7. SENSITIVITY ANALYSIS AND CASE STUDY

Sensitivity analysis of the main input parameters to the new module, and a case study on land use change and water resources development scenarios are undertaken following the validation and verification of *ACRUSalinity*. The case studies are carried out for the same catchment used in the verification process, *viz.* the Upper Mkomazi Catchment in KwaZulu-Natal province, South Africa. This chapter therefore describes the following:

- A sensitivity analysis of the main *ACRUSalinity* module parameters
- Case studies that include an assessment of temporal and spatial changes in streamflow salinity, as well as
- Modelling the impacts of land use change and water resources developments on the catchment's TDS balance.

7.1 Sensitivity Analysis of the Basic *ACRUSalinity* Parameters

The testing of a model's performance is only considered to be complete once a careful and detailed sensitivity analysis has been conducted. This is also a very useful tool for building confidence in the model's structure (Schulze, 1995). Sensitivity analysis helps to examine the impact of less accurate data on model outputs. Görgens *et al.* (2001) suggest that, where sound data are not available from field observations or theoretical knowledge, those model components which are affected should be subjected to well designed sensitivity tests.

A sensitivity analysis is performed by assuming various values for given parameters. According to Konikow (2002), this helps to determine the sensitivity of the model to factors that affect flow and transport and to errors and uncertainty in data. Evaluating the relative importance of each factor helps determine which data must be defined most accurately and which data are already adequate or require minimal further definition. If additional data can be collected in the field, such a sensitivity analysis helps to decide which types of data are most critical and how to get the best return on the costs of additional data collection. If additional data can not be collected, then the sensitivity tests can help to assess the reliability of the model by demonstrating the effect of a given range of uncertainty or error in the input data on the output of the model.

Four input parameters that are specific to the hydrosalinity module are considered in this sensitivity analysis. Each of these parameters, in turn, is varied between extremes of plus or minus 50% of the base value. For the purpose of this dissertation the rate constant (k) and the salt saturation (equilibrium) parameters are assumed to remain constant down the soil profile and groundwater store. Thus, in most of the sensitivity tests the same value is used for topsoil, subsoil and groundwater store. The following sections discuss the sensitivity of model outputs to these parameters.

7.1.1 Effect of the salt uptake rate constant on subsurface water and runoff salinity

The salt uptake rate parameter is used in salt generation computations. The value of this parameter can be estimated through fitting a regression equation to a time series soil moisture and groundwater store TDS concentration values measured between two rainfall events. However, owing to the limitations in the availability of such data for the Mkomazi Catchment its value was estimated through calibration of the model. Therefore, a sensitivity analysis was performed to evaluate the effect of errors in this parameter on the topsoil, subsoil and groundwater stores as well as on runoff salinity.

Runoff salinity is the result of the combined effect of quickflow and baseflow as well as their associated TDS concentrations. In the case of quickflow, unless there is a contribution otherwise from saturated upward flow, its TDS concentration is neither directly nor indirectly influenced by the value of the salt uptake rate constant, whereas, baseflow salinity is affected directly by the value of this parameter. Therefore, based on this idea, one would expect to see a major deviation in the curves representing change in baseflow salinity and change in runoff salinity in response to changes in the salt uptake rate parameter. However, no significant difference can be noticed between the two curves (Figure 7.1). This phenomenon is attributed to the nature of the land use of the sub-catchment used for simulation of this sensitivity test. The first *ACRU* sub-catchment in the Upper Mkomazi Catchment is used for the various sensitivity test simulations. The land use of this sub-catchment is dominated by forest. Forest plantations are generally characterised as having high interception levels and increased rates of infiltration that result in reduced stormflows. Therefore, runoff volumes from these areas are mainly comprised of baseflow. The simulated stormflow, for example, was found to be only 5 % of the total runoff from the sub-catchment used in this sensitivity test. This results to closer TDS concentration values between runoff and baseflow from such areas (Figure 7.1). A small difference can be noticed only at the two extremes of change in *k* values. This small difference reveals that runoff salinity is relatively less sensitive than baseflow salinity to changes in salt uptake rate constant. In general both output parameters, baseflow and runoff salinity, have shown low sensitivity to changes in the value of the salt uptake rate constant.

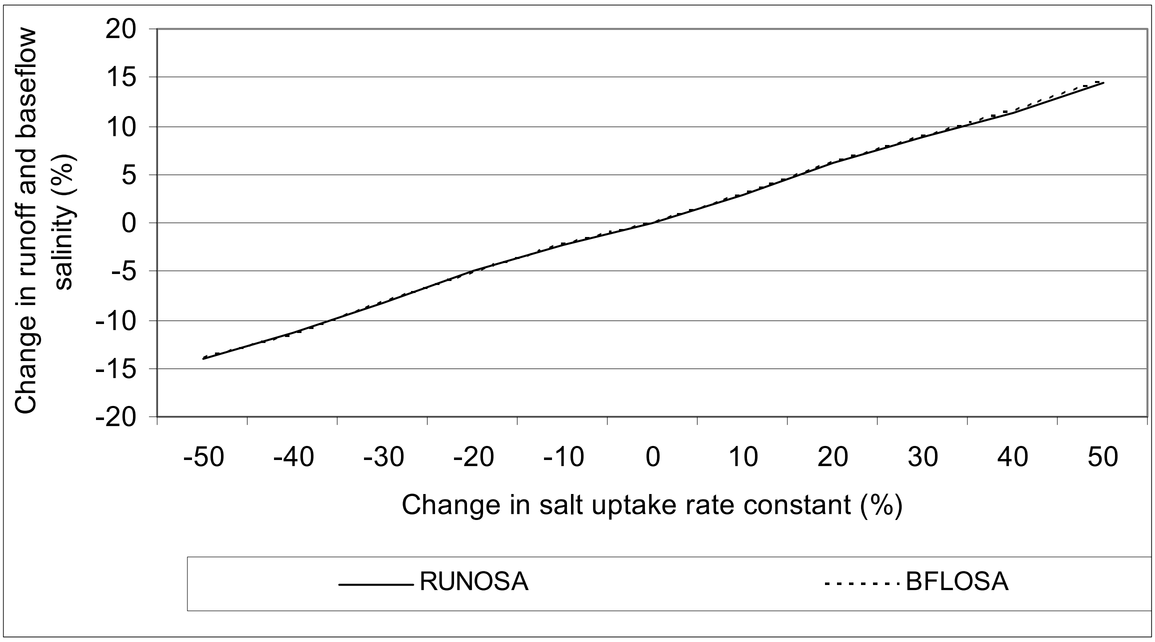

Figure 7.1 The effect of changes in salt uptake rate constant, *k*, on baseflow salinity (BFLOSA) and runoff salinity (RUNOSA)

Figure 7.2 shows the effect of change in salt uptake rate constant on topsoil, subsoil and groundwater store salinity. As it can be seen from the various curves, the sensitivity to changes in salt uptake rate constant increases from the topsoil down to groundwater store. Thus the topsoil moisture salinity (TOPSSA) is less sensitive to changes in the salt uptake rate constant than the subsoil moisture salinity (SUBSSA). The subsoil moisture salinity in turn is less sensitive than the groundwater store salinity (GWSA). The difference in sensitivity between the different subsurface components can be attributed to the variation in "evapoconcentration" and the degree of dilution by rainfall between these components. In general, the three subsurface components have shown low sensitivity to changes in the salt uptake rate constant.

Another remarkable observation that can be noticed from Figures 7.1 and 7.2 is that the change in surface and subsurface water salinity response to changes in salt uptake rate constant increases at a decreasing rate. This phenomenon can be described by the fact that, as the salt uptake rate increases it results in increased subsurface TDS concentrations. The upper limit of subsurface water salinity (salt saturation) value then starts to take control of the amount of salt that can be generated on a particular day, where a further increase in the value of salt uptake rate results in lower increase in subsurface water salinity. A similar trend can also be noticed of the effect of decreasing values of the salt uptake rate constant on subsurface water salinity. In this case, however, the change in subsurface water salinity decreases at an increasing rate. This can also be explained by a similar reason, where at low values of subsurface water salinity (as compared to the salt saturation value) salt generation is less constrained by the salt saturation value and hence a small decrease in the value of salt uptake rate constant results in a significant difference in subsurface TDS concentration . Therefore, the sensitivity of subsurface water salinity to salt uptake rate constant increases with a decrease in *k* value and decreases with increase in *k* value.

