# Research in Soil and Water Conservation Engineering Progress Report No. 2, 1960-1961. January 1962.

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THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY


REPORT No. 57

# Research in Soil and Water Conservation Engineering

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by

John R. Burton and T. R. Fietz

JANUARY, 1962

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# RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING-

# PROGRESS REPORT NO. 2, 1960-61.

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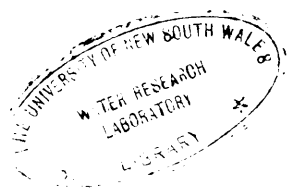


Report No. 57

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# PREFACE.

Within the School of Civil Engineering of the University of New South Wales, several research projects, which, together come under the heading of Conservation Engineering Research, have been in progress since 1957.

These projects are financed by the Water Research Foundation of Australia Limited, the Rural Credits Development Fund of the Commonwealth Bank and the University of New South Wales.

This second Progress Report outlines research activities during the period July 1960 to December 1961. An earlier Progress Report covering the period January 1957 to June 1960 has previously been published as Water Research Laboratory Report No. 51.

Since 1959 conservation research activities have been centred at the Water Research Laboratory, Manly Vale, N.S.W. The research programme is under the direction of Mr. J.R. Burton of the Laboratory Research staff.

H.R. Vallentine,
Assoc. Professor of Civil Engineering,
Officer-in-Charge of the Water
Research Laboratory.

25th January 1962.

# RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING - PROGRESS REPORT NO. 2, 1960-61.

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## 1. Introduction

Since 1957 the School of Civil Engineering of the University of New South Wales has pursued research into some of the engineering aspects of agricultural water management, and this work has been classified under the general heading of conservation engineering.

A report outlining the early activities in this field has previously been published as "Research in Soil and Water Conservation Engineering - Progress Report No. 1, 1957-1960" (June 1960: re-issued as Water Research Laboratory Report No. 51 in January, 1962). This second report discusses progress over the period July. 1960, to December 1961.

During this period the conservation research programme has continued along the three avenues previously established; the hydrologic and economic design of small reservoirs, the structural design and construction of low earth dams, and the control of seepage losses from farm ponds. Some of the research under these headings has been supported by grants from the Water Research Foundation of Australia and the Rural Credits Development Fund of the Commonwealth Bank. The major financial contributor to the programme is the University, through the staff and facilities of the Civil Engineering School.

This report outlines progress under the several research topics, and discusses matters of staff, finance and organisation associated with the research programme. Some proposals for further activities are presented. Detailed reports for some of the major research topics are appended.

## 2. The Conservation Research Programme

### 2.1 General Progress, 1960-61

The period under review was largely one of consolidation for the conservation research programme. For almost the entire period Mr. J. R. Burton was overseas on sabbatical leave (2nd September, 1960 to 2nd December, 1961) and research activities were carried out virtually single-handed by Mr. T. R. Fietz, who was employed as a Research Fellow under grants from the Commonwealth Bank and the Water Research Foundation of Australia. Research was therefore restricted for the most part to the topics covered by these grants.

The research programme has been divided into three major topics; the hydrologic design of small reservoirs, the structural design and construction of farm dams, and the control of seepage losses from farm

ponds. Outside funds for the first two of these topics have been provided by annual grants from the Water Research Foundation of Australia, under the general heading of "Improved methods for the design and construction of farm dams under Australian conditions". During 1961 the Foundation decided that in future two separate grants should be made, and the first of these, for research in the structural design and construction of farm dams, was approved late in 1961. It is anticipated that a new grant for research in the hydrologic design of farm dams will be made early in 1962.

Seepage control research has been supported by two grants; one from the Water Research Foundation of Australia for an investigation of the possible application of plastic membranes, and one from the Rural Credits Development Fund of the Commonwealth Bank for general seepage control research. At the beginning of the period under review it was agreed that sufficient progress had been made with the plastic membrane study to render further grants unnecessary, and the Foundation grant discontinued. Seepage research involving other techniques has been carried forward with the support of the Rural Credits Development Fund.

