detailed investigation required.**
Red	Barr Creek	0.15 +. Use 0.25	Barr Creek as defined by zones in SKM 2008	0.08 to guard against risk of double counting with Barr Creek Strategy (see next section). This represents the upper bound of the lowest impact zone within Barr Creek.	0.16 from SKM 2008 (see next section. A higher coefficient may be warranted in certain parts of Barr Creek and for increases in irrigation above the baseline.)

There may also be a lag effect between irrigation reductions and EC reductions at Morgan; this could be influenced by the climatic sequence at the time. Although it is expected that the lag effect will be much smaller in the Riverine Plains than the Mallee.

These zones are mapped in Figure 3 below.

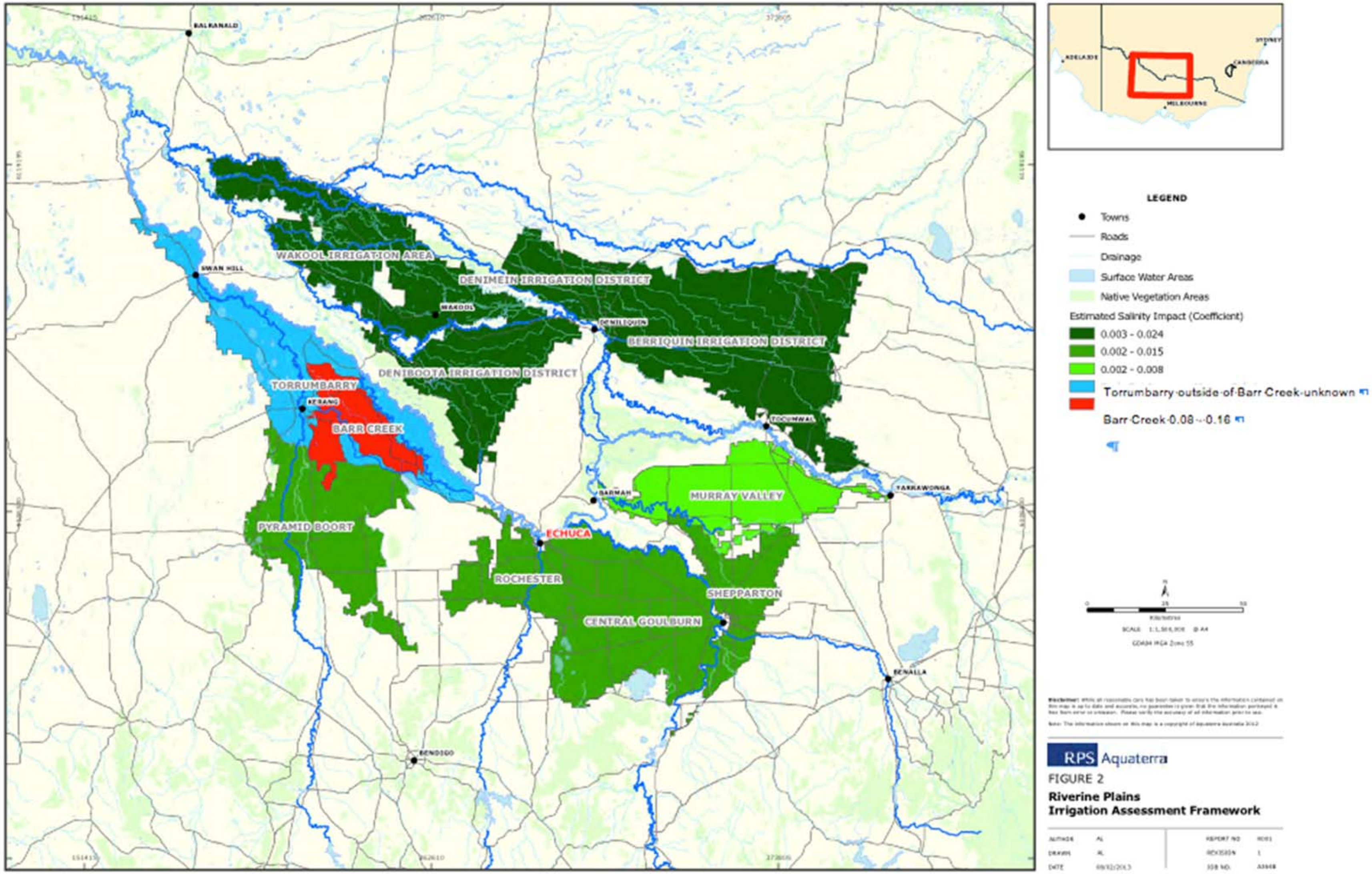

Figure 3: RP Coefficients

The following table shows the volumetric change (ML) required in order to trigger an accountable action of 0.1 EC using the above coefficients. For context the coefficients used by the Victorian Mallee salinity zones have also been included.

Table 4.3: Indicative change in ML required to generate a BSMS accountable action

Zones [1]	Low estimate		High estimate	
	EC impacts per 1,000 ML	Reduction in water (ML) required to generate a BSMS accountable action (0.1 EC)	EC impacts per 1,000 ML	Reduction in ML required to generate a BSMS accountable action (0.1 EC)
Torrumbarry outside Barr Creek			-0.1(uncertain)	1,000
Mallee LI1			0	na
Murray Valley Victoria	0.002	50,000	0.008	12,500
Shepparton/ Goulburn/ Loddon Victoria	0.002	50,000	0.015	6,667
Mallee LI2			0.020	5,000
NSW irrigation	0.003	33,333	0.024	4,167
Mallee LI3			0.050	2,000
Mallee LI4			0.070	1,429
Mallee LI5			0.100	1,000
Mallee LI6			0.150	667
Torrumbarry Barr Creek (more detailed sub-zoning with a range of impacts is possible as per SKM 2008)	0.080	1,250	0.160	625
Mallee LI7			0.200	500
Mallee HI1			0.300	333
Mallee HI2			0.350	286
Mallee HI3			0.400	250
Mallee HI4			0.450	222
Mallee HI5			0.500	200