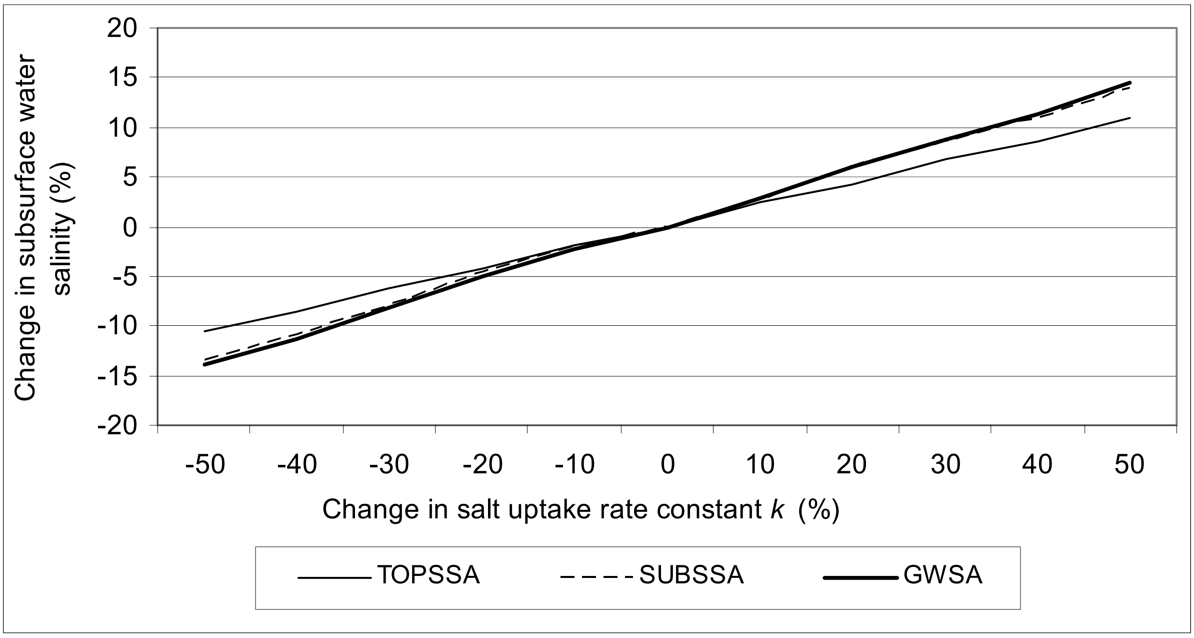

Figure 7.2 The effect of change in salt uptake rate constant on the topsoil salinity (TOPSSA), subsoil salinity (SUBSSA) and groundwater salinity (GWSA)

7.1.2 The influence of changes in salt saturation values on runoff and subsurface water salinity

Salt saturation is one of the major input parameters to the salt generation equation. This value represents the maximum subsurface water salinity beyond which no salt generation takes place. As can be observed from Figure 7.3, baseflow and runoff salinity have shown almost the same sensitivity for changes in the salt saturation value. This is due to the reason mentioned in the previous section, which is attributed to the nature of the land use in the sub-catchment used for the sensitivity test simulations. In general, both curves show low sensitivity of baseflow and runoff salinity to changes in value of the salt saturation parameter.

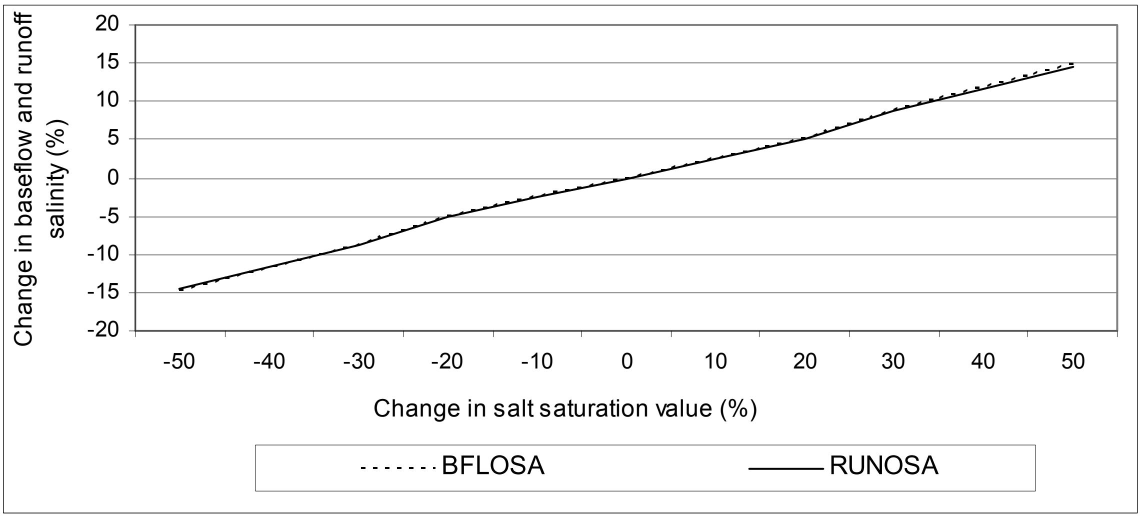

Figure 7.3 The impact of changes in value of the salt saturation parameter on runoff salinity (RUNOSA) and baseflow salinity (BFLOSA)

Figure 7.4 shows the effect of changes in salt saturation value on subsurface water salinity. The different curves reveal that groundwater TDS concentration (GWSA) is relatively more sensitive than subsoil water salinity (SUBSSA) which in turn is more sensitive that the topsoil water salinity (TOPSSA). The difference in sensitivity between the three subsurface components can be attributed to the variation in "evapoconcentration" and the degree of dilution by rainfall between these components. In general, the topsoil, subsoil and groundwater salinity have shown low sensitivity to changes in value of the salt saturation parameter.

All the curves in Figures 7.3 and 7.4 show a certain degree of upward curvature. This curvature shows an increase in subsurface water salinity at an increasing rate with an increase in the salt saturation value. This can be explained by the fact that as the salt saturation value increases, the asymptotic value (the maximum TDS concentration value) at which, the salt generation becomes zero, is pushed forward resulting in an increased rate of change in subsurface water salinity. Similarly, a decreasing change in salt saturation value results in a decrease in subsurface water salinity at a decreasing rate. This can also be explained by the same reason. As subsurface water salinity decreases, the salt generation mechanism is less governed by value of the salt saturation parameter. Rather, the other parameters of the equation, such as the salt uptake rate constant, will have more control on the salt generation processes, as described in the previous section.

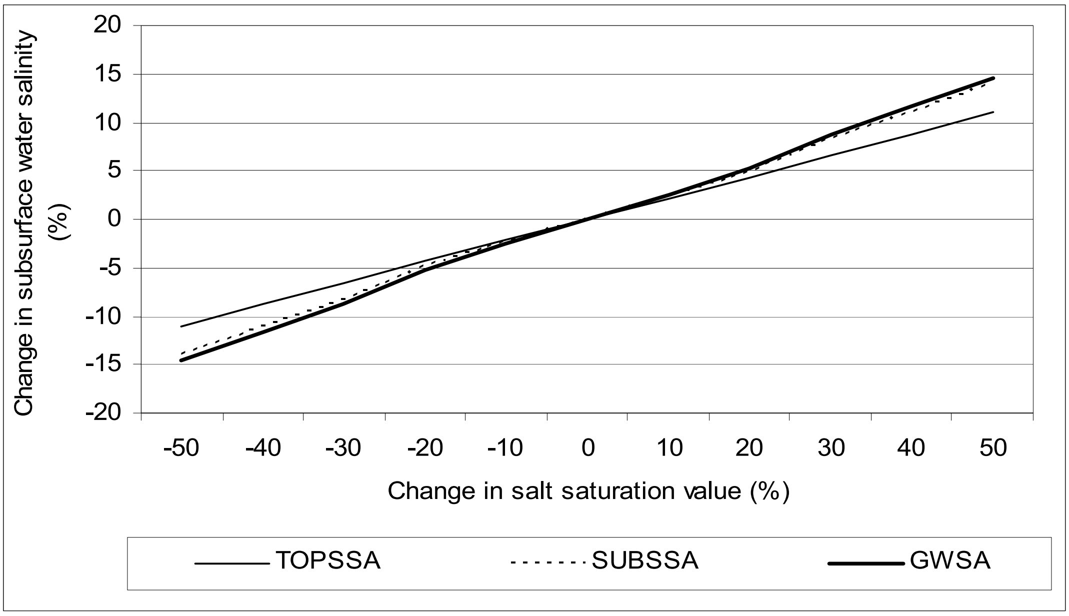

Figure 7.4 Sensitivity of the topsoil salinity (TOPSSA), subsoil salinity (SUBSSA) and groundwater salinity (GWSA) to changes in values of the salt saturation parameter

7.1.3 Effect of initial soil water salinity on time series subsurface water and runoff salinity

The initial soil moisture salinity parameter is one of the basic inputs to the module. This parameter is input to the module in order to account the effect of the initial soil moisture at the beginning of the simulation period on surface and subsurface TDS balance. A sensitivity test was conducted to assess the impact of this parameter on topsoil, subsoil, groundwater store and runoff salinity.

