

7 Water and catchments

7.1 INTRODUCTION

The wise management of water resources of the RFA area is central to the current and future needs of the economy, the environment and the community of the south-west of Western Australia. Reliable quantities of water, which meet quality standards for a range of uses, are essential for maintaining natural environments and for domestic, agricultural, industrial and recreational uses. As the region's population grows, further water resource developments in the RFA area will be required. As growth is expected well into the middle of the next century, the task of managing these developments in an environmentally sustainable way will be challenging and important. Equally important will be the continuing task of protecting water resources of high environmental and social (in-situ) value and completing restorative programs aimed at improving resources which are currently of marginal salinity. These water resource management issues are discussed in the context of the Comprehensive Regional Assessment process below.

7.2 HYDROLOGY, LAND TENURE AND LAND USE

The relationship between water, forests and forest use is complex and is based on extrinsic factors such as climate, geology, soils, and topography, in addition to intrinsic factors such as landcover and land use change. Streamflow yields in south-west Western Australia are low given the annual rainfall rates and are strongly dependent on rainfall and landcover. Reduction of the vegetation cover significantly increases catchment yields, but the subsequent impacts on groundwater recharge rates and stream salinity are the major hydrological issues in south-west Western Australia. Conversion of forest to agricultural land use clearly affects water quality and quantity and mining and timber harvesting have the potential to affect water quality and quantity in forested catchments. While conversion of forest to agriculture has been demonstrated to lead to increases in stream salinity, the impacts of timber harvesting and surface mining are much more subtle.

Land tenure and land use

The RFA region is used for timber harvesting, agriculture, mining, urban, recreation, conservation and social/cultural activities, which directly or indirectly affect water quality or quantity. The relative distribution of land tenure (see Chapter 2) and the consequent land use, particularly the development of the conventional annual crop and pasture-based agriculture on private land, in areas where salt has accumulated in the soil prior to clearing, have profoundly impacted the salinity of streams and rivers of the region.

River systems

The major river systems that drain the northern part of the RFA area include the Helena, Canning, Serpentine, North Dandalup and South Dandalup. With the exception of a small percentage of the Helena River catchment, all are largely uncleared. However the Swan-Avon and Murray river systems drain through the study region, rising inland in the true wheatbelt area of south-west Western Australia. The central portion of the RFA area is drained by the major systems of the Harvey, Brunswick, Collie, Preston and Margaret rivers. The catchments of the Harvey, Brunswick and Margaret rivers include some agriculture but only in areas where salts had not accumulated in the soil prior to clearing. The Collie River, which rises within the study region has significant clearing throughout its eastern and southern tributaries. The Blackwood River system also drains this central area, but like the Murray and Swan-Avon systems extends inland to the wheatbelt areas. In CALM's Southern Forest Region, the major river systems include the Donnelly, Warren, Gardner, Shannon, Deep, Frankland, Kent, Denmark and Hay. The Frankland River catchment is the only river that extends inland from the study area, however, the Hay, Denmark and Kent rivers have significant clearing in their upper catchments.

Streamflow

Most of the water yields of the large river systems are generated in the high and intermediate rainfall zones of the catchment, where rainfall exceeds 900mm per annum. In the forested high rainfall zone, where catchment average rainfall exceeds 1100mm, annual streamflows are commonly 10% to 15% of rainfall (up to 160mm per annum). These flows have relatively low annual variability and can be readily harnessed using moderate storage reservoirs. The larger river systems that have catchments which extend into the low rainfall zone (areas with annual rainfall less than 900mm) have much lower average water yields (often below 100mm). Annual variability increases and larger storage volumes are necessary to reliably divert the same proportion of streamflow than less variable streams.

Groundwaters

Groundwater resources of the region are centred on the high-yielding aquifers located in the Southern Perth Basin (Donnybrook Sunklands) and within Permian Sedimentary Basins (Collie Coal Basin).

7.3 IMPACTS OF LAND USE ON WATER VALUES

The physical, chemical and biological characteristics of water determine its quality. Any significant loss of quality may have a deleterious effect on aquatic ecosystems and reduce the value of the resource. Land use practices resulting in erosion and the transport of nutrients, urban runoff or point source discharges of pollutants are major causes of poor water quality in stream networks.