[1] Zone sorted by high estimate impacts for Riverine Plains zones (note the figures for the Mallee zones are assumed here to be at the high end of whatever range is implicit in their reckoning – this would be consistent with the conservative nature of the Mallee zoning system)

4.5 Application of ISAF

The requirement of the project was to test the methodology via case studies. The following case studies have been developed considering the recommended approach.

The proposed coefficients for evaluating change were then applied to three scenarios that involve a 30% reduction in water use. This being a constant 1,400 GL to meet the Basin Plan SDL from the 2008 cap model run applied to:

4) A 30% reduction involving all of the water coming out of the highest impact zones. (This would involve no irrigation in Barr Creek or Torrumbarry and a significant reduction in outflows from NSW drains.)

5) A 30% reduction spread uniformly across the entire Riverine Plains.

6) All of the 30% reduction coming out of the lowest impact zones.

As a test of the coefficients a further scenario was developed. This was:

7) the extreme case of nil irrigation (scenario 4) to see how this compared with the total EC impacts of irrigation from BigMod.

Table 4.4 below illustrates the results for the low estimate and Table 4.5 provides the high estimate. It should be noted that the results are indicative only, because actual usage for Barr Creek is unknown.

There would also be a lag effect, between irrigation removal and EC impact. Although, this may be influenced by the climate at the time; and is likely to be lower than the lag effects for the Mallee Region.

As discussed in Section 4.4.1 a risk-averse approach would be to use the low estimates to assess potential credits associated with irrigation departure and the high estimates to assess the debits with irrigation arrival.

Low estimate results compared to BigMod irrigation drains

For all areas, excepting Barr Creek, the results for Scenario 4 with the low estimates gives a similar order of magnitude to the drain impacts from BigMod, excluding the BigMod unaccounted salt loads.