Figure 7.5 shows sensitivity of baseflow and runoff average salinity to changes in initial soil moisture salinity. Only a minor difference can be noticed between the sensitivity curves of baseflow and runoff salinity. As explained in the previous sections, the reason for this phenomenon is associated with the nature of the land use in the simulated catchment. However, baseflow salinity (BFLOSA) shows relatively higher sensitivity than runoff salinity (RUNOSA).

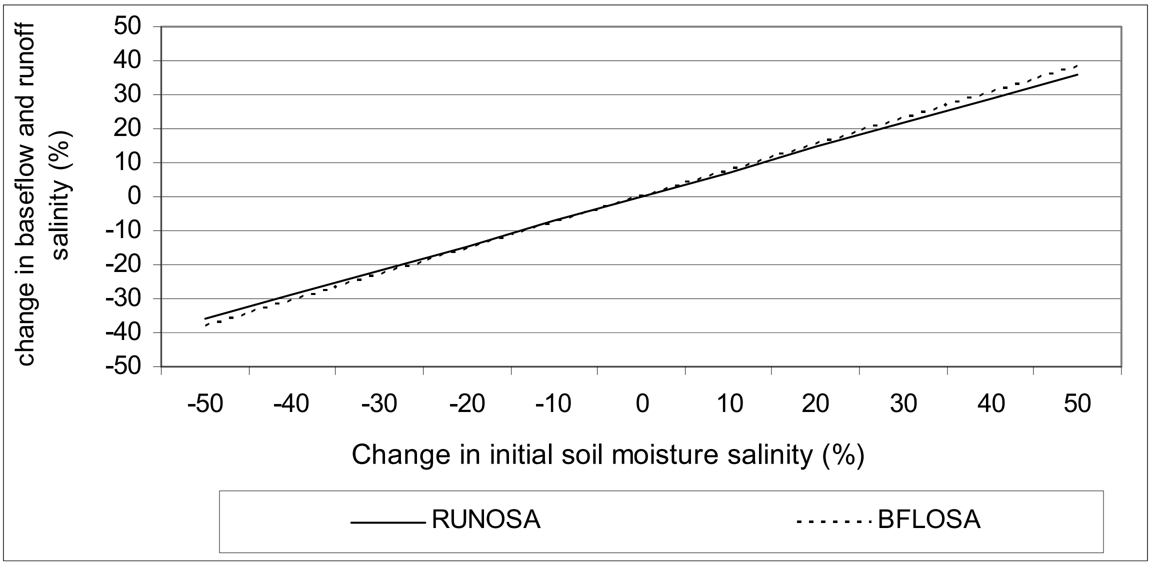

Figure 7.5 Sensitivity of baseflow salinity (BFLOSA) and runoff salinity (RUNOSA) in response to changes in initial soil horizon salinity

Simulated time series TDS concentration values of the topsoil horizon at different initial TDS concentration values (INITOPSSA) are plotted on the same graph to view the general trend in subsurface water TDS concentration with time in response to changes in value of this parameter (Figure 7.6). For the first few months of the simulation period, a considerable difference can be noticed between the five curves representing daily topsoil TDS concentration outputs simulated at different initial TDS concentration values. However, this difference between these curves decreases with time. Therefore, the impact of initial topsoil TDS concentration values on subsequent daily TDS concentration values shows a decreasing trend with time. The impact of initial subsoil salinity on subsequent daily subsoil TDS concentration values has also shown a similar trend with time (Figure 7.7).

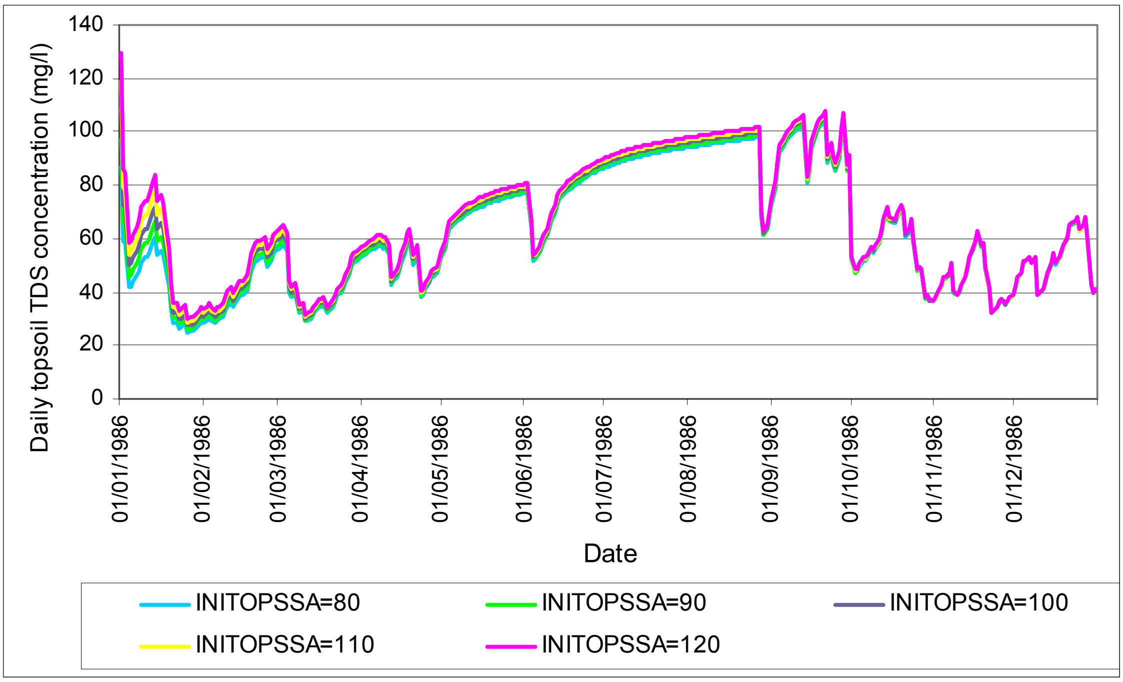

Figure 7.6 Daily simulated topsoil TDS concentration curves at different initial topsoil salinity (INITOPSSA) values

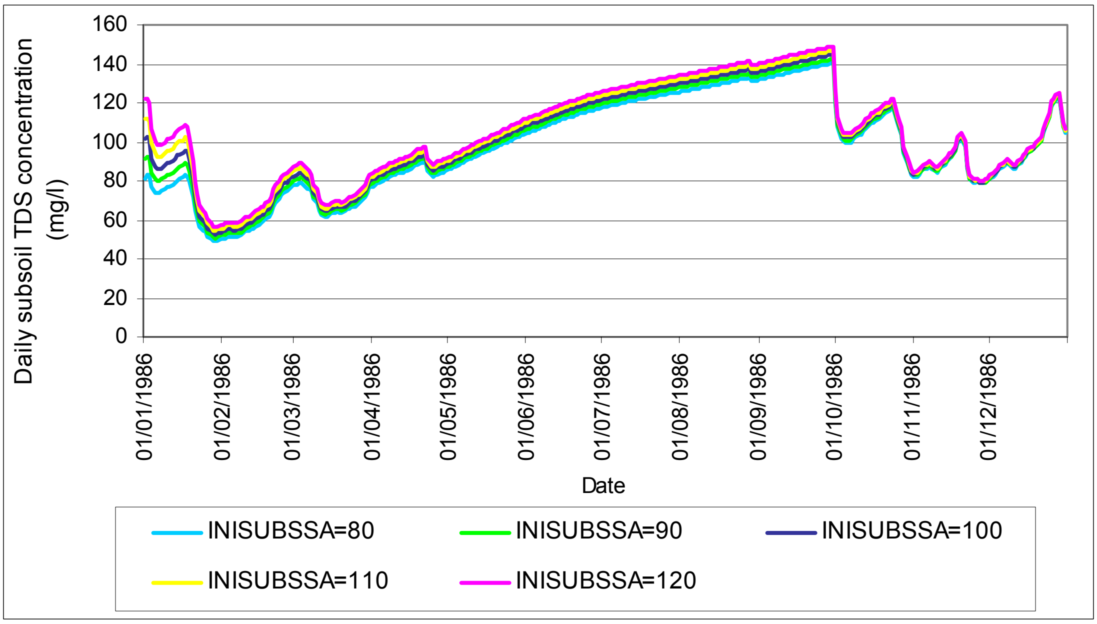

Figure 7.7 Daily simulated subsoil TDS concentration curves at different initial subsoil salinity (INISUBSSA) values

