MANAGING AND PROTECTING WESTERN AUSTRALIA'S MOST VITAL RESOURCE

DRAFT INTERIM WATER ALLOCATION PLAN

ORD RIVER, WESTERN AUSTRALIA

Water Resource Allocation and Planning Series, WRAP 2

May, 1999

WATER AND RIVERS COMMISSION

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Ord River, Western Australia

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WATER RESOURCE ALLOCATION AND PLANNING SERIES
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Foreword

The Water and Rivers Commission is responsible for ensuring the sustainable management of the State's surface and groundwater resources. One of the ways that this is done is through the allocation of water resources to meet public and private water needs whilst maintaining environmental values.

To achieve this, water allocation plans are required for each water management system to define the amount of water to be made available for use based on ecological sustainability, and to allocate that water between competing uses. That is, the plans define the amount of water that is allowed to be diverted from river systems and groundwater aquifers, while ensuring sufficient water is maintained to meet the needs of key water dependent ecosystems. Allocation plans are implemented through licensing under the *Rights in Water and Irrigation Act (1914).* Licences formalise the allocations and are subject to conditions necessary for good management of the resource. As the State's water allocation system evolves to meet the requirements of the Council of Australian Government's Water Reform Framework Agreement, the licences will become the means to identify water allocations and their holders.

Water from the Ord River has been used for irrigation for more than thirty years. With the recent commissioning of a hydro-electric power station, proposed expansion of the irrigation area, and the re-structuring of the water industry, a water allocation plan for the Ord River is now required. This plan is required to define the water allocations for these different uses and allows the development of a licensing system, which will meet the particular requirements of Ord River users.

There is limited information currently available on environmental water requirements and on several of the components of the irrigation water demand. This document is therefore an interim plan and will be reviewed when better information is available.

The purpose of this interim plan is to:

- define bulk water allocations based on the available hydrological data and the estimates of demand for current and potential water uses;
- describe the system by which licences will be issued under current legislative arrangements;
- describe the investigations required to allow allocations to be refined, and the process by which any review of allocations will be undertaken.

This approach will allow users continued security of access to water supplies while the outstanding issues are resolved.

This draft plan is intended for:

1. discussion and comment by stakeholders and the community;
2. review by the Environmental Protection Authority (EPA) if they deem it necessary; and
3. revision following stakeholder and EPA input.

A final report will then be prepared and approved by the Water and Rivers Commission.

During development of this plan, the Water and Rivers Commission consulted the Ord Irrigation Cooperative Ltd, Water Corporation (Head Office and Kununurra), Department of Resources Development, Kimberley Development Commission, the Shire of Wyndham-East Kimberley (Shire Clerk), Ord Development Council, and the Department of Conservation and Land Management. There will be further consultation with all stakeholders before its finalisation. In particular, the Commission will involve the local aboriginal people and representatives when finalising the plan.

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Need for an Interim Water Allocation Plan

The Water and Rivers Commission manages the allocation of water resources so that water is used efficiently within sustainable limits and to balance the needs of people and the environment. In accordance with the established principles of ecologically sustainable development, the Commission endeavours to base its allocation decisions on the best available scientific evidence and, where that evidence is lacking, to take a precautionary approach to its allocation decisions.

An important aspect of the allocation process is the preparation and implementation of allocation plans which define the upper limit of water to be made available for use based on ecological sustainability, and allocate that water equitably between uses.

The Ord River has been used for irrigation for more than thirty years, but has only utilised a small proportion of the water resource during that time. A hydro-electric power station has been in operation since early 1996, and planning for a major expansion of the irrigation area is now under way. The permanent water in Lakes Argyle and Kununurra and the changed flow regimes downstream of the storage structures have had major consequences for the ecology of the river and the associated riparian vegetation. It has also had major consequences for the water-related recreation and tourism industries based in Kununurra.

The Water Corporation, as operators of the storage systems, and the Ord Irrigation Cooperative Ltd, as operators of the water distribution system in the existing irrigation areas (Stage 1 of the planned total irrigation area), require clear definition of their rights to take and use water. The proponents for the proposed Stage 2 development need a clear indication of the amount of water which will be available for future irrigation use.

Objectives of the Interim Plan

Given the above needs, the objectives of the plan are to:

- make an interim provision of water to the Lower Ord River system and its associated environment;
- determine the remaining water that may be available for diversion for consumptive uses;
- document interim allocation decisions as to how much water should be assigned to the Stage 1 and Stage 2 developments, and
- ensure those existing commitments and longer term demands for hydro-power generation can be accommodated within the interim allocations and that a feasible reservoir operating strategy can be developed that meets all commitments.

Approach Taken to Formulating the Interim Plan

This is an interim allocation plan because there are several areas in which further definition of water demands and improvements in irrigation practices are required. For the most part, this is likely to be possible within the next three to four years. The key areas of uncertainty include:

- limited information on the ecological water requirements of the lower Ord River;
- undefined, or differences in views on, social and recreational values of water in the reservoirs and the lower Ord River , and
- uncertainties in crop water demands in the area
- potential but unquantified water savings from improved water distribution efficiency.

Nevertheless reasonable estimates of these elements have been made to allow interim allocation decisions and meet the objectives of the plan.

These estimates of water demands and environmental water provisions can be used to enable the simulation of the operation of the reservoirs and diversion works on the Ord River for a number of different operating scenarios. A monthly water balance model of Lake Argyle and Lake Kununurra was used. From estimates

of catchment inflows between 1905 and1990, different water demands and constraints on reservoir operation, the quantities of water able to be diverted and fluctuations in water storage levels each month were calculated. Conservative estimates were made of water demand. The simulations included consideration of seasonal demand patterns and reflected the range of potential irrigation and hydro-power requirements during the next few years and in the longer term.

Environmental water provisions were simulated by setting reservoir operational constraints that required minimum quantities of water to be maintained in the lower Ord River. For each scenario, the amount of water that could be diverted from Lake Kununurra was determined, while meeting these constraints.

Interim Allocations

Until more detailed study can be carried out, the Commission considers that the monthly flow volumes in the Ord River just below the Dunham River confluence should be maintained at levels that at least equal the 20th percentile of their "pre dam" monthly values. The 20th percentile value is the monthly flow volume that is not likely to be exceeded on 20% of occasions. Given this interim Environmental Water Provision (EWP), an upper limit of 1500 GL could be available annually for sustainable use at a reasonable level of reliability and still allow the operation of the hydro-power station for town electricity supply at an acceptable reliability.

The Commission considers it unwise to make a decision that allocates the maximum potential divertible yield of 1500 GL/year to irrigation at this time. As discussed above, reasons for this include limited information on the ecological social and recreational values of water in the lower Ord River, and limited information on irrigation water demands. These current uncertainties and the approaches to their resolution are elaborated in the sections on updating the interim plan.

The Commission is, however, prepared to allocate a total of 1235 GL/year to irrigation purposes at this time. The Commission believes that this precautionary approach allows adequate water for the planning for development of the Stage 2 irrigation area while also maintaining flexibility for future allocation decisions.

When further information is available, any additional needs of water dependent ecosystems, additional irrigation needs, or other additional needs such as releases to mitigate water quality problems in the lower Ord River, can be determined. Evaluation of the social, environmental and economic costs and benefits of different allocation options can then be determined and a full allocation plan completed.

Proposed Licences

Allocations will be recognised through licences under the *Rights in Water and Irrigation Act (1914)*. For the existing irrigation area, a licensed allocation of an annual average of 300 GL will be issued subject to certain conditions relating to the operation of the distribution system. The Commission considers this a generous allocation and will require the Stage 1 distributors to improve on-farm and distribution efficiencies over time. While water has been readily available in the past, water for the environment, hydropower generation, and the Stage 2 developments all must now be provided. All users will be expected to use water efficiently. An improvement in the efficiency is also required to reduce the risk of water quality problems occurring in the Lower Ord River. The Commission will work with the Stage 1 distributors to promote reductions in drainage flows from their area as part of these efficiency improvements.

The Commission is prepared to allocate up to a further 55 GL for Stage 1 if clear evidence for the irrigation demand can be demonstrated. This would require evidence that over 90% of the area irrigated is to be planted to sugarcane, and clear field evidence that research estimates of high sugarcane crop water demands were critical for economic production. Improvements in on-farm and distribution efficiencies and commitments to a sustainable land and water management plan must also be demonstrated before additional water would be allocated. It is planned to separately licence the new irrigation service providers that distribute water to landowners in the proposed Stage 2 Irrigation areas.

In the past, licences have been issued for a maximum of ten years in accordance with established Commission policy, and with an expectation of

renewal subject to water being available and compliance with licence conditions.

However, the policy on licence duration and the expectation of renewal is under review as part of the implementation of the COAG Water Reform Framework Agreement. Proposals for longer duration licences, and the Commission's powers to amend licence conditions during their life, have been considered in this overall reform context over the last 12 months. Given the public submissions received on the COAG reform proposals, the Commission considers that it is premature to lengthen licence tenure without a ready acceptance by licence holders that they must adapt to changing requirements. Accordingly, the current practice of issuing licences for specified periods will continue. Long term licences will be issued where it can be shown that there is little risk to the resource or other users.

In other areas, where the risk is high, licences will be issued for shorter periods to allow periodic review." (Water and Rivers Commission, 1998)

Consequently, in the context of the Ord River situation, new licences are proposed to be issued until the interim allocation plan is updated or for a maximum of five years (which ever is the sooner). The intent is to move to longer licences after that date, if the risks to the resource and other users are shown to be low.

When the Stage 1 distribution assets are transferred to the Ord Irrigation Co-operative and the Stage 2 development proposals proceed the Commission will licence water use in accord with this interim plan as summarised in the following table and associated paragraphs.

Licences for consumptive use	**Annual Licensed Quantities**
A licence to take water from the Ord River at Lake Argyle to be issued to Argyle Diamond Mines for mining purposes	12 GL
A license to take water from the Ord River to be issued to the Ord Irrigation Co-operative for the purpose of irrigation in their Irrigation Service Provider's Operating area. **(when the distribution assets for Stage 1 are transferred)**	300 GL
A Licence to take water from the Ord River at Lake Kununurra for use issued to the Irrigation Service Provider of the new irrigation area serviced by the M2 channel. **(when the M2 Channel Development of Stage 2 has environmental approval)**	740 GL
A licence or series of licences to take water from the Lower Ord River for irrigation purposes to be issued to Irrigation Service Providers in the Carlton Plain, Mantinea Flats and Ord West Bank areas **(when the Lower Ord Development of Stage 2 has environmental approval)**	195 GL

The licence quantities for irrigation purposes are expected to be available in 98% of months and 95% of years.

The Ord Irrigation Co-operative and any other water service provider for the Stage 2 developments will be required to prepare a distribution operating strategy as a condition of their take and use licence. This will include:

⇒ estimates of the expected areas of irrigation by crop type and the expected total water demand for the forthcoming season;

⇒ a procedure, managed in real time, for determining the additional volume that can be taken for the remainder of each water year, based on the recorded rainfall in the irrigation district, the current quantities already diverted and the licensed annual quantity;

⇒ measures to be taken to promote efficient water distribution and use;

⇒ monitoring and reporting details as requirement by the Commission. (These will include details of the drainage flow and water quality leaving the irrigation district and will cover salinity, nutrient, sediment and pesticide aspects).

In addition to the licences for using water from the Ord River, the operation of the dams that affect the flow regime of the river also needs to be licensed. Through this licence the Commission places a legal obligation on the Water Corporation to prepare and regularly update an Operating Strategy for the Ord River and Kununurra Diversion Dams. The operating strategy will describe:

- how the interim environmental water provisions of this plan are to be met;
- how the licensed consumptive use requirements will be met;
- how the existing hydro-power (non-consumptive) contractual commitments are to be met, and
- monitoring and reporting commitments.

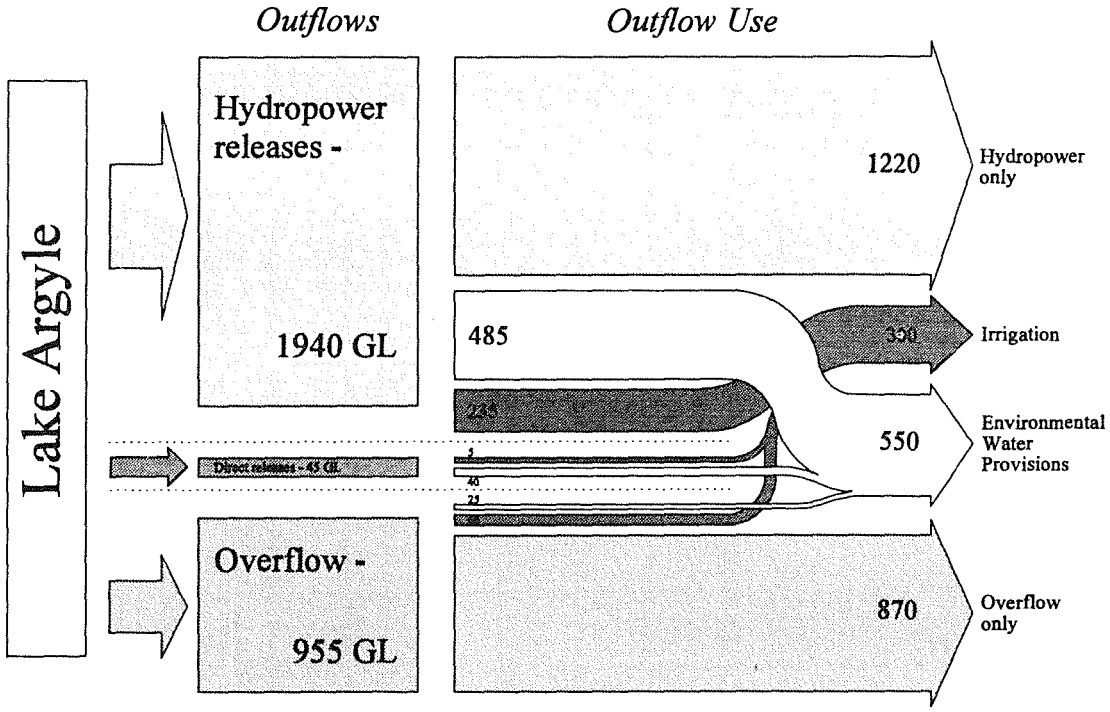
The operating strategy will require a method to ensure that the flows in the Lower Ord River below the Dunham River confluence are maintained at least to the 20th percentile of their natural monthly flows. Exceptions will be made in periods of severe droughts (periods where irrigation water is restricted).

The headworks operating strategy must also estimate how much water is to be to released to meet hydro-power commitments under the Water Supply Agreement for the next 12 months given the current water levels and power demands.

Expected Outflows and Uses of Water Released from Lake Argyle

The following two diagrams indicate the annual average quantities of water released from Lake Argyle for the current situation and when Stage 1 and Stage 2 of the Ord Irrigation Project are fully developed.

The flow patterns for the two scenarios reflect the outcomes of the water balance simulations using conceptual reservoir operational strategies developed as part of this plan. The diagrams highlight the demand patterns and the downstream flow regimes from Lake Argyle under each scenario.



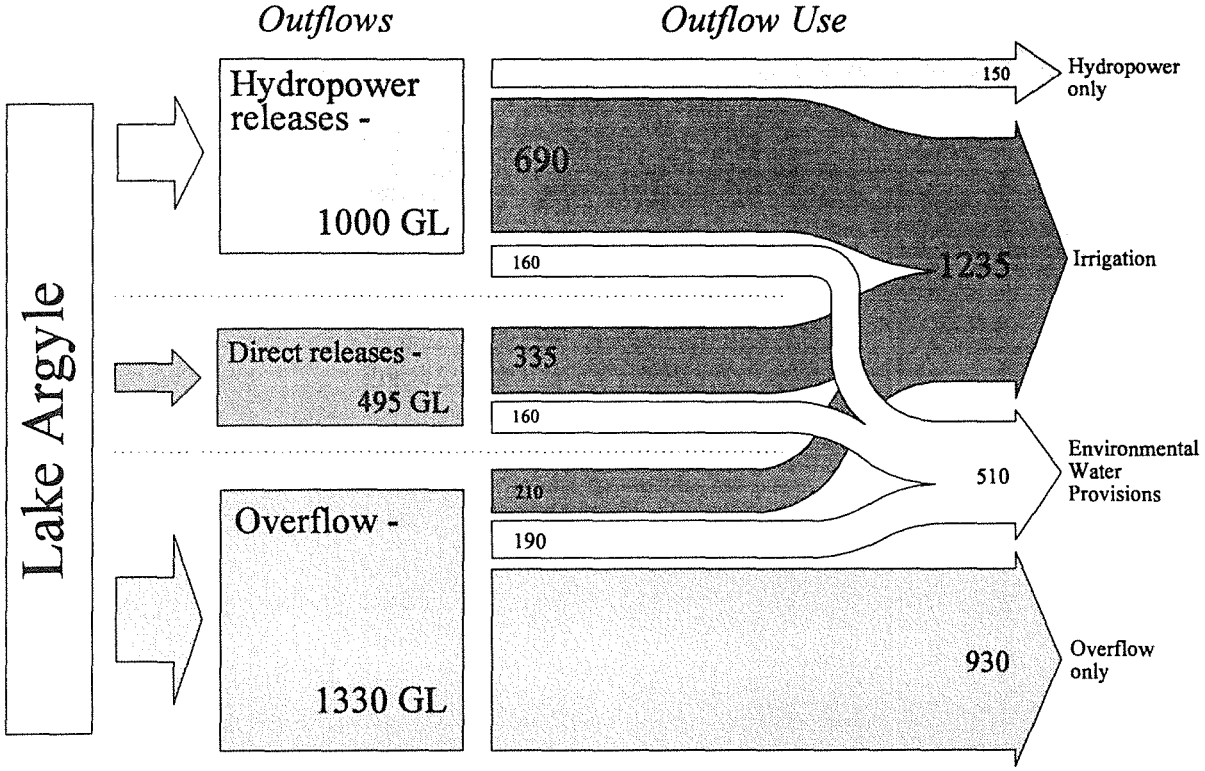
Current Situation - Ord Stage 1 - 210 GWhrs/yr Power Generation

Irrigation demand

The contrast between the irrigation demand currently and the demand at full development is clearly apparent (300 GL compared with and 1235 GL). Of the 300 GL currently diverted for irrigation use at Lake Kununurra, around 235 GL will come from hydro-power releases, and 60 GL will come from overflow. An average of only 5 GL will come from direct releases. These will only occur when there is no overflow and Lake Argyle levels are such that power production is restricted to the allowable irrigation releases.

When water diverted for irrigation increases to 1235 GL as Stage 2 becomes fully operational, about 690 GL or 56% of this water is expected to be released through the hydro plant to meet the power demand. About 335 GL or 27% of the water diverted for irrigation is expected to be directly released. Usually this will be at times when hydro demand is less than irrigation demand.

Power could be generated from these releases if the power demand existed but would be secondary to the irrigation need. About 210 GL are expected to come from overflow.



Full Development - Stage 1 and 2 - 110 GWhrs/yr Power Generation

Hydro-power Releases

Under the current situation a long-term average of 1940 GL per annum needs to be released through the turbines to meet current hydropower contracts. The actual amount released in any one year will depend on the Lake Argyle water levels throughout the year and the actual power demand at the time. Of the estimated total released through the turbines, 1220 GL are expected to be released solely to meet hydro power needs, 235GL will be diverted for irrigation and 485 GL will continue down the lower Ord River and contribute to meeting the interim Environmental Water Provisions (EWPs).

Under the second scenario, overall demand for water to be released through the Hydro-power Station is assumed to decline as the Argyle Diamond Mine energy requirement decreases. A long term average of about 1000 GL would be required to be released through the turbines to meet Western Power's regional town power demand by the year 2020. About 690 GL would be subsequently diverted for irrigation, 150 GL would be released solely for power production and 160 GL would contribute to meeting the Interim EWPs.

Interim Environmental Water Provisions

In the conceptual operating strategies simulated for this plan, the interim EWPs were met by a combination of hydro-power station releases not diverted for irrigation, overflow not diverted for irrigation and direct releases made especially to meet the EWP requirement. For the current situation about 485 GL of the hydro-power releases and 25 GL of overflow contributed to meeting the EWPs. Direct releases averaging about 40 GL will be required from Lake Argyle to meet the interim EWPs. These direct releases are most likely to occur at times of low power and irrigation demand during the wet season.

The interim environmental water provisions are likely to be reviewed and updated before full development of Stage 2 has eventuated. Nevertheless, if the interim allocations were confirmed and hydro-power demands remained as estimated, direct release to meet EWPs would increase to an average of 160 GL per annum at full irrigation development.

Review of the Interim Allocation Plan

This interim allocation plan will be reviewed in three to four years when the necessary studies to resolve the current uncertainties have been substantially completed.

The key areas of uncertainty are:

1. Environmental water requirements. The environment of the Ord River has obviously been changed by the impoundment and regulation of flows in the Ord River, and the environmental water requirements will partly depend on the environmental values which are to be maintained. This plan has not attempted to define these environmental values but proposes a process to do this in an open and objective way. After defining those values, it will be possible to determine the flow characteristics essential to their maintenance. An acceptable level of provision of those flows based on assessment of the environmental, social and economic costs would be determined..

2. Total irrigation water demand. Estimates of the irrigation water demand for both existing and future irrigation areas have been based on a number of assumptions including the mix of crop types, the crop water demands, and the on-farm, in-field and delivery system efficiencies. Best estimates of each of these components have had to be used and it is anticipated that monitoring and further investigations during the next three to four years will allow the accuracy of the assumptions to be reviewed. The Commission recognises that the estimates used for the crop water demand for sugarcane and the proportion of the irrigated area under sugarcane production have significant implications for the total irrigation water demand. Their accuracy therefore needs to be verified when this interim plan is reviewed.

3. Sustainable Irrigation Practices: The need for best practices in managing the land and water of the irrigation area have been highlighted by:
   - impacts on the health of fish stocks in the lower Ord River;
   - growing concerns with high watertables in parts of the Stage 1 area if past practices continue, and
   - the potential for serious salinity problems to develop in parts of the Stage 2 areas if not properly managed.

It is anticipated that the Ord Irrigation Cooperative Ltd (OIC) will own and operate the distribution system (with the exception of the M1 channel) for the existing irrigation area within the next two years. Construction is currently planned to commence on the M2 Area of Stage 2 by that time. Licensing the OIC and the Stage 2 developers to distribute and use water for irrigation purposes in their respective areas will also be required at that time. Investigations and monitoring prior to

issuing the updated licences will be necessary to provide better estimates of the water distribution efficiency than are currently available. Monitoring will need to continue following issuing of the licences to determine if improvements in efficiency are being achieved.

The OIC, in working on the Kununurra's community land and water management plan, are addressing these issues. Current research and on-farm monitoring over the next few years will clarify crop water needs and improve estimates of accessions to the water table. As improved water management practices are introduced, ongoing monitoring will identify water savings and reductions to groundwater accessions. In addition the Wesfarmers Marubeni Joint Venture (the preferred tenderers for construction and operation of the Weaber, Knox and Keep River Plain irrigation areas of Stage 2) will be completing their feasibility investigations over the next 12 months. They will be finalising their approach and making commitments on water management as part of the environmental assessment process of the project. Long term water demand, given improved water management practices, will therefore emerge over the next three to four years.

