Rooded catchments for farm water supplies

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During the years 1948-51, the West Australian Public Works Department carried out a programme of drought relief storages in the south-eastern wheatbelt. These were in the nature of “key” storages and it was essential that they should contain water in the poor rainfall years when the farmers’ supplies had failed. Many old Government dams were enlarged and rehabilitated in this period, and a unique opportunity presented itself to study the causes of success or failure in the older schemes in order to develop and improve the new works. An energetic team of Departmental engineers worked on this programme and all assisted in developing what has become known as the “roaded catchment” which was the outstanding achievement of this works programme.

One of the most enthusiastic of the engineers was the late V. C. Munt, M.E., M.I.E. (Aust.), who said: “... the institution of these roaded catchments for farmers is the greatest single advance in water conservation that has been made in this State.”

Brief History of Development
It was observed that the amount of runoff from a natural catchment depended primarily on the intensity of rainfall. None of the natural catchments would run on falls of less than 75 points per day and many required more than an inch.
Methods of catchment improvement such as burning of surface litter and scrub and rolling the surface were tried, but these did not make the catchments run on light rains.

The three million gallon dam at Lake Biddy, for instance, had a very large catchment of several thousand acres. The surface was reasonably good but very flat. This catchment did not run at all in normal years but in the odd good year, sheet flooding occurred. A long contour drain from the dam picked up about half a mile of gravel road and it was noticed that this drain carried water in quite light rainfalls. Several other similar instances could be quoted.

It was decided to try forming roads on the catchments of the key dams. The first experiment was at James Dam just north of Lake Grace. In the winter of 1949 a single road 16ft. wide by 1,000ft. long was constructed using a small horse-drawn grader behind a T.D.9 tractor. The road was rolled with a three-ton steel roller. Alongside this road a similar strip was simply rolled to improve the surface but not graded. The whole area had been under cultivation for many years and the general slope was good for shedding water.

It was observed that the road ran extremely well on light rainfalls whereas the rolled strip did not run at all. This was conclusive proof that steep bare slopes are essential for shedding water. The water only had to travel a few feet on the average before it reached the drain at the side of the road and from there it ran away rapidly in a strong stream to the dam.

A further five roads were put in side by side using the Road Board grader and a rubber-tyred roller, making a total of about two acres. The roads all ran into a collecting drain at the lower end. The general results were most encouraging and it was decided to do much larger areas on the other key dams.

One serious fault was noticed at James Dam. The roads were put in on a grade of 1 in 100. This gave too high velocities on the lower sections of the roads which carry all the water, and led to erosion difficulties where the roads joined the collecting drains. Since this experiment, grades of roads have been limited to 1 in 200 except for short roads in good tight soils. Collecting drains must be limited to a grade of 1 in 400 or less provided with drops or concrete lined throughout.

**THEORY OF ROADED CATCHMENTS**

Much of the rain falling on wheatbelt catchments does not run off because it is either absorbed in the soil or it evaporates back to the atmosphere. If the rain is allowed to lie about or move only slowly, it will all disappear as fast as it falls.
A typical roaded catchment at Carnamah, showing collecting drain.

The top photograph shows a grader forming-up a roaded catchment on newly-cleared land. Below, the rubber-tyred roller is being used to compact the newly-formed roads. Rolling is essential.
In the roaded catchment the soil is compacted by heavy rollers to make it more impervious. The rubber-tyred roller used under moist conditions is doubly effective because it tends to produce a layer of finer material at the surface which is more impervious than the soil underneath. The roaded catchment provides a relatively steep fall and the total result is that water runs off much more readily. Further, the path of travel is quite short before the water reaches the defined drains in the Vees between roads. Once in these drains the water will run at veloci-

\[
\text{Average } \% \text{ run off } \frac{1.77}{7.44} = 23.8\% \text{ on effective storms over 30 pts.}
\]
\[
\frac{1.77}{14.12} = 12.5\% \text{ on total rainfall}
\]
ties up to 2ft. per second, and 3ft. per second in the main drain, so that further seepage losses are kept to a minimum.

The effect of weeds and leaf litter is to hold up the progress of the water allowing it greater time to seep away and evaporate.

**RAINFALL ANALYSES**

With the knowledge that roaded catchments will in general run on 30 points or better, an analysis of daily rainfall records has been made to see how much rain would be effective each year.

Analyses were made for Kulin, Lake Grace, Kondinin and Dalwallinu as shown on figures 1 to 4. For the 17 years from 1939-1955, the total rainfalls are shown on the left and the total falls exceeding 30 points on the right. On the average this represents 52.5 per cent., 52.2 per cent., 57
per cent. and 60 per cent. of the total rain-
fall respectively.

