OPTIMAL TIMING OF RESOURCE PROTECTION: INTERACTIONS OF GROUNDWATER MANAGEMENT WITH ROOTZONE PRODUCTIVITY AND SALT BALANCE IN THE SHEPPARTON REGION

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Use of pumped groundwater in conjunction with surface water is currently the most cost effective method for controlling water tables and rootzone salinity in the Shepparton Region. The cost to present and future generations of salt disposal to the Murray River in order to maintain a regional salt balance and delay aquifer salinisation was compared with the cost of earlier installation of evaporative disposal capacity. River disposal was more expensive under all groundwater salinity scenarios considered, particularly so for slow rates of degradation. Concepts concerning regional salt balance and pumping groundwater for salinity control before local salinity losses occur are discussed.

1. Background

If irrigated agriculture is to be sustainable, irrigation salinity needs to be controlled. Use of pumped groundwater in conjunction with surface water (conjunctive use) is currently the most cost effective method of controlling irrigation salinity in the Shepparton region. However other options exist for controlling salinity, so the cost effectiveness of conjunctive water use must be seen in the context of alternative salinity control measures.

Under conjunctive water use the salinity of pumped water usually increases with time. This increase in salinity occurs because of: (a) rainfall and irrigation salt inputs into the pumped aquifer, (b) upward leakage of groundwater into the pumped aquifer, (c) spatial constriction of the area of conjunctive use and (d) through mixing (Prendergast *et al.* 1993a). The effect of these processes on changes in groundwater salinity are additive. The rate of deterioration of groundwater quality resulting from these processes depends on the depth to the base of the pumped aquifer (for example an aquifer with a depth of 10 m is likely to degrade at twice the rate of an aquifer with a depth of 20 m).

Disposal of salt from the pumped aquifer to the Murray River through use of salt disposal allocations (SDAs) can reduce this rate of degradation. However the mass of salt which can be disposed of to the river is limited to a quantity approximately equal to the mass of salt inputs to the irrigation region (salt balance). Therefore disposal for salt balance is sufficient to offset degradation caused by irrigation and rainfall salt inputs alone (process (a) above). Only in special cases will disposal to the river be sufficient to make groundwater degradation zero (for example where there is no spatial constriction of conjunctive water use, and no upward leakage into the pumped aquifer). However in most cases disposal to the river will reduce the rate of groundwater degradation.

2. Rationale of Analysis

The benefit of disposal to the river then becomes a question of the time that this disposal delays the higher cost of alternative salinity control measures. Scenarios of both zero groundwater degradation (which can result from disposal to the river), and positive rates of degradation (which is the more widespread scenario likely to result after implementation of disposal) are examined in this paper. Only one other possible scenario exists under conjunctive water use, and this is where groundwater degradation is negative (i.e. where groundwater salinity improves over time). Under this scenario disposal is clearly uneconomic and therefore the scenario of negative degradation is not examined here.

The rate of groundwater degradation used in the analysis ranges from high levels of degradation (70 EC/y), to low rates of degradation, so that the sensitivity of the cost effectiveness of SDAs to typical rates of degradation can be examined. The high rate of degradation of 70 EC/y is taken from the Tongala area, where degradation is affected by both spatially constricted conjunctive water use (item (c) above), and by upward leakage of high salinity groundwater into the pumped aquifer (item (b) above).

The cost of salt disposal to the Murray River under the current Groundwater Pumping Incentive Scheme (GPIS) is compared with no disposal to the river. This enables an indication of the conditions under which disposal of salt from groundwater pumps to the Murray River is most likely to be cost effective.

Five cases covering a range of initial aquifer salinities and rates of aquifer salinisation are considered. The examples assume that salt disposal will reduce the rate of aquifer salinisation. Without annual disposal to the river, some groundwater disposal to an evaporation basin will be required earlier.

3. Assumptions

Assumptions used in this paper are considered to be the most appropriate at the time of writing. More information will become available in the future and a more precise analysis will then be possible.

The rate of degradation is considered to be linear, whereas in reality in some cases the rate of degradation may slow down after some decades. This assumption should not be necessary after current project work is completed at ISIA when data from a typical area will be available. It is noted that groundwater degradation in the Tongala area is very close to linear.

Salinity control is considered to be possible through conjunctive use on perennial pastures (threshold tolerance 1.6 dS/m) while groundwater salinity is below 5 dS/m (as suggested by Prendergast *et al.* 1993b). When groundwater salinity exceeds this threshold of 5 dS/m some other means of disposal is required to augment conjunctive water use.

Economic costs are estimated for a 60 hectare dairy farm. The economic cost of SDA is taken as $710 per pump per year. This cost comprises purchase of salt disposal entitlement and coordination and monitoring of disposal by the Rural Water Commission. No additional pumping costs are assumed. Nor is any opportunity cost of the pumped water allowed.

The alternative means of disposal of saline groundwater is considered to be evaporative disposal. It is likely however that disposal to salt tolerant crops or pastures (e.g. perennial ryegrass threshold tolerance 5.8 dS/m) will in fact be more economic. So this analysis will make river disposal appear more economic than is likely to be the case. A 2 hectare basin is considered adequate for the first 50 years of partial disposal (up to 25% of pumped volume) of 60 Ml of groundwater to evaporation. The remaining volume is used conjunctively on dairy pasture. No extra operating costs are included for disposal to basin rather than conjunctive use. Capital cost of the basin is amortised over 50 years. Capital cost is estimated as $12,500 or $6,250/Ha, which is slightly more than the $5,000/Ha suggested by Hallows *et al.*(1993).