Progress under the heading of hydrologic design has been largely confined to development of the HYDRA data collection scheme. This scheme has now been in operation for three years and a review of the results obtained is given in Appendix B.

A survey of the experimental catchments operated in Australia by various streamgauging authorities was completed during the period.

Whilst in the United States Mr. Burton investigated current developments in hydrologic design and undertook research aimed at developing optimal design and operation procedures for small reservoirs and reservoir systems of the Water Harvesting type.

The major activity under the heading of structural design and construction was the conducting of a survey of farm dam use in New South Wales. 1247 landholders were questioned concerning water requirements, water storage facilities, and the construction and performance of farm dams. A preliminary analysis of this survey has been made.

A field construction study was undertaken at North Richmond, N.S.W., in order to evaluate the dam construction techniques advocated by Mr. P.A. Yeomans. Soil studies were made during the construction of a large farm dam and observations of the behaviour of the structure have been continued.

Seepage control studies were handicapped by staff shortages (as were all the research projects), particularly through the lack of a qualified technician for soil testing. The University made funds available for the employment of a laboratory technician in August, 1961, and a detailed laboratory study of sealing techniques using trace chemicals was then undertaken. Some further work on plastic membrane testing was carried out in order to finalise this topic.

## 2. 2 Hydrologic and Economic Design of Small Reservoirs

### 2. 21 General

The reasons for, and basis of, the research activities coming under the heading of "Hydrologic and economic design of small reservoirs" have already been discussed in some detail in "Research in Soil and Water Conservation Engineering - Progress Report No. 1, 1957-1960", to which the reader is referred.

Briefly, this research has two objectives - to provide immediately techniques which will permit at least an approach to the economical design of farm reservoirs, on the basis of available knowledge, and to establish a data collection scheme so that ultimately precise design information will be available. This research is concerned with the hydrologic design of the storage reservoir, which involves a determination of the volume of water to be stored and the area of catchment needed; for the time being, at least, the question of spillway design is not being considered. The use of the term "economic" implies that an attempt is made to provide the most efficient, i. e. most economical, design and operation of the catchment-reservoir-water use system.

Previous research (see Progress Report No. 1) has attempted to develop methods for estimating catchment yield from available rainfall records and has commenced a data collection scheme known as HYDRA, which makes use of farm dams as water measuring devices.

### 2. 22 The Catchment Survey

Earlier work under this topic attempted to develop methods for estimating the yield of ephemeral catchments used for farm dam watersheds. An attempt was made to establish rainfall-runoff relationships using available records from some small experimental watersheds in N. S. W.

In order to assess what sort of runoff information is already available throughout Australia a questionnaire was sent, at the end of 1960, to all streamgauging authorities and organisations known to be interested

in runoff measurements throughout Australia. A total of 23 authorities was contacted; these are listed in Table 1. The questionnaire asked for detailed information on catchment location, characteristics and instrumentation for all experimental catchments or gauged watercourses having a catchment area of less than 10 square miles. Detailed replies have been received from 15 authorities; several others have no appropriate watershed areas. The results of this survey are to be published in the near future.

2.23 The HYDRA Scheme

The HYDRA Scheme is a scheme of hydrologic data collection which aims to collect approximate information about catchment yield by measuring the inflow into farm dams. As originally conceived it involved an extensive network of gauged farm dams, with observations made by landholders. This network was to be supplemented by a series of fully-instrumented experimental watersheds for precise measurements of rainfall and runoff. The original development of the Scheme has been discussed in detail in Progress Report No. 1. A survey of the results so far achieved is appended to the present report as Appendix B.

At the commencement of the period under review the HYDRA Scheme comprised 19 recording stations as follows:-

8 Class I stations (Simple gauged dams with raingauge).
3 Class II stations (Farm dam with water level recorder).
8 Class III stations (Experimental watershed with gauging station or flume and pluviometer).

By 31st December, 1961, a total of 22 HYDRA stations had been set up. Of these, however, 5 had been closed down and 5 were inoperative for various reasons, leaving a total of 12 active stations as follows:-

4 Class I stations
2 Class II stations
6 Class III stations

A brief summary showing the status of each station is given in Table 2. Evaluation reports for all stations are given in Appendix B.