In the centre of these graphs is shown the 
total of rains exceeding 75 points 
which might have caused a good natural 
catchment to run. On the average, these 
amount to only 25 per cent., 22 per cent., 
21 per cent., and 25 per cent. of the total 
rainfall respectively. Furthermore, about 
one year in three is a complete failure, 
these sometimes occurring in succession.

The design basis of Departmental 
roaded catchments is 25 acres per million 
gallons storage. This works out to an 
equivalent runoff of 1.77 in. per year and 
is shown in the figures. It can be seen 
that the percentage of runoff required is 
about 24 per cent. based on the average 
of effective rains over 30 points. In all 
these records an adequate runoff would 
seem probable without any failure.

SOIL TYPES

In the early work, heavy clay type 
catchments were naturally preferred but 
it was found that light gravelly or sandy 
soils could be roaded successfully using 
modern rubber-tyred rollers for compac-
tion. In fact, rolling is so important that 
it should never be omitted or underdone. 
It is also many time more effective when 
the soil is wet than when it is dry. The 
minimum rolling time should be about 1½ 
hours per acre.

The grading curve in Fig 5 gives the 
limit in soil type from the experience of 
the Public Works Department. Briefly the 
percentage of clay should be 3 per cent. 
or greater and the percentage of gravel 
(retained on 3/16-inch screen) should 
not exceed about 25 per cent. Naturally 
less gravelly soils with more clay are to be 
preferred but this is not always possible.

On the other hand, extremely high clay 
contents are not desirable either. Such 
soils often become too sticky and slippery 
to roll properly and may tend to cake and 
crack after drying out.

In some parts of the wheatbelt the clay 
soils are very friable and crumbly. This 
is due to a high percentage of calcium in 
their make-up, and often nodules of cal-
cium carbonate or lime are present. These 
soils are associated also with sinkholes 
and crabholes which are well known 
features of some wheatbelt areas.

The Department has sunk dams and 
constructed roaded catchments in calcium 
clays, filling in sinkholes where neces-
sary. However, these soils do not compact 
very well and it is not recommended that 
they be used.
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SWIMMING POOLS
TOWN WATER SUPPLY
FIRE FIGHTING

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<table>
<thead>
<tr>
<th>Capacity</th>
<th>Diameter</th>
<th>Height</th>
<th>Weight</th>
<th>Price</th>
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<tr>
<td>50,000</td>
<td>33' 5&quot;</td>
<td>10' 4&quot;</td>
<td>2 1/2</td>
<td>£450</td>
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<tr>
<td>25,000</td>
<td>23' 10&quot;</td>
<td>10' 4&quot;</td>
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<td>75,000</td>
<td>40' 7&quot;</td>
<td>10' 4&quot;</td>
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<td>£564</td>
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<td>100,000</td>
<td>45' 9&quot;</td>
<td>10' 4&quot;</td>
<td>3 1/2</td>
<td>£642</td>
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Prices C.I.F. capital cities available on application

10,000 Gallon Water Tanks (tall or squat) are available also

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<thead>
<tr>
<th>Capacity</th>
<th>Diameter</th>
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<tr>
<td>14' 4&quot; Dia., 10' 7&quot; High</td>
<td>Basic unit — £132</td>
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<td></td>
</tr>
<tr>
<td>19' 1&quot; Dia., 6' 5&quot; High</td>
<td>Basic unit — £99</td>
<td></td>
<td></td>
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The possibility of replacing the calcium content with sodium by means of soda ash has been examined but the cost would seem prohibitive.

Another soil type worth mentioning is that known as solonetz, in which the top few inches are almost pure sand in the virgin state. Underneath is usually an extremely heavy clay with a rounded dome type of structure, each dome being some inches in diameter and divided from its neighbours by a crevice. These soils look hopeless for roaded catchment from surface indications but are, in fact, excellent, as the topsoil can be dozed off during clearing. The solonetz soil is betrayed by the
vegetation it carries, i.e. salmon gum and mallee, etc., which is not characteristic of true sandy country.

**THE KULIN CATCHMENT**

This was the first large area of roaded catchment. An area of 100 acres was prepared in 1950 from virgin country to provide for the new 4.7 million gallon town dam.

The soil varied from a heavy mallee type at the lower end to lateritic sandplain at the higher end. The method used was to scrub-roll and allow to dry, burn, remove debris by hand and grader, grade and roll, remove more debris by hand or scrub rake and and finally re-roll.

This method proved slow and inefficient. The mallee and scrub was just broken off, leaving a lot of roots which gave trouble later with regrowth.