In the south-west, stream salinisation poses the greatest threat to water quality and impacts both the economy and environment.

Agriculture

Impact

Stream salinity increases occur in response to changes in catchment water balance, with consequent rising watertables mobilising salts stored in the deep soil profile (Schofield et al. 1988). Related disturbances to the ground surface through clearing, compaction and on-farm activities increase sediment mobilisation and transport. Sediment transport data (as turbidity or suspended sediment concentrations) are indicators of erosion within a catchment. Agriculture can also impact on water quality through the application of agrochemicals. The use of these chemicals is integral to the reduction of production costs and losses, together with increased production and product quality. Surface runoff and groundwater recharge contaminated by these chemicals can reduce the water quality of streamflow and the groundwater.

About 2600 giganlitres of the 5900 giganlitres mean annual streamflow of the region are currently diverted each year to provide water for consumptive uses through construction of conventional dams and related diversion works. Prior to agricultural development virtually all these technically divertible surface water resources of the region were believed to be fresh. Currently only 53% remains fresh, 17% is of marginal quality and 30% is brackish.

The major source of additional salt in streamflow comes from cleared areas where salt has accumulated in the subsoil prior to clearing. Salts have accumulated in the deep subsoils of the Darling Range and the Leeuwin-Naturaliste Ridge, particularly in areas where the annual rainfall is less than 900mm.

For any stream east of the Darling scarp and the 900mm isohyet, clearing as little as 10% of its catchment is sufficient to cause it to become either brackish or saline. Without higher rainfall areas to dilute the additional salt discharge from the small cleared area, average stream salinities are commonly over 2000mg per litre of total soluble salts (mg/L TSS). Stream salinities frequently exceed 10 000mg/L at low flows.

The permanent clearing of native vegetation in the 900 to 1100mm rainfall zone can lead to average stream salinities of marginal quality. Streams draining these areas commonly have average salinities between 500 and 1000mg/L TSS. (Schofield et al. 1988). The salinity risk is low in areas where rainfall exceeds 1100mm per annum.

Table 7.1 shows the salinity of 10 of the major rivers of the south-west of Western Australia. The Swan-Avon, Murray, Blackwood and Frankland catchments, which extend into the wheatbelt region, have the

highest salinities and will continue to deteriorate well into the middle of the next century. This is primarily a consequence of the slow response times of groundwater systems to past clearing in these catchments.

The Collie, Warren, Kent and Hay rivers are the most highly salt-affected river systems which drain the study region. While diluted by fresh inflows from the forested higher rainfall parts of their catchments, the salinities of all four catchments are either of marginal salinity or brackish. The degree of dilution varies between catchments. The proportion of the total catchment cleared of the Warren and Kent river catchments is similar (36% and 40% respectively). The salinity of the Kent is significantly higher as it has less fresh streamflow from the higher rainfall portion of its catchment than does the Warren River.

Table 7.1 Stream salinity in major rivers in the south-west of Western Australia

River	Catchment area km ²	Annual flow mean m ³ x 10 ⁶	Cleared as at 1996 %	Salinity mg/L TSS	Salinity increase mg/L/yr
Denmark	525	31	17	560	26
Collie	2 830	185	24	790	24
Warren	4 022	290	36	855	13
Kent	1 852	84	40	1 195	58
Helena	1 470	50	3	360	na
Hay	1 211	72	70	1 800	na
Murray	6 840	297	75	2 260	93
Frankland	5 800	179	56	2 750	74
Blackwood	20 500	659	85	1 760	58
Swan-Avon	119 000	335	75	6 300	na

Source: Government of Western Australia (1996)

Management response

Groundwater recharge is continuing under the current agricultural practices and stream salinities can be expected to increase further as the discharge from groundwater systems approaches the groundwater recharge. Salinity increases on the Helena, Collie, Warren, Kent and Denmark river systems have been limited by the introduction of clearing control legislation (under the *Country Areas Water Supply Act*) in the 1970s.

Studies have shown that high density reforestation plantings can lower the groundwater level up to eight metres relative to pasture over a 10-year period (Bari and Boyd 1994).

Active reforestation has been carried out on the Collie and Helena river catchments and private investment in commercial tree farming encouraged on the Warren, Kent and Denmark river catchments. Research and development programs to improve the commercial viability of reforestation and agro-forestry options have been carried out and actively promoted. These activities are being adopted by many landowners in target areas across the south-west (see Chapter 5).

