TALK ON WATER RESOURCES

TO

KIMBERLEY CONSULTATIVE COUNCIL

AT KUNUNURRA

14th September, 1965

K. J. KELSALL
B.E., A.M.I.E. (AUST.)

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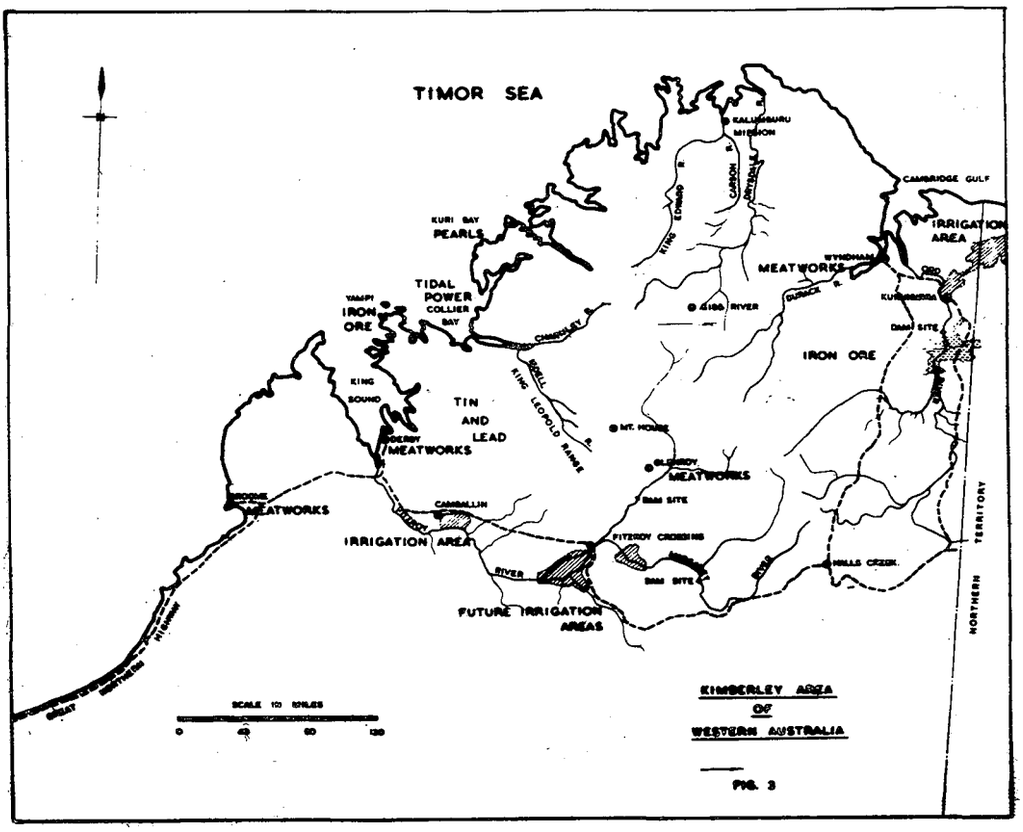


INTRODUCTION:

When rain falls, a certain proportion of the water is returned to the atmosphere by evaporation from the soil or through the process of transpiration from vegetation. Some of this water is wasted but quite a large portion sustains the country's forests, together with the agricultural and pastoral industries.

However, when discussing the water resources of a country we normally refer to that comparatively small portion of the rainfall which can be stored for later use in schemes or development.

In Australia the proportion of the rainfall which cannot be held in storage is estimated to be as high as 90% compared with about 70% in the U.S.A.

DEFINITION OF TERMS:

Before commencing to discuss water resources it is desirable to define the two principal units of measurements in common use. These are -

(a) the acre foot which as its name implies, is the amount of water contained in an acre of area submerged to a depth of

1 foot and is equal to 272,000 gallons.

(b) the cusec which is a rate of flow one cubic foot per second or approximately 22,500 gallons per hour.

AUSTRALIAN WATER RESOURCES:

Australia is a dry continent and one factor that influences this is the lack of high mountains since less than 7% of Australia is above 2,000 ft. in elevation.

The mountains we do have are mainly in the south-east of the continent. They are close to the Coast and help to keep the interior dry by intercepting a greater part of the moisture of the South-east trade winds. The prevailing westerlies - which are the other main rain bearing winds - generally pass too far south of the mainland to benefit any but the southern fringes. They do, however, bring heavy rain to the west coast of Tasmania. As a result our average annual rainfall is only 18" compared with 29" of the U.S.A. and 45" for India. Only about 33% of Australia has an annual rainfall of 20" or more while nearly 40% has less than 10". By comparison only 7% of the U.S.A. has such a low rainfall.

The rainfall pattern of the country is reflected in the river systems. No other continent has such a small number of rivers as Australia and very few streams are of a perennial nature. A large area of the country has no rivers at all.