The present method adopted is to remove vegetation and topsoil by dozer into stacks or windrows and burn. The mallee roots are largely cleared out by this method. The grader forms the roads immediately and rolling follows.

The roads at James Dam and Kulin were 16ft. wide which proved too narrow, as the sides were too steep and short causing the roller to slip. The standard now is 24ft. wide with a side slope of between 1 in 10 and 1 in 20. This seems to be about the optimum.

Runoff from the Kulin catchment was observed from time to time with the following results:

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall</th>
<th>Per cent. Runoff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 28</td>
<td>16</td>
<td>19.3</td>
</tr>
<tr>
<td>1951</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 10</td>
<td>42</td>
<td>26.3</td>
</tr>
<tr>
<td>January 16</td>
<td>40</td>
<td>23.3</td>
</tr>
<tr>
<td>March 29</td>
<td>47</td>
<td>*45.6</td>
</tr>
<tr>
<td>June 7</td>
<td>99</td>
<td>30.7</td>
</tr>
<tr>
<td>June 21</td>
<td>47</td>
<td>24.4</td>
</tr>
<tr>
<td>July 3</td>
<td>30</td>
<td>23.8</td>
</tr>
<tr>
<td>1952-53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July to March</td>
<td>Five falls over</td>
<td>24.2</td>
</tr>
<tr>
<td></td>
<td>30 pts., total</td>
<td>545 pts.</td>
</tr>
</tbody>
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<tr>
<td></td>
<td>30 pts., total</td>
<td>545 pts.</td>
</tr>
</tbody>
</table>

From these figures it can be seen that a lot depends on the intensity of the rain. Nevertheless it can be said that daily falls less than 30 points are generally ineffective while greater falls are effective and give an average runoff of about 25 per cent. on the total effective rainfall.

Various methods of deducting an arbitrary number of points for wetting the catchment have been tried. This approach is sound in principle but the number of points to wet the catchment varies tremendously with the intensity of rainfall.

**THE NARROGIN CATCHMENT**

An area of 50 acres of roaded catchment was constructed at Narrogin in early 1953 and provided with a flume and recorder for measuring rate of flow. A pluviometer was installed on the catchment also.

This area is in a higher rainfall belt than Kulin but the runoff data quoted here is for the winter of 1954 which was one of the driest on record.

The total rainfall from 21/5/54 to 8/9/54 was approximately 10 inches. The total runoff from the 50 acres was 3.93 million gallons, equivalent to a percentage runoff of about 35 per cent. In individual storms the percentage was as high as 71 per cent. from 98 points falling over a period of 10 hours. Sixty nine per cent. was obtained from 120 points falling over 56 hours. On the other hand, falls of 25, 20 and 19 points gave no runoff. An important factor in the percentage of runoff was whether the previous day’s fall had been sufficient to wet the catchment.

The Narrogin catchment thus gave considerably higher percentage runoffs than Kulin. The main reasons would be better rainfall and possibly lesser seepage and evaporation losses.

The total area of this roaded catchment at Narrogin is 150 acres which was constructed in the main by the Main Roads Department whose assistance on this work and the general development of roaded catchments is acknowledged.

**THE DALWALLINU CATCHMENT**

A roaded catchment of 100 acres was constructed here for the town dams. The runoff has been extremely good but the winter of 1952 was a critical test. This was the worst winter in 23 years at that time and only 667 points of rain fell in the winter period.
The total runoff was only 1.315 million gallons equivalent to 9 per cent on the total rainfall. No runoff was produced from falls of 38, 23, 30, 26, 23, 32 and 35 points which occurred in light drizzles lasting all day.

Since 1952, the Dalwallinu catchment has been progressively improved by cleaning up and rolling. This appears to have increased the runoff considerably as in recent years the 100 acres has been adequate for 4½ million gallons of storage, i.e., about 22 acres of roads per million gallons.

MAJOR DEPARTMENTAL ROADED CATCHMENTS
These might be listed as follows:

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Acres</th>
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<tr>
<td>Narrogin</td>
<td>150</td>
</tr>
<tr>
<td>Wicherina</td>
<td>100</td>
</tr>
<tr>
<td>Kulin</td>
<td>100</td>
</tr>
<tr>
<td>Brookton</td>
<td>100</td>
</tr>
<tr>
<td>Carnamah</td>
<td>150</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>100</td>
</tr>
<tr>
<td>Morawa</td>
<td>100</td>
</tr>
<tr>
<td>Tambellup</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>840</strong></td>
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</tbody>
</table>

In addition a large number of key storages have roaded catchments roughly at the rate of 25 acres per million gallons. The total is probably around 1,500 acres up to the end of 1955.