Full resolution of the current uncertainties will also require input from the Water Corporation, other agencies and the local community. To co-ordinate this input the Commission outlined a proposed program of data collection and investigations on water related aspects in mid 1998 (see Appendix B) and proposed an approach to updating the Interim Environmental Water Provisions (see Appendix A).

Solid progress has been made over the last 12 months on the program of investigation, co-ordination and data collection. Key elements of the program are:

- ⇒ improved monitoring of inflow to and drainage from the Stage 1 area (mostly now operational);
- ⇒ an Environmental Water Requirements Technical Working Group to develop and oversee the scientific work program to determine Environmental Water Requirements (established 1997);
- ⇒ the initial planning of detailed studies of the water dependent nature of ecosystems of the lower Ord River (commenced in early 1998);
- ⇒ establishment of studies into the social aspects of in-situ water values for the Lower Ord River by late 1999;
- ⇒ a consultative process to balance ecological, social and economic values and establish the final Environmental Water Provisions by 2002/3.

1. Introduction

1.1 Location of the study area

The Ord River Catchment is situated in the east Kimberley region of Western Australia and extends into north-western Northern Territory. It is drained by the 650 kilometre long Ord River, which flows into Cambridge Gulf near Wyndham. The lower Ord River and main irrigation areas downstream of the Ord River Dam are shown in Figure 1.

1.2 Overview of the Ord River system

The Ord River is one of the major river systems of Western Australia with a catchment at the site of the Ord River Dam of 46,100 sq km. The mean annual streamflow of the Ord River (inflow to Lake Argyle) of 3940 GL is the second largest in Western Australia after the Fitzroy River (Ruprecht, 1995). Aspects of the hydrology are discussed further in Chapter 4 and in Ruprecht and Rodgers, 1998.

The Kununurra Diversion Dam was constructed in the early 1960s and the Ord River Dam which forms Lake Argyle was constructed in the early 1970s. Together they allowed the development of a major irrigation area centred on Kununurra and the generation of power from a hydroelectric station, commissioned in 1996, at the Ord River Dam. In 1995 some 12,966 ha were rated as irrigation land and supplied from the channel system in the Ivanhoe and Packsaddle Plains areas. There is a further 342 ha of rated land supplied through Pipe and Pump Supplies upstream of the Kununurra Diversion Dam and a further 120 ha supplied downstream. Approximately 10,500 ha are actually irrigated at any one time. These irrigation areas are referred to here as the Stage I development.

There are proposals for the expansion of irrigation into the Weaber, Knox Creek and Keep River Plains east of the river. These areas would be supplied with water via a new channel (termed "M2") from Lake Kununurra. There are also plans for irrigation development downstream of Lake Kununurra on Mantinea Flats, Carlton Plain and the West Bank of the Ord River downstream of the Dunham River. Collectively they are referred to as the Stage 2 developments.

Inflows to Lake Argyle occur as a result of markedly seasonal rainfall over the catchment and on the reservoir itself. There are minor abstractions of water directly from the Lake for mining purposes and for water supply to the Lake Argyle Tourist Village. Water is released from the Ord River Dam to meet the hydro power demands, to meet some in-stream (boating) demands below the Dam, and to maintain the water level in Lake Kununurra for irrigation purposes. Overflows from the Lake Argyle spillway join Stonewall Creek and flow back into the Ord River below Carlton Gorge.

Lake Kununurra is the body of water which extends upstream from the Kununurra Diversion Dam to Carlton Gorge. Water levels within this Lake are maintained within a narrow range primarily to meet the needs for irrigation of the Packsaddle Plain and Ivanhoe Plain, but also in consideration of other factors including dam operating requirements and foreshore flooding considerations. Releases from the Diversion Dam are also made to meet the needs of irrigators pumping directly from the river and some in-stream requirements below the dam. The in-stream needs include provision for safe boating conditions and some control of water levels to allow stock watering on Carlton Hill Station. The Dunham River joins the Ord just downstream of the Diversion Dam.

The construction of the dams and the subsequent altered water flows in the Ord River has had considerable impacts on the ecology of the riverine system of the Ord River between the Carr Boyd Ranges and Bandicoot Bar. There remains some uncertainty as to the ecological impact of the change in hydrology downstream of the Kununurra Diversion Dam. Lakes Kununurra and Argyle now provide permanent water and are valuable dry season refuges for waterbirds. The lakes are listed under the Convention *on Wetlands*

of International Importance especially as Waterfowl Habitat, known as the Ramsar Convention. The Ord River Floodplain, which includes an extensive system of tidal mudflats and mangroves, seasonal wetlands and permanent waterholes associated with the Ord, is also listed under the Ramsar Convention.

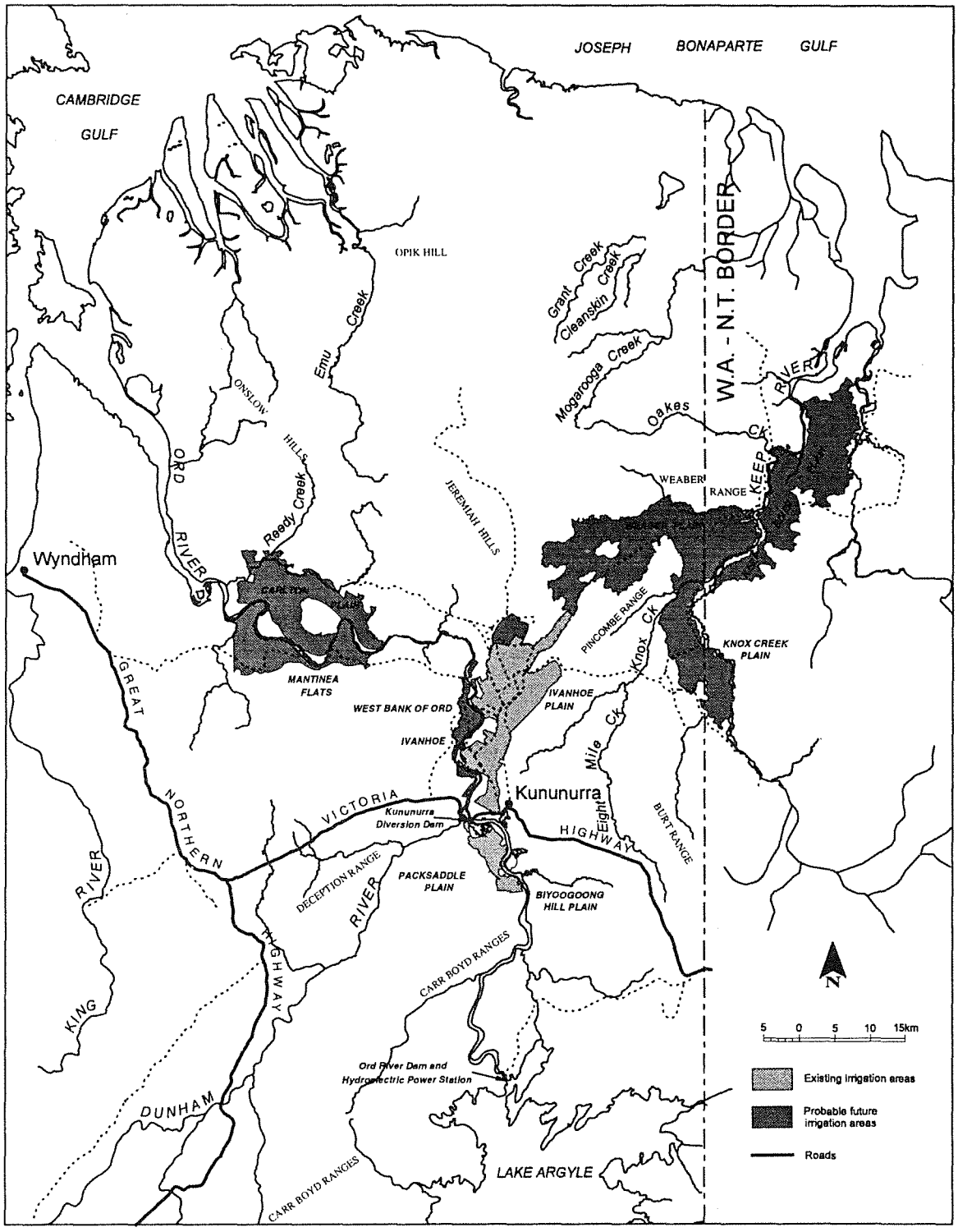


Figure 1. Location map of area downstream of the Ord River Dam

The presence of the dams and the permanent water has also had significant impacts on recreation and tourism in the region. Lake Argyle is a major attraction for visitors by road, air or river, and tour boats operate between Kununurra and the Ord River Dam as well as on Lake Argyle itself. Fishing charter operations are popular below the Diversion Dam. There are commercial fishing and aquaculture operations, and proposals for expansion of aquaculture, on Lake Argyle.

The demands for all these uses and the operational considerations for management of the water resource are discussed in Section 6.1.

1.3 Roles of water management and distribution agencies

1.3.1 Water and Rivers Commission

The Water and Rivers Commission is responsible for the sustainable management of all surface and groundwater resources on behalf of the State.

The Commission is responsible for licensing the diversion and use of water from any water course proclaimed under Part III of the Rights in Water and Irrigation Act. The Ord River and its tributaries are proclaimed (Figure 1) and therefore any diversion of waters requires licensing under that Act. The licensing provisions only apply to diversions from the water course as defined under the Act; and this does not include irrigation channels away from the watercourse.

Under present legislation therefore the Water and Rivers Commission can:

- Issue a licence to divert (or regulate the natural flowing) waters of the Ord River at the Ord River Dam and the Kununurra Diversion Dam.
- Issue licences to take and use water from Lake Argyle and Lake Kununurra water storage or from the regulated flow of the Ord River down stream of the dams. This includes pumping from Lake Argyle, taking water from the M1 offtake and taking water from the river or lakes via pipe and pump supplies.
- Issue licences to take and use water from the unregulated streams within the proclaimed area (although not considered in this plan)

1.3.2 Office of Water Regulation

The Office of Water Regulation regulates the standards of provision of water services, including supply, sewerage, drainage and irrigation. They protect the interests of customers of water service providers by ensuring that reliable water services are maintained at reasonable cost. This involves overseeing the engineering and financial performance of water service providers. This is primarily done through reporting mechanisms established under operating licences issued by the Coordinator of Water Services. Water Service Operating licences are required by the Water Corporation and the Ord Irrigation Cooperative Ltd.

Unlike the Commission, the Office of Water Regulation is not involved in managing how water is harnessed from the natural environment.

1.3.3 Water Corporation

The Water Corporation is the owner and operator of the headworks, which includes the Ord River Dam and the Kununurra Diversion Dam (Figure 1). The Corporation currently owns the irrigation infrastructure but is in the process of transferring most of these assets to the Ord Irrigation Cooperative Ltd.

As a water service provider, the Water Corporation operates under an operating licence from the Coordinator of Water Services and currently holds a water allocation licence from the Water and Rivers Commission to divert water from the Ord River at the Ord River Dam and the Kununurra Diversion Dam for supply to its customers.

1.3.4 Ord Irrigation Cooperative Ltd

The Ord Irrigation Cooperative Ltd (OIC) currently operates the irrigation distribution system within the existing (Stage 1) irrigation area. It is anticipated that OIC will become the owner of the distribution assets within Stage 1(other than the M1 channel) within the next few years and will continue to distribute water to irrigators within that area. The OIC is required to have an operating licence from the Coordinator of Water Services because it is a provider of a water service. It will also be required to have a licence from the Water and Rivers Commission under the Rights in Water and

Irrigation Act to take water from the Ord River at the M1 offtake structure and at the Packsaddle Plain pump station and use it for irrigation purposes.

The following table summarises the licensing responsibilities currently and when the irrigation distribution assets are transferred to the Ord Irrigation Co-operative.

Table 1: Water Allocation and Irrigation Service Provision Licensing

Licences			Holder	
Issued By	Type	Sub-category	Currently	When the Distribution Assets are Transferred
Water & Rivers Commission	Water Resources Allocation Licences	To Divert Water (for operation of the headworks)	Water Corporation	Water Corporation
		To Take and Use Water (for the distribution to and use by landowners for irrigation)	Water Corporation (& river pumpers)	OIC, river pumpers & Stage 2 developers
Office of Water Regulation	Service Provider Operating Licence	Irrigation Service	Water Corporation	OIC & Stage 2 Developers

Commercial contracts between the Ord Irrigation Cooperative Ltd and its customers (irrigators) and the contract between OIC and the Water Corporation are outside the scope of this plan.

1.4 The allocation planning process

Figure 2 shows the general process undertaken when preparing allocation plans. The Commission has been guided by the "National Principles for the Provision of Water for Ecosystems" (ANZECC/ARMCANZ, 1996) in the formulation of this policy.

To fulfil this task, the Commission estimates the total water flow down a river, determines how much is needed to maintain agreed environmental values and then shares the remainder between public, agricultural and industrial uses.

The best information will be used to determine environmental water needs. The Commission will err on the side of caution if little scientific data is available.

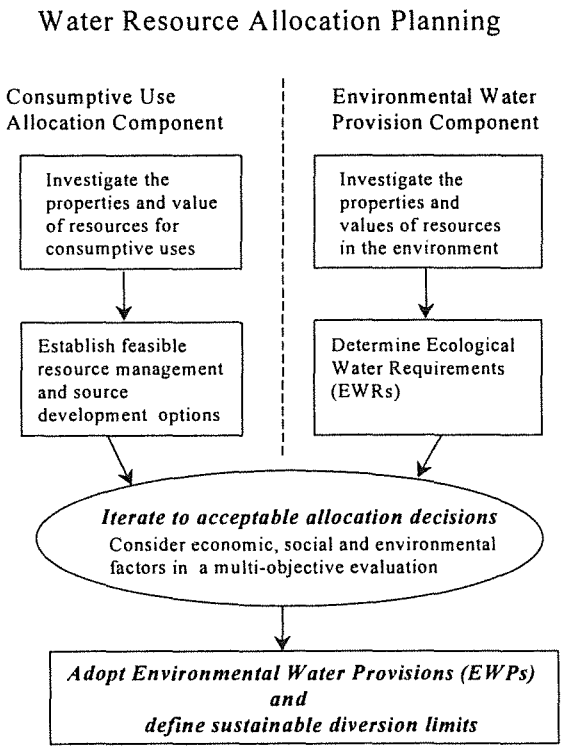


Figure 2. The Allocation Planning Process

The Commission implements these principles and processes when preparing water resource allocation plans. These include broad strategic plans which may be prepared to assist allocation decisions and licensing policy in individual water resources, or more detailed plans covering those parts of a river catchment where special management is needed. All plans will include explicit consideration of the water needs of the environment.

The Commission will prepare draft plans that allow for public review of the proposed allocations. This enables review of the environmental water provisions by the Environmental Protection Authority.

1.5 Interim allocation process

This is an interim allocation plan because there are several areas in which further definition of water demands and improvements in irrigation practices are required. For the most part, this is likely to be possible within the next three to four years. The key areas of uncertainty include:

- limited information on the ecological water requirements of the lower Ord River;
- undefined, or unresolved views on, social and recreational values of water in the reservoirs and the lower Ord River ,
- uncertainties in crop water demands in the area; and
- potential but unquantified water savings from improved water distribution efficiency.

Nevertheless estimates of these elements have been made to allow interim allocation decisions and meet the objectives of the plan.

The approach taken was to adopt interim values of water demands and environmental water provisions to enable the simulation of the reservoir and diversion works on the Ord River for a number of different operating scenarios. A monthly water balance model of Lake Argyle and Lake Kununurra was used. From estimates of catchment inflows between 1905 and 1990, different water demands and constraints on reservoir operation, the quantities of water able to be diverted and fluctuations in water storage levels each month were calculated. Conservative estimates of water demand were made. The simulations included consideration of seasonal demand patterns and reflected the range of potential irrigation and hydro-power requirements during the next few years and in the longer term.

Environmental water provisions were simulated by setting reservoir operational constraints that required minimum quantities of water to be maintained in the lower Ord River. For each scenario the amount of water that could be diverted from Lake Kununurra, while meeting these constraints, were determined.

2. Economic and Social Environment

2.1 The Kimberley Region

2.1.1 Population

Archaeological digs indicate that Aboriginal occupation of the Kimberley region dates back at least 40,000 years. Recent archaeological finds in the Keep River area suggest that occupation may have been for substantially longer than this.

The Kununurra-Wyndham area was occupied by the Miriuwung, Gajerrong and Dulbung peoples (based on language groupings) at the time of European settlement in the 1880s when the first pastoralists from eastern Australia arrived. Baimbarr and Djangada peoples occupied areas west of Cambridge Gulf.

Since European settlement the population has slowly grown in response to the economic development of the paroral, mining paerling irrigated agriculture and tourism industries. In 1995 the estimated resident Kimberley population was 24,968 (Kimberley Development Commission, 1997). The distribution across the region showed 8,779 in the Shire of Broome, 7,066 in Derby/ West Kimberley, 6,275 in Wyndham/ East Kimberley and 2,848 in Halls Creek.

It is estimated that the population will grow by between 2.0% per annum from 1991 to 2001 increasing to 2.4% per annum between 2001 and 2011. This projected population growth is influenced by expected expansion of the irrigation industry and will require a similar growth in potable water for domestic supply.

2.1.2 Economic activity and land and water resource planning

The current features of the Kimberley economy are:

- Mining. In 1995 the mining production was valued at approximately $551 million which included diamonds, iron ore, gold, lead-zinc and petroleum.
- Tourism. This is considered to be one of the major areas of growth in the region, which will result in a benefit to the retail and infrastructure industries.
- Pearling and fishing, based mainly in the West Kimberley.
- Irrigated agriculture. This industry is experiencing rapid growth based on targeting seasonal markets in domestic and international markets.
- Pastoral. Based solely on cattle with 35% of the State's total herd.

To varying degrees each element has affected land and water resource management in the region. Past mining, cattle grazing associated with the pastoral industry and irrigation development have had the most widespread impact on the water and land resources. Tourism and pearling have contributed to the growth of the existing towns of the region and added pressure on the local land and water resources near them. Past land and water resource planning and management by Government has responded to these pressures. The accommodation of Aboriginal values and aspirations in land use and water resource planning and management will be increasingly important in the future.

2.2 Irrigated Agriculture in the East Kimberley

Developing markets for irrigated agricultural products and the prospects for world traded commodity production both point to the Ord River Irrigation Area as a major opportunity for economic development in the east Kimberley. There are a number of likely growth areas:

- Niche markets for horticultural crops, especially melons, bananas and mangoes have been established in southern and eastern Australia;
- Grains such as chickpeas, which are grown for high value niche markets in Australia and overseas;
- Hybrid seed is supplied from the Ord to most parts of Australia and overseas;

- Leucaena pastures which are used for growing out rangelands cattle to improve the quality of beef prior to export.

Since 1985/86 the gross value of agricultural production from the Ord River Irrigation Area has grown from $6 million to around $63 million in 1996/97. This growth has been possible by penetrating niche markets and maintaining a range of crops.

The actual pattern of development over the longer term (10 years and beyond) is difficult to predict. However, the growth in irrigated land in the area is likely to be driven by growth in world traded commodities such as sugar and cotton.

In recent years strong interest has been shown in sugar. The CSR company commissioned a 560 thousand tonne per year cane processing mill in late 1995 to take cane grown in the Stage 1 area. A new joint venture (Wesfarmers Ltd. and the Marubeni Corporation) recently commenced a major feasibility study of establishing a large-scale sugar industry in the Weaber, Knox Creek and Keep River Plains (or the M2 area) of the Stage 2 Irrigation area by early in the next decade. The growth in horticultural area is likely to be less dramatic as these crops are less land intensive and expansion will be linked to the development of new markets.

To meet these irrigation needs a commensurate growth in the demand for water is expected from the Ord River.

3. Natural Environment

3.1 Climate

The Ord River catchment area has a climate that may be described as semi-arid to arid monsoonal. The average annual rainfall ranges from 450 mm to 780 mm, with a catchment average annual rainfall of about 550 mm. The long term average annual rainfall at the Ord Dam is 630 mm.

Eighty percent of the rainfall occurs in the four months December to March. It results from thunderstorms or monsoonal activity including cyclone disturbances. The five months from May to September produce only 3% of the rainfall and periods of several consecutive months without rain are not uncommon.

Daytime temperatures throughout the year are high, with daily maxima commonly over 40°C in the months preceding the wet season. Evaporative losses are consequently high, with maximum lake evaporation losses of over 200 mm per month in October and January.

Ruprecht and Rodgers (1999) discuss the climate more extensively.

3.2 Physiography

The Ord River drains the north eastern part of Western Australia. The river originates about 80 km north of Halls Creek and together with its tributary, the Bow River, flows northward into the southern end of Lake Argyle. The flooding of a large area of the Upper Ord Plains after the construction of the Ord River Dam formed this lake. Downstream of the Ord River Dam the river flows through the Carr Boyd Ranges in a meandering gorge 250 m deep called Carlton Gorge, before reaching the Lower Ord Plains about 10 km south of Kununurra. The Dunham River flows into the Ord just downstream of the Kununurra Diversion Dam.

3.3 Vegetation

The catchment of the Ord River Dam is composed of rough hilly country with thin soils and numerous rocky outcrops. In the middle and lower reaches of the Ord River, the river flows through flat or slightly undulating plains. The soils of the catchment are strongly influenced by topography, with the various soils being derived from their respective geological formations. The ranges and plateaus have a stony skeletal soil, while deep sandy soils dominate the valley floors. The floodplains are dominated by grey and brown heavy cracking clay soils and in the West and East Kimberley, eucalyptus and acacia woodlands on deep reddish sandy soils dominate.

The vegetation of the flat or slightly undulating plains within the Ord River Catchment is primarily a grassland and grassland savannah woodland complex dominated by the perennial grass species. The rough hilly country within the catchment is only sparsely covered with spinifex and small trees. River gums, paperbarks and coolibahs are prevalent along the creeks and rivers, while the trees on the plains are predominantly small eucalypts such as bloodwoods and nutwood.

Over time, the vegetation has been altered by grazing and, in certain areas, the regeneration process and the introduction of exotic grass and shrub species has led to a dominance of exotic/naturalised grass species with few native grasses evident.

3.4 Hydrogeology

The hydrogeology of the Ord River region is discussed in McGowan (1987), Laws (1991 & 1993) and Nixon (1987). The critical issue for the Ord River Irrigation Area is the change in the hydrogeological processes in response to the intensive irrigation since 1964. Watertable levels are increasing at a rate up to 0.5m/year in parts of the Ivanhoe Plain and consequently there is a risk of water logging or groundwater and soil salinisation if the issue is not

adequately managed. A land and water management plan is now being prepared to address this important issue.

3.5 Ecology

Lakes Argyle and Kununurra were formed by the construction of the Ord River Dam and the Kununurra Diversion Dam, which also resulted in many of the formerly seasonal wetlands associated with the Ord River, such as Packsaddle Swamps, becoming permanent. The permanent water and the controlled water levels have resulted in changes in the structure of the vegetation and faunal communities of the river, although there have been no detailed studies to show the extent of such changes.