The most important river system in Australia is the Murray basin in the South-East corner of the country. However, compared with other rivers of the World, the Murray is not an outstanding stream. In size of catchment area, the Murray is larger than the Columbia River in the U.S.A. and the Indus in Pakistan, both of which are used for irrigation, but the annual average flows are very different. The Indus discharges roughly 13 times and the Columbia 15 times as much water as the Murray each year. The variability of stream flow presents an even worse picture, e.g. the Murray has been dry on occasions while in 1956 the record flow of 44,000,000 acre feet was nearly 4 times the annual average.

From an irrigation point of view this means not only that we are short of water, but also that we need to provide a greater volume of dam storage for each acre we irrigate.

Again, some further comparisons are helpful in getting Australian irrigation in its right perspective. If we compare the amount of storage of water necessary to supply one acre of land, we find that Australia has 3 acre feet of storage for every acre irrigated. The U.S.A. has roughly half this figure, Egypt a quarter and India less than a tenth. We have seen then that in Australia both the amount of rainfall and consequently the stream flow are low

and extremely variable by World standards. This means that water for irrigation is doubly precious.

AUSTRALIAN WATER RESOURCES:

The whole of Australia's surface water resources has been assessed at 280,000,000 acre feet. By comparison this is only approximately 60% of the annual flow of the Mississippi River in the U.S.A. In accordance with the Information published by the Department of National Development for the Australian Water Resources Council in 1965, the Australian surface water resources are distributed approximately as follows:-

North East Coast	24%
South East Coast	10%
Tasmanian	14%
Murray Darling River System	7%
South West Coast	3%
Indian Ocean	2%
Timor Sea	21%
Gulf of Carpentaria	18%
Lake Eyre	1%

The Kimberleys make up a little more than half of the run off in the Timor Sea Division.

You will notice from these figures that on the basis of area, West Australia is the second driest state on the Australian mainland. South Australia obtains great benefits from the lower reaches of the Murray River, but essentially it has no rivers of its own and is therefore by far the driest State in the Commonwealth.

WEST AUSTRALIAN WATER RESOURCES:

Looking at West Australia in particular, we find that only approximately 25% of the State's surface water resources are in the South West Land Division. Two of the largest rivers in the South West are the Blackwood and Swan-Avon. Both these river systems have their head waters in the wheat-belt and receive the run off from the belt of salt lakes which cover a large area to the east of the Great Southern Railway. The result is that 47% of the water resources in the South West of the State is too saline for normal domestic or irrigation purposes under the present stage of technical knowledge. The fresh water is restricted to those streams along the South and South-west coast which have catchments located in the general area of the Darling Ranges. These rivers include the Canning, Serpentine, Harvey, Collie, Preston, Warren, Shannon and Denmark. The largest of these fresh-water rivers are the Shannon and Warren. The Murray is quite a large stream by local standards, but one of its tributaries (i.e. the Hotham) receives run off from the salt lakes East of Pingelly and this has the effect of rendering the water in the river quite saline even though the major portion of the flow is obtained from fresh catchment areas in the hills country to the east of Pinjarra.

The North West Division covers a large portion of the States area. On the map it has an impressive series of major river systems (e.g. Murchison, Gascoyne, Ashburton, Fortescue and De Grey). Of these the Gascoyne promises to be the most useful. However, like other areas of Australia in the 10" or less average rainfall belt the North West is a region of drought. It is subject to short periods of heavy rain followed by long periods in which no rain at all falls.

The rivers have large catchment areas that are generally devoid of any large vegetation and flooding often occurs with each flow of the river.

The position in the Kimberley Division is much more promising. The area is principally drained by two major river systems (i.e. the Ord in the East Kimberleys and the Fitzroy in the West Kimberleys) and in addition there are also some very useful rivers in the North Kimberleys.

The region is characterised by two distinct seasons (i.e. the wet and dry). During the wet season which occurs during November to March, cyclonic storms often bring intense rainfall and falls in excess of 6" per day are not uncommon. The rainfall over the area is not high, varying from 18" in the South to about 40" in the North, but it is comparatively reliable and severe droughts are infrequent.

The Kimberley river we know most about is, of course, the Ord. This River has been gauged for over 20 years and its annual flow is assessed at 4.3 million acre feet from a catchment area of 21,000 square miles.

The catchment area of the Ord is only 70% of that of the Gascoyne River, but its annual average flow is approximately 9 times greater. The Ord is subject to large floods and in a comparatively short period (as shown by the detailed records) flows in excess of 1 million cusecs were recorded in 1956 and 1959.

The information available about the Fitzroy River system is not so detailed. The catchment area of 33,400 square miles is 50% larger than the Ord; the average rainfall is lower and the run off is possibly 16% greater than the Ord. Both the Fitzroy and the Ord have average annual flows greater than the run off from the entire Snowy Mountain Area. The Snowy Mountain Area has of course, the advantage of altitude which makes it so ideally suited for hydro-electric development.