All of these catchments have been reasonably successful with the exception perhaps of Morawa and Wicherina. Morawa appeared to be a good catchment but never came up to expectations. The reasons for this have never been fully determined, but light rainfall, relatively hot climatic conditions with high evaporation losses and high absorption rates are the likely possibilities.

Wicherina catchment would have the same disabilities plus the fact that the soil was too sandy and the roads never appeared very impressive.

REGROWTH AND WEEDS
The problem of regrowth of mallee and scrub can be lessened by thorough bulldozing during construction. Regrowth must be attacked immediately in the first couple of seasons. Grubbing and flame throwers are used and the regrowth can be soon beaten.

If regrowth is left three or four years, it will reach a height of 6ft. to 8ft. in some cases and practically ruin a catchment.

Weeds are a problem on the crown of the roads. They do not often grow in the Vees as the subsoil is generally unsuitable. Weeds should be burnt off in early sum-
An example of a well-constructed dam on falling ground. Note how the bank holds water thus saving excavation costs. There is an outlet pipe running under the bank on the lower side, a cemented inflow, and provision for an overflow in the far corner.

Weeds should not be removed by grading as this upsets the surface which improves as the years go by. The weed problem is worst in the first year or two after construction and will become insignificant if attended to.

FARMERS' CATCHMENTS

The ideal application of the roaded catchment is to the farmers' dam rather than to large-town supplies. A typical dam and catchment is shown in the sketch at the commencement of this article.

The Public Works Department commenced a scheme for constructing catchments for farmers in the winter of 1952 using graders from the irrigation areas in their off season.

Up to the end of 1955 the Department has constructed 332 such catchments, aggregating about 1,350 acres. Of this number only six were done during 1955 because the Department had other grading commitments and did not attempt to "sell" the scheme, as it had done previously.

It is felt however, that when farmers fully appreciate the benefit resulting from catchment roading there will be a steady demand for this service which is done at actual cost.

The cost of 6 acres of roaded catchment is about £100. This is sufficient to fill a 1,500 cubic yard dam (250,000 gallons), poor years included. If one takes the annual charges on this outlay as £6 the cost of water stored is about 6d. per 1,000 gallons which is very cheap.

The roaded catchment has made extensive water conservation economically possible throughout the wheatbelt areas. For instance, an average farmer with say 3,000 acres can provide himself with a million gallon dam (6,000 cubic yards) for about £1,200. If he makes good use of sloping land and holds in bank, the cost is only about £600. The necessary 25 acres of roaded catchment would cost about £400 and extras such as stone-pitching...
the inlet and bywash, provision of silt pit, oftakes, etc., would make the total cost about £1,200.

Such a storage makes the farmer independent and free from worries about droughts provided he looks after the catchment. The annual charge on the outlay at 6 per cent. is £72 for a million gallons of water per year. This amounts to Is. 6d. per 1,000 gallons which is still extremely cheap. The price of water in areas reticulated from the Goldfields Water Supply Scheme is 4s. per 1,000 gallons for rebate and excess.

Because of the few fresh streams and rivers in this State and the high cost of piped supplies the necessity for farmers to provide their own storages using roaded catchments cannot be over-emphasised.

WATER HARVESTING

Many farmers, agriculturists and engineers are familiar with the work being done by Mr. Geddes at Badgery Creek near Sydney. About two-thirds of the farm is utilised purely as catchment for water storage. The remaining third of the farm is sprinkler irrigated from these storages and the overall production from the farm as a whole would appear to have been greatly increased.

The annual average evaporation at Badgery Creek is 43in. and the rainfall 26in. giving a ratio of precipitation to evaporation of 0.60 which is very much higher than for the wheatbelt areas of Western Australia. At Badgery Creek the runoff has been adequate, i.e. of the order 20 per cent., and more, without any catchment improvements so far.

Obviously this system does not apply to our wheatbelt areas in its present form, but with roaded catchments it would seem that the idea of water harvesting can be used with great benefit.

CONCLUSION

It should never be forgotten that every inch of natural rain on every acre amounts to nearly 23,000 gallons, or every 12 inches to 270,000 gallons. If the current price of water of 4s. per 1,000 gallons is applied, an annual rainfall of 12in. is worth £54 per acre per year. In this dry State of ours, we cannot afford to neglect this water potential. If even a small percentage can be conserved, the return in water could be by far the best harvest that the land can yield.

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<td>Binding Covers</td>
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<td>9 0</td>
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<tr>
<td>Filing Cases (with tapes and flaps)</td>
<td></td>
<td>12 6</td>
</tr>
</tbody>
</table>

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