Water levels in Lake Argyle can have an annual fluctuation of over 10 metres, and can vary by 20 metres over a sequence of years. Water levels in Lake Kununurra are controlled to within about 0.4 metres of the top of the Diversion Dam to ensure secure irrigation supplies. The fluctuation in Lake Argyle water levels has limited the development of fringing vegetation on its shores. However, Lake Kununurra and its associated wetlands have a well developed fringing vegetation of grasses, Cumbungi (*Typha domingensis*) and other rushes, woodlands including dense stands of Cadjeput (*Melaleuca leucodendra*) close to the waters edge and stands of River Red Gum (*Eucalyptus camaldulensis*) higher on the banks in better drained soils. In some areas, notably Lily Creek, the spread of Cumbungi in recent years has been of concern because of the impacts on visual amenity, recreational use and as a habitat for mosquito larvae, a major vector for arbo viruses. Stands of Cumbungi are widespread along the river reaches below the Diversion Dam and are well established on the exposed sandy sediments of the river bed and banks. The problem appears to be increasing and many consider the problem serious now.

Both Cadjeput and River Red Gum have specific water requirements for successful regeneration. Along the Lower Ord there is evidence of recruitment of Cadjeput during the period since the dams were constructed but the effect of the altered water regime on recruitment and regeneration of River Red Gum is less clear. Cattle grazing has been heavy in some sections of the river bank and foreshore to the extent that little plant life has been left in some areas at some times of the year. River Red Gum saplings may not or have not established in some of these areas because of this grazing pressure.

The lakes and permanent wetlands are important dry season refuges and year round resources for waterbirds and this has been recognised in the listing of Lakes Argyle and Kununurra under the Ramsar Convention. Lake Argyle also supports a large population of freshwater crocodiles (*Crocodylus johnstoni*) and fish species including Silver Cobbler, Black Bream and Cherabin. Occasional Saltwater Crocodiles (*C. porosus*) have been reported. Barramundi hatchlings are raised commercially at a site near the Tourist Village, but as this species normally requires salt water for part of its life cycle it no longer occurs naturally upstream of the dams.

The Ord River Floodplain, an area comprising about 116,000 ha of nature reserves including mangroves and mudflats of the False Mouths of the Ord River and seasonal wetlands including Parry Lagoons to the south, is also listed as a Ramsar wetland. The False Mouths of the Ord is the most extensive mudflat and tidal waterway complex in Western Australia and contains some of the best stands of mangrove in the Kimberley in terms of species diversity, structural complexity, and size of the stands. The area supports a number of bird species that are restricted to this habitat type and provides important habitat for Saltwater Crocodiles.

Apart from some studies on Barramundi, there is limited information specific to the Ord River on ecological impacts of regulated flows. Some generalised assumptions can be made about the impacts of the generally lower and more regular flows that have resulted from the impoundment and regulation of the Ord, but the significance of these have not been assessed. Hydrologic impacts which are believed to have affected the ecology of sections of the Ord River include the less frequent and less extensive inundation of the floodplain; an altered pattern of salt water intrusion in the lower reaches of the river; altered sediment deposition in the lower Ord and the False Mouths; and the less variable water levels in all stretches of the river below the Ord River Dam.

4. Hydrology

The hydrology of the Ord River is detailed in reports by Ruprecht (1995) and Ruprecht and Rodgers (1999). Only the most pertinent aspects are included in this chapter.

4.1 Streamflow

Streamflow occurs during the wet season when rainfall exceeds evaporation. Thunderstorm activity during the wet generates localised rainfall events of high intensity. Streams respond rapidly to these events often producing local flooding. However, local thunderstorms only produce small flow events in the larger tributaries of the Ord. Broad scale monsoonal low-pressure systems generate more widespread rainfall and cause the major flow events of the wet season. The number of monsoonal depressions that occur over the Ord catchment each "wet" governs the amount of the streamflow discharge. In some years only local thunderstorms occur and annual streamflow is low. In other years many monsoonal depressions develop and some build up to into intense cyclones. In these years widespread heavy falls are common, major flooding results from the cyclone events and large volumes of annual streamflow are generated.

During the remainder of the year falls are light and sporadic, and several consecutive rainless months are not uncommon. Evaporation is dominant, soils dry rapidly and streamflow recedes and most river systems dry up by June each year.

A sequence of estimated monthly streamflow volumes at the Ord River Dam site has been prepared by Ruprecht and Rodgers (1999) for the period 1905 to 1990. It was compiled from a mixture of stream gauging data, rainfall runoff modelling, long term catchment rainfall data and reservoir water balance calculations.

The annual flow sequence at the Ord Main Dam site is shown in Figure 3.

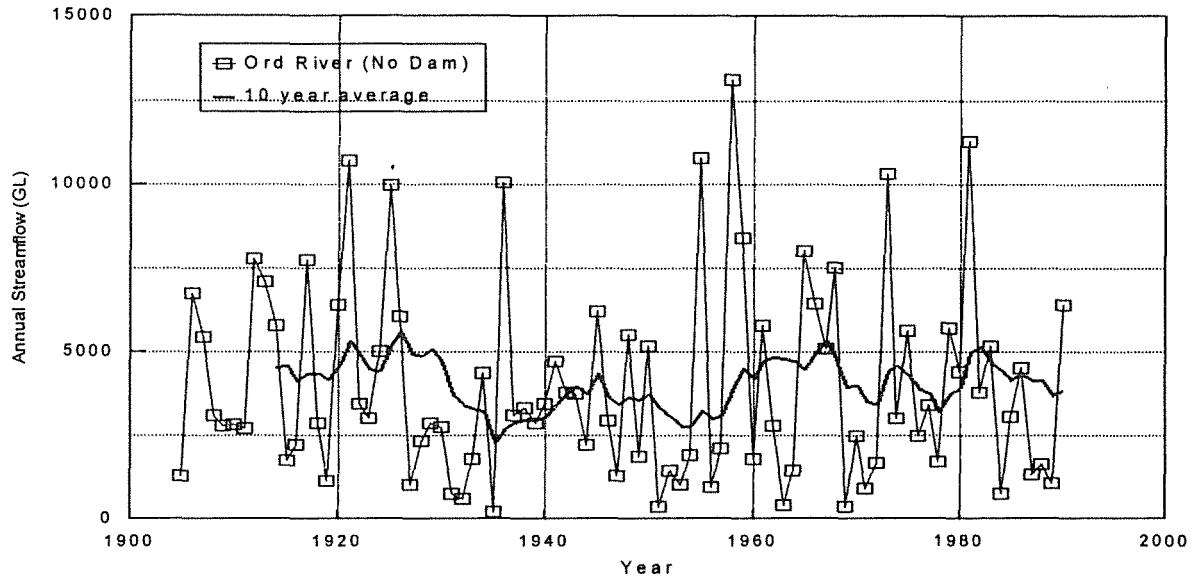


Figure 3. Annual streamflow sequence

The long term (1905-1990) annual average discharge is 3980 GL/a and represents an average annual runoff from the whole catchment of 86 mm/a or 16% of the catchment rainfall. The annual series is positively skewed, having a median value of only 3044 GL/a, significantly less than the mean. Key features of the

record are the drought periods in the early 1930s and early 1950s and the wet years of 1958, 1981 and 1955.

The seasonal distribution of streamflow and the monthly and annual volumetric percentiles are summarised in Table 2 below.

Table 2. Seasonal distribution and variability of monthly streamflow volumes

Month	10th percentile * (GL)	20th percentile (GL)	30th percentile (GL)	50th percentile (GL)	90th percentile % (GL)
Jan	97.3	199.8	286.9	490.6	2725.8
Feb	114.4	221.1	378.3	739.5	3951.8
Mar	66.2	145.6	204.6	349.1	1995.8
Apr	3.2	18.8	35.5	69.8	397.8
May	0.0	2.5	6.4	12.5	104.1
Jun	0.0	0.0	0.8	2.5	22.9
Jul	0.0	0.0	0.1	0.5	9.0
Aug	0.0	0.0	0.0	0.1	2.2
Sep	0.0	0.0	0.0	0.0	0.7
Oct	0.0	0.0	0.0	0.0	36.2
Nov	0.0	0.2	3.7	11.4	128.0
Dec	3.6	27.0	53.0	133.9	772.1
SUM	285	615	969	1810	10146
Annual	970	1585	2110	3044	7740

* The xth percentile value of a series of observations is the value of the observation which has x% of the observations equal to or less than it. It is determined by ranking the series from smallest to largest and finding the value of the observation that is x percent of the way through the series. For example the January monthly flow volume is likely to be less than or equal to 97.3 GL in ten percent of years. Similarly the January monthly volume is likely to be less that 2725.8 GL in 90 percent of years. SUM is the total of the 12 monthly values for each particular percentile. The median annual flow volume (or 50th percentile of the annual flow series) is 3044 GL/a

The streamflow response to the wet season rainfall is clear from Table 2 as is the variation in the duration of streamflow between drought conditions (10% percentile figures) and wet conditions (90% percentile figures).

4.2 Impact of regulation

There has been a marked change in the streamflow since construction of the Ord River Dam and the Kununurra Diversion Dam. The change has been both in terms of annual streamflow and in the seasonal pattern of flow. As shown in Table 3, since the construction of the main dam, about 30% of the inflow is lost from the surface of Lake Argyle. The net evaporative losses (lake evaporation minus rainfall) is about 1100 GL/a. This represents over half the water released from the storage.

Table 3. Annual Components of the water balance for Lake Argyle

Component	Amount* (GL/a)
Inflow (GL)	3940
Rainfall (GL)	650
Lake evaporation (GL)	1750
Overflow (GL)	890
Releases (GL)	1950

(* Adapted from Ruprecht and Rodgers 1998, based on the "current" scenario – Chapter 7)

The seasonal distribution of flow has been altered from a strongly seasonal one, with peak flows in January to March, to a more even distribution with highest flows in February to April. The extent of the changes is discussed further in Ruprecht and Rodgers (1999) and in Section 8.4.

5. Environmental Water Provisions

5.1 Definitions

To ensure clear understanding, some of the terms used in this draft plan are defined in this section. The definitions are based on the "National Principles for the Provision of Water for Ecosystems" and were developed jointly by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC).

These principles have the goal of providing water for the environment to sustain and where possible restore ecological processes and the biodiversity of water dependent ecosystems. The principles can be broadly grouped under:

- Determining environmental water provisions;
- Provision of water for ecosystems;
- Management of environmental water allocations;
- Further research; and
- Community involvement.

The term environment refers to the natural components of aquatic ecosystems, the flora and fauna, and the natural ecological processes that take place between individual plants and animals, their surroundings, and between each other. The maintenance of species biodiversity, community structure and functioning and natural ecological processes are important elements (and indicators) of the maintenance of overall environmental integrity.

Water dependent ecosystems are those parts of the environment, the species composition and natural ecological processes of which are determined by the permanent or temporary presence of flowing or standing water. The in-stream area of rivers, riparian vegetation, springs, wetlands, floodplains and estuaries are all water-dependent ecosystems.

Ecological values are defined as the natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.

Ecological water requirements (EWRs) are descriptions of the water regimes needed to sustain the ecological values of aquatic ecosystems at a low level of risk. These descriptions are developed through the application of scientific methods and techniques or through the application of local knowledge based on many years of observation.

Environmental Water Provisions (EWPs) are the water regimes that are to be maintained. They are set by water allocation decisions that may involve some compromise between ecological, social and economic goals. They define water regimes that protect ecological and social values of water resources, to levels consistent with the allocation decisions made. Environmental water provisions may refer to:

- unregulated flows in rivers and water in wetlands and aquifers;
- specific volumetric allocations and/or releases from storages;
- water levels maintained in wetlands; and
- water in transit for other users, the pattern of flow of which may be defined to meet an environmental need.

5.2 Constraints on application to the Ord River system

Ideally, EWRs should be determined before the construction of major storages on a river system. The environmental impact of the development can then be minimised through ensuring that critical elements of the natural flow regime necessary for the maintenance of the ecological values of the system are maintained. These critical elements can be established as clear conditions or criteria to be met in the operation of the reservoir. Simulations of different reservoir operating strategies, which ensure that these criteria are met, can then be carried out to determine the water available for diversion for consumptive uses.

As outlined in Chapter 3, since the Ord River Dam and the Diversion Dam were constructed and Stage 1 of the Ord River Irrigation Area established, the water regime

in the river has changed significantly. The total annual flow down the river has decreased, largely due to evaporative losses, and there is less seasonal and annual variation in flows.

With the commissioning of the hydro power station early in 1996, further changes in the water regime have occurred although these are less significant (hydrologically) than those that occurred as a result of reservoir construction. The main impact is a further decrease in the seasonal variability of flows (see Ruprecht and Rodgers 1996). The development of Stage 2 of the irrigation area is likely to have a more significant impact on the amount of water reaching the lower end of the Ord River below Carlton Plain. Ruprecht and Rodgers (1999) estimate that this could result in a 30% further reduction in the annual streamflow.

Key issues to be resolved before the environmental water requirements, and hence the environmental water provisions, can be determined are:

- What are the key ecological processes and communities that need to be protected in each reach of the Ord River (ie Lake Argyle, downstream of Lake Argyle, Lake Kununurra, downstream of Lake Kununurra)?

- What are the critical flow characteristics which will provide adequate protection for these processes and communities?

As indicated in Chapter 3, there is little quantitative data from which environmental water requirements for the Ord River can be estimated. Furthermore, there is no clear understanding of how ecological communities may have adapted to the lower annual flows and decreased seasonal variability of flows during the past 20 to 30 years, particularly in the reach of river between the two dams where water levels have been stable. In the absence of quantifiable relationships between hydrology and ecology, it is also difficult to predict how further changes to the flow regimes due to the operation of the hydro power station and the potential expansion of the irrigation area will affect vegetation and fauna communities.
Chapter 9 and Appendices 2 and 3 propose procedures and additional monitoring to answer these questions and refine this interim allocation plan. The studies which are required are likely to take some years, but some allocation decisions are needed before then to allow irrigation and hydro power generation to proceed. A basis for determining interim allocations in the absence of reliable scientific data is therefore needed.

5.3 Approach adopted for this study

Appendix A summarises some approaches to environmental water provisions which have been used elsewhere in Australia. Although methodologies vary, the essential task is to determine relationships between aspects of the naturally occurring flow regime (including volumes, rates of flow, water levels, seasonal and annual variations, and water quality) and the maintenance of ecological processes and communities. The next task is to determine what can actually be provided and then to monitor and review the adequacy of the environmental water provisions in meeting ecological objectives.

As indicated in earlier sections there has been insufficient scientific study to determine with certainty a flow regime that will support specific environmental values.

The lack of scientific knowledge, combined with the requirement that interim water allocations be made quickly to allow current water users to continue their activities and to facilitate planning of Stage 2, has meant that the critical step of identifying environmental objectives for the system has not yet occurred.

In the absence of quantitative studies of the system, an approach that has been used elsewhere is to designate a fixed percentile for each month based on the analysis of historical discharge records. Arthington *et al* (1992), for example, refer to the recommendation of the mean monthly 50^{th} percentile flow to maintain optimum fish habitat in Victorian streams, with the mean monthly 20^{th} percentile flow as an acceptable low flow during periods of drought. In a Queensland river, Arthington *et al* (1992) recommended a strategy based on dry, average and wet conditions (as indicated by 20^{th}, 50^{th} and 80^{th} percentiles of monthly flows expressed as average daily discharge values. This approach has been used for the Ord River to set a

minimum environmental provision until the definition of ecological values and field-based studies to determine their water dependencies can be undertaken.

The 20th percentile monthly flow in the lower Ord River below the Dunham River confluence has been adopted as the minimum flow to be maintained. There is no direct evidence to link the 20th percentile monthly flows to the maintenance of any specific ecological functions in the Ord River system. The selection of this as an interim EWP is therefore largely to ensure recognition of the need for some level of provision of water to the environment and to provide a starting point for a more clearly justified EWP.

In adopting the interim EWP of the 20th percentile monthly flow, consideration also needs to be given to the following points:

- EWPs need to be expressed in terms of both quantity and timing of flows;
- Water released for other purposes (irrigation, power generation and navigational purposes) can contribute to meeting environmental requirements;
- A significant change to the hydrology of the Ord system since dam construction has been the reduced variability of flows. Without better knowledge of the ecological components and processes, including changes that have already occurred over the past 20–30 years, there is insufficient justification at this time to attempt to designate high or low flow criteria as part of the interim EWP. This may change once the recommended ecological studies have been completed.

6. Water and Power Demands

6.1. Stage 1 Irrigation

The Ord River Irrigation Scheme was undertaken as a staged development project. Stage 1 included construction of the Diversion Dam and the works required to irrigate around 10,000 ha of land as well as construction of the town of Kununurra and road infrastructure (Kimberley Water Resources Development Office, 1993).

The main offtake structure for the irrigation area is located about 2 km upstream of the Diversion Dam, and feeds water along the main channel (M1) to the irrigation areas of the Ivanhoe Plain (Map 1). Irrigation water is mainly gravity fed, with some pumped supply to Packsaddle Plain and to small areas of black soil, sands and levee soil. Over 134 km of channels and over 155 km of drains service a gross area of almost 13 000 ha of land from the Kununurra Diversion Dam.

Most of the irrigated area is supplied by the 134 km of irrigation channels, although a number of irrigators pump water directly from either Lake Kununurra or the Ord River downstream of the Diversion Dam.

Agricultural production is diverse, including field crops such as maize, chickpea, and various seed crops; leucaena pasture for fattening animals prior to export; and horticultural crops, including melons, bananas and mangoes. Row crops and broad area horticultural crops are grown with furrow irrigation while tree crops generally use under-tree sprinklers or drip irrigation. A sugar mill was constructed in 1995, which has encouraged the establishment of significant areas of sugarcane.

Water demand for Stage 1 irrigation is determined from the area irrigated, the mix of crops established, their respective crop water demands, the on-farm water efficiency and the efficiency of delivery through the channel system to the farm gate. Estimates have had to be made for some of these components and will need to be verified through improved monitoring and field investigations. Some assumptions also need to be made about the potential for changes in the mix of crop types grown, particularly the likelihood of increasing the areas under sugarcane production as this has a high crop water demand.

Kinhill Engineers (1995) made estimates of total water demand for the Stage 1 irrigation and Ruprecht and McCosker (1995) used similar estimates. Kinhill (1995) estimated annual deliveries to the farm gate for three scenarios, which gave deliveries at the farm gate of up to 180 GL by the end of 1998, and up to 200 GL by 2005. With a water distribution efficiency of 67%, this would require the supply of 270 GL to the end of 1998 and 300 GL by 2005 to allow for the expected development of Green and Martins Swamps. Both areas have development more rapidly. Martins Swamp was released as one farm in 1995 and was cropped for the first time in 1996. Green Swamp is likely to be fully developed within the next few years. These initial estimates were based on an average crop water demand of 20ML/ha for sugarcane and an asumption that sugarcane would expand to 60% of the total irrigated area by the year 2000.

The Ord Irrigation Cooperative Ltd has suggested that the proportion of land under sugarcane production will increase when the sugar mill capacity is increased. As discussed in Section 6.2 below, the crop water demand for sugarcane used to determine the irrigation requirements, may not allow for optimal economic production. Marsden Jacob and Associates (pers comm, October 1996) have since provided alternative estimates of the likely water demand for Stage 1, which are shown in Table 4.

6.2 Stage 2 Irrigation

Stage 2 commenced with the construction of the Ord River Dam in the early 1970's and was intended to include the construction of works to irrigate a further gross area of about 64,000 ha (net irrigable area about 40,800 ha), including about 25,000 ha in the Northern Territory. The expansion of the distribution infrastructure was delayed as growth in water demand in Stage 2 was limited in early years. As economic

prospects of further irrigation expansion looked promising in the early 1990's an updated concept study and preliminary engineering design for the Stage 2 development was prepared (DRD, 1997). The Governments of Western Australia and the Northern Territory then called for expressions of interest from the private sector to finance the completion of Stage 2.

Table 4. Estimates of predicted water demand for the Stage 1 irrigation area

	Ruprecht and McCosker (1995)		Marsden Jacob & Associates (Oct 1996)	
	1998	2000*	1998	Max*
Predicted area of sugarcane (ha)	4700	7100	4700	9850
Percentage of Stage 1 area under sugarcane	40	60	40	82
Sugarcane water demand at farm gate (ML/ha)	20	20	25	25
Total area under irrigation (ha)	10200	11780	10370	11950
Total water demand at farm gate (GL)	164	203	180	268
Efficiency of water delivery system	0.67	0.67	0.67	0.67
Total water demand (GL)	245	303	269	400

Max = Maximum possible water demand

* Estimates are based on net irrigation areas and include the Green and Martins Swamps areas

In 1998 a Wesfarmers Marubeni joint venture was awarded preferred developer status and is carrying out detailed feasibility studies of establishing a major sugar industry on the black soils of the Weaber, Knox Creek and Keep River Plains. Other irrigation areas that would take water from the lower Ord River are also being promoted. These include areas located adjacent to the banks of the Ord River at Ivanhoe (west bank of the Ord River), Mantinea Flats, Mantinea Loop and the Carlton Plain where intensive horticulture, such as banana and mango crops are planned (DRD, 1997). A further 1800 ha of broad-acre irrigation on the Carlton Plain is also proposed.

The Weaber, Knox Creek and Keep River Plains areas would be reliant upon water supply from a new main channel (M2) constructed alongside the existing channel between Lake Kununurra and Cave Springs Gap. The areas could be augmented by water harvested from drainage and from the Keep River. The irrigation areas downstream of the Diversion Dam would be supplied with water from a series of pump stations on the Ord River.

Ruprecht and McCosker (1995) estimated potential water demands for the full Stage 2 development for a variety of irrigation scenarios. These scenarios are summarised in Table 5 and the water demand for each scenario estimated. Total annual water demand estimates vary between 780 GL and 1500 GL depending on the mix of crops, crop water demand and assumptions about on-farm and water delivery system efficiencies. Ruprecht and McCosker's estimates were based on Agriculture WA's best estimates of crop water demands, which included a figure of 22.1 ML/ha for sugarcane production. More recent theoretical modelling work by Muchow *et al* (1996) indicated that maximum sugar production may occur at crop water demands as high as 29.3 ML/ha.

Field trials have commenced to confirm the accuracy of this modelling. If the highest crop water demand were proved to be required for economic sugar production then the water demand figures in Table 4 and 5 and the areas of potential sugar cane would need review. It does not follow that the whole M2 area should be allocated water on the basis of the highest crop water demand per unit area. This issue is addressed further in Section 9.5 in presenting how the proposed water allocation strategy may be updated.

The M2 development is to be formally assessed by the EPA by review of a full Environmental Review and Management Program prepared by the Wesfarmers Ltd and Marubeni joint ventures. Issues of concern, which will be examined in the assessment, include the potential for groundwater accession, water logging and subsequent development of salinity problems. Best practice land and water management will be required to avoid crop yield reductions and soil degradation. Minimising accessions to the groundwater will be critical, particularly in areas of low permeable sub-soils. The management effort required to minimise groundwater accessions in different parts of the M2 area have already been mapped (DRD, 1997b) and are being updated (Water and Rivers Commission, in prep.) Direct pumping from alluvial sequences (palaeo-channel gravels) will provide a useful tool to assist in the control of high water tables in the low to moderate areas. Careful crop selection (to favour those with lower water demands), best watering practices and drainage will need to be considered in the areas where subsoils are less permeable (areas of high management effort).