UTILISATION OF WATER BY IRRIGATION:

In any country it is customary that the first stage in water conservation is the utilisation of natural flows by diversion from streams. To be effective on anything, except on a very small scale, this system requires large perennial streams and this system has been used extensively in India and Pakistan where major rivers are fed by melting snow from the Himilaya

Mountains. In Australia, as mentioned previously, we have very few perennial streams and the system of stream diversion is not adaptable in most areas because the periods when streams are flowing does not generally coincide with the growing period of the crops to be watered.

In Australia it has generally been necessary to proceed immediately into what might be classed the second stage of conservation, namely, the storage of winter or wet season-flow in the rivers to be used in the following summer, or dry, period. This stage requires that the storages be sufficiently large to hold the river flow in wet seasons for use in subsequent dry seasons (i.e. it involves the construction of carry-over storages which must be big enough to "iron out" variations over a dry cycle of many years(as revealed by the river gauging records).

This concept implies a very strict control of the water used each year. The demands for irrigation water in most areas in Australia are enormous, but if supplies over a dry season are to be assured, there must be some limit to the supply in average years. The setting of these limits known as the "safe draw" from a reservoir is one of the most difficult tasks of an irrigation authority and particularly does it bring criticism from farmers during the better than average years when restrictions are applied in districts where the reservoirs appear to be regularly overflowing.

IRRIGATION DEVELOPMENT IN W.A.

(a) South West

In the South-West area there is a comparatively small, but efficient irrigation district which extends along a narrow strip of the coastal plain from Waroona in the North to Dardanup in the South. The total area of the irrigation district is 85,000 acres and the total number of acres watered each year is approximately 30,000 acres.

This irrigation system was developed in the first place in 1916 as a small diversion system on the Harvey River to supply the citrus industry, but has now been developed principally for the purpose of pastures for beef and milk cattle.

Of the fresh water streams along the South-West Coast, the rivers closer to Perth such as the Helena, Canning and Serpentine have been reserved for domestic water supplies and the irrigation system is supplied from storage dams on the Drakesbrook, Samson Brook, Logue Brook, the Harvey and Collie Rivers. The highest dams in this system are the Stirling Dam on the Harvey River and Logue Brook Dam, both of which are earth embankments approximately 150 ft. high. From the view point of storage capacity, the largest dam, however, is the Wellington Dam on the Collie River with a wall only 112 ft. high. The storage in Wellington Dam is double of that in the Canning Dam which has a retaining wall 218 ft. high. Canning Dam, which supplies water to the Metropolitan Area is the highest

dam in this State.

(b) North West

Irrigation development in the North West Region is currently restricted to the Carnarvon Area where on the banks of the Gascoyne River there is an established irrigation area of some 1500 acres growing bananas and vegetables with an annual production of approximately £1,000,000 value. This irrigation area was commenced in the early 1930s and has considerably expanded in recent years. Unfortunately the irrigation at Carnarvon is limited by the amount of water which may be pumped from the river sands. Because of this limited supply of water and the irregularity of the river flows, the Government is maintaining a strict control of water which may be supplied to or pumped by a grower in order that a fairly even level of production can be maintained over the period between river flows. In other words an effort has been made to establish a "safe draw" from the aquafers.

The Government is fully aware of the importance of the irrigation area at Carnarvon and is actively engaged in determining the full potential of irrigation water which is available from the river sands in this area. In planning for the future expansion of the irrigation area, three possible dam sites have been chosen which would provide a major reservoir in the area. The most promising of these appears to be at the Kennedy Ranges some 100 miles upstream from Carnarvon where a storage of approximately 850,000 acre feet could be provided. This dam would be approximately 80 ft. high with a crest length of 9,000 ft. and these dimensions are quite unusual by normal standards. A diversion dam in the lower reaches of the river - possibly at Rocky Pool, would also be required in the ultimate system. At this early stage of investigations, however, there are many problems which have still to be solved and of course the over-all problems of economics will feature very prominently in any future planning.

All soil types in the Gascoyne Flats are not suitable for development, but there is available near Carnarvon approximately 25,000 acres of land suitable for irrigation and this area is adequate for the water available from a dam on the Gascoyne River.

(c) Kimberleys

In the Kimberleys the first experiments in irrigation were carried out in 1951 on the Liveringa property by Northern Developments Pty. Limited. This project which was initially developed for the growing of rice had the support of the State Government which has completed the construction of a barrage across the Fitzroy River and also the associated irrigation structures such as channels, levees, pumping equipment etc.

This scheme is typical of the systems mentioned previously as being the first stage of development where water is obtained by the diversion of

stream flow. There is however a small amount of storage available in the barrage itself and also in a reservoir on Uralla Creek, known as the 17 Mile Dam.

This irrigation area at Liveringa (known now as Camballin Irrigation Area) is only a small beginning to the complete development of the Fitzroy River system. Planning is now in course for a multi-purpose project primarily for irrigation but with ancillary effects for both flood control and hydro-electric power for the Fitzroy and Margaret Rivers.