Under the State Salinity Action Plan (Government of Western Australia 1996) increased resources are to be available to farmers to help implement the restorative programs in the catchments of the Collie, Warren, Kent and Denmark rivers. Targets have been set to achieve potable salinity levels in the supply from reservoirs on these rivers by the years 2015, 2030, 2030 and 2020 respectively.

The Salinity Action Plan is also promoting active involvement of the farming community in other areas to restore key wetlands, minimise areas of salt-affected land and protect designated rural infrastructure throughout the south-west.

Mining

Mining is a high disturbance activity which has the potential to impact on water quality and quantity. The jarrah forests and coastal zones of the south-west are subject to open cut mining. Major mining operations within catchments include coal, bauxite, gold and mineral sands. Bauxite mining is a major land use within the forests of the south-west, with leases covering 50-60% of the northern jarrah forest (CALM 1992b). Loh et al. (1984) concluded that over a 13 to 15-year period there were increases in streamflow draining from two catchments which had been under the influence of bauxite mining and rehabilitation. More recently, Ruprecht and Stoneman (1993) reported that bauxite mining in a high rainfall catchment increased water yield by 8% of annual rainfall with a return to pre-disturbance water yields after 12 years.

Management response

Future bauxite mining poses ongoing pressures on streams in the forested intermediate rainfall zone of the forest. This was recognised at the time bauxite mining expanded to the Willowdale mine and Wagerup area in the late 1970s. Bauxite mining was effectively excluded from the intermediate and low rainfall zones until long-term research and monitoring programs could demonstrate that the salinity of water supplies would not be significantly affected.

A long-term research program involving both field experimentation (trial mining) and detailed model development is ongoing. The trial mining studies will validate models so that regional scale predictions can be made.

Timber harvesting and regeneration

One of the main management issues within the jarrah and karri forests of the south-west is the possible effects of intensive timber harvesting and associated operations on stream salinity, sediment load and streamflow volume.

As with the impact of agricultural clearing, the risk of increased salinity following logging operations can be related to the high, intermediate and low rainfall zones.

Historic records of intensive logging within the karri forests in the south of Western Australia suggest that water quality has remained high and clearfelling in karri and heavy selection cutting in jarrah forests have minor effects on salinity and sedimentation levels (Christensen 1992). However, onsite soil erosion and compaction associated with harvesting can impact on downstream water quality. Mean annual sediment concentrations are higher during logging and for two to three years following harvesting and then revert to pre-treatment levels. Highest sediment loads are associated with logging during wet periods. There is no evidence to suggest that harvesting of jarrah and karri leads to long-term or severe increases in sediment loads and salinity, as long as regeneration occurs soon after completion of logging (Borg et al. 1987).

Moulds et al. (1994) studied the effects of forest thinning on streamflow and salinity associated with rainfall. The catchment studied had an average annual catchment rainfall of 1100mm and had low salt storage typical of the high rainfall zone. Results of the study indicated that salt flow increased, but increases in streamflow diluted additional salt load so that it was generally lower than pre-treatment levels. In effect forest thinning produces a significant increase in water quantity without reducing quality.

Detailed monitoring of experimental catchments in the Southern Forest Region identified some increases in groundwater levels and groundwater discharge areas and temporary increases in stream salinities following forest logging operations (Borg et al. 1987, Bari and Boyd 1993). The greatest salinity increases occurred within one catchment in the intermediate rainfall zone where complete clearfelling took place and where local groundwaters were shallow and salt storage moderate. The annual stream salinity increased by 300mg/L TSS to more than 500mg/L TSS in one dry year following clearfelling (Bari and Boyd 1993). Base flows exceeded 2000mg/L TSS. Five years following logging, groundwater levels and salinities began to return to pre-logging levels as the regenerating forest began to re-establish the original water balance. These temporary increases are minor relative to the impacts of permanent clearing for agricultural development. Earlier estimates indicated that streamflows would return to pre-logging levels within about 12 years of treatment (Water Authority of Western Australia 1987).

