

MANAGEMENT OF REGULATED RIVER SYSTEMS IN NSW, AUSTRALIA FOR DROUGHT

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INTRODUCTION

Australia is the world's driest continent and streamflows are more highly variable than anywhere else (McMahon and Mein, 1986; Finlayson, et al, 1986). Together, these factors mean that droughts in Australia are frequent and severe, and may persist for several years.

For management purposes in Australia, drought is broadly defined as a severe water shortage typified by a prolonged period of rainfall deficiency (Drought Policy Review Task Force, 1990b). Primary producers generally refer to drought as occurring when the available rainfall over a period of time is insufficient to generate adequate plant growth and there is a consequent reduction in agricultural production.

In the community the perceptions of drought vary widely. Many regard it as a natural and recurring phenomenon that should be planned for and accommodated, while others regard it as a freak of nature and a disaster (Drought Policy Review Task Force, 1990b).

Given that droughts are frequent and severe, government is promoting a more self reliant approach to drought management (Drought Policy Review Task Force, 1990a). It is also promoting the concept that drought is a part of the natural variability of climatic conditions, not a natural disaster, and that this variability needs to be taken into account, through risk management strategies, in the operation of agricultural and other rural enterprises.

In New South Wales there have been ten drought periods in the 20th Century covering all or most of the state, ranging in duration from 3 to 12 years (Department of Water Resources, 1993), of which the latest was from 1992 to 1995. The situation was similar in the 19th Century also.

WATER RESOURCES DEVELOPMENTS FOR DROUGHT MANAGEMENT

In NSW major dams have been constructed by government to regulate rivers to reduce the impact of drought and increase agricultural production by providing access to irrigation water, especially in the Murray-Darling Basin (Figure 1). The first major dam for irrigation was Burrinjuck Dam on the Murrumbidgee River, completed in 1919. There are now 17 dams in New South Wales whose primary function is irrigation water supply, all except five of which are in the Murray-Darling Basin, and most of these have been built since 1948. Other water resources developments include re-regulating weirs and irrigation infrastructure.

Publicly funded structural development in all these systems is now largely complete. However, privately funded development is continuing, mainly in the north of the state where irrigators are constructing large on-farm storages and pump installations to improve the reliability of their water supply.

All the major dams are located in the Great Dividing Range and are generally a considerable distance from the irrigation areas they supply. The rivers are used as the main supply carriers from the storages to the irrigators and travel times for water released from storage to reach the irrigators, particularly in the inland rivers, are of the order of weeks.

Main irrigated crops are cotton in the north of the state and rice, horticulture and pastures in the south. Demands for irrigation water have grown rapidly in the last ten years, especially in the cotton growing areas, and the water resources are now very highly committed for this purpose.

DISTRIBUTION OF WATER AVAILABILITY AND DEMANDS

A feature of the availability of water in New South Wales is that 80% of the runoff volume occurs on the eastern side of the Great Dividing Range, whereas 80% of the demand for water is to the west of the range (that is, in the Murray-Darling Basin). The Snowy Mountains Scheme diverts some of

this eastward flowing water to the west, but its primary function is hydro-electric power generation.

Most of the main inland rivers of New South Wales were prone to ceasing to flow before construction of dams and the dams have not eliminated this. The Darling River itself ceases to flow from time to time, and this occurred most recently in 1995. Most of the coastal streams are perennial, as are the Murrumbidgee and Murray Rivers.

WATER SHARING AND USE MANAGEMENT

Most irrigators have elected not to use the dams for drought proofing, instead preferring to obtain greatest use of water in storage on yearly basis. This approach has created conflict with those irrigators and other users still requiring high security protection against droughts. Regulated rural water supply management in NSW, therefore, involves ensuring that the drought proofing requirements of high security users are satisfied and allowing maximum supply to normal security irrigators on a yearly basis, while also meeting environmental needs and the requirements of interstate water sharing agreements.

Water usage in regulated rivers is accounted on an annual basis using water years. The water year varies slightly from system to system, but generally starts in July or October. The main irrigation season, which is for summer crops, extends from about September to March.

Access to water is authorised by licences which have a licensed volume attached to them; users may hold more than one licence and transfers are permitted (Birch and MacLock, 1992). Availability of regulated water to irrigators in a water year is expressed as a percentage allocation relative to their licensed volume. Allocations can vary from over 100% to zero depending on water availability. High security users receive 100% allocation whenever there is sufficient water available. During droughts their allocation is reduced, but not before the normal security allocation reaches zero.

Most of the regulated rivers have unregulated tributaries downstream of the dams that can generate significant flows, even during droughts, as a result of summer storms. When the flows are sufficiently large, and environmental needs have been satisfied, a period of off-allocation may be declared. During off-allocation periods any water diverted is not debited against the allocation allowance, although water charges are still levied. Off-allocation flows represent a substantial additional resource, particularly in the north of the state. To ensure equity of access to off-allocation flows between users, including the environment, event sharing policies have been developed and are being refined to suit changing management needs.