The Barr Creek coefficients underestimate the BigMod impacts, but the ISAF coefficients need to be lower in Barr Creek to avoid the risk of double counting the salinity benefits of the Barr Creek Drainage Diversion Scheme.

Table 4.4: Case Study Results Low estimate (excludes unaccounted for salt loads)

Low estimate	Change in water use Barr Creek	Change in Water use NSW	Change in Water Use Goulburn system	Change in Water use Murray Valley	Change in water use in rest of Torrumbarry (not Barr Creek)	Totals
Baseline water diversions GL/y	187 (SKM 2008)[16] from Barr Creek	1,700	1,579	620	433	4,519
salinity coefficients	0.080	0.003	0.002	0.002	0.0	na
1) Highest Impacts zones –GL reduction	-187	-1,213	-	-	0.0	-1,400
EC reduction	-15.0	-3.6	0.0	0.0	0.0	-18.6
2) Uniformly spread –GL reduction	-58	-527	-489	-192	-134	-1,400
EC reduction	-4.6	-1.6	-1.0	-0.4	0.0	-7.6
3) All from lowest impact zones –GL reduction	0	0	-780	-620	0	-1,400
EC reduction	0.0	0.0	-1.6	-1.2	0.0	-2.8
4) All irrigation ceases GL/y reduction	-187	-1700	-1579	-620	-433	-4519
EC reduction	-15.0	-5.1	-3.2 Goulburn plus -1.2 Murray Valley = -4.4 EC		Not calculated no coefficient (could be +ve)	-24.5
Scenario 4 compared to BigMod for irrigation drains	Compares to 31 EC impact from BigMod. Avoids risk of double counting Barr Creek Strategy benefits	Compares to 4.5 EC in BIgMod	compares to 5.3 in Big Mod (Shepparton drains+ Campaspe)			compares to 40.8 from BigMod. Main difference is in Barr Creek.

[16] Note DPI estimated >200GL/y use in 2004/5

Table 4.5: Case Study Results High estimate (partially includes unaccounted for salt loads)

High estimate	**Change in water use Barr Creek**	**Change in Water use NSW**	**Change in Water Use Goulburn system**	**Change in Water use Murray Valley**	**Change in water use in rest of Torrumbarry (not Barr Creek)**	**Totals**
Baseline water diversions GL/y	187 (SKM 2008[17]) from Barr Creek	1,700	1,579	620	433	4,519
salinity coefficients	0.160	0.024	0.015	0.008	0.0	na
1) Highest Impacts zones –GL reduction	-187	-1,213	-	-	0.0	-1,400
EC reduction	-29.9	-29.1	0.0	0.0	0.0	-59.0
2) Uniformly spread –GL reduction	-58	-527	-489	-192	-134	-1,400
EC reduction	-9.3	-12.6	-7.3	-1.5	0.0	-30.8
3) All from lowest impact zones –GL reduction	0	0	-780	-620	0	-1,400
EC reduction	0.0	0.0	-11.7	-5.0	0.0	-16.7
4) All irrigation ceases GL reduction	-187	-1700	-1579	-620	-433	-4519
EC reduction	-29.9	-40.8	-23.7 Goulburn plus -5.0 Murray Valley = -28.7 EC		Not calculated no coefficient	-99.4 EC
Scenario 4 From BigMod EC impacts for irrigation drains + groundwater in baseline	31 drains + 22.5 groundwater =53.5 EC impact. Avoids risk of double counting Barr Creek Strategy benefits when including g.water	4.5 EC drains + 20.3 groundwater = 24.8 EC impact plus potential legacy of history=24.8 +?	Compares to 5.3 in Big Mod (Shepparton drains+ Campaspe) plus 2.9 EC unaccounted groundwater in this reach= 8.2 EC.			40.8 irrigation drains + 22.5 Torrumbarry gwater =63.3 EC If NSW g.water included = 80.6 EC All gwater included= 83.5 EC

[17] Note DPI estimated >200GL/y use in 2004/5

High estimate results compared to BigMod irrigation drains plus unaccounted salt

The high estimates in Scenario 4 were compared with the BigMod drains plus BigMod unaccounted salt load (groundwater). The Scenario 4 results overstate impacts for NSW, Goulburn and the Murray Valley. But they understate the impact from Barr Creek.