As mentioned in the earlier sections, the water resources of the Fitzroy basin are quite extensive and regional soil surveys carried out by the C.S.I.R.O. have revealed potential irrigation areas on the flood plains of the Fitzroy and Margaret Rivers totalling some 300,000 acres which are more than adequate to utilise the full water resources of the system. Present investigations indicate that the major storage reservoir will be at the Dimond Gorge on the Fitzroy.

Dimond Gorge is a magnificent damsite and possibly the most impressive so far discovered in the Kimberleys. The basic rock is a hard quartzite and the geology of the site is not complex. A dam on this site could have the same general dimensions and storage capacity as the Main Dam on the Ord.

Additional storage reservoir sites are also available on the Margaret and Leopold Rivers. Two barrages or diversion weirs would be required to provide gravity command to the main irrigation areas.

In the East Kimberleys there is a well planned scheme based on the development of the Ord River basin. Stage 1 of the scheme commenced in 1960 and is now nearing completion. It consisted of the construction of a diversion dam at Bandicoot Bar and the development of 30,000 acres of irrigable land including the provision of channels, drains, structures etc.

Water availability from this first stage is of course limited to the stream flow which can be diverted during the wet season and in addition it has the Diversion Dam which has a storage capacity of some 80,000 acre feet which can be made available to the irrigation area by pumping. As a point of comparison the capacity of the Diversion Dam is approximately the same as that of the Canning Dam.

Before any further development of the irrigation potential of the area can be made, it will be necessary to proceed with Stage 2 of the scheme. This involves the construction of a rock fill dam 200 ft. high above the stream bed in the Gorge 30 miles upstream from the Diversion Dam. This reservoir will provide for a storage of 3½ million acre feet. Water from this main storage will be released downstream to the Diversion Dam where it will be diverted to

irrigate up to 200,000 acres of black soil plains which stretch over and into the Northern Territory.

The Third Stage of this project is the construction of the hydro-electric power station immediately downstream of the main dam. This station will have an installed capacity of 30 megowatts.

UNDERGROUND SUPPLIES

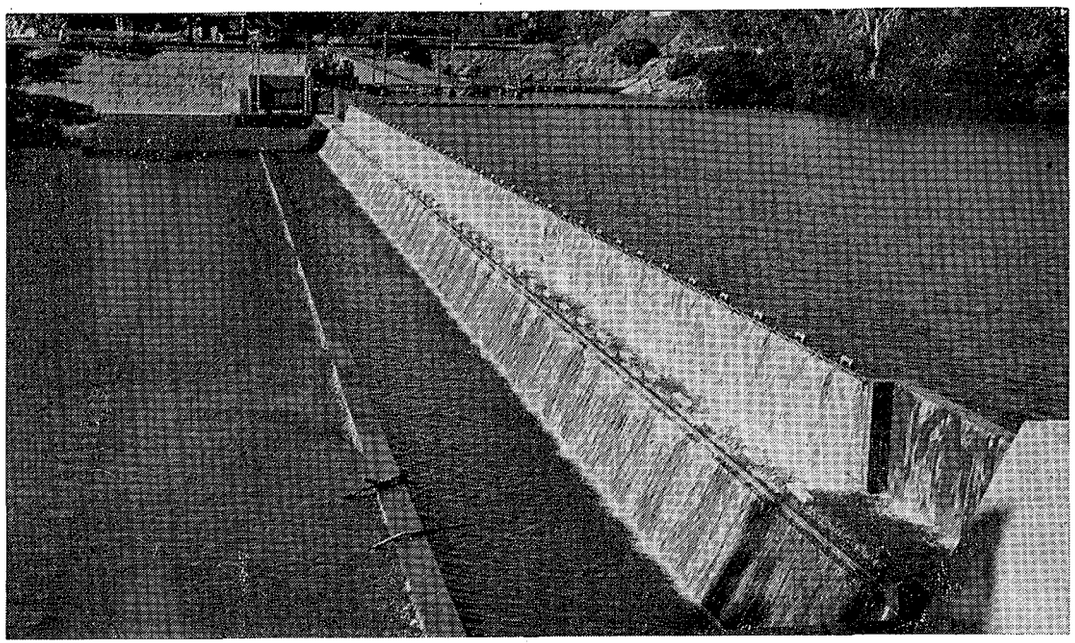
It is the surface water resources which provide the incentive for the construction of the spectacular dams and hydro-electric schemes. However in the north west all are familiar with the importance of underground water since, with the exception of Wyndham, all town water schemes are supplied from these sources.

Underground storages consist of the cavities and voids in rocks and soils. A common example being a clean course sand where the voids between the grain can represent as much as 30% of the volume of the sand and these voids are available for the storing of water. Most underground storages, however, do not contain anything like this proportion of water.