The most satisfactory results have been obtained from the Class III stations. With the exception of the two catchments at Futter Park, Harden, which were closed in January, 1961, because the King's School no longer desired to assist in their operation, all Class III stations have been operated continuously and over 30 useful hydrographs

## TABLE I

## CATCHMENT SURVEY

## LIST OF AUTHORITIES QUESTIONED

1. NEW SOUTH WALES
   a. Water Conservation and Irrigation Commission, Sydney.
   b. Metropolitan Water Sewerage and Drainage Board, Sydney.
   c. Soil Conservation Service of N. S. W. Sydney.
   d. C. S. I. R. O. Sheep Biology Laboratory, Prospect.
   e. Snowy Mountains Hydro-Electric Authority, Cooma.
   f. Hunter Valley Research Foundation, Newcastle.

2. VICTORIA
   a. Soil Conservation Authority, Kew.
   b. State Rivers and Water Supply Commission, Melbourne.
   c. Metropolitan Board of Works, Melbourne.
   d. Latrobe Valley Water and Sewerage Board, Traralgon.
   e. State Electricity Commission, Prahan.

3. QUEENSLAND
   a. Irrigation and Water Supply Commission, Brisbane.
   b. Department of Agriculture and Stock, Brisbane.

4. SOUTH AUSTRALIA
   a. Engineering and Water Supply Dept. Adelaide.
   b. Department of Agriculture, Adelaide.

5. WESTERN AUSTRALIA
   a. Department of Public Works, Perth.
   b. Metropolitan Water Supply, Sewerage and Drainage Board, Perth.

6. NORTHERN TERRITORY
   a. Northern Territory Administration, Darwin.

7. AUSTRALIAN CAPITAL TERRITORY
   a. C. S. I. R. O. Division of Plant Industry, Canberra.
   b. C. S. I. R. O. Division of Land Research and Regional Survey.
   c. Bureau of Mineral Resources.
   d. Land and Stock Section, Dept. of the Interior.

8. TASMANIA
   a. Hydro-Electric Commission, Hobart.

# TABLE 2

## THE HYDRA SCHEME; DETAILS OF STATIONS

## AS AT 31ST DECEMBER, 1961.

| Station | Location | Mean Rainfall Ins. | Date Set Up | Remarks |
|---|---|---|---|---|
| CLASS I STATIONS | | | | |
| HI/ 1 | Parkes (Central West) | 18 | Jan. 59 | Inoperative at present, instruments not set up. |
| HI/ 2 | Dubbo | | | Inoperative at present, instruments not set up. |
| HI/ 3 | Urana (Riverina) | 17 | Nov. 58 | J. F. observer. Operating satisfactorily. |
| HI/ 4 | Mathoura (Riverina) | 15 | Nov. 58 | J. F. observer. Inoperative, move to new site pending. |
| HI/ 5 | Temora (S. W. Slopes) | 25 | Nov. 58 | J. F. observer. Operating satisfactorily. |
| HI/ 6 | Marrar (S. W. Slopes) | 22 | Nov. 58 | J. F. observer. Changed to Class II April, 1961. |
| HI/ 7 | Humula (S. W. Slopes) | 30 | Nov. 58 | J. F. observer. Closed 1960, observer left district. |
| HI/ 8 | Merriwagga (Riverina) | 15 | Apr. 61 | J. F. observer. Operating satisfactorily. |
| HI/ 9 | Wentworth (Western) | 10 | Apr. 61 | J. F. observer. Operating satisfactorily. |
| HI/ 10 | Fowler's Gap (Western) | 7 | - | Instruments at site but not installed. |
| HI/ 11 | " " | 7 | - | " " " " |
| CLASS II STATIONS | | | | |
| HII/ 1 | Richmond | | Jul. 58 | Closed 1960. Of little value. |
| HII/ 2 | Lismore | 60 | Feb. 60 | Operating satisfactorily. |

Continued over

TABLE 2 (CONT'D)