In the high estimate for Barr Creek-Scenario 4 there is a -29.9 EC reduction and this closely matches the 31 EC for Barr Creek drainage (excluding unaccounted groundwater). As the 31 EC excludes the unaccounted (groundwater) impacts, the high estimate coefficient, is potentially too low for assessing new irrigation arrivals.

Therefore, a higher coefficient for Barr Creek (higher than the 0.16 used) would be warranted for any irrigation expansion above the baseline, if this unlikely event were to occur.

It should be noted that the coefficients are sensitive to location within Barr Creek and the use of the higher location specific coefficients within Barr Creek (produced by SKM 2008) may be warranted especially if large claims are being investigated.

Summary of scenarios across the Riverine Plains

The summary of the low and high estimates across the whole of the Riverine Plains is shown in Table 4.6 below.

Table 4.6: Summary of Scenarios

Scenario – GL reductions	Low Estimate & % reduction from BigMod total of 40.8 EC for irrigation drains		High Estimate & % reduction from BigMod total of 63.3 EC (irrigation drains + Torrumbarry groundwater)	
1) Highest Impacts zones -1400GL	-18.6 EC	-41%	-59.0 EC	-93%
2) Uniformly spread -1400GL	-7.6 EC	-19%	-30.8 EC	-49%
3) All from lowest impact zones -1400 GL	-2.8 EC	-7%	-16.7 EC	-26%
4) All irrigation ceases -4519 GL	-24.5 EC	-60%	-99.4 EC	-157%

The results from the fourth scenario suggests that across the Riverine Plains the low estimate coefficients underestimate impacts as they are only 60% of the irrigation drainage flows from BIgMod. Mostly because of needing to avoid the risk of double counting the Barr Creek Drainage Diversion Scheme.

On the other hand, the high estimate suggests the coefficients may overestimate impacts by 157%. In this case it is likely all areas except for Barr Creek is over estimated.

These potential changes need to be contemplated in the context of the dilution flows associated with the increase of entitlements for environmental flows. Assuming the return of 1400 GL to the environment, the salinity impact of these return flows could involve a potential salinity credit as high as 70 EC. This is significantly higher than the potential benefits of a reduction in irrigation water use in different irrigation districts from a uniform spread (Scenario 2).

There would also need to be some consideration of a policy mechanism in order to 'lock in' the reductions for any potential claim. For example, there is potential to cap the total volume of annual use limits in different parts of the Riverine Plains as has already happened in parts of the Victorian Mallee. This could prevent subsequent back-trade undermining any EC credits claimed against reduced water use in different parts of the Riverine Plains. However, given the significant change currently in train in the Victorian part of the Riverine Plains as a result of the modernisation of the irrigation delivery system it may be prudent to evaluate that potential in say five year's time after the modernisation is complete.

4.6 Climate influences

As discussed in the temporal risk assessment, based on the Sustainable Yields modelling project completed by CSIRO 2008, and accepting the baseline sequence, as being equivalent of historic climate, there is:-

- An approximate 25% chance of a wetter sequence in which salt loads can be 20% higher than the benchmark; and
- An approximate 75% chance of a drier sequence, in which salt loads can drop by up to 80% to 20% of the benchmark loads.

The zone coefficients adopted in the previous section are based on the benchmark period and in order to assess temporal risk the impact of wet and dry sequences on these impacts needs to be tested.

This is more complex than it sounds. The change in salt loads can be roughly estimated based on:

- The Phase 2 work for a dry sequence i.e. up to 80% reduction in irrigation drain salt loads for an extreme extended drought period; and
- From SKM 2006 for the 1984-95 wet sequence. i.e. around 20% increase in irrigation drain salt loads.

But the impact of the change in salt loads will not be directly related to the EC impacts as the river flows/dilution factors change in these wet and dry sequences.