EVALUATION OF ALLOCATIONS

The percentage allocation available is based on the results of a resource assessment which is carried out at the start of the water year and updated at various times during the water year known as assessment dates. The principles behind this assessment are a modification of the linear decision rule approach (Tickle and Wright, 1978), with priority given to high security users such as town water supplies, stock and domestic water and certain environmental uses. The following factors are considered in the resources assessment procedure:

1. Net volume of water in storages (i.e. current storage less dead storage and estimated cumulative evaporation loss to the end of the water year), excluding on-farm storages.
2. Cumulative minimum historical inflows into headwater storages (from the assessment date to the end of the water year), adjusted to account for the expected inflow recession volume if there is a significant inflow event occurring at or shortly before the assessment date.
3. Cumulative minimum historical major unregulated tributary inflows (from the assessment date to the end of the water year).
4. Known commitments for town water supplies, permanent plantations, high security licences, environmental requirements, and losses (fixed requirements).

5. Allowance for transmission and operation losses as a function of allocation level accumulated to the end of the water year.
6. Carry over reserve storage to provide for high security needs for following water years under worst historical drought conditions, which is a function of reservoir level and time of the year.

The total resource available for allocation is then the sum of Items 1,2 and 3 less the sum of Items 4, 5 and 6 in the above list. From this the allocation level is the sum of the total resource available and the on-allocation water already used in the current water year divided by the product of the total normal security licensed volume and a development factor, expressed as a percentage.

The development factor is an indicator of the overall development of irrigation farms in the valley. The factor allows for farmers who do not use their licence (sleepers) and farmers that do not fully utilise their entitlement. In most valleys this factor is set to one.

The philosophy behind this approach is to impose the minimum amount of risk on the users in advising their availability of water. A consequence of this approach is that normal security allocations usually increase during the water year. Irrigators are generally prepared to take greater risks in assessing the volumes of water that will be available to them during the season when making their planting decisions for annual crops. Apart from their expectation that normal security allocations usually increase during the water year, irrigators also take into account water already in on-farm storage (if they have one), expected rainfall and expected access to off-allocation water.

ANALYTICAL TOOLS FOR POLICY DEVELOPMENT

For developing and refining water sharing policies in the inland regulated river systems in NSW and the Hunter River, which is a coastal stream, simulation models have been used for over 15 years. The first generation of these models comprised a group of valley specific monthly time step models, many of which had a common origin in the GAVAS model developed in the late 1970's (Wright, 1980). The regulated river systems for which

monthly models are available are shown in Figure 1, and comprise the Border Rivers (on the border between NSW and Queensland), Gwydir, Namoi, Peel, Macquarie, Lachlan, Hunter and Murrumbidgee (downstream of the Snowy Mountains Scheme) River systems. All the inland rivers are in the Murray-Darling Basin. A monthly model is also available for the Darling River (upstream of Menindee Lakes) which is managed as an unregulated river, although it is downstream of several regulated river systems.

For many of the current water management issues short term variability of flows (that is, variability of flows over a few days or hours) is important. Some of these issues are concerned with water quality and environmental effects, others are concerned with water quantity. The main water quality issues at present are salinity and nutrients. The main water quantity issues where short term variability of flows is important are sharing of off-allocation flows in regulated rivers, water sharing in unregulated streams and environmental flow management. The existing monthly models are not able to adequately address these issues.

Consequently, a new generic, hydrologic, river system simulation package, known as the Integrated Quantity and Quality Model (IQQM), is being developed and progressively implemented in regulated river systems in NSW and a number of unregulated systems as well. This new planning model operates on a daily time step and is designed for investigating policy options where short duration flow variability is important, such as in event sharing.

The new model is a strategic planning tool that is designed for investigating water sharing issues at the river basin, inter-state or international level, and between competing groups of users including the environment.

IQQM simulates river system behaviour at a time step of one day with an option to use smaller time steps, with a minimum of one hour, for some processes. It is able to simulate water quality behaviour and water quantity behaviour in an integrated manner, and is capable of application to both regulated and unregulated streams.

IQQM is designed specifically to be effective in investigating issues where short duration variations in flows or other parameters are important, such as environmental flows and event sharing. Because it operates on a daily time step, it can provide a much more detailed representation of relevant processes than is possible with a monthly model.

IQQM is structured as a modelling shell with component modules linking together to form an integrated package. This shell has been designed to facilitate the incorporation of additional component modules as required.

The selection of computational algorithms for IQQM is based upon the practicability of obtaining calibration data and computational efficiency. Proven modelling techniques have been used wherever these are available. The main modelling components are for instream water quantity; instream water quality; and rainfall-runoff and pollutant washoff.

Key elements of the instream water quantity module are hydrologic streamflow routing routines for which either the Muskingum method (Miller and Cunge, 1975) or non-linear routing with lag (Laurenson 1986) are available, and procedures for modelling other river features such as wetlands and floodplain storages and operating rules which have been developed specifically for IQQM. The water quality modules are based on routines available in QUAL2E and QUAL2E-UNCAS (Brown and Barnwell, 1987), and the rainfall-runoff module is based on the well known Sacramento Model (Burnash et al, 1973).

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