Table 5. Annual irrigation water requirements for Stage 2 Developments

Scenario	Upstream of Diversion Dam			Downstream of Diversion Dam	
	Existing	Expansion		Expansion	
A	300 GL	32,000 ha sugar High water demand No tailwater return	992 GL	1800 ha Leucaena 5000 ha bananas 2000 ha tree crops	195 GL
B	300 GL	32,000 ha sugar High water demand Tailwater return	740 GL	1800 ha Leucaena 5000 ha bananas 2000 ha tree crops	195 GL
C	300 GL	32,000 ha sugar Expected water demand No tailwater return	800 GL	1800 ha Leucaena 3000 ha bananas 2500 ha tree crops 2000 ha veg crops	166 GL
D	300 GL	32,000 ha sugar Expected water demand Tailwater return	608 GL	1800 ha Leucaena 3000 ha bananas 2500 ha tree crops 2000 ha veg crops	166 GL
E	300 GL	21,333 ha cotton No tailwater return 10,667 ha rotation crops	430 GL	1800 ha Leucaena 2500 ha bananas 2000 ha mangoes 2000 ha veg crops	148 GL
F	300 GL	21,333 ha cotton Tailwater return 10,667 ha rotation crops	331 GL	1800 ha Leucaena 2500 ha bananas 2000 ha mangoes 2000 ha veg crops	148 GL

(Adapted from Ruprecht and McCosker, 1995)

6.3 Hydroelectric power demands

The hydro-electric power station was allowed for in the original design and construction of the Ord River Dam. However the power station was only recently built by Pacific Hydro Pty Ltd and commissioned in 1996. The Station provides power to both Argyle Diamond mine and to Western Power's East Kimberley electricity grid. This includes the Argyle Tourist Village, Kununurra, Wyndham and surrounding areas.

The total demand for power is dominated by the Argyle Diamond Mine (ADM) and is currently about 210 Gwhr per year.

In 1994 Ashton Mining Limited, the principal stakeholder in the mine, contracted to purchase 1015 Gwhr of energy from Pacific Hydro Ltd. The energy was considered sufficient to cover their major power needs for the then projected life of the mine (to about 2003). In mid 1998 Ashton Mining Limited announced a three phase expansion plan for the mine that will add several years to the life of the mine. Consequently more power is likely to be sold to the diamond mine in the medium term. However, the long term hydropower demand will be controlled by Western Power's expected regional grid demand, unless new long term power demands develop in the region.

The projected East Kimberley electricity grid demand is shown in Figure 4. Assuming no new long term mining or industrial demand develops to replace the demand from the diamond mine, by 2020 the power demand will decline to about 100 to 110 GWhr/yr.

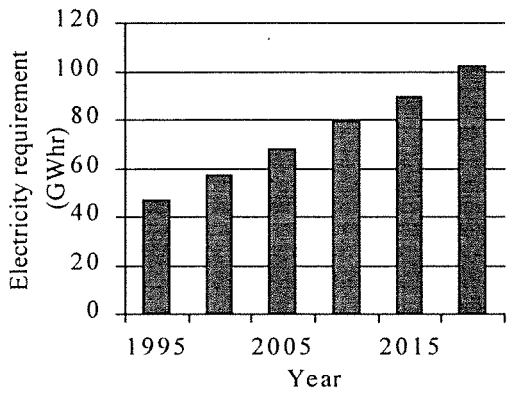


Figure 4. Western Power's projected electricity requirements for the East Kimberley

6.4 Other Water Demands

6.4 1 Mining

Argyle Diamond Mine has in the past taken water directly from Lake Argyle through pumps mounted on a pontoon moored on the lake shore. A dam has recently been constructed on Smoke Creek to supplement the water supply for the mining operations. The capacity of the dam at Full Supply Level is 6.5 GL and the system yield (based on the design demand of 0.8 GL per month) is 2.45 GL per year.

The total water demand for the mine has been less than 12 GL per year during the operation of the mine. This is not expected to increase significantly.

6.4 2 Lake Argyle Tourist Village Water Supply

The tourist village takes its water supply from Lake Argyle, pumping from the area of the irrigation outlet valves to a water treatment plant at the top of the hill. The volume of water taken (approximately 0.03 GL) is insignificant by comparison with other diversions. The Water Corporation currently provides this water service.

6 4.3 Pastoral use

Carlton Station waters its stock from the Ord River downstream of the Kununurra Diversion Dam. The actual volume of water taken is insignificant by comparison with upstream uses, but larger volumes of water have sometimes been released from Lake Kununurra in order to maintain freshwater at the pump intake points, particularly during periods of reduced flow and high tides. In the past, water has also been released to maintain water levels in order to limit the mixing of stock from Ivanhoe and Carlton Stations, and to prevent stock being isolated in the mud flats due to rapid decreases in water levels.

While releases of water to meet these purposes may have been an acceptable operating practice when the level of demand for other uses has been low, alternative management of the cattle will be necessary in future. Stock water will continue to be supplied from the river, but releases from the dams specifically for this purpose are unlikely. A clear operating strategy for the dams and communication between the operators and the station managers will allow pastoral needs to be met through releases for other purposes.

The access of cattle to the riverbanks will need to be considered when environmental objectives are determined for this stretch of the river.

In addition stock-watering issues will need to be addressed as part of the major changes to land tenure

and land management arrangements that will occur when the lower Ord River developments proceed.

6.4.4 Tourism and recreation

Since construction of the dams and the town infrastructure, tourism has become an important economic activity in the Kimberley region. Apart from the attractions of Lake Argyle and the Ord River, Kununurra is a convenient centre for visitors to Purnululu (Bungle Bungle) and other features in the East Kimberley region. The growth in tourism has been particularly significant since mid 1980s and it has been estimated that the amount of tourism expenditure in 1990/91 directly attributable to the Ord River Project was about $17 million (Kimberley Water Resources Development Office, 1993).

Water-dependent activities include tour boat operations on Lake Argyle and on the Ord River between Kununurra and the Ord River Dam, and charter fishing boat operations in the river downstream of the Diversion Dam. A hydroplane uses Lake Argyle as a departure point for scenic flights. Fishing charters operate downstream from the Diversion Dam. There are other activities, including canoeing, rowing and yachting, which are attractions for both tourists and residents. Most rely on some stability of water levels.

The tourism related activities, which require some water releases, are the tour boat operations below the Ord River Dam and the charter boat operations below the Diversion Dam. Below Lake Argyle, the reach between the Ord River Dam and Carlton Gorge is too shallow for safe navigation without releases of between 50 and 60 m^3/sec depending on weed growth and water levels. Releases of 40 m^3/sec are required from the Diversion Dam for easy operation downstream.

6.4.5 Kununurra Town Water Supply

Kununurra's town water supply is from a well field, which draws from the alluvial deposits of the Ord River and is located south of the townsite adjacent to Lily Creek. There are six production wells, three of which are operated at most times and three that tend to be high in iron and manganese and are operated occasionally to meet peak demands. The total capacity of the well-field is 2000 ML/year. Groundwater abstraction is licensed under a separate section of the Rights in Water and Irrigation Act and is not considered further in this plan because the impact of this level of abstraction does not significantly affect the surface water resource.

6.4.6 Aquaculture

A commercial Barramundi farm currently operates on Lake Argyle. The Kimberley Aquaculture Development Group proposes the expansion of commercial operations to 10,000 tonne per annum of Barramundi. While there may be issues to be resolved in terms of the maintenance of water quality and the provision of infrastructure, these will primarily be the subject of negotiations with the Water Corporation and will not affect the allocation plan.

7. Matching demand with available water

7.1 Planning scenarios

The different demands discussed in the previous chapter were formulated into seven main scenarios and two variations and used by Ruprecht and Rodgers (1999) as a basis for reservoir simulation. The scenarios span the current water demand situation and a range of ways the Stage 2 water demand may development. Two main scenarios are summarised here and the implications of other simulations summarised.

A scenario was developed to reflect the current situation likely to exist during the lifetime of this interim plan. Stage 2 of the irrigation project may commence construction during the life of plan but is unlikely to require the licensing of its full allocation. The current scenario was therefore based on full development of the Stage 1 area. It was designed to reflect current irrigation practice based on the existing Stage 1 infrastructure. The assumptions used and simulation results obtained are discussed in Section 7.3 below.

The longer-term scenario summarised here is based on full development of Stage 2 consistent with Scenario B of Table 5. This scenario represented the establishment of a water-efficient, sustainable irrigation industry and the continued generation of hydro power based on Western Power's expected East Kimberley regional grid requirements. The adopted irrigated crop areas were 3200 ha of sugar cane in the M2 area and a mix of 8800 ha of irrigated horticultural and fodder crops downstream of the diversion dam. While the crop mix is not precisely the same as the 1998 Wesfarmers Ltd Marubeni Corporation proposal for the M2 area, it is sufficiently similar for planning purposes. The details of the assumptions used and simulation results obtained are discussed in Section 7.4 below.

Variations of the above scenarios were also simulated. They were carried out to scope the possible amount of water that may be available to meet additional ecological, social or agricultural needs (in excess of those required needed to meet Scenario B above), once current environmental and demand uncertainties are resolved.

7.2 Reservoir simulations

Simulations of the response of Lake Argyle and Lake Kununurra to different water demand scenarios were carried out to determine the amount and reliability of the sustainable diversion limit from the Ord River at Lake Kununurra. The interim environmental water provisions described in Section 9.2.2 were used as a constraint in these simulations. A model that calculated a monthly water balance of Lake Argyle and Lake Kununurra was used. From estimates of catchment inflows between 1905 and 1990, different water demands and constraints on reservoir operation, calculations were made of the quantities of water able to be diverted and fluctuations in water storage levels each month. Iterative calculations of the water balance equations were necessary each month as overflow and release volumes were functions of other variables in the equations.

The simulations were undertaken for the full range of demand patterns in each planning scenario. Where the full target demand could not be met toward the end of a dry series of years, restriction policies were simulated. The frequency and severity of restrictions were computed.

The environmental water provision constraint was simulated in the following way. Calculations of the additional water necessary to be released from Lake Argyle to maintain the 20^{th} percentile natural flow regime in the Ord River downstream of the Dunham River confluence at the start of each month. Additional releases were only necessary when releases for power generation, spillage in excess of irrigation demand, and Dunham River inflow volumes, were insufficient to meet the downstream EWPs. Any additional releases necessary became a demand on Lake Argyle and included in the iterative calculations of the monthly water balance of the lakes. Further details of the simulations are included in Ruprecht and Rodgers (1999).

7.3 The Current Situation

7.3.1 Assumptions

Irrigation water demand:

An annual average demand of 300 GL was adopted for this scenario. The demand was based on

- 11,780 ha of net irrigable area[1];
- an average irrigation water requirement of 13.0 ML/ha (equivalent to an average crop water demand of 17.2 ML/ha with an effective rainfall of 4.2 ML/ha);
- an average crop water demand of 20 ML/ha for sugarcane, the average used by Kinhill (1995), assumed to be planted over 60% of the irrigable area;
- an average crop water demand of 13.2 ML/ha for a mix of horticultural and fodder crops over the remaining 40% of the irrigable area;
- an on-farm and in-field efficiency of 75%, and
- a 67% efficiency for the water delivery system to the farm gate.

Uncertainties in these assumptions are discussed in Section 6.1 and their implications for allocation decision making discussed in Section 9.2. The adopted 300 GL annual demand is sufficient to meet higher crop water demands if greater water distribution efficiencies are achieved (Section 9.2).

Hydro power demand

As discussed in Section 6.3 the current hydropower demand is about 210 GWhrs/yr of energy and made up of ADM and Western Power components. A constant power demand was assumed to simulate ADM requirements and a seasonal power demand pattern based on Western Power's current pattern was adopted.

In-stream (Navigation) Use

The simulations included the potential to release water for in-stream uses. Currently a discharge rate of 55 m^3/s is required to enable tour boats to travel up from Lake Kununurra to the Ord River Dam. If other releases from Lake Argyle did not exceed 55 m^3/s then additional releases have been made to ensure that this minimum flow rate was maintained. No specific in-stream releases were included downstream of Lake Kununurra.

7.3.2 Simulation results

The long term average releases from Lake Argyle for the current situation are summarised in Figure 5. The variations in Lake Argyle's level, overflow, water released for hydro-power demand and the downstream irrigation diversion is shown in Figure 6.

The figures show that the current water demand is dominated by releases for Hydro power generation. While the long term average release is 1940GL/a (Figure 5) the common release is about 1800 GL/a when the reservoir is close to the full supply level. Releases increase as the reservoir level (pressure head) reduces through a dry period (Figure 6). This occurs until restrictions on power generation are introduced, at which time water releases reduce significantly (mid 1930s in Figure 6).

Figure 6 also shows that the 300 GL/a demand can be reliability supplied in 98% of months. Similarly to the hydropower demand irrigation demands would have had to be restricted during the very dry sequence of years in the 1930s.

Figure 5 shows that of the 300 GL/a irrigation demand from Lake Kununurra, around 235 GL will come from Hydro-power releases, and 60 GL will come from overflow. An average of only 5 GL will come from direct releases. These will only occur when there is no overflow and Lake Argyle levels are such that power production is restricted to the allowable irrigation releases.

Of the estimated long term average release of 1940 GL/a for power generation, only 235GL will be diverted for irrigation. The remaining 1705 GL will continue to flow down the lower Ord River. About 485 GL are expected to contribute to meeting the interim Environmental Water Provisions (EWPs) while 1220 GL are expected to be released solely to meet hydro power needs (Figure 5).

[1] Includes provision for Green and Martin Swamps

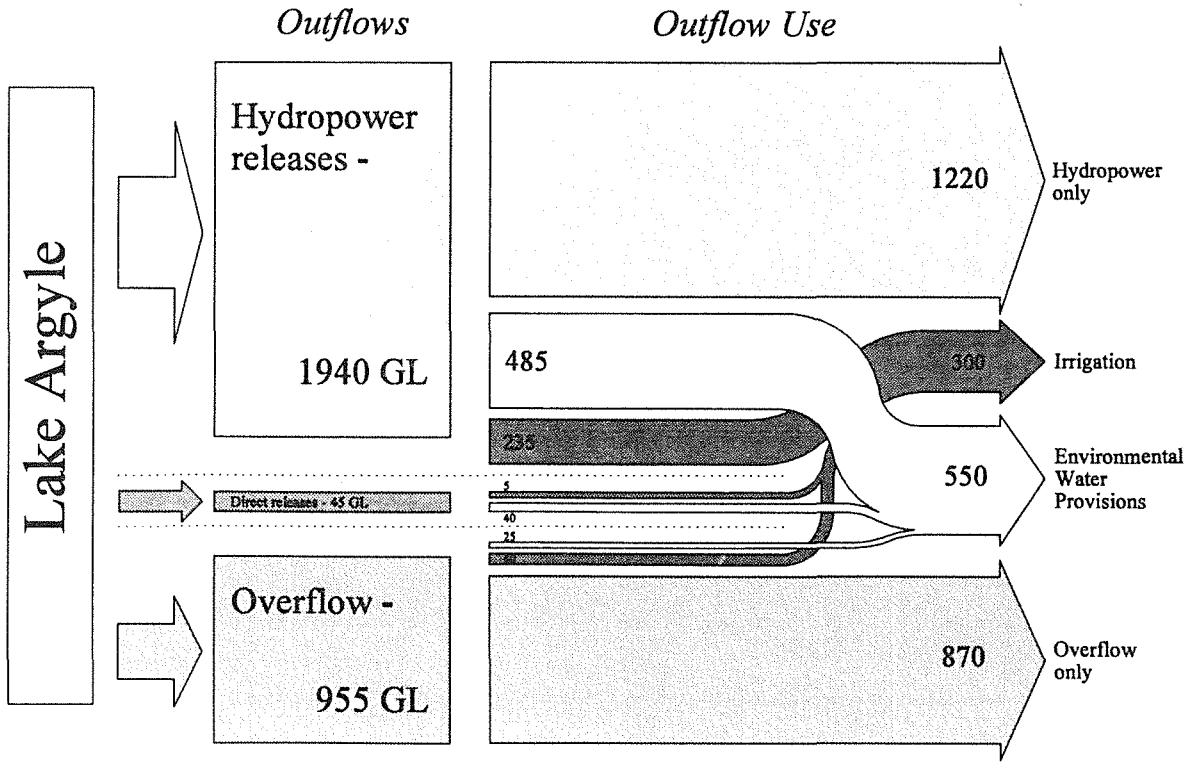


Figure 5. Long term average releases from Lake Argyle -Current Situation - Ord Stage 1 - 210 GWhrs/yr Power Generation

7.4 Full development of Stage 2

7.4.1 Assumptions

Irrigation Demand

A total irrigation demand of 1235 GL/a was adopted for this scenario. As indicated in Table 5, this total is composed of 300 GL/a for Stage 1, 740GL/a for the M2 area of Stage 2 and 195 GL/a for the Stage 2 areas downstream of the Diversion Dam.

These adopted demand figures reflect a water-efficient irrigation industry for the Stage 2 area, consistent with the concept of this scenario. In the new M2 area, high water delivery system efficiencies and on-farm and infield efficiencies of 80% and 90% respectively have been assumed. These are considered achievable with new distribution systems that include significant storage to balance channel demands and on-farm measures to pick up return flows and minimise drainage discharges.

Other key assumptions include:

- the whole 32000 ha of irrigable land in the M2 area was assumed to be planted to sugarcane, and
- an irrigation water demand of 16.6 ML/ha (equivalent to a sugarcane water requirement of 22.1 ML/ha, the maximum used by Kinhill (1995), and an effective rainfall of 5.5 ML/ha).

Similarly to the current situation, uncertainties in these assumptions are discussed in Section 6.1 and their implications for allocation decisions discussed in Section 9.2.

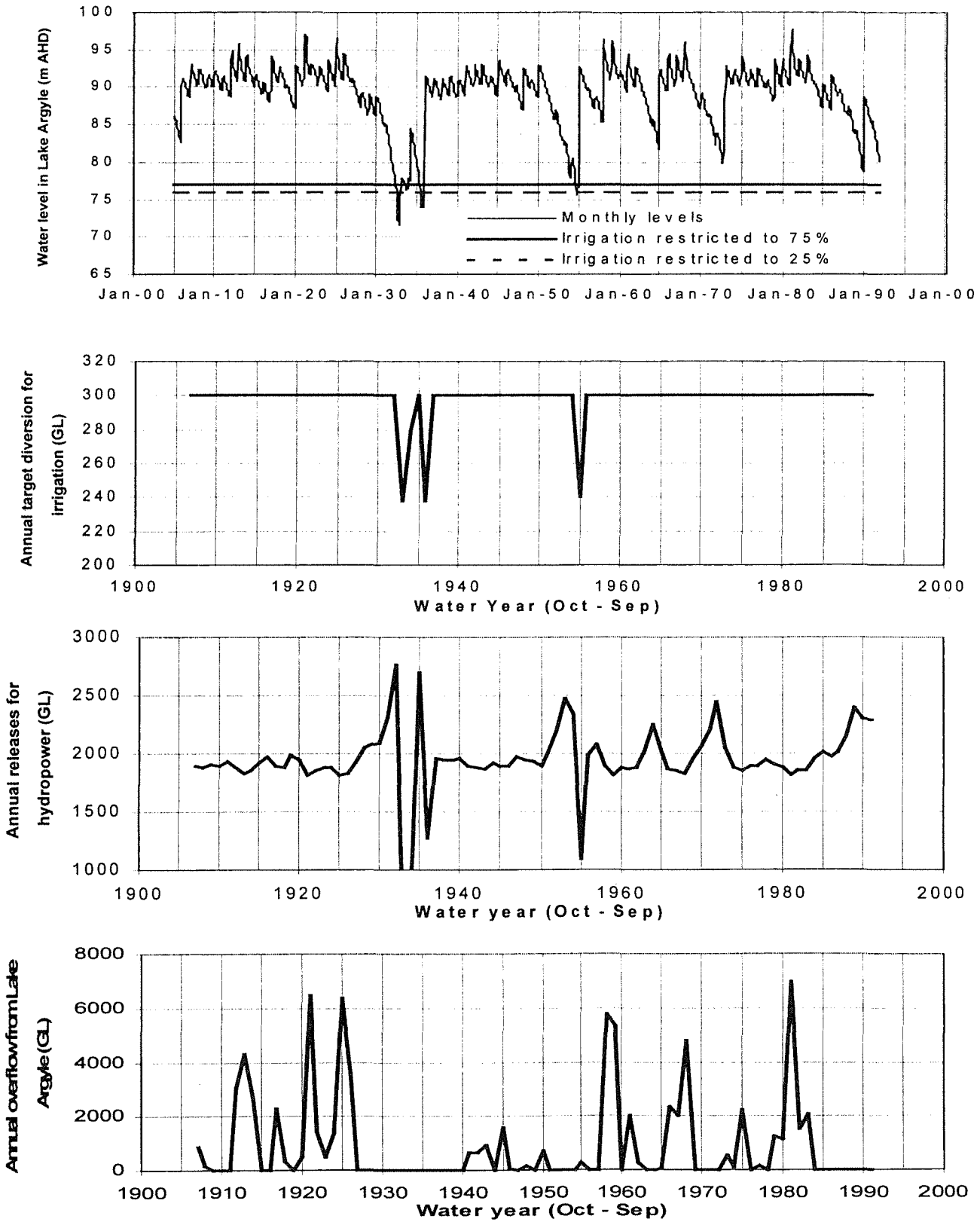


Figure 6. The Current Situation – Changes in reservoir variables over time

Hydro power demand:

An annual power demand of 110 GWhr/yr (predicted to occur soon after 2020) was adopted for this scenario. As discussed in Section 6.3 the long term hydro-power demand is expected to be governed by the growth in the requirements of the East Kimberley electricity grid. The current electricity grid seasonal demand pattern was assumed to be maintained. While additional power will be available to be generated from irrigation releases as Stage 2 develops, no additional long-term industrial or mining power demand has been included in this scenario.

It was assumed that any additional power demand over the 110Gwhr per yr would be constrained to times of irrigation release.

7.4.2 Simulation results

The long term average releases from Lake Argyle for the water efficient full development of Stage 2 are summarised in Figure 7. The variations in Lake Argyle's level, overflow, water released for hydropower demand and the downstream irrigation diversion is shown in Figure 8

Figure 7 shows that, of the 1235GL/a diverted for irrigation under this scenario, on average 210 GL/a (or 17%) originates as overflow, and about 690 GL/a (or 56%) is released through the hydro plant to meet the 110 Gwhr power demand. About 335 GL or 27% of the water diverted for irrigation is expected to be directly released. This will usually be at times when hydro demand is less than irrigation demand. Power could be generated from these releases if the power demand existed but would be secondary to the irrigation need.

Releases through the hydro power station to meet the power demand of 110 Gwhr/a average about 1000GL/a (Figure 7) in the long term. This is directly related to the lower power demand when compared to the current situation (Figure 5). The lower power demand increases the reliability of the irrigation supply relative to the current situation even though the demand is over four times higher. No restrictions occur in the target irrigation demand through the critical dry years of the mid 1930s (Figure 8). This contrasts with the current situation scenario (Figure 6).

Similar fluctuations in yearly releases for power generation occur in relation to reservoir level as for the current situation, albeit at a lower average values. Releases are commonly about 950GL/a when the reservoir is near full supply level but increase to about 1100 GL/a when the reservoir level reduces to about 85 AHD(Figure 8).