The decreasing impact of changes in the initial topsoil salinity value on subsequent days' TDS concentration with time initiated the idea of conducting separate sensitivity tests for different periods of the year. Therefore, the simulation period was divided into four quarters, each quarter representing three months of the simulation period. Figure 7.8 shows sensitivity of daily soil moisture salinity to changes in the value of initial soil moisture salinity. The result shows that topsoil TDS concentration is highly sensitive to changes in initial soil moisture TDS concentration in the first three months of the year (first quarter) compared to subsequent periods of the year. Although the remaining quarters of the year show similar sensitivity of the topsoil TDS concentration to changes in initial soil moisture TDS concentration, the sensitivity does decrease from the third quarter to the fourth quarter of the year. Sensitivity of the subsoil and groundwater store TDS concentration to changes in this parameter are also shown in Figures 7.9 and 7.10. From comparisons of these three graphs, it can be concluded that sensitivity of subsurface TDS concentration to changes in initial soil moisture salinity decreases with time and increases downward from topsoil to groundwater store. This can be explained by the following reasons:

- With time, part of the initially stored soil moisture is displaced by the infiltrated rainfall or irrigation water applied on the area resulting to dilution and subsequent reduced impact of the initial value on daily TDS concentration.
- The topsoil's TDS concentration is more frequently diluted through rainfall or irrigation water recharge as compared to subsoil or groundwater store. This is because the topsoil horizon is almost always recharged during a rainfall event or during irrigation. However, the recharge of subsoil and groundwater store is controlled not only by the quantity of water stored in the topsoil horizon but also by the physical characteristics of the topsoil horizon that control its moisture release characteristics. Therefore, impact of the initial TDS concentration value on subsoil and groundwater store lasts for a longer period of time than on topsoil horizon.

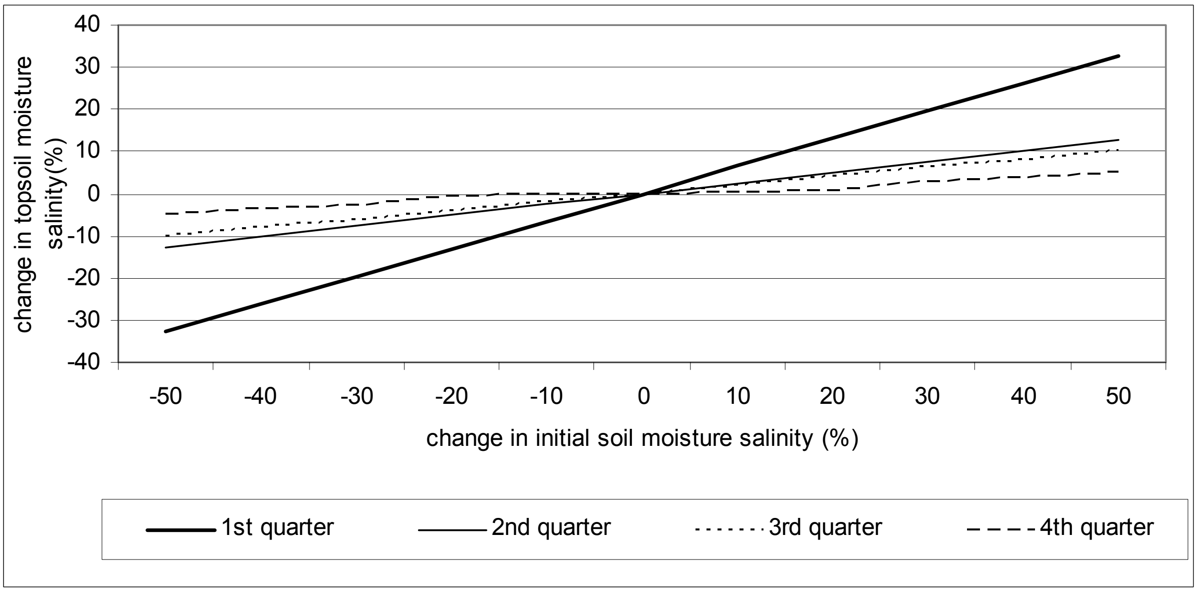

Figure 7.8 The influence of changes in initial soil moisture salinity on topsoil moisture average salinity at different times during the year

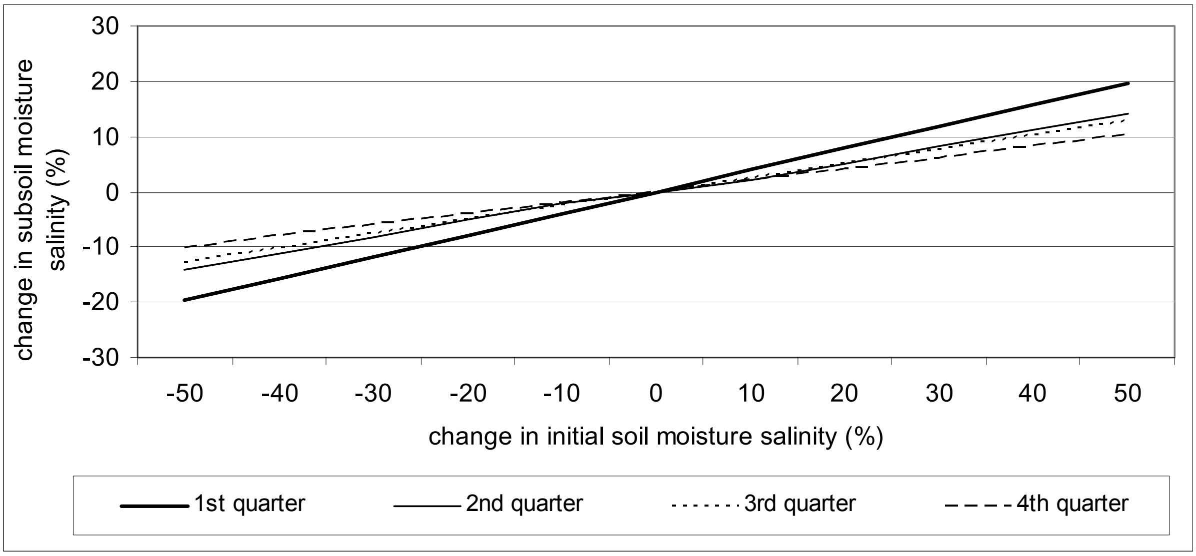

Figure 7.9 The influence of changes in initial soil moisture salinity on subsoil moisture average salinity at different times during the year

The preceding relevant graphs are also displayed in the same graph (Appendix E) for the ease of comparison of model sensitivities between parameters.