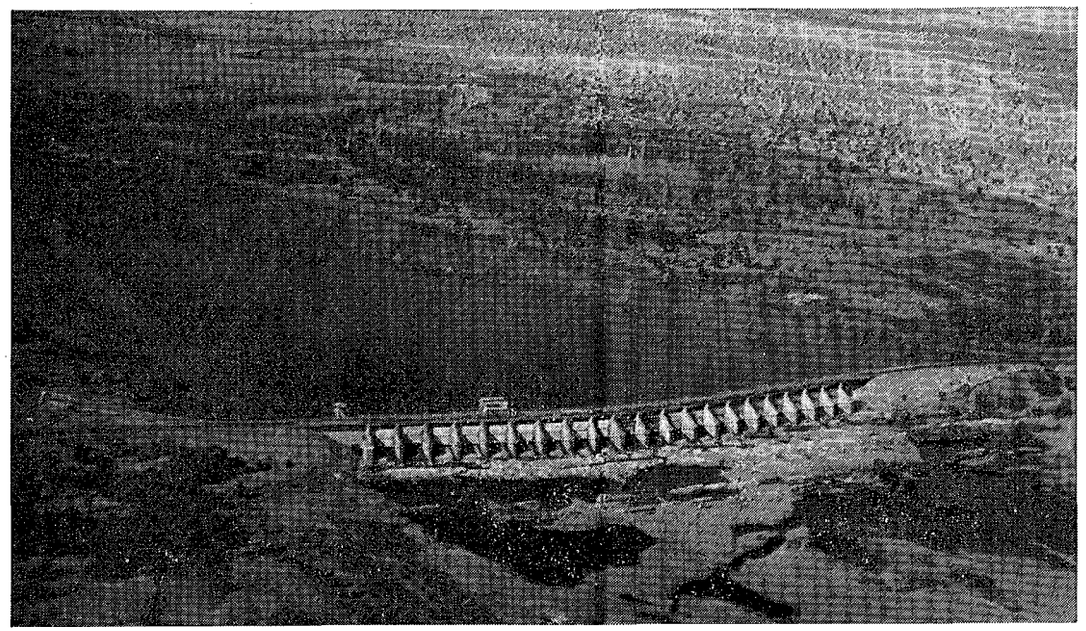
Because of their location, underground water resources are more difficult to assess than surface water resources and there still remains a considerable amount of work to be carried out in this respect in Australia.

Underground water storages have the great advantage that they are much less subject to evaporation than are surface storages.

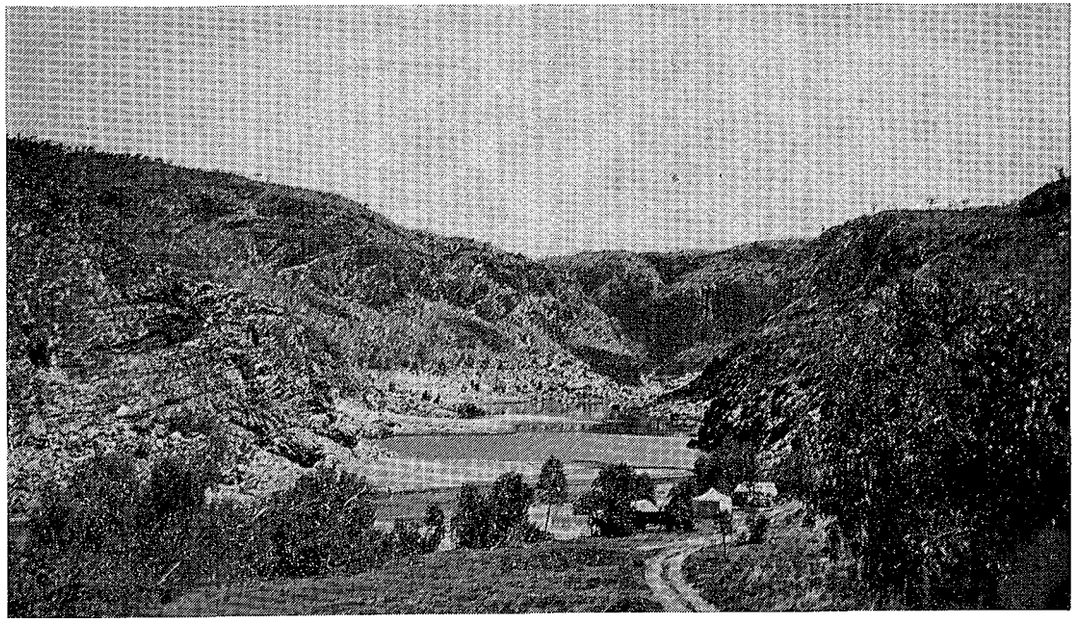
Like conventional surface storage dams, underground storage can be used to conserve water in wet periods for supply in dry periods. The result - as with surface storage - is to use water at a rapid rate during dry periods and there is a decline in the ground water level until recovery occurs during the next period of recharge. The essential point to always appreciate is that the long term average withdrawals during the dry period do not exceed the average replacements otherwise a permanent lowering of the water table will occur and the desired quality and quantity of water will no longer be obtained.