Therefore a simplistic 20% increase in the coefficients for wet periods and a 80% decrease in the dry periods would not hold. Even though the salt loads may change by this order of magnitude

4.7 Extended drought impacts

The Basin Plan SDL is similar to the 7-year drought (2002/3 to 2007/8) for Victorian districts and both represent a 30% reduction to long-term water use, which was calculated in the ISAF scenario 2.

However, the actual salt load reductions found in the Phase 2 analysis (approximately -80% for irrigation drains) during the extended drought appears to be a higher impact than the -30.8 EC or -49% using the high estimate ISAF.

But it should be noted that the extended drought reductions in salt load reported in Phase 2 would have been influenced by general falls in water tables from dryland as well as the reduction in irrigation. Changes in dryland accessions would also influence tributary loads and groundwater inflows to the river.

The high market price of water during the drought also had a large influence of the level of irrigation management, some of which, but not all may be permanent. The permanence of the changes might be more easily assessed say 5 years hence.

5. RECOMMENDED DECISION PROCESS

The ISAF has been developed to manage risks associated with changes in water use on the RIverine Plains. It is recommended that the decision process shown in Figure 4 be adopted to continuously assess district scale water use changes and to determine what actions are reasonable for partner governments to take to ensure ongoing compliance with the accountabilities set out under the BSMS.

A number of tools are also available to support the decision process including:

- Salinity Impact Coefficients – Figure 4 and Table 4.2
- Cap water use, diversion and trading data – See Phase 2 report for analysis of changes in actual and modeled data.
- BigMod data files and model runs – Phase 1 and Phase 2 reports describe the context for assessing seasonal variability.

The specific technical procedures for assessing water use change have not been prescribed beyond the decision process above. However, there is and need beyond the outcomes of this project to undertake further work to define:

- The timeframes/period over which water use change should be assessed
- Any BSMS and/or Cap reporting mechanisms that might be formally adopted to support the implementation of the ISAF
- The nature of any agreement amongst the MDB jurisdictions on the data sets and models that will be required to support the ISAF and
- Considerations for updating the BSMS protocol/s

These, and possibly other items, will need to be considered by the MDBA and partner governments as part of the endorsement of the ISAF developed under this project.