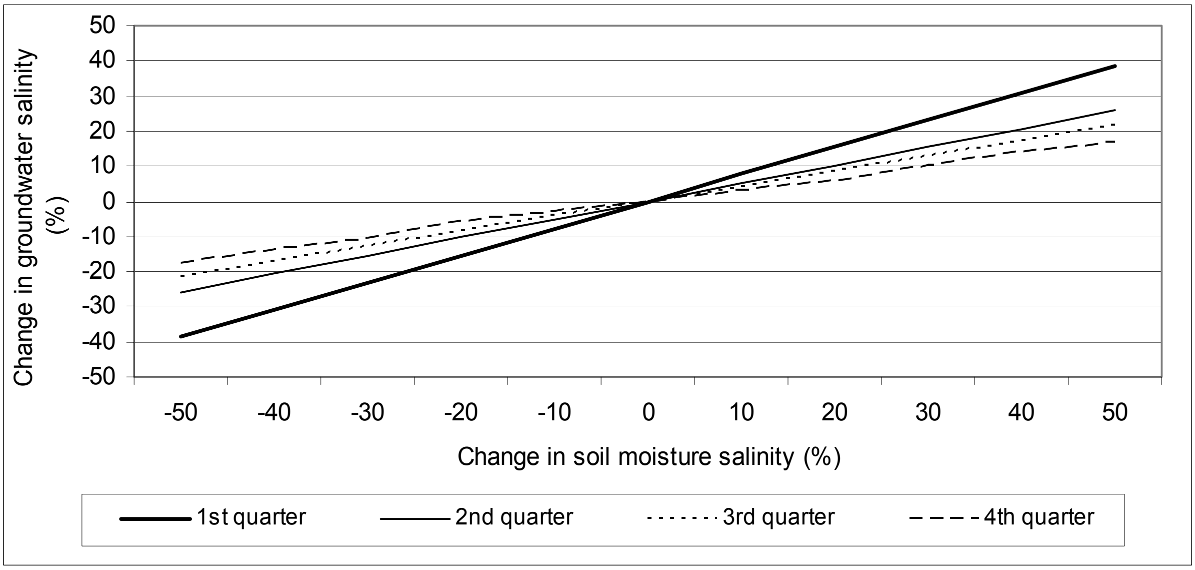

Figure 7.10 The influence of changes in initial soil moisture salinity on groundwater average salinity at different times during the year

7.1.4 Effect of initial reservoir storage salinity on time series reservoir storage and outflow salinity

The initial reservoir storage salinity value is an important input for reservoir TDS balance computations in *ACRUSalinity*. Hence, it is appropriate to conduct sensitivity tests on this parameter. To assess if a certain trend exists in the impact of the initial reservoir storage salinity, INIRESSA, on daily TDS concentration values, as in the case of subsurface salinity, the daily TDS concentration outputs from the module are plotted in the same graph (Figure 7.11).

From this figure it can be seen that no significant difference can be observed between the various reservoir storage TDS concentration curves simulated at different initial reservoir salinity values varying between 46.4 mg/l and 69.6 mg/l, i.e. plus or minus 20 % of its base value (58 mg/l). Therefore, there was no need to conduct different sensitivity tests at various intervals of the year as was done for the case of soil moisture salinity.

The impact of changes in initial reservoir salinity on mean reservoir storage and outflow salinity is shown in Figure 7.12. The figure shows that the TDS concentration of water discharged from the reservoir (OUTFSA) is relatively more sensitive to changes in reservoir initial storage salinity than the reservoir storage TDS concentration (RESSA). However, the overall sensitivity of the reservoir storage and outflow salinity to changes in initial storage salinity is very low.

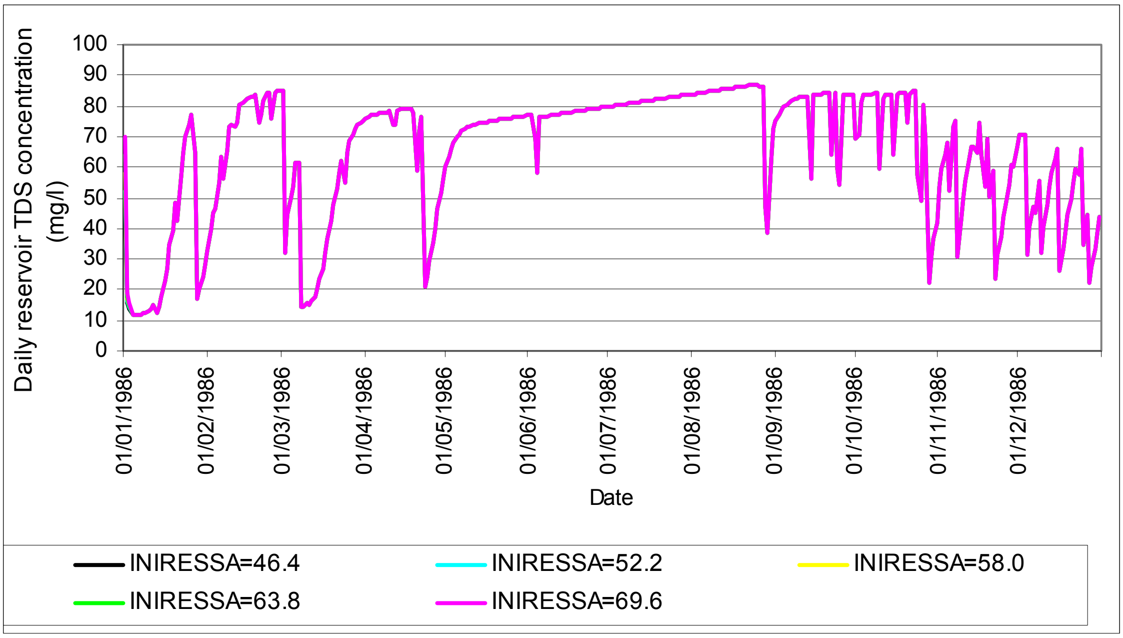

Figure 7.11 The impact of initial reservoir storage salinity on simulated daily reservoir storage average salinity

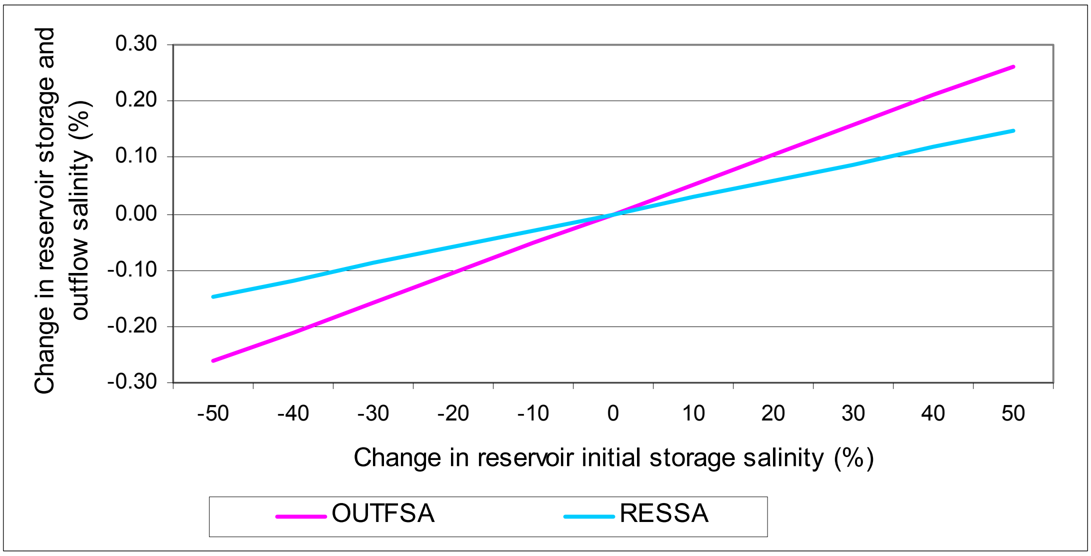

Figure 7.12 Sensitivity of reservoir storage and outflow average salinity to changes in reservoir initial storage salinity

7.2 Some Applications of *ACRUSalinity*: Case Study in the Upper Mkomazi Catchment

This section demonstrates some applications of the hydrosalinity module of *ACRU* with scenarios and case studies in the Upper Mkomazi Catchment. The scenarios and case studies include:

- spatial change in streamflow TDS concentration and salt load at various sub-catchment outlets
- seasonal and long term temporal changes in streamflow TDS concentration and salt load at the catchment outlet
- the impact of a new reservoir on downstream TDS concentration and
- the influence of future land use change on downstream TDS concentration.

7.2.1 Spatial and temporal variations in streamflow salinity within the catchment

One of the major applications of hydrological and water quality models is for an assessment of temporal and spatial changes in values of a variable of interest (for example streamflow and its TDS concentration). This allows catchment managers to anticipate the duration of elevated salinity and salt load and to identify which part of their catchment is likely to have a greater or lesser contribution to the total salt load at the catchment outlet. Such information may then be used to take appropriate measures or management options at the right place. Similarly, the result from an assessment of temporal changes in salt load and concentration may help to understand the general long term trend and seasonal fluctuations in TDS concentration and salt load. Model outputs with seasonal TDS concentration trend might, for example, help to identify months of the year on which various management options such as blending options should be considered.

7.2.1.1 TDS concentration at sub-catchment outlets and reaches

An assessment at various reaches of the Upper Mkomazi Catchment based on simulations undertaken with *ACRUSalinity* for a period of 10 years, i.e. from 1986 until 1995, shows that streamflow TDS concentration spatially varies within the catchment and it is generally higher at downstream than at upstream end of the catchment. This can be attributed partly to the re-use of water for irrigation and subsequent enrichment in dissolved solutes as it flows downstream. Figure 7.13, shows the relative TDS concentration at the outlet of each sub-catchment. The corresponding simulated mean TDS concentration and salt load values at the outlet of each sub-catchment are given in Table 7.1.