The fourth and fifth examples in Tables 1 and 2 allow for construction of 10 hectares of evaporation basin and loss of rainfed production from the basin site. It is assumed that available water resources are used by intensification of irrigation on the protected land and productivity of water is unchanged by intensification.

4. Present and Future Points of View.

4.1 Present value of costs.

The method of economic evaluation for salinity management is to bring real future values back to the present by compound discounting at 4% p.a. (Victorian Government, 1988). Table 1 sets out the comparison of costs by showing the present value of the cost of starting evaporative disposal earlier when there has been no disposal to the river. This may be compared with the present cost of using SDAs up to the time when evaporative disposal is required for both options. In all cases, the cost of salt disposal to the river is higher than "nil, then basin" disposal.

INIT SAL EC	S D A	AQU. DEPT (m)	DEGR RATE EC/y	YRS TO EVAP	XTRA TIME y	COST OF EARL -IER EVAP $	COST OF SDA $	BREAK EVEN COST OF SDA $
3000	Y	10	55	36			13000	60
	N	10	70	29	7	1120		
3000	Y	10	25	80			17000	40
	N	10	35	57	23	924		
2000	Y	10	20	150			18000	9
	N	10	30	100	50	247		
2000	Y	20	5	600			18000	0.50
	N	20	10	300	300	11		
2000	Y	20	0	∞			18000	
	N	20	5	600	∞	0.01		0.01

Table 1: Present value of cost streams per pump for river disposal of aquifer salt and for nil disposal followed by earlier disposal to an evaporation basin.

4.2 Future Value of Costs

Sustainability of resources over several or many generations involves programs lasting for long time periods. the practice of discounting future cash flows back to present value is often criticised as, even at low discount rates, future values are discounted to insignificance. Discounting is seen to trivialise the rights of future generations to inherit resources. One approach to deal with this criticism is to view the annual costs and benefits of different options from the perspective of the future generation who must face the consequences of a choice between options made by a previous generation. This can be done by compound appreciation of annual cash flows starting from year 1 of the project, until the time that non river disposal is required for both options. The annual costs of salt disposal to the river are expressed as the future value of an annuity invested each year at 4% until non-river disposal is necessary. The annual costs of disposal to a basin are considered similarly, except that the flow of costs begins later in the project. For example, in the first case, salt disposal allocation costs are paid for 36 years but there are no costs for the nil river disposal option until the last 7 of those 36 years.

Table 2 sets out the comparison of costs by showing the future value of the cost of starting evaporative disposal earlier when there is no disposal to the river. This may be compared with the future value of the cost of salt disposal to the river for all those years up to the time when evaporative disposal is required for both options.

For the fifth case, even when there is no aquifer degradation with disposal to the river, there is still the cost of river disposal for 600 years when no basin disposal is required.

In all cases, the cost of salt disposal to the river is higher than "nil, then basin" disposal.

INIT SAL EC	SDA	AQU. DEPT (m)	DEGR RATE EC/y	YRS TO EVAP	XTRA TIME y	COST OF EARL -IER EVAP $	COST OF SDA $	BREAK EVEN COST OF SDA $
3000	Y	10	55	36			55000	60
	N	10	70	29	7	4600		
3000	Y	10	25	80			391000	40
	N	10	35	57	23	21000		
2000	Y	10	20	150			$6.4*10^6$	9
	N	10	30	100	50	89000		
2000	Y	20	5	600			$2.9*10^{14}$	0.50
	N	20	10	300	300	$1.6*10^9$		
2000	Y	20	0	∞			$2.9*10^{14}$	0.01
	N	20	5	600	∞			

Table 2: Future value of cost streams per pump for river disposal of aquifer salt and for nil disposal followed by earlier disposal to an evaporation basin.

4.3 Break Even Cost of Salt Disposal to the River

The break even cost of salt disposal to the river is shown in each table. Whether viewed from the perspective of future or present generations, the answer is the same. Salt disposal to the river for the purpose of maintaining a regional salt balance is more expensive than a more rational approach to the management of aquifer salinity.

The economic welfare of present and future generations will be reduced by a policy aimed at regional salt balance unless the cost of salt disposal to the river can be reduced to the break even cost set out in the table for each scenario.

5. Conclusions

1. The two groundwater degradation scenarios (positive and zero rates of degradation) where disposal to the Murray River is likely to be economic have been examined in this paper. For the only other possible scenario (i.e. groundwater degradation is negative) SDAs are clearly uneconomic.

2. On the basis of the assumptions set out above, from either the current or future generation's point of view, salt disposal to the river is much more expensive than the saving it creates by delaying the necessity for an evaporation basin. This is particularly so when the rate of aquifer salinisation is relatively slow, and/or initial aquifer salinity is low (e.g 2000 EC) Conversely, when pumping rates are high (such as when additional water resources are being sought, as opposed to pumping for salinity control) disposal is less uneconomic and farmers could be encouraged to take up SDAs, if sufficient private benefits accrue, such as reduced waterlogging or reduced winter soil pugging, relative to the cost of SDAs.

3. If lower rates of groundwater degradation are desirable, groundwater management to sustain groundwater quality should be encouraged because SDAs are uneconomic and insufficient to offset degradation. This approach is possible through provision of incentives on a $/Ha for conjunctive use, or through applying incentives up to a maximum Ml/Ha (e.g. at 0.5 to 1 Ml/Ha max).

The compounded cost of disposal to the river to achieve regional salt balance will greatly reduce the capacity of future generations to invest in projects required for continued sustainability.

REFERENCES

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