7.4.3 Additional simulations

New studies are required to determine if additional water is needed for the environment, above the minimum interim provisions set in Section 5.3 and 9.2.2. However, if no additional water proves necessary, 1500 GL/year can be diverted for irrigation purposes while generating a supply 110 GWhrs per year of electricity. The simulations indicate that the full power demand could be met 98% of months and 97% of years. This sets an upper bound for allocations of water for irrigation purposes, if a reliable a power demand of 110 GWhrs per year is to be achieved. Higher diversion rates for irrigation were not possible without accepting restrictions on power generation considered excessive for a base load power supply.

If the current power demand of 210 GWhr per year were incorporated in longer term contracts as Stage 2 became fully developed, then only a little over 1200GL/year could be reliably diverted. No additional water would be available to meet environmental water requirements. Significant efficiency gains in current irrigation practice and some constraints on the water efficient scenario described above would be required.

7.5 Concluding remarks

As noted in Chapters 5 and 6 the simulations include many assumptions and uncertainties. They are discussed further in Section 9.3, where the uncertainties have been considered in the determination of the interim allocation strategy of this plan.

However, before discussing the proposed allocation strategy, other legal considerations, policies and Commission strategies are discussed in Chapter 8.

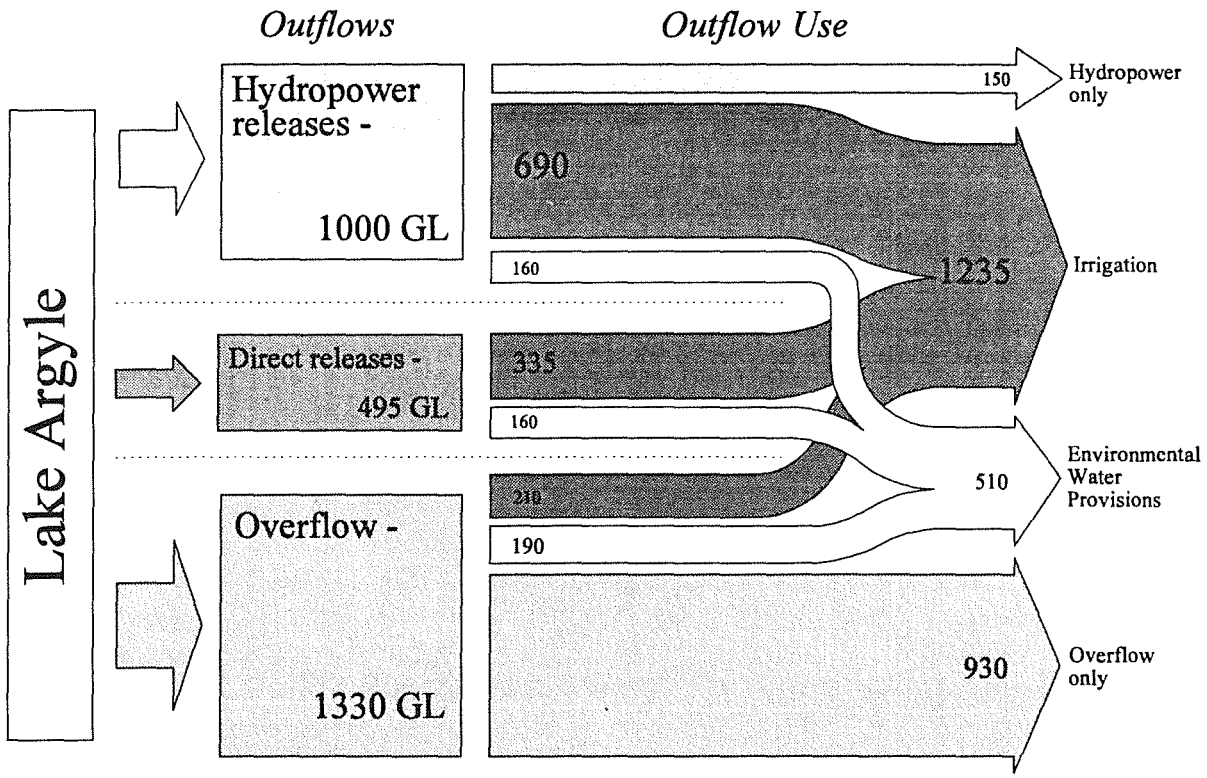


Figure 7. Long term average releases from Lake Argyle -Full Development of Stage 1 and 2 - 110 GWhrs/yr Power Generation

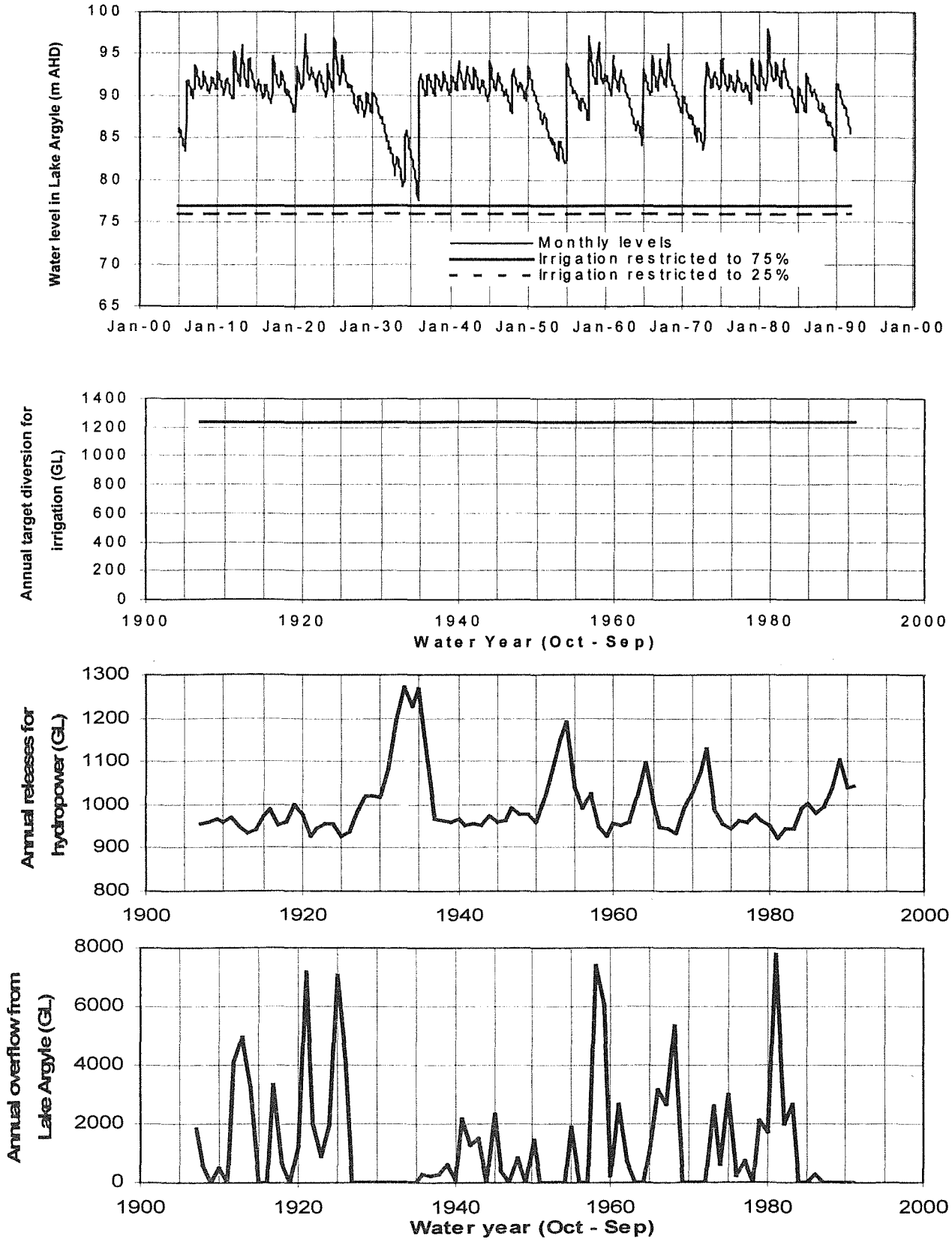


Figure 8. Full Development – Changes in Lake Argyle and irrigation supply over time

8. Legislation, policies and strategies affecting water allocation decisions

8.1 Water reform under the Council of Australian Governments (COAG)

The Council of Australian Governments (COAG) agreed in February 1994 that action was needed to stop degradation of natural resources and to minimise unsustainable use of water resources. It was agreed to implement a strategic framework of reforms to achieve an efficient and sustainable water industry. The package of reforms includes arrangements for water entitlements and trading, environmental requirements, institutional reform, public consultation and education, water pricing, and research. A four to seven year implementation period was set.

With the other States, Western Australia has agreed to implement reforms including:

- comprehensive systems of water allocations or entitlements, backed by separation of water property rights from land title, and clear specification of entitlements in terms of ownership, volume, reliability and trade-ability;
- formal determination of water allocations or entitlements, including allocations for the environment as a legitimate user of water; and
- trading, including cross-border sales, of water allocations or entitlements, within the social, physical and ecological constraints of catchments.

A set of principles was prepared by ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand) in order to establish a strategic framework for the implementation of property rights in water. These may be adapted to meet Western Australia's specific requirements. The ARMCANZ principles are:

Principle 1:
That all consumptive and non-consumptive water entitlements be allocated and managed in accordance with comprehensive planning systems and based on full basin-wide hydrologic assessment of the resource.

Principle 2:
That water entitlements and institutional arrangements be structured so as not to impede the effective operation of water markets and such that, as far as practicable, trading options associated with property rights in water reside with the individual end users of water.

Principle 3:
That water entitlements be clearly specified in terms of:

- rights and conditions of ownership tenure;
- share of natural resource being allocated (including probability of occurrence);
- details of agreed standards of any commercial services to be delivered;
- constraints to and rules on transferability; and
- constraints to resource use and access.

In regard to water allocations it was agreed:

- that States are to give priority to formally determining allocations or entitlements to water, including allocations for the environment;
- that environmental requirements are to be determined on the best scientific information available and will have regard to the inter temporal and interspatial needs required to maintain the health and viability of river systems;
- that where significant future irrigation activity or dam construction is contemplated, that in addition to economic evaluations, assessments will be undertaken to ensure that the environmental requirements of river systems can be adequately met.

The Water and Rivers Commission is progressing recommendations for reforms to Western Australia's legislative and administrative framework in accordance with the COAG agreement. Changes to the current law

to meet the COAG requirements have been subject to extensive public debate over the last 12 months. A guide to the proposed legislation is available from the Water and Rivers Commission.

The interim environmental water provisions discussed in Chapter 5 and stated in Section 9.2.2 meet the environmental elements of the reform program.

In relation to the water entitlement elements of the reform, the Commission's intent for irrigation water allocations is that they are to ultimately be held by water users in an appropriate form of property right, that may be traded in a properly managed and regulated market, at the discretion of the allocation holder. This trading is to operate within a system that retains the Crown's ability to ensure the resource is managed sustainably for the overall State benefit (Ventriss 1996).

For irrigators using water from irrigation distribution systems such as the M1 and M2 channel networks, a two tiered property right system is proposed. As discussed in Section 1.3.4, the service provider (the body distributing the water to irrigators in each service provision area) will hold a take and use licence for their area from the Commission. This will include allowances for distribution losses. Individual irrigators will have their right to water (property right) defined through contractual relationships will the service provider.

This arrangement exists in the formerly public owned irrigation districts of Waroona, Harvey and Collie. Individual irrigators now hold shares in the distribution agency (the South West Irrigation Co-operative). Each share is associated with a water entitlement and irrigators can trade water entitlements between themselves by trading their shares. The share total cannot exceed the distribution agency's licence to use water from the Commission.

The proposed reforms of the Rights to Water and Irrigation Act will enable the trade in water licences issued by the Commission. However the implementation of trading in any area will be on a needs basis and will only occur when water use reaches the sustainable divertible limit. Market rules will be developed with stakeholders and affected communities and included in a publicly reviewed water allocation plan approved by the Minister.

8.2 Rights in Water and Irrigation Act

This Act currently provides the legislative basis for the Water and Rivers Commission to licence the diversion and use of water from any water course proclaimed under Part III of the Act. The Ord River and its tributaries were proclaimed under Part III in February 1960.

Licences under this Act provide users with a formalised right of access to water, while providing a mechanism for the Commission to prevent over-use or indiscriminate use of the water resource.

The definition of a water course in the Act clearly allows the licensing of diversion or use of water from Lakes Argyle and Kununurra and from the Ord River itself; it does not include the irrigation channels. Therefore the Water and Rivers Commission can license the taking of water at the point that it is diverted from the water course, but not the individual end users of the water within the irrigation district where they are taking water from the channels.

This Act currently contains no provisions for transferability of licences. Regulations under the Act do allow for a person who becomes an occupier of a property in respect of which a licence was already in force to be issued with a licence in the new occupier's name as long as licence conditions continue to be met. Licences are issued in the name of the person/company applying and specify the land subject to the licence. Licences do not allow the use of water from other sources or on land other than that specified on the licence.

The Act does not specify the term of the licence but gives the Commission the discretion to do this. The Commission's current policy is to issue licences for a maximum of ten years. Licences are usually re-issued unless conditions have not been met or there has been a change in land use that requires a change to the allocation. The Act provides for changes to be made to the conditions and for an appeal process if a licence

application is refused or licence conditions are in dispute.

The Act provides for the owner or occupier of land abutting a water course to use water free of charge for the watering of stock and domestic animals. If use is only for these purposes, a licence is not normally required.

8.3 Water Supply Agreement

This Agreement was signed by Pacific Hydro Group Two Pty Ltd, Pacific Hydro Group Three Pty Ltd and Pacific Hydro Group Four Pty Ltd (these three groups are known as the Project Entity) and the Water Authority of WA in 1994. This agreement forms the basis for the release and use of water from the Ord River Dam for the generation of hydro-electric power. Under the Agreement the Project Entity is allowed to release sufficient water to enable the generation of at least 210 GWhr/yr.

The Agreement covers an initial contract period of 1994 to 2021, with an option for the Project Entity to extend the Agreement by 15 years. It defines some basic rules, including the restrictions to apply at low supply levels in Lake Argyle. These are summarised in Table 6 below.

The Water Release Rules are to be re-negotiated between the parties after the sale of an initial 1015 GW/hr to Argyle Diamond Mine. They can be renegotiated by agreement of the parties at any stage. These renegotiations will need to involve Pacific Hydro, Water and Rivers Commission and the Water Corporation. Any re-negotiation will need to consistent with allocation decisions in this plan.

8.4 The Ramsar Convention

Australia is a signatory to the Convention on Wetlands of International Importance especially as Waterfowl Habitat, commonly known as the Ramsar Convention. This establishes certain obligations in regard to wetlands generally, but particularly in regard to the planning and management of wetlands listed under the Convention. Lakes Argyle and Kununurra and the Ord River Floodplain are listed wetlands. CALM, in conjunction with Environment Australia, is currently reviewing the management and condition of these wetlands in preparation for the development of management plans for each wetland area.

Table 6. Principles governing water release rules

	Conditions in the original Water Supply Agreement
1	The Project Entity (power station operators) may release water at rates sufficient to generate at least 210 GWhr/year of electricity when the water level exceeds 78 m AHD
2	When the water level in Lake Argyle is between 76 m AHD and 78 m AHD, the Project Entity may release water at rates sufficient to generate power for the East Kimberley grid but not for Argyle Diamond Mine
3	At water levels below 76 m AHD the Project Entity will release water in accordance with the allocation process *.
4	Power may be generated from any water released from the Dam.
5	The Project Entity has the right to vary the water release rates in order to follow daily variations in electricity load. The Diversion Dam will be required to regulate variations in the water release rates to ensure conformity with irrigation and other uses.

* The allocation process refers to the decision making on water licensing within the Water Authority at the time. This is now the responsibility of the Water and Rivers Commission.

9. Surface Water Allocations

9.1 Principles

The general principle underlying the Commission's allocation plans is that water must be allocated on a sustainable and efficient basis to enable sustainable development and the maintenance of environmental values. There will be no over-allocation of water resources.

Specific principles underlying the interim allocation plan for the Ord River are:

- The Ord River water resource will be managed in a way that enables sustainable development while maintaining defined environmental values.

- In recognition of the inadequate scientific basis currently available for determining environmental flow requirements, interim conservative allocations to consumptive uses will be made. That is, the precautionary principle will be applied.

- The order of priority for supply will be:

    1. environmental requirements,
    2. irrigation,
    3. hydro power generation for the East Kimberley electricity grid, and
    4. hydro power generation for the Argyle Diamond Mine.

    Water for supply to the Lake Argyle Village and for direct use by Argyle Diamond Mine is of such a small volume in comparison with irrigation, hydro power and environmental requirements that it does not need to be considered in the priority listing. Water for these purposes will therefore have a 100% reliability of supply.

- Within the constraint of provision of water for environmental purposes, water for irrigation should be supplied with a high level of reliability.

- Other beneficial uses of water are to provide for water-related tourism and recreation needs, and for continued use for pastoral purposes. While recognised as important in-stream uses of the water resource, their water needs are not be given a specific allocation in this interim allocation plan. For the life of this plan their needs can generally be provided for through other licensed releases or the contractual releases for hydro-electric power generation. Operational arrangements for meeting these in-stream needs should be prepared by the headworks operator as part of their headworks operating strategy. For example, arrangements for notifying affected parties when maintenance of the hydropower station is planned should be included.

- Water releases from the reservoirs will generally serve more than one purpose; eg water released from Lake Argyle for irrigation purposes can be used to generate power and may provide for some in-stream needs, including those for navigation, below the Ord River Dam.

9.2 Proposed allocation strategy

9.2.1 Assumptions and constraints

Definition of allocations is required to allow hydro power generation to continue and the expansion of the irrigation area to proceed without unacceptable impacts on the environment. As has been detailed in earlier sections, there are a number of areas where inadequate information is available or there is some uncertainty about future demands. The proposed allocation strategy recognises these inadequacies and uncertainties by using the precautionary principle and allocating water conservatively to consumptive purposes. This will allow for some adjustment of allocations in future in response to improved monitoring and investigations of environmental water requirements, crop water demands and efficiencies of distribution and use of irrigation supplies. Chapter 10 discusses the investigations that are necessary and

Chapter 12 describes how and when the allocation plan will be reviewed.

9.2.2 Interim Environmental Water Provisions

As discussed in Chapter 5 an interim environmental water provision was adopted as the 20th percentile of the naturally occurring monthly flows downstream of the Dunham River confluence. This flow volume is to be maintained in the lower Ord River in all but extreme drought conditions. In the 2% of months when severe drought conditions apply, environmental water provision flows would be reduced in proportion to irrigation restrictions.

Until the investigations described in Chapter 10 are undertaken to determine ecological values and their water requirements, the Water and Rivers Commission will require that the interim Environmental Water Provisions are met by the operator of the water storage and supply system.

The EWPs do not represent an allocation as such, because most of the water provision can be met through releases for other purposes. With further definition of environmental values and water requirements, it is expected that the EWPs may be set as environmental criteria relating to water levels and/or flow rates at designated points in the river system, and that these would incorporate both seasonal and climatic variability.

Until the bases for determination of Ecological Water Requirements, and the consequent environmental criteria, are defined it is not possible to estimate whether this will require more or less water to be released for environmental purposes. Therefore, it is essential that this interim allocation strategy retain sufficient flexibility to accommodate revised environmental water provisions.

9.2.3 Allocations to consumptive uses

Irrigation

Simulations indicated that an upper limit of about 1500 GL/year (with a reliability of 98% of months or 95% of years) could be diverted for irrigation when:

- sufficient water is released to meet the interim environmental water provisions
- 110 GWhrs/year of hydro-electricity is generated (with a reliability of 99% of months or 97% of years); and
- no specific releases are made for in-stream uses.

To allocate this upper limit of 1500 GL/year to irrigation at this time would require that the interim EWPs are accepted as an upper limit for the water available to meet the ecological needs of the lower Ord River. In addition it would mean that no additional provision is made to meet social needs for water (such as cultural, recreational and tourism needs) and would effectively allocate all of the available water resource. The Water and Rivers Commission view is that this should not occur unless there has been an objective and open assessment of the acceptable level of environmental values to be maintained. The Commission believes that this can best be accommodated by:

1. allocating adequate water to allow planning for Stage 2 of the irrigation project to proceed, whilst
2. maintaining flexibility in the allocation strategy to allow additional allocations to irrigation, other future demands, and/or environmental purposes based on demonstrated demand and evaluation of the social, environmental and economic implications.

To achieve this, there must be commitment to the investigations outlined in Chapter 10 to determine what environmental values need to be maintained and their flow requirements, and to further investigations of the crop water demand and on-farm and water delivery efficiencies.

Earlier sections of the plan described how the estimates of potential total demand for irrigation purposes vary according to the assumptions made about the types of crops irrigated, the crop water demand, and the

efficiency of delivery and on-farm use. For the purpose of this interim plan, irrigation allocations have been adopted to meet water demands based on

- current irrigation practices in the Stage 1 area,
- the development of a best practice, water efficient irrigation industry for Stage 2 areas, and
- assuming sugarcane will be the dominant irrigated crop of the region.

The total interim allocation to irrigation purposes has been set as 1235 GL/year. Simulation runs have indicated that this can be supplied with 98% (months) or 95% (years) reliability.

Allocation of a total of 1235 GL/year to irrigation at this time allows planning for Stage 2 to continue with a reasonable degree of certainty while the sugarcane crop water demand is refined through field investigations.

Within the total irrigation allocation, an allocation of 300 GL/year to the Stage 1 Irrigation Area is proposed. This is line with the assumptions made in the Current Situation Scenario of Chapter 7. It provides a generous allowance for water distribution losses, and while not the maximum possible water demand (based on maximum crop water demands for sugarcane), is more than sufficient for continued economic irrigated agricultural production from the area. There is significant scope to improve the distribution efficiency and make more water available on-farm before additional allocation would be considered. A crop water demand for Sugarcane of 26 GL/ha can be met within the 300 GL/yr allocation if on-farm and distribution efficiencies of 80% are achieved.

An allocation of 740 GL is proposed for irrigated agricultural production in the M2 area of the Stage 2 development. Implicit in this allocation is the expectation of a high level of efficiency in distribution and on-farm watering practice.

In line with the principle of promoting sustainable development, the Commission wishes to ensure groundwater accessions under irrigation are minimised and that long term land and water degradation problems are avoided. This is particularly important in those parts of the M2 area, which have already been identified as requiring a high level of management to minimise groundwater accessions. Given the problems with past irrigation systems, it is to be expected that a new irrigation development, proposed at the end of the 20th century, should be required to implement "best practice" design and operational procedures.

An allocation of 195 GL/yr is proposed for the lower Ord River developments. This allocation, being proposed primarily for horticultural development and expected to be mainly supplied through a piped reticulation system, also assumes a high level distribution and application efficiency.

The Commission recognises the difference between the allocations per unit area to the existing and new distribution areas. It is essential that current water use efficiency be significantly improved in the Stage 1 area. This is necessary to reduce the risk of contaminants in the drainage discharge from the Stage 1 area affecting water resource and environmental values of the lower Ord River. It will become increasingly important as the amount of water diverted from Lake Kununurra for Stage 2 increases (see Section 9.4). The Commission will require operators in the Stage 1 area to improve distribution and on-farm efficiencies over time (see Section 11.4). Some re-assessment of allocations can be expected in updates of this plan (see Section 9.5). In the longer term, some re-allocation may occur through trades in water licences.