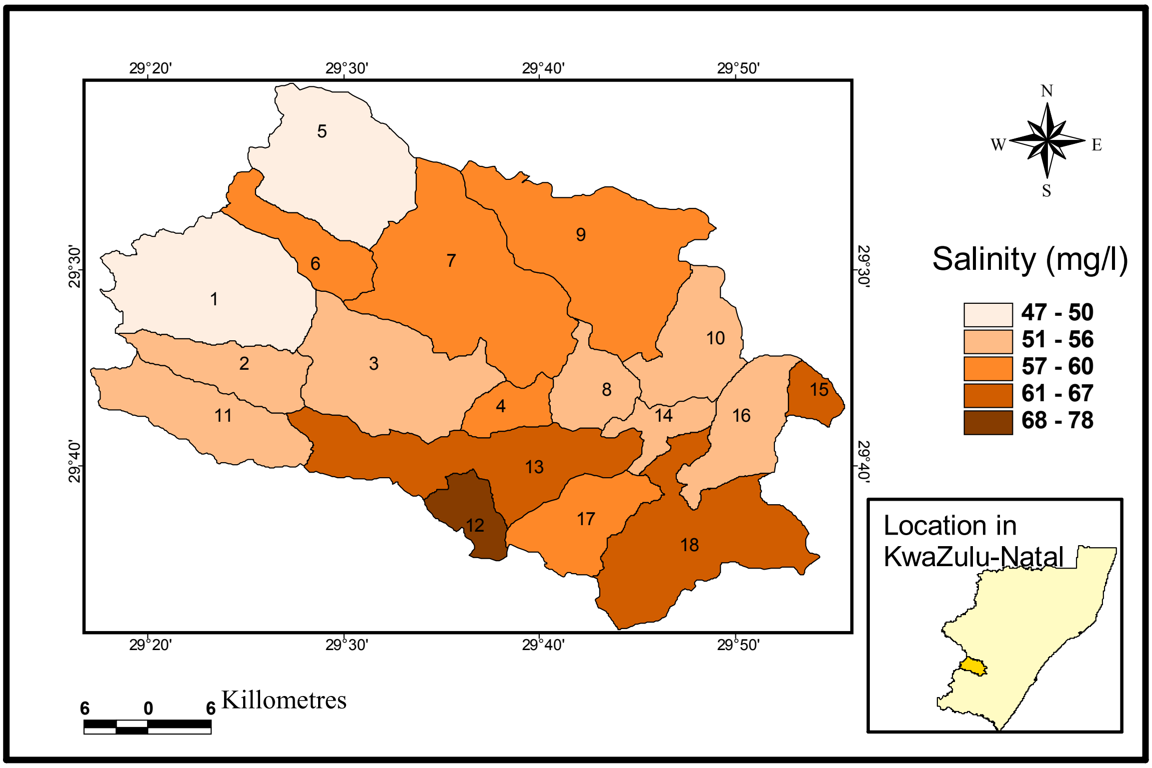

Figure 7.13 Spatial variation of mean TDS concentration at sub-catchment outlets of the Upper Mkomazi Catchment based on the simulation from 1986 to 1995

The difference in streamflow salinity between the various sub-catchments is as a result of the spatial variation in hydrologic, climatic and physiographic factors within the catchment. For example, Sub-catchments 1 and 12 have the lowest and highest simulated streamflow TDS concentration respectively (Figure 7.13). The main reason for the difference in streamflow salinity between the two sub-catchments is found to be as a result of the spatial variation in precipitation, evaporation, land use and other hydrologic, climatic and physiographic factors as shown in Appendix D. Sub-catchment 12 has the highest percentage of irrigated land compared to the other sub-catchments. Similarly, this sub-catchment has lower mean annual precipitation but higher mean annual evaporation compared to Sub-catchment 1. All these factors together with the other factors result in relatively higher TDS concentration in Sub-catchment 12 compared to Sub-catchment 1.

The streamflow salt load increases downstream at various reaches of the main channel. For example, as it can be seen from Table 7.1 the streamflow salt load at the outlet of Sub-catchment 3 is less than that of Sub-catchment 4 which in turn has lower salt load than Sub-catchment 8. This is attributed mainly to the increase in streamflow volume downstream at various reaches along the main channel. The direction of flow and salt transport within the Upper Mkomazi Catchment is shown in Figure 6.6.

Table 7.1 Simulated average TDS concentration and salt load at the outlet of sub-catchments in the Upper Mkomazi Catchment

Sub-catchment No.	Average TDS concentration (mg/l)	Average Salt load (kg)
1	50.26	7761.5
2	57.05	3108.7
3	58.38	18490.0
4	57.92	20002.6
5	47.21	7351.9
6	53.04	3089.2
7	54.07	21578.6
8	55.65	44449.4
9	55.25	9157.6
10	54.37	13344.6
11	54.46	4357.6
12	64.04	1742.4
13	60.88	14547.3
14	56.47	74470.5
15	63.18	1137.9
16	67.83	5149.8
17	78.23	3885.3
18	59.30	92120.5

7.2.1.2 Temporal variations in streamflow salinity and catchment salt export

A preliminary assessment of salinity in the Mkomazi Catchment based on observed TDS concentration values is described in Section 6.1.5. However, most of the observed records used for that assessment were monthly samples, and at irregular intervals of time. Therefore, this topic will examine the temporal variations in TDS concentration of streamflow from the

Upper Mkomazi Catchment based on model outputs at a daily time step. Similarly, in this section the salt load export to the Lower Mkomazi Catchment will also be discussed.

Figure 7.14 shows the seasonal and long term variations in monthly averages of daily streamflow TDS concentrations (mg/l) and salt load (mg) at the outlet of the Upper Mkomazi Catchment. Seasonal fluctuations in TDS concentration can be noticed from the figure that can be attributed mainly to "evapoconcentration" and the dilution effect of rain falling on the area. The long term trend (ten years) for the area reveals an increasing streamflow TDS concentration with time. This can be due to an increase in reuse of water with time for irrigation and other purposes. Similarly, the salt load export of the catchment has shown seasonal fluctuations, although, the long term trend shows a decreasing trend with time. The decreasing trend in streamflow salt load, despite of increase in streamflow salinity, is attributed to the decrease in streamflow volumes.

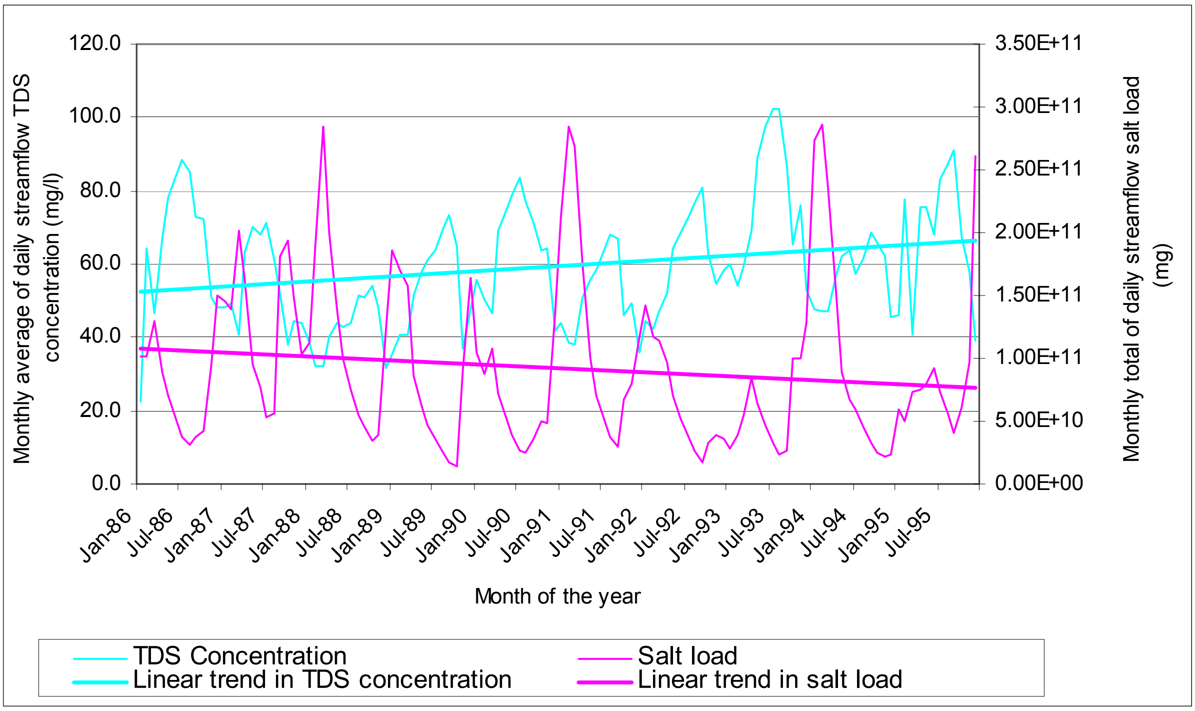

Figure 7.14 Simulated monthly average of daily TDS concentration and salt load at the outlet of the Upper Mkomazi Catchment (U1H005)

7.2.2 Modelling future scenarios

In order to demonstrate some potential applications of the new module, this section will attempt to examine scenarios of future water resource development and land use change in regard to their effects on downstream TDS concentration, *viz*. evaluating the impact of a proposed reservoir and the impact of land use changes from grassland to forest and to irrigated areas.