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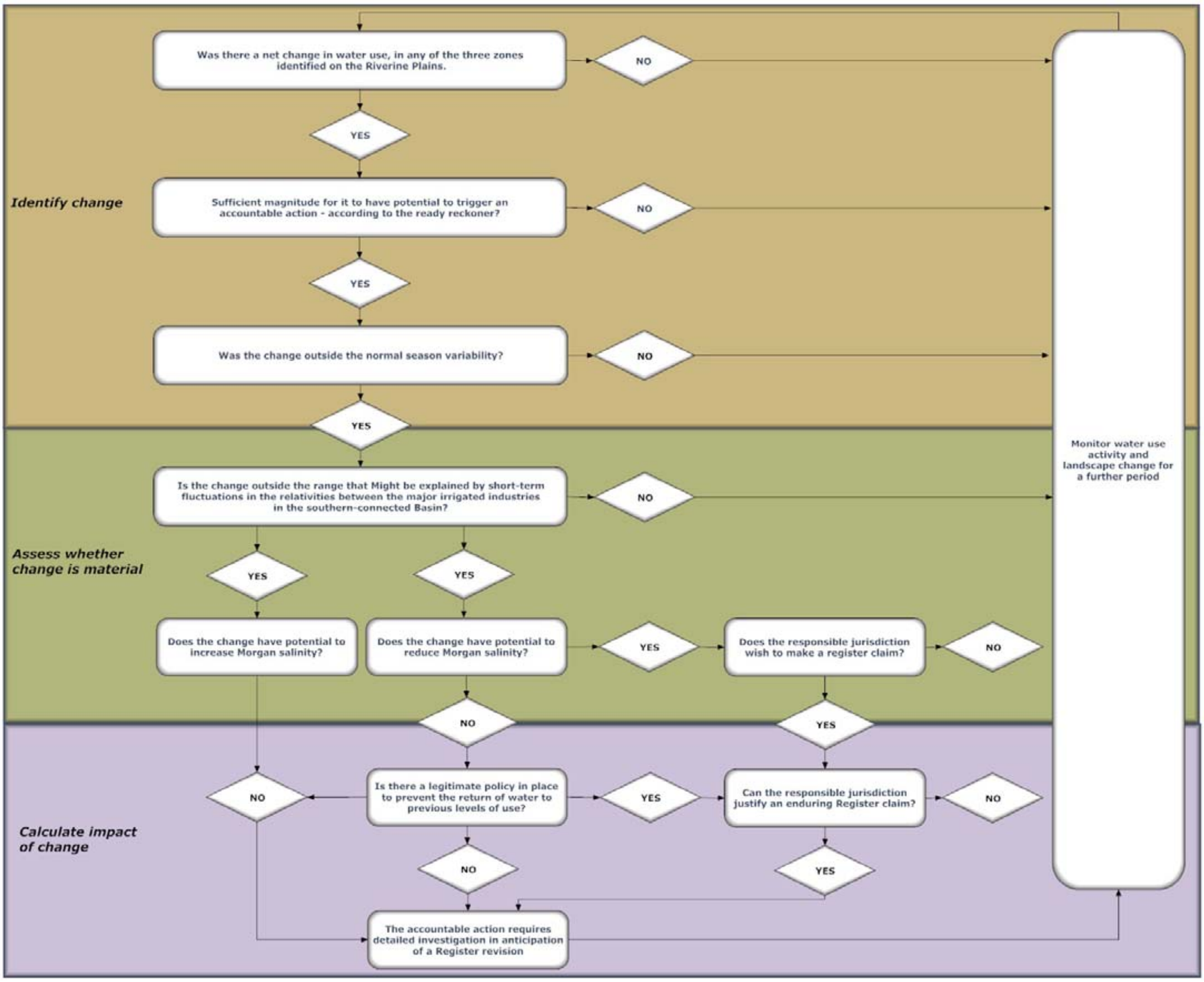