THE HYDRA SCHEME: DETAILS OF STATIONS

AS AT 31ST DECEMBER 1961.

| Station | Location | Mean Rainfall Ins. | Date Set Up | Remarks |
|---|---|---|---|---|
| CLASS II STATIONS (cont'd.) | | | | |
| HII/ 3 | Orange | | | Closed 1960, dam no longer used as intended. |
| HII/ 4 | Marrar | 22 | Apr. 61 | Originally Class I. J. F. observer. Operating O. K. |
| CLASS III STATIONS | | | | |
| HIII/ 1 | Badgery's Creek | 28 | 1958 | Univ. N. S. W. Joint project Operating satisfactorily. |
| HIII/ 2 | Mt. Vernon | 28 | 1958 | do. |
| HIII/ 3 | Parramatta | | 1960 | do. |
| HIII/ 4 | Scone | 25 | 1960 | Joint project with S. C. S. Operating satisfactorily. |
| HIII/ 5 | Scone | 25 | 1960 | do. |
| HIII/ 6 | Barcaldine, Q'land. | 17 | 1960 | Joint project with West. Q. Local Govt. Authorities. Operating satisfactorily. |
| HIII/ 7 | Harden | 23 | 1958 | Closed 1961. |
| HIII/ 8 | Harden | 23 | 1958 | Closed 1961. |

have been obtained. It is interesting to note that no surface runoff has yet occurred on the catchment at Barcaldine, Queensland, giving some indication of the severity of the present drought in that area.

All Class III stations have been operated as joint projects, in which other authorities have co-operated in supplying some of the instrumentation and have supplied maintenance staff. The outstanding example of this is the Barcaldine catchment. In this case the cost of constructing the weir and wing walls was met by the Western Queensland Local Authorities Association, whilst the pluviometer and waterlevel recorder were provided by HYDRA. A firm of consulting engineers in Barcaldine, who initiated the project, maintain the station in an extremely satisfactory manner. It is proposed that future Class III stations shall conform wherever possible to this model.

Two of the original Class II projects originated as seepage control experiments. At the conclusion of these experiments it was found that the dams were not well suited to HYDRA and the stations were closed. A third seepage experiment has continued successfully as a HYDRA station. A new Class II station was installed on an original Junior Farmer Class I station at Marrar in April, 1961. The operator is extremely keen and a most conscientious observer and excellent results have been obtained from his station. In general it now appears that Class II stations are of little value and they will in future be installed only in special cases.

The least satisfactory results have been obtained from the Class I stations. Of the 7 stations set up at the commencement of the HYDRA Scheme only 2 continue to operate. Of the others, two have never been properly set up and the observers who are not Junior Farmers, have lost interest; this has largely been the fault of the University, which has not had the staff to follow up the original installation. One Junior Farmer station has been closed because the observer left the district, whilst another has become inoperative because the observer married and lost interest in Junior Farmer activities. A proposal to transfer this station to another Junior Farmer in the same district is in hand. The third Junior Farmer station has become a Class II station, as mentioned above, and the observer deserves credit for his interest.

The remaining two HYDRA stations are located at Fowler's Gap, 70 miles north of Broken Hill, on a research station operated by the N. S. W. Department of Conservation. Mr. Fietz visited this district in April, 1961 in order to instal the instruments and carry out catchment surveys, but heavy rains isolated the station and made field work impossible. The instruments have been left at the site with instructions

for their installation, but so far as is known they have not yet been set up.

A detailed study of the records from the Class I stations is not possible because no catchment area surveys have been completed; a lack of suitable field staff for such surveys has proven a considerable handicap. The records indicate that in some cases the bywashes overflow frequently, and water passing over them cannot be measured. In future, careful selection of dam-sites will be necessary to ensure that catchment areas are small in relation to dam capacities, and some attempt must be made to instal spillway flow measuring devices. The development of a cheap recording instrument for this purpose would greatly enhance the value of the Class I stations.