The estimates of the irrigation demand are the annual average requirements that would be delivered in years of average rainfall and normal reservoir supply levels. In reality, the amount of water required to be taken each year will vary according to the amount and the effectiveness of the rainfall received. The licensing will allow for a defined variation in the amount of water to be taken each year based on rainfall and storage conditions.

The licensing details will also be influenced by the organisational and management responsibilities for water distribution in each of the different distribution areas (ie. the Stage 1 area, the M2 area of Stage 2 and the different downstream riverside developments). The proposed licensing arrangements are discussed in Sections 10.2 and 10.4.2. The issue of defining the right of individual irrigators to water within each distribution area is also discussed.

Mining purposes

The allocation of water for use for mining purposes is 12 GL/year. The licensing arrangements are covered in Sections 10.2 and 10.4.3.

Drinking water supply

The allocation of water for supply to the Lake Argyle Tourist Village is 0.03 GL/year.

9.2.4 Non-consumptive uses (other than environmental)

Significant flow will remain in the river below the Diversion Dam. Contributions to this flow will come from hydro power releases that are not diverted for use in the M1 or M2 irrigation areas, EWP releases, Dunham River and other local inflow, drainage return flow from Stage 1 and releases for the lower Ord irrigation developments.

For the duration of this plan downstream flows will be dominated by water released for hydropower generation. Consequently many of the in-stream demands such as navigation will be able to be met without a formal allocation of water to that purpose. The operating strategy to be prepared by the headworks operator (see Section 10.2.1) will establish the way in which water is released to take account of the different demands, their seasonal and daily variations, and the need for efficient use of the resource.

Hydro power generation

As discussed in Section 7.3, under the Water Supply Agreement water released for any purpose may be used for the generation of power. The Agreement also provides for the release of water specifically for power generation as required to meet contracts for supply. The actual volumes to be released specifically for the generation of power will vary according to the volumes and seasonal pattern of releases for other purposes.

There is sufficient water to meet the irrigation allocation for Stage 1 and the current power generation needs of 210 GWhrs/yr. This can be maintained during the generation of the first 1015 GWhrs of electricity under the Water Supply Agreement expected to be reached in the year 2003. As indicated in Figure 5, a long-term average release of 1940 GL/yr is required to meet the current hydro-power demand. About 1705 GL/year (or 88%) would need to be released in excess of that needed to meet the Stage 1 irrigation demand.

There is sufficient water to meet the 1235 GL/yr irrigation allocation when Stage 2 is fully developed, so long as the power demand declines to about 110 GWhrs/yr. This represents sufficient power to meet the East Kimberley electricity grid demand until beyond the year 2020. A long-term average release of about 1000 GL/year is required to generate this power demand (Figure 7). Only 31% or 310 GL/year would be in excess of that released for irrigation.

Consequently the Commission will ensure that sufficient water is available for the continued generation of 110 GWhrs/yr of hydro-electricity, after the first 1015 GWhrs of electricity has been generated.

Additional power (above the 110 GWhrs/yr long-term regional grid demand) can be generated when Stage 2 is fully developed. However long term contracts that require the generation of more than 110 GWhrs/yr would only be considered if they were conditional on generating the additional power at times of irrigation releases.

Competition between hydro-power releases and irrigation releases may occur around the year 2005 if Stage 2 demand grows rapidly, as currently planned, and the Argyle Diamond mine power requirements extend beyond this time.

The Commission sees a need to review the water release rules associated the Water Supply Agreement now, so that contractual arrangements related to power generation can proceed without risk of over-allocating the water resource. The Commission will initiate this review as part of updating the licensing arrangements as a result of this plan.

The licensing arrangements for provision of water for hydropower generation are covered in Section 11.4.1.

In-stream uses downstream of the Ord River Dam

The main in-stream requirement for water release at present is to allow safe navigation below the dam to Carlton Gorge. Based on the maintenance of a minimum flow rate of $55m^3$ per second, this would require approximately 1740 GL per year. Under both planning scenarios this in stream demand can be met by other releases in all but restriction periods.

The Water and Rivers Commission considers that the release of water to meet in-stream requirements associated with tourism and recreation is a valid use of the resource. However, it is considered to be of lower priority for supply (during restriction periods) than the provision for the environment and irrigation, and the simulations indicated that it could be supplied with a similar level of reliability as town hydro power (see Ruprecht and Rodgers, 1999).

Current licensing arrangements do not accommodate licensing specifically for this use. The release of water for this purpose will remain a matter for the Water Corporation to negotiate with other interested parties, and to include in their operating strategy. Section 10.4.1 describes how in-stream uses will be recognised in the licensing system.

In-stream uses downstream of the Kununurra Diversion Dam

The release of water to meet other in-stream demands (water for navigation purposes and maintenance of fresh water, particularly during high tides, at the stock watering points on Carlton Hill Station) downstream of the Diversion Dam have not been given a specific allocation. During the lifetime of this plan the Commission considers that a reasonable level of supply for these purposes can be met through releases for other purposes, and that the specific operational and management requirements can be determined through negotiations between the Water Corporation and down-stream users. The Water Corporation's operating strategy will include consideration of the ability of releases for the priority purposes to meet these needs. The high hydropower demand relative to the current irrigation demand makes additional releases to meet in-stream needs unnecessary at this time.

9.3 Effects of the allocation strategy

9.3.1 The flow regime in the Lower Ord

The construction of the Kununurra Diversion and the Ord River Dams occurred before environmental impact assessment procedures were fully established in Western Australia. Consequently the environmental impact of storing the Ord River's wet season flow in Lake Argyle, and its subsequent diversion from the lower reaches of the Ord River at Lake Kununurra have never been explicitly addressed.

The direct environmental effects of the "M2" proposal are to be assessed by the EPA via a review of an Environmental Review and Management Program prepared by the proponents. There will be a separate assessment of the downstream river developments.

Management approaches to mitigate any adverse impacts of the land use change to irrigated agriculture are an integral part of these environmental reviews. Issues such as whether long term stable water and salt balances can be maintained in each area and the impact of any drainage return flow to the downstream environment will also be addressed.

The direct effects of the reservoirs and the allocation strategy on the flow regime of the Ord River below the Kununurra Diversion Dam have been considered here.

The flow regime for the following three cases were estimated:

- the natural flow regime (prior to construction of the reservoirs);
- the likely flow regime over the next few years (full Stage 1 development with the current high hydro-power demand and interim EWP releases when necessary); and
- full Stage 1 and Stage 2 development with a hydro-power demand serving the towns in the East Kimberley region and interim EWP releases when necessary.

Figure 9 shows the lower Ord River reach from Lake Kununurra to its estuarine section at "The Rocks" as it enters Cambridge Gulf. Key features of the reach are shown together with indicative abstraction points for

the Mantinea Flats and Carlton Plain lower Ord River developments. The locations and areas to be served by each abstraction point have been based on preliminary studies (Department of Resources Development, 1995 and QDNR, 1998) of the Lower Ord developments. They are sufficiently accurate for illustrative purposes.

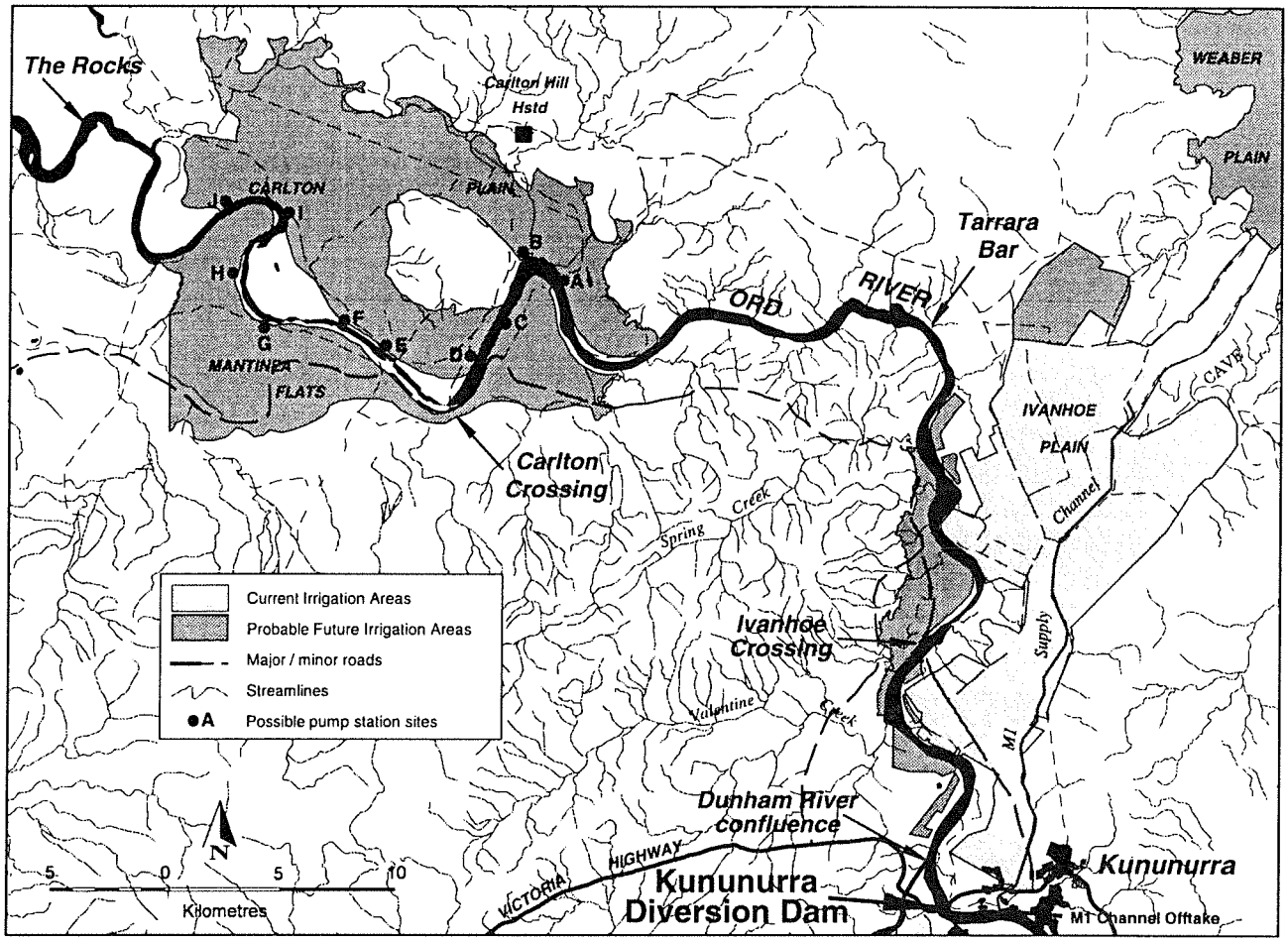


Figure 9. The Lower Ord River downstream of Lake Kununurra

Annual Flow Characteristics

Figure 10 shows the annual flow statistics for the three cases immediately downstream of the Dunham river confluence.

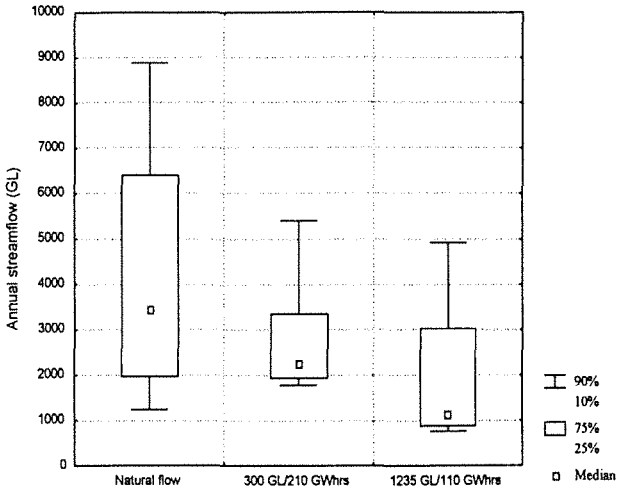


Figure 10. Annual Flow Statistics of the Ord River at the Dunham River Confluence

The reduction in the annual flow volume is clearly apparent from the pre-dam situation to the case of full irrigation development. Prior to construction of the dams the annual median flow was 3840 GL/year. It is now 2335 GL/year and will reduce to 1190 GL/year at full development.

The annual variability has also reduced. The 10^{th}, 25^{th} and median annual flows are very similar for the current situation, reflecting low variability. The full development case is very similar. However much greater variation occurred in the natural flow case. In below average years no spillage occurs from Lake Argyle and flow in the lower Ord River is dominated by regulated flows from the Ord River Dam that are not diverted from Lake Kununurra. Most of the annual variability in below average years is generated from Dunham River inflows.

Annual streamflow volumes in the wet years have been substantially altered by the construction of the Ord River Dam. In the case of full development the 90^{th} percentile flow year will be less than 5000 GL/year. This compares with almost 9000 GL/year for the natural or pre-dam situation. The major flood waters of each wet are now either captured in Lake Argyle, lost as lake evaporation, slowly discharged through the spillway over the dry season or released through the hydro-power station.

Irrespective of the proposed allocation strategy the lower Ord flow regime will never carry the large floods which occurred prior to the construction of the Ord River Dam. Floods generated in the upper catchment are substantially reduced by the large flood storage of Lake Argyle, in turn a result of the deep narrow spillway of the Main Dam. The smaller peak flows in the lower Ord River are now generated when floods from the unregulated Dunham River occur at times of high spillway flows from Lake Argyle.

Monthly Flow Characteristics

Figures 11 and 12 show the average monthly flow volumes and water levels at Carlton Crossing respectively. Like the annual statistics, the average monthly flows during the wet season are reduced for both full development and the current situation relative to the natural flow regime.

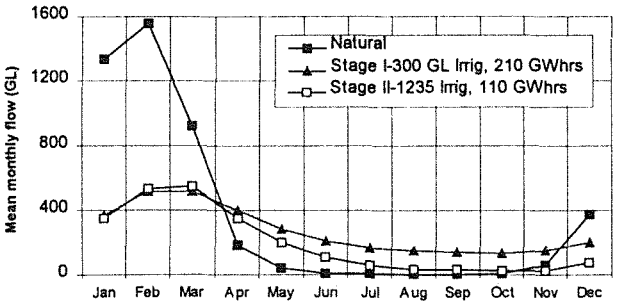


Figure 11. Average Monthly Flow Volumes at Carlton Crossing

The new EWPs will ensure that at least the 20 percentile of natural flows are maintained in the lower Ord River reach each month. Additional releases to meet EWPs in the next few years are only likely to be needed in the wet season when storage is low and when power demand is low. Simulations indicate that on average only about 40 GL per year is required (see Figure 5).

In contrast the dry season flows are much higher than occurred naturally. These regulated dry season flows are dominated by water released for hydropower generation that is not diverted from Lake Kununurra. They are much higher than occurred naturally while the Hydro-power demand is 210 GWhrs per year (current situation).

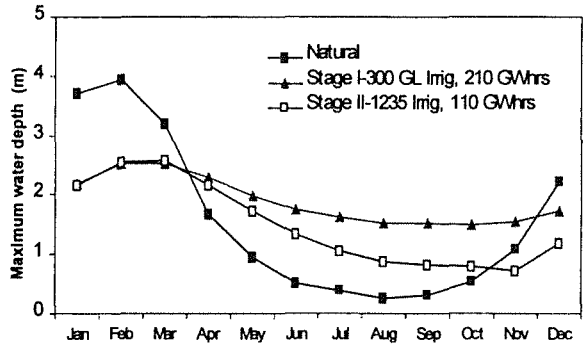


Figure 12. Mean monthly depth of flow at Carlton Crossing

In the full development scenario, flows during the dry season approach the natural conditions as more water is diverted from the river and as hydropower demand reduces to 110 GWhrs per year. However the flow at Carlton Crossing remains greater than the natural regime. These flows are maintained by irrigation return flows from Stage 1 and irrigation releases from Lake Kununurra for diversion downstream (as discussed below).

This is shown more clearly in Figure 12 where the average maximum depth at Carlton Crossing in August reduces from 1.5 metres under current conditions, to 0.88 metres under full development. Under natural conditions the average maximum depth of flow in August was only 0.25 metres. The median August natural flow was zero.

Flow changes along the lower Ord River

Figure 13 shows changes in the median annual flow along the Ord River from Lake Kununurra to Cambridge Gulf for the three scenarios. Current irrigation practices and estimates of return flows from Stage 1 have been assumed to remain unchanged so that their effect can be evaluated.

Increases in flow occur at the confluence of tributaries such as the Dunham River enter and drains that carry return flows from the Stage 1 irrigation area. As proposed during earlier investigations irrigation return flows from the Stage 2 developments have been assumed to be minimal. Decreases in flow occur at the pumping station points for the lower Ord developments.

The flow regime was estimated by simulating the release of the proposed water allocation for the lower Ord developments from Lake Kununurra and calculating the sequential abstractions downstream. For illustrative purposes the following sequence of Stage 2 developments were adopted:

- the M2 area
- the M2 area plus Mantinea Flats
- full development.

This was considered the most likely development sequence.

On an annual basis variations along the river reach are secondary to the changes between the pre-dam, current situation and full development cases. The dominant inflow comes from the Dunham River with small additions from wet season runoff and dry season drainage from the Stage 1 area. Reductions in flow result from the abstractions for the lower Ord developments.

During a typical dry season month of August, however, the relative changes along the river reach are much larger. This is shown in Figure 14 where the irrigation return flows become are over one third of the total flow 30kms downstream of Lake Kununurra and remains so for the last 60 kms of the river until it becomes estuarine at "The Rocks". This situation occurs because releases for the Hydropower demand of 110 GWhrs per year are fully diverted to Stage 1 and the M2 Area of Stage 2 upstream of the Diversion Dam.

As discussed in Section 9.4.4 below additional releases may be necessary to meet other social and environmental needs and to manage potential water quality problems.

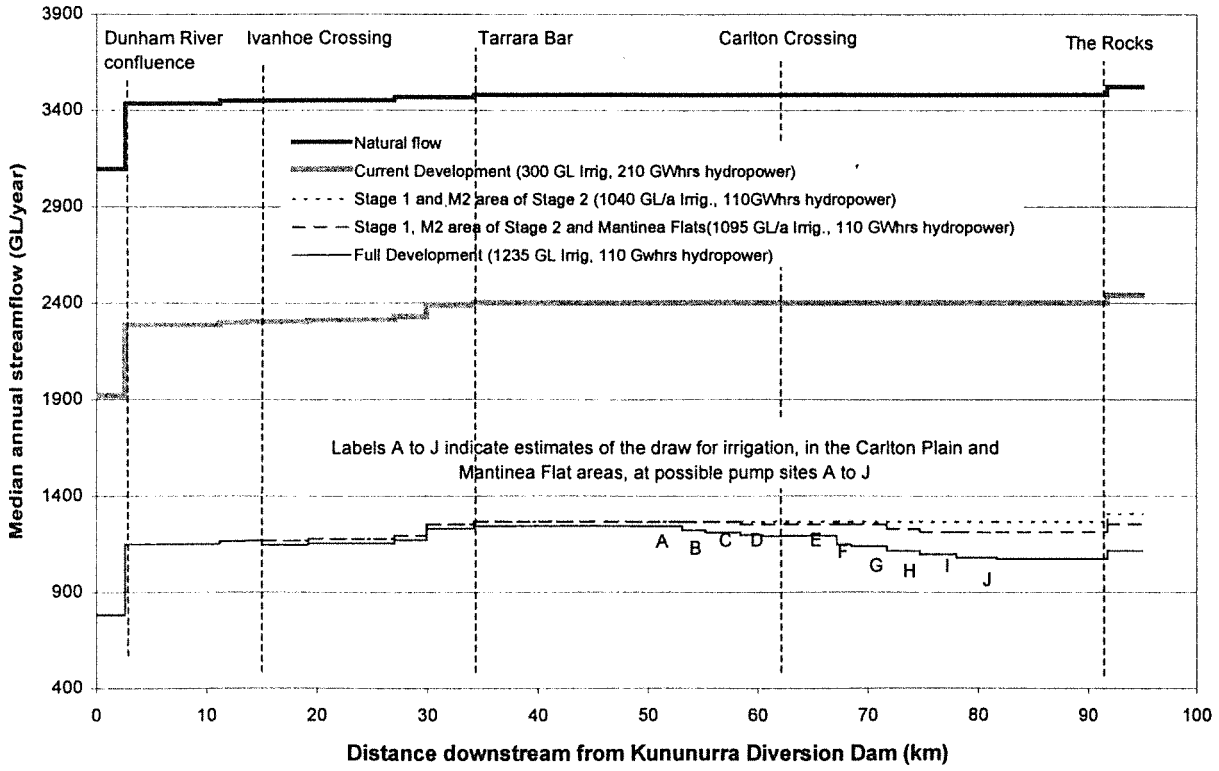


Figure 13. Changes in Median Annual Flow along the Lower Ord River

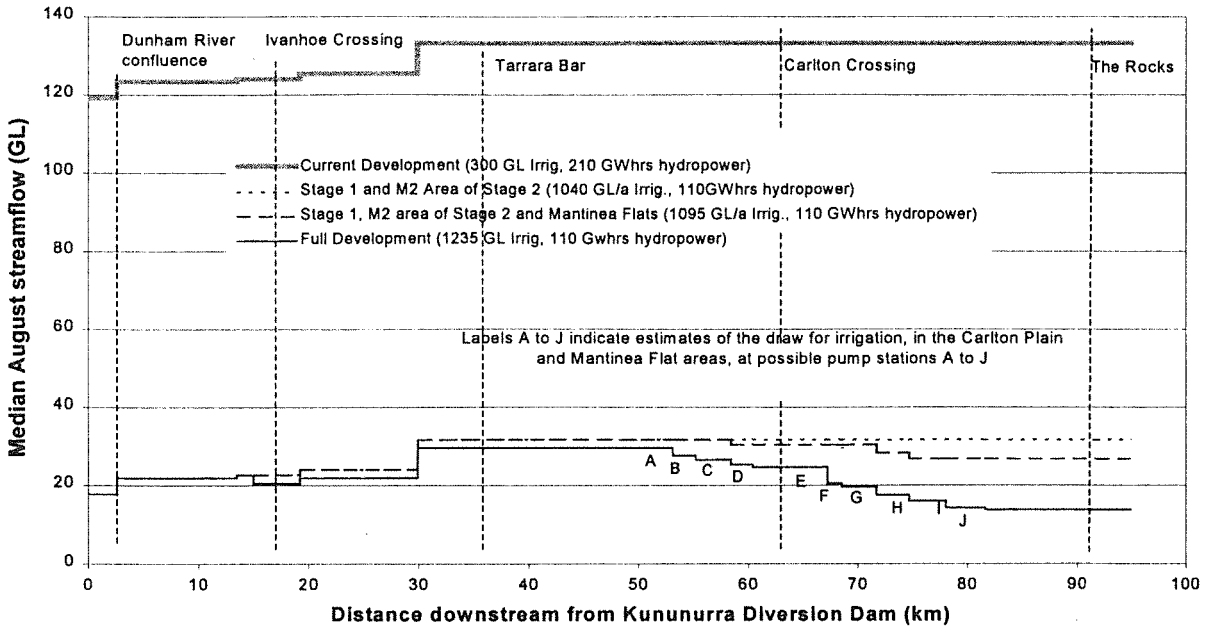


Figure 14. Changes in the median August flow along the lower Ord River

9.3.2 Preliminary Assessments of Water Quality Changes

The actual environmental impacts of these different flow regimes and their effects on current in-stream uses along the lower Ord are critically dependent on the quality and quantity of drainage water return flow from the Stage 1 area. In turn the quality and quantity of drainage water strongly interacts with the efficiency of water, fertiliser, pesticide and erosion control practices of the Stage 1 Irrigators.