Figure 4: Recommended Riverine Plains Irrigation Salinity Assessment Framework

APPENDIX A: ACTUAL DIVERSIONS SOURCED FROM MDBA

														Averages	
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	last 12 years	5 yr pre drought	7 years drought
New South Wales															
Intersecting Streams	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3	3	3
Border Rivers	202.0	182.5	197.1	247.5	198.3	137.5	119.5	124.6	152.4	145.9	131.4	136.7	165	205	135
Gwydir	532.1	305.9	447.7	424.3	461.9	237.8	169.2	164.9	230.2	139.5	89.4	153.5	280	434	169
Namoi/Peel	305.1	322.3	350.0	354.7	363.5	293.9	173.1	190.2	234.1	166.0	141.8	188.1	257	339	198
Macquarie/Castlereagh/Bogan	442.3	395.8	437.4	521.5	596.7	411.2	218.7	102.5	224.1	252.2	74.5	105.6	315	479	198
Barwon-Darling/Lower Darling	265.9	427.6	260.4	487.0	202.5	126.5	291.5	185.7	198.8	17.2	220.8	158.5	237	329	171
Lachlan	429.0	293.2	300.6	423.2	457.1	253.0	58.5	36.5	127.7	72.5	46.3	40.2	211	381	91
Murrumbidgee	2585.5	2505.3	1874.9	2747.4	2348.0	1793.1	1775.5	1618.1	2200.3	960.1	514.8	602.1	1794	2412	1352
Murray	1889.6	1999.7	1233.7	2069.7	2113.4	879.0	1311.5	1240.8	1667.2	601.5	243.6	341.0	1299	1861	898
Total New South Wales	6654.8	6435.5	5105.2	7278.6	6744.7	4135.3	4121.0	3666.4	5038.1	2358.2	1465.9	1729.1	4561	6444	3216
Victoria															
Goulburn/Broken/Loddon cap valley	1909.0	1698.5	1553.5	1568.8	1700.3	1075.6	1595.6	1552.8	1592.4	651.3	684.5	628.3	1351	1686	1111
Campaspe	95.5	75.9	73.4	112.6	123.7	74.3	72.7	40.3	21.5	14.1	25.5	26.3	63	96	39
Wimmera-Mallee	184.1	159.5	103.2	67.9	83.8	60.5	66.4	49.7	60.2	18.7	44.8	11.5	76	120	45
Murray/Kiewa/Ovens Cap valley	1743.0	1803.7	1555.4	1712.0	1916.4	1754.7	1477.7	1492.9	1577.9	1406.3	800.5	837.4	1506	1746	1335
Total Victoria	3931.6	3737.6	3285.4	3461.2	3824.3	2965.1	3212.3	3135.7	3252.0	2090.4	1555.3	1503.4	2996	3648	2531
South Australia															
Metro-Adelaide & Associated Country Areas	153.1	152.9	138.7	103.6	82.5	164.7	82.1	71.6	73.9	203.1	89.4	149.5	122	126	119
Lower Murray Swamps	91.6	90.8	89.7	89.5	90.1	89.2	67.4	56.9	58.7	27.1	14.7	10.2	65	90	46
Country Towns	35.2	36.4	36.5	37.9	35.5	39.2	35.4	38.5	40.3	40.9	37.0	37.0	37	36	38
All Other Uses of Water from the River Murray	384.2	409.2	377.2	430.6	412.6	443.2	422.5	453.3	417.0	355.1	281.5	288.2	390	403	380
Total South Australia	664.1	689.2	642.2	661.6	620.6	736.3	607.4	620.4	589.9	626.2	422.6	484.9	614	656	584
Queensland															
Condamine/Balonne	544.9	467.1	366.4	360.4	161.6	123.1	575.0	167.0	186.2	57.4	775.8	189.9	331	380	296
Border Rivers/Macintyre Brook	185.7	123.2	162.7	288.1	163.3	78.0	203.7	191.6	124.7	70.8	209.7	156.7	163	185	148
Moonie	8.3	8.1	8.2	30.6	5.7	6.1	25.8	23.2	2.3	9.4	41.5	29.0	17	12	20
Nebine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0	0	0
Warrego	2.0	10.2	3.5	9.2	10.5	7.2	10.8	10.5	3.1	20.6	23.1	6.0	10	7	12
Paroo	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	2.0	4.0	1.0	1	0	1
Total Queensland	740.9	608.6	540.8	688.4	341.0	214.2	815.5	392.4	316.3	160.3	1054.1	382.7	521	584	477
Australian Capital Territory	44.2	23.2	26.5	33.8	36.4	40.1	27.8	27.4	32.0	25.0	15.6	18.5	29	33	27
Total Basin	12035.5	11494.2	9600.2	12123.6	11567.0	8091.1	8784.0	7842.2	9228.2	5260.1	4513.6	4118.6	8722	11364	6834
Kiewa	12.0	9.0	9.0	11.0	6.0	12.0	5.0	4.0	4.0	6.0	4.0	5.0	7	9	6
Murray (VIC)	1696.0	1765.0	1523.0	1657.0	1860.0	1711.0	1447.0	1448.0	1556.0	1383.0	779.0	807.0	1469	1700	1304
Lower Darling	67.9	194.3	85.1	240.6	126.1	106.9	23.2	28.9	41.4	15.8	11.1	9.2	79	143	34
Upper Darling	197.9	233.2	175.3	246.4	76.4	19.6	268.3	156.8	157.4	1.4	209.7	149.3	158	186	
Goulburn	1807.1	1623.0	1452.2	1450.9	1591.3	1004.3	1532.3	1476.8	1494.9	620.5	658.8	614.0	1277	1585	1057
Broken	38.6	26.1	24.6	16.6	27.2	39.1	31.2	26.7	29.0	20.8	16.5	10.5	26	27	25
Loddon	63.3	49.5	76.6	101.3	81.9	32.2	32.1	49.4	68.4	10.0	9.2	3.8	48	75	29
Border Rivers (QLD)	127.5	186.3	147.0	270.4	157.5	76.5	189.9	170.6	116.1	45.5	200.7	143.1	153	178	135
	10.7	5.7	9.4	12.5	14.5	11.8	8.1	14.5	18.9	13.3	9.0	13.6	12	11	13
Border Rivers (QLD)	185.7	123.2	162.7	288.1	163.3	78.0	203.7	191.6	124.7	70.8	209.7	156.7	163	185	148
Southern connected system	8886.6	8772.4	6933.1	8872.0	8822.4	6313.1	6840.3	6565.2	7649.2	4259.6	2691.5	2919.9	6627	8457	5320