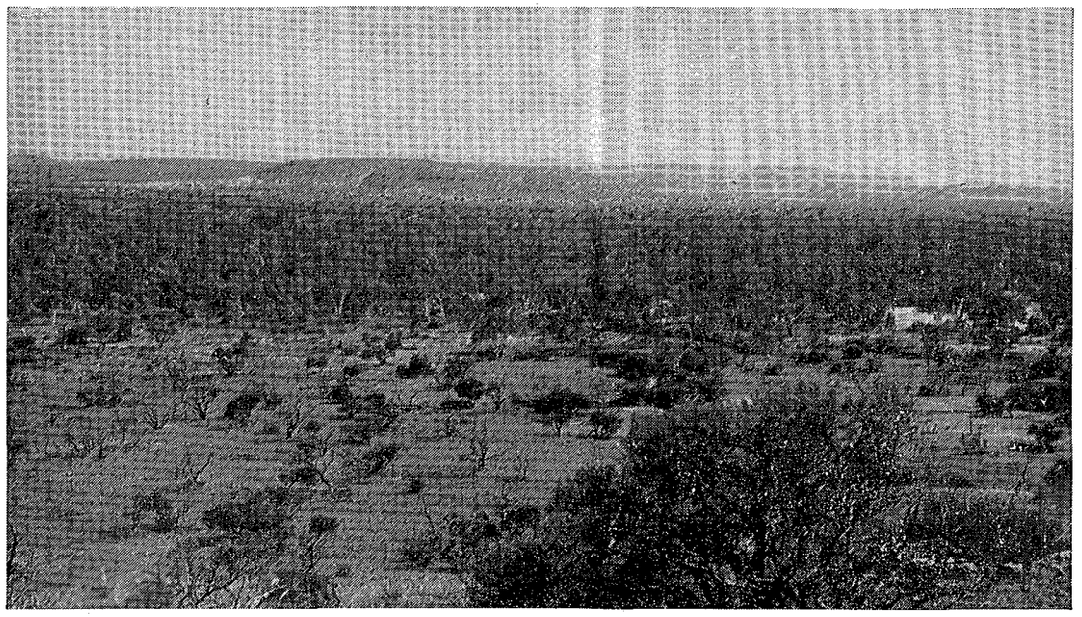
Barrage on Fitzroy River. Camballin.



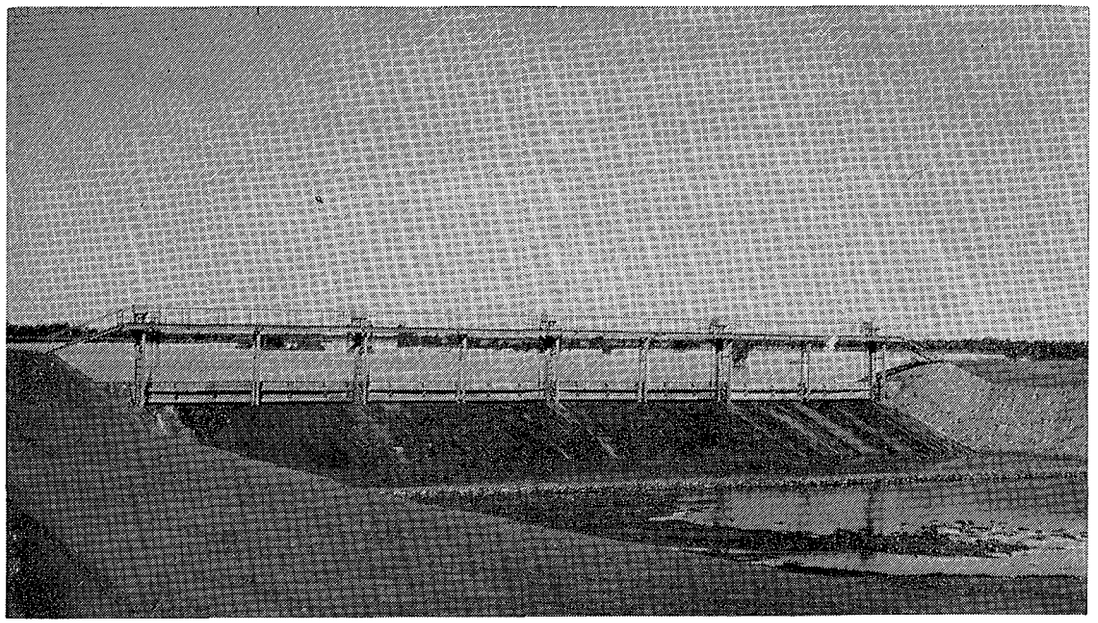
Ord Irrigation Area. Diversion Dam at Bandicoot Bar.