7.2.2.1 Evaluating the impact of a proposed reservoir on downstream TDS concentration

The Impendle is one of the proposed dams in the Mkomazi Catchment under the Mkomazi-Mgeni transfer scheme. This reservoir will be situated at the outlet of the 14th *ACRU* sub-catchment (Taylor, 2001). An analysis to optimise reservoir size was carried out by Ninham Shand Consulting Engineers. The first two reservoir sizes considered under this study for the Impendle Reservoir are 135 and 270 million m^3 (10^6 m^3). The impact of this proposed reservoir on downstream streamflow TDS concentration was assessed using simulation results from the hydrosalinity module of *ACRU*. This assessment considers impacts of the reservoir at the two sizes (135 and 270 million m^3) assuming the present land use (baseline).

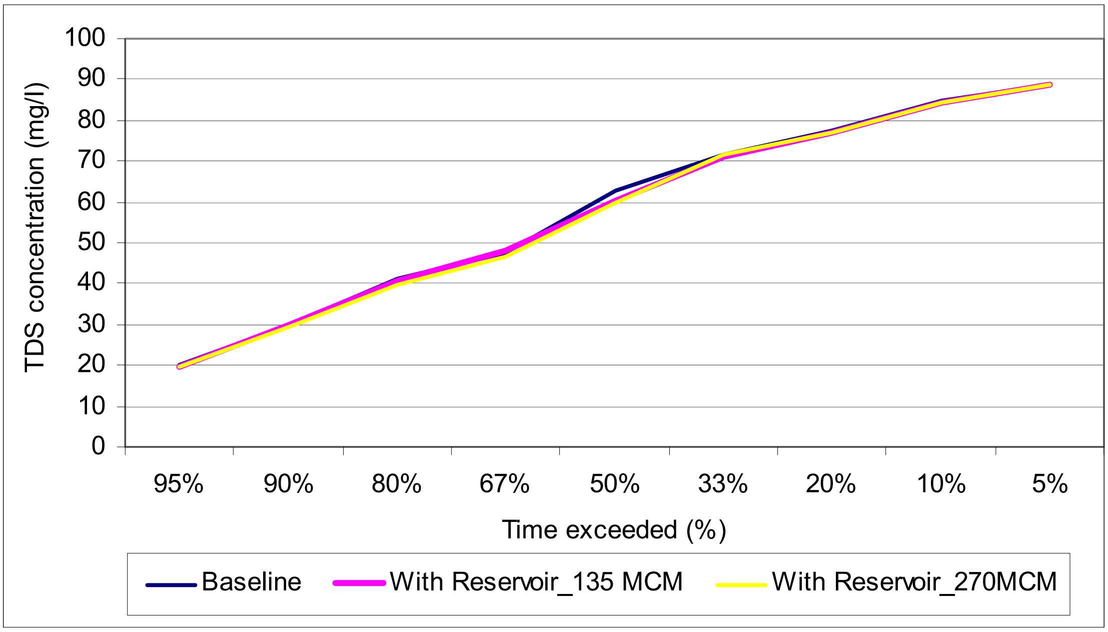

Figure 7.15 Impact of the proposed Impendle Reservoir on streamflow TDS concentration as simulated at the outlet of Sub-catchment 13 at two reservoir sizes

There is little difference on downstream streamflow TDS concentration as a result of the presence of the reservoir at the two different sizes. From Figure 7.15 it can also be seen that no significant difference exists between the two curves and the baseline. Only a minor difference can be noticed around the median TDS concentration values. Therefore, the proposed dam will not have significant impact on downstream streamflow TDS concentration both at reservoir size of 135 and 270 million m^3 especially on high and low TDS concentrations. This can be attributed to the low evaporation that characterises the Mkomazi Catchment, compared to many arid and semi-arid areas, where evaporation is a major cause of increased salinity due to "evapoconcentration" effect. The little "evapoconcentration" in the reservoir that could have resulted in increased downstream streamflow salinity is offset by the reduced area of the grassland where subsurface salt uptake and increased soil and groundwater salinity as a result of evaporation from the soil surface and transpiration from the plant could have been imposed.

7.2.2.2 The impact of land use change on downstream TDS balance

Any activity that alters the water balance of an area also alters its salt budget. Therefore, a change in land use practice is expected to result in a subsequent shift in downstream TDS concentration and salt load. For example, in the Murray-Darling Basin of Australia, the formation and growth of dryland salinity has been mainly attributed to land use changes from native forest vegetation to grazing and irrigated lands (Blackmorea *et al.*, 1999).

An assessment of the impact of commercial forest on downstream TDS concentration is undertaken through replacement of the original grassland (baseline) with forest in the sub-catchment chosen for this purpose (*ACRU* sub-catchment No. 13). The area coverage of the various land uses in this sub-catchment is shown in Table 6.2. The scenarios included in this assessment are what would be the impact on downstream streamflow TDS concentration if:

- 50 % of the sub-catchment was afforested and
- 75 % of the sub-catchment was afforested with eucalyptus.

The simulated average streamflow TDS concentration downstream of the afforested sub-catchment shows relatively lower values compared to those of the baseline grassland. This can be seen from the curves in Figure 7.16. Forest plantations consume much water and from a greater soil depth as compared to grasses. This results in very low baseflow discharge. Therefore, flow from the other land use categories, such as impervious urban areas will constitute most of the streamflow at the sub-catchment's outlet. In *ACRU* the flow from impervious areas does not include baseflow. Hence, it is characterised with low TDS concentration. In general, from these scenarios it can be noticed that afforestation of grasslands especially in high water table areas, which are prone to dryland salinity, might be a viable management option to prevent land and water salinisation. On the other hand, these scenarios show that land clearing for grazing purposes might have a significant impact on dryland salinity.

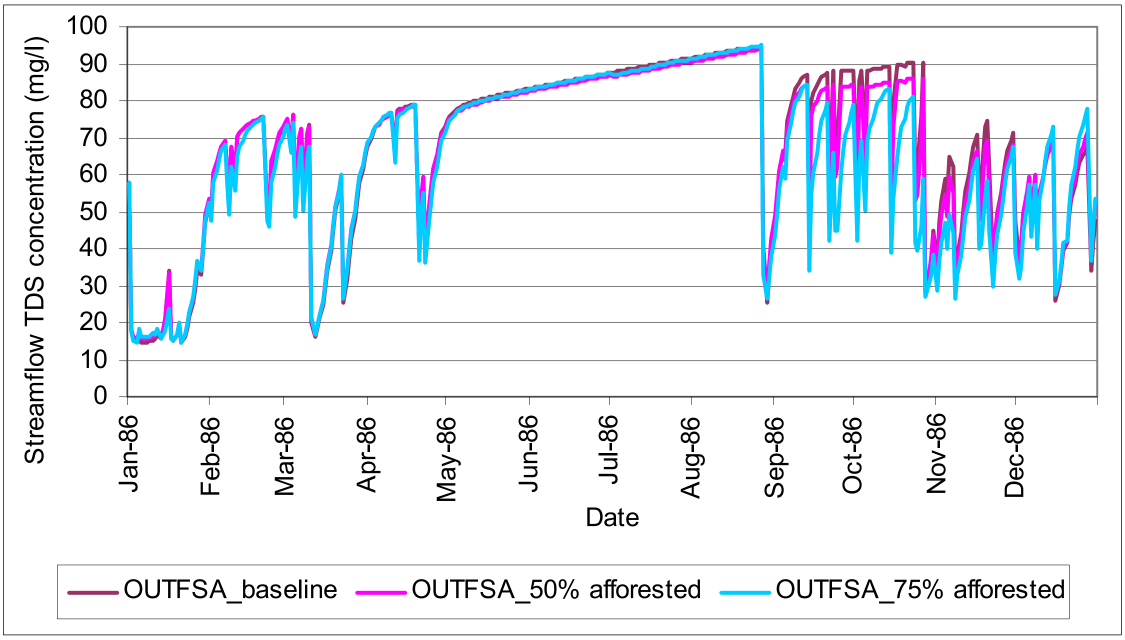

Figure 7.16 The impact of forests on downstream streamflow TDS concentration at the outlet of Sub-catchment 13