Catchment water yield increases immediately after timber harvesting as a result of lower evapotranspiration and reduced interception. Yields then decrease in response to greater water requirements of regrowth and return slowly to pre-logging conditions in response to revegetation and canopy recovery (Dargavel et al. 1995). A rate of 40mm per annum change in yield per 10% cover reduction has been estimated but this represents an upper limit (Bosch and Hewlett 1982). A decrease in water yield has the potential to:

- adversely affect aquatic ecosystems;
- produce conflicts between users downstream; and/or
- necessitate further development of water storage capacity/groundwater resource to maintain adequate supply.

The reduction of tree density in the low salinity, high rainfall zones of forested catchments is one of the least expensive options for increasing the existing water supplies to accommodate future demands (Moulds et al. 1994). Thinning in these areas provides an effective method to achieve increases in water supply (Stoneman and Schofield 1989).

Management response

Key management strategies to reduce sediment loads and maintain low stream salinity levels include the retention of vegetation, particularly along stream zones, as well as the exclusion of harvesting from all river and stream zones and diverse ecotype zones and sensitive design of roads.

The Forest Management Plan 1994-2003 modifies the informal reserve system on road, river and streams and reduces maximum coupe size, in part as a way to minimise the temporary impacts on stream salinity. These new procedures, together with the associated Ministerial conditions, minimise the risk of saline groundwater discharge to selected second order catchments considered environmentally sensitive to such saline discharges.

Experimental research and related modelling work will continue on the forest management regime set out in the Forest Management Plan 1994-2003.

7.4 WATER RESOURCE DEVELOPMENT

The Water and Rivers Commission is responsible for managing the water resources of Western Australia for the benefit of present and future generations. The Commission recognises that water resources are used for consumptive water supply, recreation and maintenance of ecosystems and other natural resources. The Commission therefore carries out regional water allocation planning studies jointly with other natural resource management agencies and the community, to ensure that environmental and social water values and water supply development needs are appropriately balanced and protected. The Commission interacts with the planning activities of other natural resource management agencies.

A key aspect of this interaction is to identify strategically important potential water supply reservoirs which may constrain the selection of new proposals for forest conservation reserves. The Commission and CALM have previously negotiated satisfactory outcomes in considering conflicts between proposed conservation reserves and reservoir sites through the public consultation period for the Forest Management Plan 1994-2003.

Regional inventories of water use, water resources and long-term demand have been updated so that the need for future reservoir developments is placed in context. Map 18 shows the strategically important potential reservoirs which should be considered as RFA options are developed.

Development of any of the reservoirs shown in Map 18 will require the following steps:

- confirmation of the allocation of the water resource to consumptive use through Commission regional or sub-regional planning studies, such as the Busselton-Walpole Regional Allocation Study and the Harvey River Basin Allocation Study;
- approval of the allocation plan and any associated environmental water provisions by the EPA;
- a water service provider (such as the Water Corporation) to seek access to develop the resource and carry out further engineering and environmental investigations at the site;
- approval by the Commission to the water service provider to develop the site at a set future time;
- the expected water demand to develop and the water service provider to prepare its detailed development proposal for review by the EPA within five years of proposed construction; and
- final approval by the Minister for the Environment.

While most of these sites will not be developed in the short term, and some not at all, it is important that their future value is recognised at this stage.

The potential reservoirs shown in Map 18 are only those ones which may directly impact land managed by CALM. Many additional potential reservoirs and dam sites have been identified. While not relevant here they will continue to be presented to community groups as part of the Commission's ongoing allocation planning program.

Pipehead development sites also have not been included at this regional scale. The pipelines and services associated with them can impact the conservation values of proposed reserves and may need to be designed in such a way to minimise their environmental impact. Consideration of the impact of any proposed reserves on potential pipehead sites will be necessary during the development of RFA options.

7.5 CONCLUSIONS

Potential impacts of forest management on catchment hydrology include dynamic changes to water quality and yield. Results derived from studies in a number of research catchments suggest that these impacts vary temporally and spatially. This research has identified and quantified potential and/or actual changes in water yield and quality in relation to a range of land use impacts on forests. New forest management practices have been developed to minimise the risk of saline groundwater discharges to streams considered sensitive to such discharges. Monitoring and research into the effectiveness of the new measures is continuing.

Regionally significant potential water supply reservoir sites, that would impact land managed by CALM, have been mapped (see Map 18). Their long-term importance should be recognised by considering them during the development of RFA options.