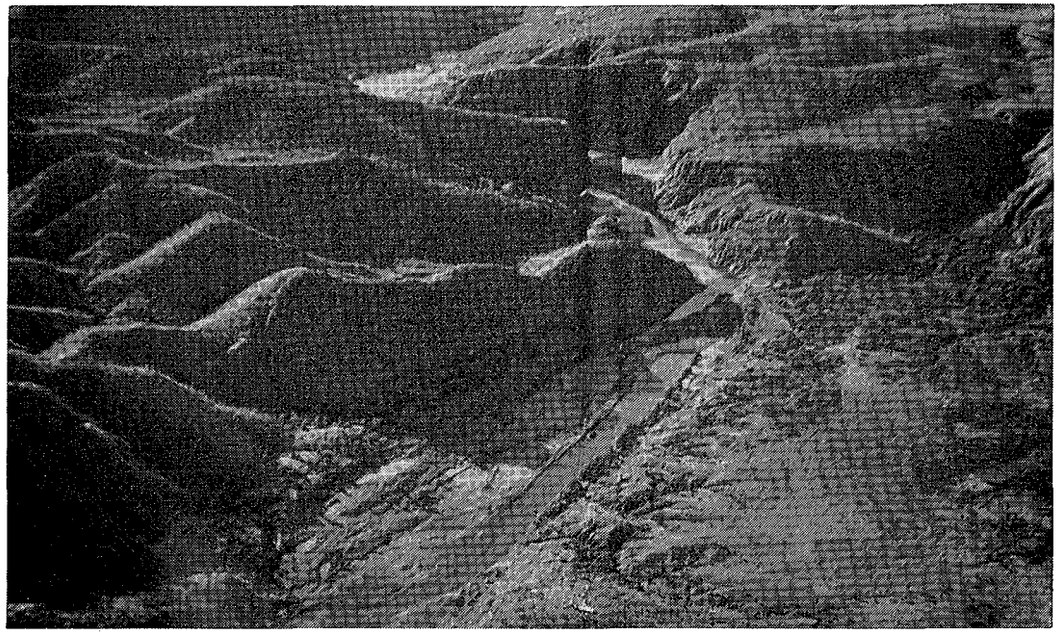
Ord River Gorge, site of the main Dam, viewed from upstream side.



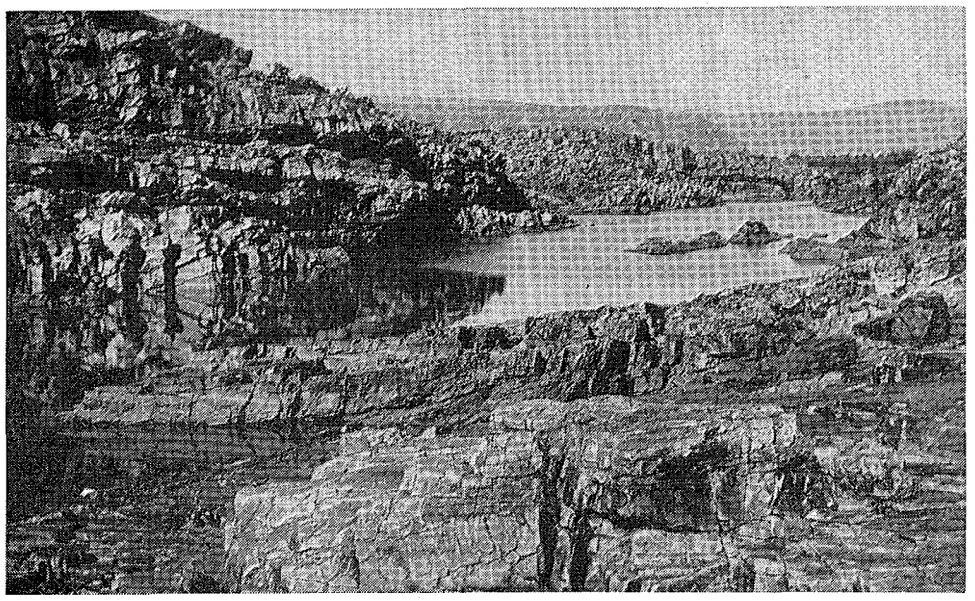
Gascoyne River Irrigation damsite at Kennedy Ranges. View taken from South abutment. The sand of Gascoyne River is visible in right centre.