The Commission is committed to working with the Ord Irrigation Co-operative to improve these practices over time. While some initial investigations on the water quality characteristics of the drainage water has been carried out, further investigations are required before the effects on the down stream environment can be reliably assessed.

Preliminary data on the nutrient concentrations of waters entering and discharging from the Stage 1 area were collected as part of the preliminary environmental studies associated with the Stage 2 development. As described in Ruprecht and Rodgers (1999) only one season's data was available. Assessments of average monthly concentrations of Total Phosphorus (total P) were made based on the relatively stable concentrations during the dry season and the tendency for higher concentrations to occur during periods of high flow following rain during the wet season months. While the estimation of average monthly concentrations involved some extrapolation, the figures enable indicative estimates of the effects of the changed flow regimes on nutrient concentrations to be made. The results are shown in Figure 15.

Given the current conditions (diversion of 300 GL for irrigation purposes) the graph shows little change in Total P concentrations throughout the year. This is a result of the relatively high dry season flows in the lower Ord River from hydro-power releases (as evident in Figure 7) which dilute the effect of the drainage discharge from the Stage 1 area. As irrigation demand grows through development of Stage 2, and without commensurate reductions in the agricultural waste discharge including nutrient and sediment discharge from Stage 1, significant increases in the pesticide and nutrient levels can be expected along the lower Ord River.

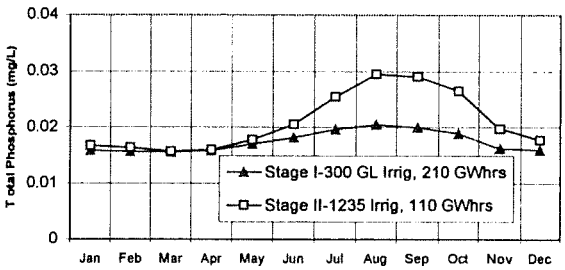


Figure 15. Average monthly Total Phosphorus (TP) concentrations at Carlton Crossing

This is clearly shown in Figure 15 where the increase in estimated concentration of Total Phosphorus from the current situation to the full development case is apparent during the dry season period.

Already fish kills have been reported down stream of the drainage return flows, particularly in the side tributaries such as the Dunham River where dilution flows of the main Ord River have not been present. These deaths were related to pesticide toxicity. Events like this clearly emphasise the direct relationship between water and land activities in the irrigation districts and the ecology and health of the Ord River and its tributaries. Efforts are continuing to minimise the risk of such events occurring in the future. The avoidance of any future agricultural waste discharge will be extremely important when there is less water available for dilution as Stage 2 is implemented.

As full development will not occur during the lifetime of this plan, the way of best managing the flows in the lower Ord will be developed as part of the review of this interim plan. Options for management are discussed in Section 9.4 below.

9.3.3 Possible Environmental and Social Impacts

The changes in flow regime described in the preceding sections have had an impact on the ecology of the riverine system and further changes can be expected as the development of Stage 2 proceeds. Few of the changes to date have been well documented, but changes in the channel morphology, distribution of

plant communities and habitats for some fish species and waterbirds have been observed.

The reduction in seasonal and annual variability of flows is likely to have had the most impact, and there is limited ability to reinstate the large flood flows are likely to have played a significant role in supporting wetland ecosystems in the floodplain. The full development scenario may have further impacts through the reduction in the frequency of the medium flood events, and additional changes to the ecology can be expected.

One of the most apparent changes to the riverine ecology has been the proliferation of *Typha*, a species that is favoured by constant water levels. It is expected that *Typha* may become more prolific in the lower reaches of the Ord. *Typha* and aquatic weed species are also favoured by nutrient enrichment, and the discussion in Section 9.4.2 suggests that this could become a more significant issue as the Lower Ord water levels are reduced.

As well as the environmental changes, there are significant social values that are affected by the changed flow regimes. Fishing is popular recreational use of the Lower Ord and could be affected by changes to fish reproduction and migration.

9.4 Options for managing the lower Ord River flow regime

Options exist for minimisation of the adverse impacts of the allocation strategy on the lower Ord River environment and on the quality of water in particular.

While the Commission will require improvement in water management in the Stage 1 area over time so that the causes of possible water quality problems are directly addressed, the impacts could also be mitigated by release of additional flows from Lake Argyle.

The available "unallocated" water would be re-assessed following updating of the ecologically sustainable draw given better knowledge of the ecological needs of the river. It is partly for these reasons that a cautious approach to allocation in this interim plan has been taken.

Figure 16 indicates the potential water quality effect of releasing an additional five or ten cubic metres per second of flow from the Kununurra Diversion Dam during the low flow winter months.

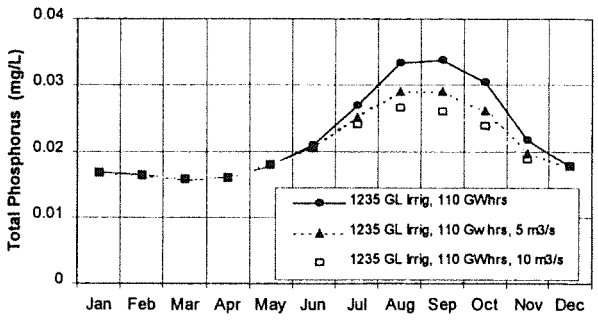


Figure 16. Effect of dilution flows on Total Phosphorus Concentrations at Carlton Crossing

Such dilution releases would imply additional allocations of approximately 70 GL and 140 GL for $5m^3$ sec and 10 m^3/sec respectively. They would contribute to other social (mainly recreational) benefits but would potentially affect other allocations and need to be fully assessed as part of the overall review of the interim plan.

The need for dilution flows will not arise in the lifetime of this interim plan. There will be sufficient time for studies into ecological water requirements to be completed before irrigation demands approach the maximum planned levels under Stage 2. In addition there will be sufficient time to complete related investigations, on aspects such as the details of development proposals for the Mantinea Flats area, and evaluation of the impacts of return drainage flows from Stage 1 to the lower Ord River. Results from all these studies will enable environmental water provisions to be determined and the need for any other mitigating flows assessed, and quantified before major problems arise. It is therefore essential that these studies be initiated without further delay. The interim allocation plan can then be revised and licences updated accordingly.

9.5 Updating the allocation strategy

It is expected that the revision of this plan will occur following the passage of legislation to implement the water reforms discussed in Section 8.1. The guide to the proposed changes to *the Rights in Water and Irrigation Act (1914)*, describes a process for preparing or updating Allocation Plans and the concept trading in water licences (Water and Rivers Commission, 1998). Under the revised legislation the Commission will be obliged to explicitly address the needs of the environment.

The general allocation planning process was summarised in Section 1.4 and will be used in updating the strategy. The following sub-sections discuss the proposed approach to updating central elements of the plan.

9.5.1 Ecological Water Requirements

In recent years there have been significant advances in identifying and describing the interactions between ecological parameters and flow regimes. This allows flow regimes for regulated systems to be developed to incorporate elements of the natural flow regime that will maintain the identified environmental values.

A study is proposed to identify the environmental values supported by the Ord River and to undertake targeted research to determine the spatial and temporal water requirements that will maintain those values. Analysis of the historical flow records will then allow the environmental risks associated with different flow regimes to be assessed.

The research will include analysis of aquatic food webs to determine the importance of flows in maintaining primary productivity; further work on channel morphology and flow distributions to determine the impacts on off-channel ecosystems; determination of vegetation requirements for regeneration and maintenance; and special habitat requirements for fish and waterbird species.

Studies will commence in the first half of 1999 and are expected to take two years to allow for seasonal requirements for surveys and sampling. At the end of that period, a determination of the Ecological Water Requirements will be possible.

9.5.2 Environmental Water Provisions

The EWRs consider only the ecological values. The next step in the process is to determine the other values supported by the flow regime, including social values such as recreational use and aesthetics, and economic values such as irrigation, power generation and aquaculture. Protection or maintenance of cultural values is also considered, as is the requirement for any special purpose flows, for example to maintain water quality. Consideration of this wider set of values allows the Environmental Water Provisions (EWPs) to be set. The general approach is outlined in Section 1.4.

The setting of EWPs is done through a public process so that those affected by the changed flow regime have the opportunity to participate in the final outcome. It is anticipated that this will commence immediately after the EWRs study, and that water efficiency studies will have been substantially completed by that time also. The modelling which has been used in the preparation of this interim allocation plan will be expanded to allow various flow requirements to be iterated and the consequences of each to be described.

In the unlikely event that additional water in excess of that "unallocated" was necessary to meet special EWP needs and dilution requirements, then a reduction in other consumptive use allocations (either by a market or an equitable reduction with compensation where appropriate) would be necessary.

9.5.3 Consumptive Use Allocations

The allocation for irrigation has been set based on full development of Stage 2 with an expected water demand based on the maximum likely area for sugar production and estimates of sugarcane water requirements per unit area made in 1995. As discussed in Chapter 6 higher crop water requirements are possible for maximum sugar production per unit area. It does not follow, however, that allocations should be made solely on the basis of maximising sugarcane production. Other economic, environmental and social aspects need to be assessed.

In considering how the irrigation allocations may be reviewed when updating this plan the following approach will be taken.

Higher irrigation allocations would be considered provided that:

- higher in-field crop water demands are, in fact, proved to be necessary for the economic production of sugarcane,
- such high water application rates can be shown to be applied without excessive groundwater accessions
- additional water is available after environmental water requirements have been determined and the interim environmental water provisions updated.

For the Stage 1 Area, up to an additional 55 GL/yr could be allocated providing the Ord Irrigation Co-operative can also demonstrate that

- improved distribution efficiencies have been achieved and accounted for,
- over 60% of the area has been planted to sugarcane, and
- programs are in place and progress has been made on reducing groundwater accessions and drainage discharges.

For the Stage 2 areas additional water may be allocated if, in addition to the conditions above, controls on water management practices, targeted to the different groundwater accession management zones, were approved and enforceable.

The Commission's intent is that any necessary changes in allocations would first be met by 'unallocated' water. If the 'unallocated' water is insufficient and changes can only be effected through reductions in existing allocations, those allocations will be reduced in a fair and equitable way across the total resource available for sustainable use. This would normally be a proportional reduction but may be different in special circumstances where some existing users have contributed disproportionately to the need for the re-allocation.

With the passage of the legislative reforms, such adjustments could be achieved through trading in water licences. However the decision to introduce trading and the rules of trade would be developed with the affected community and included in a draft of the updated allocation plan. It would only proceed after extensive public consultation and approval by the Minister.

10. Investigations and Monitoring

Refinement of this interim allocation plan is dependent on a number of investigations being undertaken. It is expected that the beneficiaries of the water supply, including the Water Corporation and irrigators, will contribute to the cost of monitoring and investigations through the licensing and/or water pricing systems.

10.1 Environmental investigations

The determination of environmental water requirements is urgently required to enable the review of this interim allocation plan and the refinement of the allocations available for consumptive uses.

The first priority is to identify the water dependent ecosystems and to assess their conservation value. From this, a program for more detailed study and monitoring of key communities and processes will be developed. Stakeholders (and particularly local interest groups) will be involved in the development of the environmental management objectives for the water dependent ecosystems and their associated fringing vegetation. The proposed approach to the environmental water allocation studies is outlined further in Appendix 1.

The licensing conditions in Section 10.2.1 require the Water Corporation to release water to maintain the environmental health of the Ord River. In the sense that the management of environmental impacts of regulated flows is an intrinsic cost of the provision of water from the dams, the cost of the studies and subsequent monitoring should be met in part by the Water Corporation. The studies will, however, add to the ability of both the Water and Rivers Commission and CALM to improve their management of riverine systems so contributions from all agencies should be sought. The proponents of the Stage 2 expansion of the irrigation area should also be required to contribute. The proposed responsibilities for future water resource investigations and monitoring are set out in Appendix B.

10.2 Water resource investigations

10.2.1 Surface water

To improve the hydrological data base and allow better analysis for future review of the allocation plan, some additional hydrological monitoring will be required. In particular, gauging points to monitor streamflow at the lower reaches of the Dunham River (close to the confluence with the Ord), and at least one point in the lower reaches of the Ord River is required.

More detailed investigations are also required to enable an accurate water balance for the Ivanhoe Plain and Packsaddle Plain areas to be calculated and to reduce the uncertainties around estimates of the efficiencies of the water delivery and on-farm systems. This will then enable potential savings in water from improved water distribution efficiency to be quantified.

Further investigations including field trials to clarify the sugarcane crop water demand are essential.

10.2.2 Groundwater

Results of a recent exploratory drilling program throughout Stage 2 of the Ord River Irrigation Area (ORIA) have indicated that it is unlikely that there is a groundwater resource suitable for solely supplying and sustaining broad acre irrigation (R. Nixon, pers. comm., 1996). However, some alluvial sequences (palaeochannel gravels) may provide useful aquifers for irrigation management, depending on recharge derived from irrigation and/or infrastructure.

Monitoring and investigations of groundwater accession and salinity effects in the Ivanhoe and Packsaddle Plains areas are under way and have been extended to the Stage 2 areas.

11. Implementation of the plan - Surface water licensing

11.1 Legal validity

Licences issued under the *Rights in Water and Irrigation Act* are the means by which allocations are legally recognised. They allow the orderly regulation of the supply and use of water while protecting the rights of the end users of that water.

Section 8.1 and 9.3 introduce proposed changes to *Rights in Water and Irrigation Act (1914)* to implement the COAG water reform program. However, the licensing arrangements proposed in this Chapter are based on Water and Rivers Commission's responsibilities under current legislation. It is not intended in this plan to either pre-empt or constrain future directions which may be taken during the reform process, but to establish licensing arrangements which allow a transition to meeting the objectives of the COAG reforms.

The Water and Rivers Commission will issue licences under Part III of the Rights in Water and Irrigation Act 1914 to give legal authority to:

- the Water Corporation to store the waters of the Ord River in Lake Argyle and Lake Kununurra for subsequent supply or release;
- those groups or individuals taking water from the reservoirs or directly from a river for specified purposes.

Licences will be issued to the Ord Irrigation Cooperative Ltd to take water at the M1 offtake and Packsaddle Pump Station and to Argyle Diamond Mine to take water from Lake Argyle and Smoke Gap Dam. The Water Corporation, which operates the water supply to Lake Argyle Tourist Village, will be licensed to take water for this purpose.

The Ord Irrigation Cooperative Ltd will be licensed to meet projected demand for the full development of the area. This is consistent with the Commission's practice in surface water and groundwater licensing throughout the State of allowing for some growth in demand. There may be one or more licences for the Stage 2 area depending on the way in which the development occurs. Licences will not be issued until the operator of the distribution system is confirmed and there is approval for the development to proceed.

The Water Corporation, the Ord Irrigation Cooperative Ltd, and the operator/s of the distribution systems for the expanded irrigation area will also require operating licences issued by the Coordinator of Water Services (Office of Water Regulation). These operating licences and the commercial contracts between the headwork operator, distribution agency/ies and their customers are not within the Water and Rivers Commission's responsibility and are therefore outside the scope of this plan.

11.2 Annual licensed quantities

The Commission will licence the taking of water in accordance with this interim plan as summarised in Table 7.

The licence will specify the amount of water that can be taken annually in normal supply years. Some variability about this value (up to 10% to 15%) will be allowed in normal supply years (ie Lake Argyle level above 79m AHD) when rainfall or rainfall effectiveness is significantly different from that used in demand estimates on which the allocations are based. The method to be used to determine the actual amount of water that can be taken in any one year will be defined in approved operating strategies established as conditions of the licence (see section 10.4)

The licensed quantities cannot be guaranteed 100% of the time. They are, however, very reliable for irrigation supply purposes. Ruprecht and Rodgers (1999) have estimated that the full licensed quantities

can be fully supplied in 95% of years. Moreover, in 98% of years over 75% of licensed quantities for irrigation can be met for the current scenario. With full development of Stage 2 and the reduced power demand of 110Gwhr per annum, over 75% of the licensed irrigation quantities can be met in 100% of years.

Table 7. Licensed consumptive uses

Licences for consumptive use	Annual Licensed Quantities
A licence to take water from the Ord River at Lake Argyle to be issued to Argyle Diamond Mines for mining purposes	12 GL
A license to take water from the Ord River to be issued to the Ord Irrigation Co-operative for the purpose of irrigation in their Irrigation Service Provider's Operating area. **(when the distribution assets for Stage 1 are transferred)**	300 GL
A Licence to take water from the Ord River at Lake Kununurra for use issued to the Irrigation Service Provider of the new irrigation area serviced by the M2 channel. **(when the M2 Channel Development of Stage 2 has environmental approval)**	740 GL
A licence or series of licences to take water from the Lower Ord River for irrigation purposes to be issued to Irrigation Service Providers in the Carlton Plain, Mantinea Flats and Ord West Bank areas **(when the Lower Ord Development of Stage 2 has environmental approval)**	195 GL

11. 3 Term and renewal of licences

In the past licences have been issued for a maximum of ten years in accordance with established Commission policy, and with an expectation of renewal subject to water being available and compliance with licence conditions.

In the event that a licence renewal is refused because of breach of conditions or insufficient water, the licensee retains a right of appeal to the Minister under the Rights in Water and Irrigation Act.

The policy on licence duration and the expectation of renewal is under review as part of the implementation of the Council of Australian Governments (COAG) Water Reform Agreement. Proposals for longer duration licences, and the Commission's powers to amend licence conditions during their life, have been considered in this overall reform context over the last 12 months. Given the public submissions received on the COAG reform proposals (Water and Rivers Commission, 1998a), *"the Commission considers that it is premature to lengthen licence tenure without a ready acceptance by licence holders that they must adapt to changing requirements. Accordingly, the current practice of issuing licences for specified periods will continue. Long term licences will be issued where it can be shown that there is little risk to the resource or other users. In other areas, where the risk is high, licences will be issued for shorter periods to allow periodic review."*

Consequently, in the context of the Ord River situation, new licences are proposed to be issued until the interim allocation plan is updated or for a maximum of five years (which ever is the sooner). The intent is to move to longer-term licences after that date, if the risk to the resource and other users are shown to be low. This is expected to be the case after release of the final plan.

11.4 Specific licensing conditions

11.4.1 Water Corporation

The Water Corporation will be licensed to regulate (divert) the waters of the Ord River for the generation of hydro power, and for subsequent abstraction of water for irrigation, mining and water supply purposes. The licence will include provision to take water required for water supply to Lake Argyle Village. Conditions on the licence will include the following:

- The right to operate the Ord River Dam and the Kununurra Diversion Dams, to enable the ultimate abstraction of 1235 GL/ year from the river system (the current estimate of the ecologically sustainable diversion limit) for the purposes of meeting current irrigation use licences and future irrigation development downstream of Lake Argyle.

- The responsibility to operate the Ord River Dam so that Argyle Diamond Mine can exercise their right to use 12 GL/year from Lake Argyle for mining purposes.

- The licence will require that sufficient water be released from Lake Argyle to ensure the continued health of the environment downstream from Lake Argyle and downstream from the Diversion Dam. Initially this will be based on ensuring that at least the 20th percentile of natural monthly average flows are maintained in the lower Ord River downstream of the confluence with the Dunham River. As environmental water requirements are defined more specific criteria may be set. These may include maximum and/or minimum water levels to be met at specified points along the Ord River at a specified frequency.

- The licence will also require the Corporation to release water from Lake Argyle for the generation of hydro power in accordance with the Water Supply Agreement.

- The licence will include provision to take water for the Lake Argyle Tourist Village, as the Water Corporation is also the provider of the water service in this case.

- A reservoir operating strategy will be required to be submitted to and approved by the Water and Rivers Commission. This is to describe how the storages will be operated to satisfy the requirements of this allocation plan, the Corporation's licence, and the other licences issued to other parties. It is to be updated on an annual basis. It will be required to include:

    ⇒ procedures for ensuring that the EWP requirements can be met in real time.

    ⇒ a restriction policy established in accordance with the priorities for uses established in this plan and in the Water Supply Agreement .

    ⇒ the Water Release Rules referred to by that Agreement. (Note that subsequent negotiations of the Water Release Rules will require the involvement and approval of the Commission).

    ⇒ the expected demand for irrigation water based on areas of proposed crop types to be irrigated over the next 12 months

    ⇒ the volume of water to be released for Hydro Power generation over the next 12 months given the current storage level in Lake Argyle

    ⇒ the expected portion of the hydro-power releases not expected to be subsequently diverted for irrigation downstream, and

    ⇒ monitoring and reporting requirements based on guidelines prepared by the Commission

Input from the Corporation, the Commission and the OIC will be required to draft a thorough and satisfactory operating strategy. The responsibility for its preparation, however, lies with the Corporation. Its approval lies with the Commission.

Updating the Reservoir Operating Strategy

As discussed in Section 7.3 and 9.2.4 current arrangements are based on the existing water supply agreement between the then Water Authority and Pacific-Hydro prepared in 1994. There is already a need to update current agreements on how the reservoir is operated during drought conditions.

In analysing scenarios for this plan Ruprecht and Rodgers (1999) developed an approach based on four levels of restrictions (Table 8). This approach applies restrictions on hydro-power and irrigation supply at slightly higher reservoir levels than defined in the original water supply agreement. The approach proposed here introduces milder restrictions earlier in a drought period and is preferred to the previous operating rules. Only minor changes in supply reliability result.

Table 8. Restriction policies

Lake Argyle level at which restrictions apply	Water restriction	
	Under the existing water supply agreement	As proposed in this plan
79 m AHD		ADM hydro power demand
78.5 m AHD		Town hydro power demand
78 m AHD	ADM hydro power demand	
77 m AHD		Irrigation (mild restrictions – above 75% of yearly demand)
76 m AHD	Town hydro power	Irrigation (severe restrictions – as low as 25% of yearly demand)

The actual restriction policy adopted can be further fine tuned by the Corporation in consultation with its customers and incorporated in an updated reservoir operating strategy at any time. Water and Rivers Commission would approve a changed operational strategy provided that:

- it reflected the priorities of use set down in the allocation principles (Section 9.1)
- is responsible from a water resource management perspective, and
- is clear and agreed between all parties.

11.4.2 Ord Irrigation Cooperative Ltd

The Ord Irrigation Cooperative Ltd will be licensed to take water for irrigation purposes within the Cooperative area in accordance with an approved distribution operational strategy (see below). The licence will allow the taking of 300 GL in years when Lake Argyle is within normal supply levels. In some years when Lake Argyle is within normal supply levels, there may be a higher water demand for irrigation purposes because of lower than average effective rainfall particularly during the wet season. In these years, up to 10% to 15% extra water will be able to be taken provided it is taken in accordance with the approved distribution operating strategy (see below). Conversely in years of above average rainfall, irrigation draws should be up to 10 to 15% below averaged licensed quantity.