A numerical break down of the runoff constituents before and after afforestation is shown in Table 7.2. The results from this analysis show that water consumption as estimated by the actual evapotranspiration (AET) has increased as a result of afforestation with subsequent decrease in baseflow and quickflow depths. This in turn has resulted to an increase in baseflow and runoff TDS concentration. However, the streamflow salinity has decreased as a result of the decreased volume of runoff from the afforested land with subsequent reduction in runoff salt load contributed to the total streamflow.

Table 7.2 Flow components and their salinities of the runoff from the afforested area and the streamflow volume and its salinity at the outlet of Sub-catchment 13

Land use	Baseflow (average)		Quickflow (average)		Runoff (average)		Streamflow (average)		Average AET (mm)
	Flow (mm)	Salinity (mg/l)	Flow (mm)	Salinity (mg/l)	Flow (mm)	Salinity (mg/l)	Flow (mm)	Salinity (mg/l)	
Baseline	0.54	85.02	0.52	11.30	1.06	73.55	0.28	67.54	1.43
50% afforested	0.28	101.10	0.12	11.30	0.40	94.99	0.24	66.61	1.59
75% afforested	0.28	101.10	0.12	11.30	0.40	94.99	0.23	64.26	1.59

Land use change from natural vegetation for extension of irrigation practices have also been a major cause of salinity in most arid and semi-arid areas of the world. This problem of land and water salinisation due to increased irrigation practices is aggravated when the irrigation management is poor. The hydrosalinity module of *ACRU* can aid in providing information for efficient management of irrigated lands with the objective of reducing the impact of the irrigation activity and management on land and stream salinity. To demonstrate the applicability of *ACRUSalinity* for this purpose a simulation study is undertaken to assess the impact of increasing irrigated area under different irrigation scheduling practices. The simulation study was undertaken by converting part of the grassland in *ACRU* Sub-catchment No. 13 of the Upper Mkomazi Catchment to an irrigated land. Streamflow TDS concentration at the outlet of this sub-catchment for the present land use is represented in Figure 7.17 by "OUTFSA_baseline". Monthly totals of daily rainfall events on the irrigated area (RFLIR) are also included in Figure 7.17, for ease of comparison of the TDS trend with rainfall events.

In this land use change scenario an assessment was made of the impact of an increase in irrigation activity from the present area of 350 ha to 4000 ha, i.e. 25 % of the total sub-catchment area on downstream TDS concentration for two irrigation scheduling practices. The irrigation scheduling practices considered are:

- applying irrigation water to refill the soil profile to the drained upper limit as soon as plant stress sets in (its impact on streamflow TDS concentration being represented in Figure 7.17 by OUTFSA_ISCHED=1) and
- applying a fixed amount of irrigation water, 15 mm, in a fixed irrigation cycle of 5 days (OUTFSA_ISCHED=2).

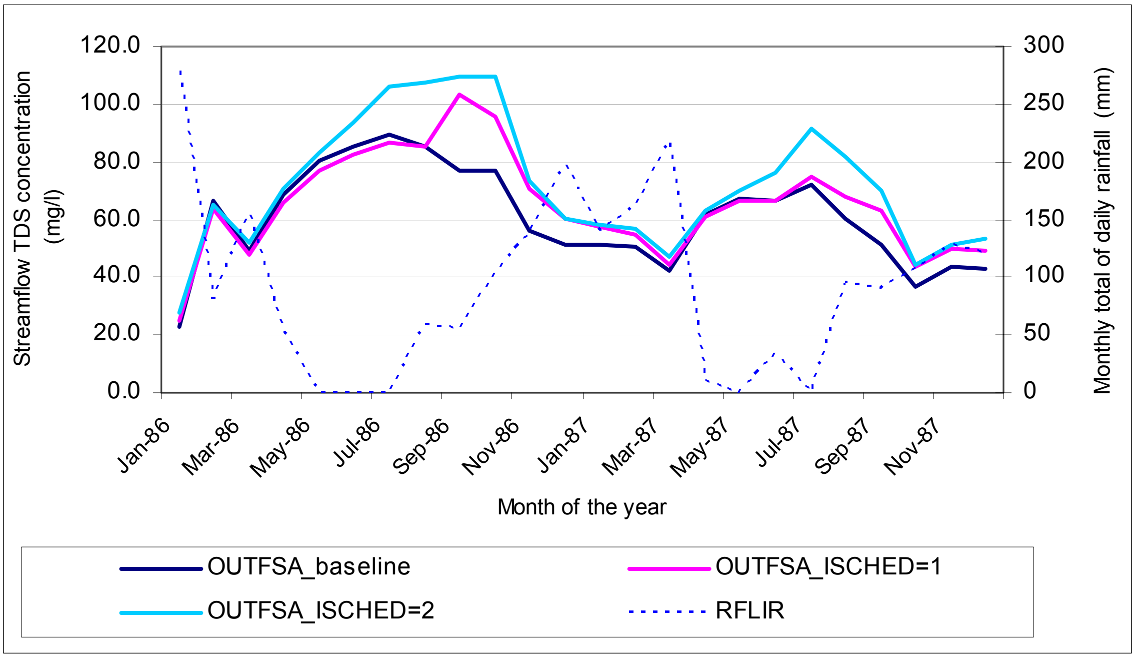

Figure 7.17 Impact of irrigation on downstream streamflow TDS concentration under different irrigation scheduling practices

The above graphical analysis of model outputs shows that increasing irrigated land generally results to increased downstream streamflow TDS concentration. However, the increased irrigation activity has less impact when irrigation water is applied to refill the soil profile to its drained upper limit than when using the irrigation scheduling with a fixed amount of irrigation water (15 mm) in a fixed irrigation cycle (5 days). The reasons for the differences in streamflow TDS concentration under the two irrigation scheduling practices are explained below.

The irrigation scheduling to refill the soil profile to the drained upper limit implies that little water percolates from the soil horizon to the groundwater store. This results in a relatively low contribution of baseflow to the total runoff from the irrigated land. Furthermore, when the soil profile is recharged by rain water to its drained upper limit, no irrigation water is applied to the soil and hence no salt is added from irrigation water. This further results in low streamflow TDS concentration especially, during the dry season where the streamflow TDS concentration is even less than under the previous natural land use (grassland). However, the limited leaching when using this irrigation scheduling practice results in salt accumulation in the soil profile. Thus, the accumulated effect of the salt in the soil profile and groundwater store appears when flushing occurs due to a rainfall event (RFLIR). This effect can be noticed on the falling limbs of the streamflow TDS concentration curves in Figure 7.17. On the other hand, the fixed amount-fixed cycle irrigation scheduling results in increased flow through the soil profile and percolation out of it throughout the year. This generally leads to more salt loading when compared to the previous natural salt loading and the salt loading when using the irrigation scheduling to drained upper limit.

7.3 Conclusions

The various sensitivity tests described in this chapter give some information on the relative importance of the major hydrosalinity input parameters in terms of their impact on surface and subsurface water TDS concentration. However, results from these sensitivity tests should not be taken as conclusive, since some of these results are expected to change from one catchment to another and with time, depending on the prevailing climatic, hydrological and catchment conditions. The case study on the Upper Mkomazi Catchment has also demonstrated the wide range application of *ACRUSalinity* that include for an assessment of temporal and spatial changes in TDS concentration and salt load, the impact of water resources developments such as the construction of a reservoir and its size on downstream TDS concentration as well as the impact of land use change on streamflow TDS concentration and salt loading. Although, this and the previous chapters are based on discussions, and conclusions were also given at the end of each chapter, the next chapter will focus on some points that need further discussion and will present a general conclusion.