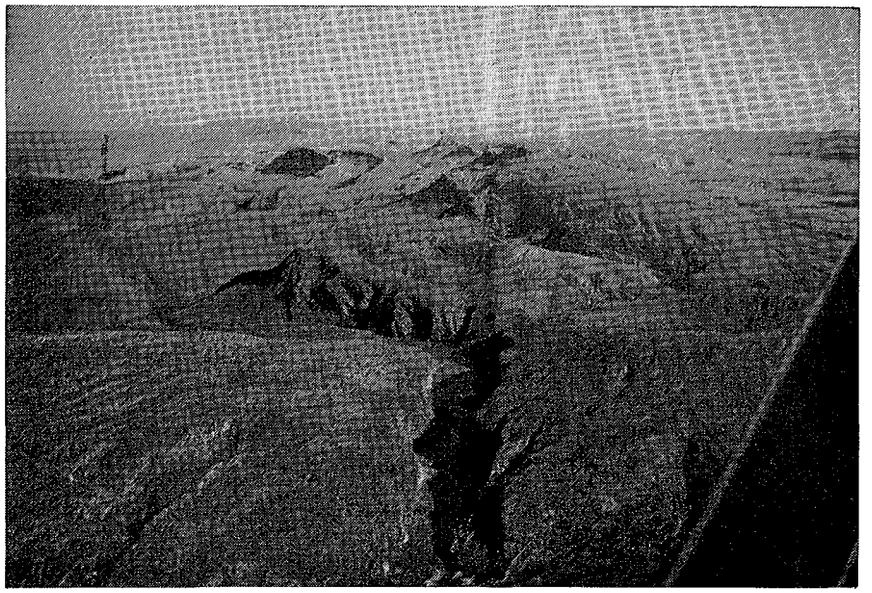
Spillway of 17 mile dam. Camballin.



Ord River Gorge site of the main Dam.



Fitzroy irrigation. Damsite at Dimond Gorge.



Damsite at Dimond Gorge.

QUESTIONS PUT TO MR. KELSALL
FOLLOWING THE ADDRESS ON WATER RESOURCES

1. QUESTION: Can you give a comparison of the water resources of the Kimberley region, to that of the Murray-Darling complex?

   ANSWER: The Murray River contributes so much to the over all economy of New South Wales, Victoria and South Australia that it is recognised as the most important river system in Australia and it is difficult in many ways to draw a full comparison with the undeveloped rivers of the Kimberleys.

   However from the point of view of surface water resources the latest report of the Australian Water Resources Council places the total resources of the Kimberley Region as being approximately 50% greater than those of the Murray System. Earlier assessments had placed the resources as being approximately the same.

2. QUESTION: Mr. Kelsall, can you give a comparison of irrigation development costs in southern areas, with that in the Ord Project Area?

   ANSWER: Costs are always difficult to compare. In the first place there hasn't been any recent large scale irrigation development in the South West and also of course the topography and types of development are so different in the two regions.

   However in general the cost of the irrigation distribution (i.e. excluding headworks and main supply channels) on the Ord is approximately £75 per acre while in the South West the cost would be approximately half this figure.

3. QUESTION: Is there any possibility of water from (say) the Fitzroy River, being impounded and piped to (say) the Three Rivers which is on the headwaters of the Gascoyne River, thus overcoming existing dry period problems on that river and making water available for irrigation?

   ANSWER: There are several major pipeline schemes in the World - including our own Goldfields Water Supply - where water is delivered over long distances by pumping through large diameter mains.

   Australian development in the future will, to a large extent, be dependent on availability of water and it will be necessary either to transport water over long distances or establish the future industries in areas where water is more plentiful.

   Generally speaking, however, it is unlikely that it would ever be economical to pump water from the Fitzroy River to the upper Gascoyne even with cheap tidal power. This is particularly the case since there is an adequate quantity of irrigable land in the Fitzroy area to utilize the resources of the river.

4. QUESTION: Does evaporation represent a great problem in water conservation projects in the Kimberley region?

   ANSWER: Yes evaporation represents a great problem on all water storages in Australia - particularly where the depths of storage is shallow and the surface area is large. In the Kimberley region the average evaporation would be approximately 8 to 10 feet per year.

5. QUESTION: Mr. Kelsall, you gave the figure of 1% of the water resources running into Lake Eyre in Central Australia. Is there any chance of developing this?

ANSWER: This is a matter for the Commonwealth Government and I am not aware of any proposals in this respect.

Generally, however, the rivers of Central Australia are much more unreliable than the rivers of our Pilbara area and I doubt whether any large scale development will ever be an economical proposition.

The water resources of a large area of inland Australia are principally confined to artesian sources.

6. QUESTION: Could not a film of oil be spread on the surfaces of our water storages to prevent evaporation in the manner that is done on the Boulder (or Hoover) Dam in the United States?

ANSWER: The retaining wall of the Hoover Dam on the Colorado River is 576 feet high above the river bed and is one of the largest dams in the World. Relatively speaking evaporation would not be a major problem and I am not aware of any attempts to reduce evaporation by use of an oil film.

The C.S.I.R.O. in Australia developed a system of evaporation control of Surface water storages using cetyl alcohol.

Although high hopes were held for the system, it has not proved very successful when used on larger storages. One of the main problems is that wave action breaks the film and also prevailing winds prevent a uniform film from being retained over the full surface area.