The Commission sets a high priority on reducing the risk of water born contamination in the lower Ord River from drainage discharge from the Stage 1 area (Section 9.2) and on promoting the efficient use of water from the Ord River. A timetable for the introduction of measures to improve the distribution and on-farm efficiency of irrigation water will be negotiated between the OIC and the Commission before the irrigation distribution assets are transferred and the licence conditions finalised.

Under terms of the licence OIC will be required to:

- optimise the use of water within their distribution area through promoting best practices in irrigation management;
- reduce drainage return flows from the district over an agreed timeframe and manage return flow quality to agreed targets
- monitor and manage groundwater systems recharged by irrigation activities
- monitor water at the inlet to all farms to enable district water balances to be calculated, and
- contribute to the monitoring of inflow and drainage quality and quantity.

The Ord Irrigation Co-operative's Land and Water Management Plan is central to developing and promoting best irrigation practices in the Stage 1 area. It will be central to helping the Co-operative to meet its licence conditions.

By-laws established under Part X of the *Rights in Water and Irrigation Act,* and administered by the Co-operative, can be used to regulate on-farm practices to help achieve these licence conditions if necessary.

The licence will also require:

- the annual preparation and update of a distribution system operating strategy. This will include:
  - ⇒ estimates of the expected areas of irrigation by crop type and the expected total water demand for the forthcoming season;

- ⇒ a procedure, managed in real time, for determining the additional volume that can be taken for the remainder of each water year, based on the recorded rainfall in the irrigation district, the current quantities already diverted and the licensed annual quantity;
- ⇒ measures to be taken to promote efficient water distribution and use in the forthcoming year(s);
- ⇒ measures to be taken to minimise any adverse effects that the use of the water has on other (mainly downstream) water resource values; and
- ⇒ monitoring and reporting details from the last irrigation year as requirement by the Commission.

In this way the Commission will promote improved water distribution and drainage management, and encourage better on-farm water practices.

How water use is shared between individual properties within the Cooperative area is not of direct concern to the Water and Rivers Commission provided that efficient use of the water resource is demonstrated through the distribution operating strategy and associated reporting. However, the means by which their entitlement is rolled down to individual irrigators will require general approval of the Commission and the Office of Water Regulation (OWR). Joint discussions between the Commission, OWR and each distribution body will be required. If trading of water entitlements between irrigators were introduced, the method by which trading is to be carried out will also need to be approved by the Commission and would require reporting on the volume of trade, and any general trends in the areal distribution of irrigation water. This could best be reported to the Commission via the distribution operating strategy.

11.4.3 Argyle Diamond Mine

Argyle Diamond Mine will be licensed for the conjunctive use of water from Smoke Creek Dam and from Lake Argyle. A condition will be that an operating strategy is prepared to describe how and when water would be drawn from Lake Argyle, from Smoke Creek Dam and from de-watering operations and that this is reported on annually.

11.5 Procedure for issuing and renewing licences

Licences for the diversion, taking or use of water from the Ord River and its tributaries will only be issued in accordance with this interim allocation plan. Applications for surface water licences must be made on the prescribed application form and submitted to the Water and Rivers Commission.

12. Review and update of the plan

12.1 Introduction

This interim allocation plan will require review when the current uncertainties related to Environmental Water Provisions and irrigation water demands are resolved. This will require the completion of investigations of ecological water requirements, social and recreational values of waters in the Lower Ord River, and monitoring and investigation studies on irrigation water demand and distribution efficiency. The formal review of the plan will be commenced in three to four years when these studies have been substantially completed.

The general approach to updating the plan has been outlined in Section 1.4 and further described in Section 9.4. The key review issues are summarised here.

12.2 Key review issues

In addition to and elaboration of aspects previously mentioned (Section 9.3) the key areas of uncertainty that need further work are discussed below.

- Ecological water requirements need to be determined and the environmental water provision reviewed. The investigations required may take some years.

- The efficiency of the water distribution system in the existing irrigation area needs to be confirmed. This should be possible within the next two to three years. There is considerable potential, through improved monitoring and improved operational practice to increase the currently assumed distribution efficiency of only 67%. Improvements are possible in the areas of:
  - ⇒ better control of the M1 Offtake to more closely match water diversions to irrigation demand, and
  - ⇒ better on-farm water practices.

- If seepage losses from the system prove to be larger than expected the response should be that the distribution assets be improved. In recognition that the Ord Irrigation Cooperative Ltd have inherited the system, the Commission would be willing to review the basis for the determination of the Stage 1 allocation if the efficiency of distribution is shown to be significantly less than the 67% assumed in the allocation plan. This would be done in conjunction with developing a strategy for addressing the efficiency of distribution in the longer term.

- Investigations are proceeding into the feasibility of the full development of the M2 portion of the Stage 2 irrigation area. These may indicate that there are areas unsuitable for development or may identify localised groundwater systems (in paleo-channel gravels) which, if used with surface waters, could assist in on-farm water management to minimise future salinity and water logging problems. Environmental assessments are expected to be released for public comment from mid 1999.

- The water release rules for hydro power generation are to be re-negotiated after the sale of the initial 1015 GWhr of power to Argyle Diamond Mine. While the Water Supply Agreement remains in place until at least 2021, re-negotiation of the water release rules may affect the way in which allocations are defined (ie. reliability of supply, normal supply levels) and need to proceed within the next 6 months.

- The COAG reform agenda is for legislative and administrative arrangements that would allow the trading of property rights in water to be in place by the end of 1998 with implementation where appropriate by 2001. Although the establishment of a water market in the Ord River catchment may not be warranted at that time, it is possible that the legislative changes may require the licensing arrangements to change so that a framework to accommodate trading of property rights in water is available.

The most significant of these uncertainties is the ecological water requirement. Therefore it is proposed that the interim allocation plan be reviewed at the completion of those studies or in five years time, whichever is the sooner.

Additional key issues in the review will be

1. The continued provision of water to meet recreation and tourism needs.

2. Waterways management, including protection of water quality in Lake Kununurra and the management of aquatic macrophytes to maintain the environmental health of the system.

12.3. Water and Rivers Commission Commitments

In recognition of the need to update this interim plan as soon as possible the Water and Rivers Commission is committed to:

- ensuring the necessary environmental water provision investigations and research studies, as outlined in Appendix 1, are substantially completed over the next four years so that information is available for definitive allocation decisions in the year 2002/2003;
- involving the local community and relevant Government agencies in assisting in the establishment of the objectives for management of the Lower Ord River and in using the best scientific means to determine the ecological water requirements to achieve those management objectives;
- ensuring that the additional hydrologic investigations, as outlined in Appendix B, are conducted and reported effectively so that data is available when the plan is reviewed and updated;
- working with the Ord Irrigation Co-operative, the Water Corporation and Agriculture Western Australia in the establishment of improved water and land management practices within the region and where necessary making such practises a condition of new water licences when issued; and
- integrating its allocation and waterways management with other planning and land management initiatives of Ministry for Planning and the Shire of Wyndham East Kimberley, as appropriate.

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Appendix A. Defining Ecological Water Requirements and Environmental Water Provisions

A.1. National Principles for the Provision of Water for Ecosystems

These have been developed by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC) to provide policy direction on how the specific issue of water allocation for the environment should be dealt with in the context of general water allocation decisions. The Principles are not in themselves a framework for water allocation but are one input to a broader process, which considers all users.

The goal for providing water for the environment is to sustain and where necessary restore ecological processes and biodiversity of water dependent ecosystems.

Basic premise of principles:

PRINCIPLE 1. River regulation and/or consumptive use should be recognised as potentially impacting on ecological values.

Determining ecological water requirements:

PRINCIPLE 2. Provision of water for ecosystems should be on the basis of the best scientific information available on the water regimes necessary to sustain the ecological values of water dependent ecosystems.

Provision of water for ecosystems:

PRINCIPLE 3. Environmental water provisions should be legally recognised.

PRINCIPLE 4. In systems where there are existing users, provision of water for ecosystems should go as far as possible to meet the water regime necessary to sustain the ecological values of aquatic ecosystems whilst recognising the existing rights of other water users.

PRINCIPLE 5. Where environmental water requirements cannot be met due to existing uses, action (including re-allocation) should be taken to meet environmental needs.

PRINCIPLE 6. Further allocation of water for any use should only be on the basis that natural ecological processes and biodiversity are sustained (ie. ecological values are sustained).

Management of environmental water allocations:

PRINCIPLE 7. Accountabilities in all aspects of management of environmental water provisions should be transparent and clearly defined.

PRINCIPLE 8. Environmental water provisions should be responsive to monitoring and improvements in understanding of environmental water requirements.

Other uses:

PRINCIPLE 9. All water uses should be managed in a manner, which recognises ecological values.

PRINCIPLE 10. Appropriate demand management and water pricing strategies should be used to assist in sustaining ecological values of water resources.

Further research:

PRINCIPLE 11. Strategic and applied research to improve understanding of environmental water requirements is essential.

Community involvement:

PRINCIPLE 12. All relevant environmental, social and economic stakeholders will be involved in water allocation planning and decision-making on environmental water provisions.

A.2. Determining Ecological Water Requirements: Summary of methodologies used in Australia

The determination of environmental flow regimes is receiving considerable attention in Australia and elsewhere, and several methods have been used for estimating environmental water requirements. Earlier techniques evolved in northern America and were primarily concerned with optimising conditions for fish species to protect recreational fishing. These and other techniques have been adapted to Australian conditions and are increasingly aimed at meeting wider ecological requirements.

Some approaches that have been used in Australia or overseas are:

- "Rule of thumb method": Some nominal environmental flows, generally expressed as a specific exceedence percentile or a volume of water, are released or allowed to pass as an interim measure in the absence of any data or detailed understanding of ecological processes within a catchment. The proportion of the flow to be released at various times of the year may be varied to take some account of, for example, fish requirements.

- Transect method: At critical sites along a stream, physical data is collected from transects across the stream for a range of discharges. This data, in combination with data on the requirements of fish species present in the system, is used to determine minimum flow requirements at which critical activities can still take place. This is based on determination of the "useable stream width" at particular discharges.

- Available habitat method: This method is similar to the transect method but uses data collected across transects at representative and critical stream reaches to measure or simulate hydraulic changes in the stream for a range of discharge values. Combined with data on habitat preferences of the species present, the area of suitable habitat present at a range of discharge values is then determined.

- Species-specific method: A specific target species and its needs are identified within a detailed catchment study and environmental flows determined to provide optimum conditions for the survival of this species.

- "Panel of experts" method: In this method an interdisciplinary group of "experts", each having a high level of local expertise, are assembled to determine the best available knowledge of ecological processes and the flows which are required to support all those processes.

- Holistic method: This aims to mimic natural flow regimes to support essential ecological processes. It requires the collection of comprehensive ecological, hydrological and geomorphological data within a catchment and can therefore take several years to complete.

The suitability of each of these methods for a particular river system is dependent on the amount of information available on the hydrology and ecology, and the time and resources available to build on that data. In practice, aspects of the various techniques may be used to provide an estimate of environmental flow requirements and monitoring and further data collection can then allow these requirements to be refined over time.

Further detail of methods can be found in the references listed.

A3. Interim approach adopted for the Ord River

Apart from some studies on barramundi, there is limited information specific to the Ord River on ecological effects of regulated flows. Some generalised assumptions can be made about the impacts of the generally lower and more regular flows which have resulted from the impoundment and regulation of the Ord, but there is insufficient knowledge at present to be able to determine with certainty a flow regime which will support all environmental values.

The approach used for the Ord River therefore is to nominate a provisional environmental water allocation, which is the minimum, which must be allowed to flow down to the lower Ord.

The 20th percentile of average monthly flows are shown in Table 1.

Table A1. Percentiles for the Ord River at Lake Argyle

Month	10th percentile (GL)	20th percentile (GL)	30th percentile (GL)
January	97.3	199.8	286.9
February	114.4	221.1	378.3
March	66.2	145.6	204.6
April	3.2	18.8	35.5
May	0	2.5	6.4
June	0	0	0.8
July	0	0	0.1
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0.2	3.7
December	3.6	27.0	53.0
TOTAL	285	615	969

When applied elsewhere, the 20th percentile expressed in terms of the daily discharge recorded each month has sometimes been used as a "base" environmental flow (ie the lowest flow permissible for stream ecosystem maintenance in drought years) The 50th and 80th percentiles have been used respectively as optimum flows for in-stream protection, and as special flows to be met in certain conditions in wet years to achieve special functions such as channel maintenance. (Arthington *et al* 1992).

No attempt has been made in this interim allocation plan to define any special purpose flows. It is obvious however that the greatest change to the flow pattern in the Ord River has been the lower flows in the period December to March. There is insufficient understanding at this time of the relationships between ecological parameters and flow components to be able to make any reasonable estimate of the magnitude or frequency of higher summer flows which may be beneficial. In the lower reaches of the Ord, the Dunham inflows will still provide some degree of seasonal variability and it has been assumed that this will continue.

A.4. Defining Ecological Water Requirements for the Ord River and refining the interim Environmental Water Provisions

As indicated in the main text, the Environmental Water Provisions identified in this Interim Allocation Plan are very preliminary and aimed at providing a general indication of the quantity of water which is likely to be available for irrigation and other uses. The Water and Rivers Commission, in consultation with key stakeholders, proposes to undertake a detailed study to establish Environmental Water Provisions for the Ord River downstream of the Ord Dam over the next three to four years.

To enable this, the Commission:

- has established an Environmental Water Requirements Technical Working Group (TWG) to develop and coordinate studies to identify the water requirements for maintenance of key ecological values;
- will coordinate funding and ensure that studies commence during 1999
- will establish the EWPs following completion of relevant studies and ensure that setting the EWPs is an open, transparent and consultative process considering ecological, social and economic values.
- will, in consultation with representatives of Ord irrigators, establish a process to ensure local participation in the review of the interim plan, as well as the initial provision of advice to the TWG on environmental management objectives for the lower Ord River region.

The Technical Working Group is preparing a detailed work program for the determination of Environmental Water Requirements. Site-based investigations are expected to commence early in 1999. The TWG will draw on the local expertise available in the Ord area to develop environmental objectives for the Ord River, including Lakes Argyle and Kununurra.. The outcome of this process will be the identification of specific criteria, which will need to be met to protect ecological and social values. New simulation studies will then be required to define the ecologically sustainable annual diversion volumes.

Decisions on what ecological values need to be protected by the EWPs are not the role of the TWG, but will be the role of Government on advice from the Water and Rivers Commission, its community consultative committee and the EPA. It is expected that the EWP part of the revised Water Allocation Plan will be formally assessed by the EPA.

The EWR Technical Working Group will be chaired by, and be responsible to, the WRC. The TWG will include scientists and water managers from the Departments of Conservation and Land Management, Fisheries and Environmental Protection, Agriculture WA and the Commission. Other people will be co-opted as required to provide additional information and expertise.

Some of the initial studies that will need to be completed include:

- review of existing literature and information (already commenced);
- collection of information on the ecosystem values and structure in adjacent similar rivers and permanent river pools;
- collection of information, including the impacts of current regulation, on the life cycles and age structure of river dependent fauna eg crocodiles, waterbirds, and fish including barramundi;
- a condition assessment of the river banks and riparian and aquatic vegetation;
- modelling of river hydraulics and flow regimes in the lower Ord; and
- an assessment of the above information to determine the degree of dependence of riparian vegetation, channel structure and form and adjacent areas on the current and previous flow regime.

It is proposed to seek funding for this work from the major beneficiaries and Federal funding agencies.

The EWR studies will need to complement other regional land planning, waterways and related Ramsar wetland management planning in the region.

A.5. References

Arthington A.H., Conrick D.L. and Bycroft B.M., 1992, *Environmental study: Barker-Barambah Creek,. Volume2,. Scientific report: Water quality, ecology and water allocation strategy*, Report to Water Resources Commission, Department of Primary Industries, Queensland.

Department of Zoology of the University of Western Australia and Centre for Catchment and In-Stream Research, Griffith University, 1995, *Environmental water requirements for lowland river systems on the Swan Coastal Plain,* Draft report to the Water and Rivers Commission, November 1995.

Kinhill Engineers Pty Ltd, 1988, *Techniques for determining environmental water requirement,* Department of Water Resources Victoria Technical Report Series, Report No. 40, November 1988.

Appendix B -Ongoing Water Related Investigations

B.1 Introduction

Further hydrologic studies are required to support:

- licensing and associated operating strategy as part of the water allocation to the Water Corporation and Ord Irrigation Cooperative;
- future development of Stage 2 of the Ord River Irrigation Scheme ;
- investigations into the environmental water requirements and provisions for the updating of the interim water allocation plan; and
- investigations associated with protection and stabilisation of the Ord River catchment.

The general investigation aims and measurements required in each key topic area are outlined below.

B.2 Stage 1 - Ord Irrigation Scheme

The monitoring required of the Water Corporation and Ord River Irrigation Co-operative as conditions of their water allocation licences will include:

- Estimates of inflows to and measurements of outflows from Lake Argyle;
- Releases and draws from Lake Kununurra;
- Flows at the Lower Ord River – Tarrara Bar
- Dunham River inflows to the Ord River; and
- Rainfall on irrigation areas.

Some of this monitoring is either already being collected by the Water Corporation or other agencies, such as the Bureau of Meteorology.

Overall Water Balance (Regional scale)

Due to the uncertainty in the efficiencies of the water delivery and on-farm systems it is very important that the water balance for the existing irrigation areas is quantified much more accurately. Some monitoring is currently in progress to define the water balance at the farm scale. There needs to be supporting computations of the water balance at the regional scale of the Ivanhoe and Packsaddle Plains.

The following monitoring is required.

Water input:

- Water delivery from Lake Kununurra to both Packsaddle (available) and Ivanhoe Plains (not currently available);
- Local rainfall on irrigation areas (available);
- Some broad indicator of the change in soil water/groundwater storage on an annual basis (adequacy of existing groundwater monitoring to be assessed).

Water output:

- Ivanhoe Plain: Water monitoring at drainage outlets;
- Packsaddle Plain: Water monitoring at the main drain entering Dunham River.

In conjunction with the water balance for Stage 1 a preliminary nutrient balance should be carried out. This will lead to a more accurate phosphorus and nitrogen budget for the lower Ord River.

In view of the recent fish deaths and associated investigations further sediment sampling programs for pesticides along some of the larger drains will be required.

Preliminary Salt Balance

A preliminary study to ascertain the relative magnitudes of the input, output and storage components of the salt balance should also be undertaken. Sufficient water conductivity data of the inflow and outflows should be collected, together with assessments of the change in annual groundwater and the magnitude of the soil salt storage, to enable initial estimates of the salt balance for Ivanhoe and Packsaddle Plains irrigation areas to be calculated.

On-farm water balance & distribution efficiencies and current crop water demand

The on-farm water balance and distribution efficiencies should be measured to enable effective water use efficiency measures. The current crop water demand should also be determined as part of these studies.

B.3 Monitoring to Support Environmental Water Requirement Studies

The hydrology of the Ord River has been significantly altered over the last 20 years and there is potential for further changes with additional irrigation development. The water regimes necessary to maintain a healthy river system and to support agreed environmental values particularly along the lower Ord River needs to be quantified.

The hydrologic monitoring requirement for determining the environmental water requirements and provisions will include:

- water level, volume, and salinity for the Ord River at Carlton Crossing;
- water level and salinity at a number of key sites downstream of Tarrara Bar- to determine the current natural range in the salt water interface each monthly and daily tidal cycle.

B.4 For Stage 2 - Ord Irrigation Scheme

Crop Water Demand for Sugarcane

The uncertainty in the appropriate crop water demand for sugarcane leads to uncertainty in the water required for irrigation. As the planning for Stage 2 of the Ord Irrigation Scheme (ORIS) progresses further investigations into the appropriate crop water demand are necessary.

Keep River

As part of the investigation into the impact of Stage 2 irrigation the hydrology (including water quality) of the Keep River needs to be evaluated. The expanded network of rainfall and streamflow gauging stations should be maintained.

B.5 Custodian and Funding Responsibilities for the Monitoring

The funding responsibility for the water monitoring and the custodianship for resulting information are outlined in the table below.

The Water and Rivers Commission will oversee the above monitoring program, working with all the stakeholder groups to ensure that quantitative information is available when revision of the interim plan is commenced in 3 to 5 years time.

Table B1. Stage 1 Area monitoring requirements

Component	Information Custodian	Funding of Monitoring
Licensing and Associated Operating Strategy	Water Corp & Water and Rivers	Water Corp
Overall Water Balance for Stage I	Water & Rivers Commission	Water Corp, OIC, Water & Rivers
Environmental Water Requirements and Provisions	Water & Rivers Commission	Water Corp, Water & Rivers
Preliminary Salt Balance	Water & Rivers Commission	Water Corp, OIC
Preliminary Nutrient Balance	Water & Rivers Commission	Water Corp, OIC
Preliminary Pesticide Monitoring	Water & Rivers Commission	Water Corp, OIC
On-Farm Water Balance	Agriculture WA	SRDC, CSIRO, OIC, Agric. WA

Table B2. M 2 Area of Stage 2 monitoring requirements

Component	Information Custodian	Funding of Monitoring
Crop Water Demand for Sugarcane	Agriculture WA Ord Development Council	DRD, Agriculture WA, Sugar Industry
Salinity Variation in the Lower Ord River	Water & Rivers	DRD
Keep River	NT Land Planning & Environment, Water & Rivers Commission Ord Development Council	DRD and NT Government

Glossary

Abstraction (of groundwater)	Pumping groundwater from an aquifer.
m AHD	Australian Height Datum. Height in metres above Mean Sea Level +0.026m at Fremantle.
Accessions (to the water-table)	Water that is recharged through soil and is added to the water-table
Allocation	The quantity of surface water permitted to be diverted from a watercourse, or abstracted from groundwater under a licence, and usually specified in Gigalitres/year (GL/a).
Aquifer	A geological formation or group of formations able to receive, store and transmit significant quantities of water.
Beneficial Use or environmental value	The current or future uses for a water resource that has priority over other potential uses because of their significance to the community. The significance may be because of ecological or social values held by the community.
COAG	The Council of Australian Governments
Confined Aquifer	An aquifer that is confined between shale and siltstone beds and therefore contains water under pressure.
Ecological Values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.
Ecological Water Requirements	Descriptions of water regimes that will maintain ecological values at a low level of risk.
Ecological values	The natural ecological processes occurring within water-dependent ecosystems and the biodiversity of these systems.
Environmental Water Provisions (EWRs)	The water regimes that are to be maintained following water allocation decisions that may involve some compromise between ecological, social and economic goals.
Evapo-transpiration	A collective term for evaporation transpiration and transpiration.
Gigalitre (GL)	A thousand million litres or one million cubic metres
Hectare (ha)	10 000 square metres or 2.47 acres.
Hydro-power	Electrical energy production (per unit time) generated from the potential energy of water held in a reservoir. When summed over a period of time (say a year) it is usually measured in Giga Watt Hours (or GWhrs) per year
Kilolitre (kL)	1000 litres, 1 cubic metre or 220 gallons.
Recharge	The downwards movement of water that is added to the groundwater system.
To take (water)	Term defined in the proposed amendments to the Rights in Water and Irrigation Act to describe the "taking" of water from a watercourse or aquifer
Water dependent ecosystems	Those parts of the environment, the species composition and natural ecological processes of which are determined by the permanent or temporary presence of flowing or standing water.