APPENDIX B: OPERATIONAL PROTOCOLS AS THEY RELATE TO THE IMPACTS OF IRRIGATION

3.7.3 Assessment and recording of the impacts of irrigation development arising from water trade

The treatment of the impacts of irrigation development is to be consistent with Schedule C and the Protocols, with particular attention to:

- The immediate recognition of any water trade transaction as having potentially a ***significant effect***, leading to its declaration as an ***accountable action***
- The aggregation of similar or associated ***actions*** that may not individually produce a *significant effect* in order to treat them collectively (Protocol 3.6.1)
- The level of detail provided, and the effort employed to assess, proposals should be commensurate with the potential salinity impact (Protocols 3.3 and 3.6.4)
- The Commission's approval of the use of SIMRAT (Salinity Impact Rapid Assessment Tool), with its associated documentation and administrative arrangements, as a modelling tool for the assessment of water trades in the Mallee Zone.

The key steps in estimating the salinity impacts of new irrigation development (using SIMRAT, or other approved model) are:

- identify the volume of water being traded
- locate the irrigation licence to which the water is trading
- identify the actual area to be irrigated (if not known assume an area based on usage of 10 ML/Ha, and located on the nearest portion of the property to the irrigation supply source)
- assume that 85% of the total water traded is used by the crop, with the 15% remaining partitioned into 5% losses (e.g. evaporation) and 10% Root Zone Drainage (RZD)
- assess the salinity impacts of the 10% RZD across the irrigated area and record impacts on the Salinity Registers.

As with all *accountable actions*, initial estimates of the salinity impacts of new irrigation development will be based on a number of theoretical assumptions (such as the location of the irrigated area, and root zone drainage rates). Monitoring of *accountable actions* (Protocol 5.4.2) should focus on testing key assumptions, with estimated impacts revised, as appropriate, through the Five Year Reviews (Protocol 5.7.5).

More details of SIMRAT and its administrative arrangements are given in Appendix 3.11. The following provisions apply to the use of SIMRAT:

- SIMRAT may be used for the assessment of arrival site debits
- SIMRAT may be used for the assessment of departure site credits when the history of water use at a disposal site can be proved
- Assessments must be based on using the best available data for each specific trade, with jurisdictions ensuring that best available input data is made available for use in SIMRAT
- SIMRAT may be used in areas of high confidence without conditions
- SIMRAT may be used in areas of lower confidence in a conservative manner under the following conditions:
- Trades into these areas are initially designated with a provisional entry pending detailed assessment
- All data shall be submitted for these trades as is necessary to make the assessments in future
- trades into these areas can be assessed using an alternative (and approved) method if available;
- if an alternative method for assessing a trade is not agreed within one year of the transaction, the trade in question will be assessed using SIMRAT as the best available model.

The cumulative transactions for each region are to be reviewed every 5 years as part of the program for rolling 5 year reviews (see Protocol 5.7.2). Reviews will take into account actual irrigation development areas and practices, and entries in the Registers adjusted if necessary.

» **SEE SCHEDULE C, CLAUSES 23, 24, 33, 34**