The greatest problem experienced to date with the HYDRA Scheme has been the lack of suitable personnel to carry out station installations and surveys and to follow up by frequent visits to observers, particularly people operating Class I stations. For the greater part of the period under review Mr. Fietz was in sole charge of the conservation research programme. His salary was paid jointly from Rural Credits and Water Research Foundation grants, in the proportion two-thirds to one-third. He was therefore entitled to devote only one third of his time to projects under the Water Research Foundation topics, which included the farm dam survey and structural design and construction research, besides the HYDRA Scheme. The services of a full-time field officer are essential if the Scheme is to develop and function efficiently. A considerable amount of clerical assistance would also appear to be necessary.

Experience has shown that the Junior Farmer observers are reliable operators, and the visits of Junior Farmer supervisors have done something to offset the lack of attention from University personnel. It is still proposed to develop the Class I stations using Junior Farmer observers wherever possible. A total of over 30 names has been received of young people willing to take part in the Scheme. It is proposed now to develop the Scheme by districts based on Class III stations, using a group of Class I dams around each Class III district to supplement the basic Class III data.

In summary it has been shown during the period under review that the HYDRA Scheme can operate successfully, particularly where regular personnel are available as in the Class III stations. The Class I stations require more careful selection in regard to the relation between catchment area and dam capacity and the possibilities of gauging bywash overflows need investigation. The services of a full-time officer are essential if proper instrumentation and station continuity are to be expected. Class II stations should be discontinued except in special circumstances.

### 2. 24 Economic Design of Small Reservoirs

During the period under review Mr. Burton continued his research into methods for the economic design of small reservoirs. This project has resolved itself into two main problems - how to estimate catchment yield, which is the principal factor governing reservoir size, and how to determine the optimal reservoir size and operating policy under given hydrologic and economic conditions.

Attempts to obtain simple rainfall-runoff correlations for Australian catchments have been unsuccessful. Whilst in the United States, Mr. Burton conferred with officers of the Agricultural Research Service and the Soil Conservation Service regarding a storm-by-storm analysis using standardised rainfall-runoff curves. Check calculations indicate that this method, suitably modified, might prove suitable for Australian catchments. A brief description of the principles of this method is given in Appendix D. Statistical methods recently developed for the extension of available data were also studied and an approximation suitable for small ephemeral catchments was tested.

Whilst at the Water Resources Center of the University of California, Mr. Burton attempted to adapt optimal planning methods to the design and operation of small reservoirs and reservoir systems. A general technique was developed and programmed for a digital computer; it was found that extremely short computer times, well within the economic limit for farm dam design, were feasible. Simple graphical procedures were also investigated. The results of this research are shortly to be published.

## 2. 3 Structural Design and Construction of Small Earth Dams

### 2. 31 General

The basis of the research activities coming under this heading have been discussed in some detail in "Research in Soil and Water Conservation Engineering - Progress Report No. 1, 1957-1960".

The research programme accepts the thesis that whilst adequate design and construction procedures are available for earth dams, the construction methods normally considered good engineering practice for larger structures are neither economical nor necessary in the building of farm storages. On the other hand, many of the procedures currently employed by farm dam builders are unsound. An attempt is therefore being made to develop standardised designs, simple construction control tests and economical construction methods.

Previous research (see Progress Report No. 1) studied failures in conventionally-built farm dams in order to discover the reasons for these failures. A programme of state-wide soil sampling and testing was also commenced in order to determine the index properties of typical dam-building soils and relate these to dam behaviour. Some trial embankment construction studies were also undertaken.

During the period under review the major research effort has been a survey of farm dams in N. S. W., aimed at collecting data on the districts in which dams are most used, the types of dams employed, failure rates, etc. A construction study has also been undertaken. Lack of soil testing staff has prevented the continuance of the "index property" studies, whilst construction studies proposed in conjunction with the New South Wales Soil Conservation Service at Bulga, near Singleton, had to be abandoned because of heavy rain for the second year in succession.

2.32 The Farm Dam Survey

The Farm Dam Survey was designed to give a picture of farm dam use in N. S. W. It was hoped that this would indicate the current problems in design, construction and use of farm dams and tanks and provide a basis for future research.

Appendix C discusses the questionnaire and method of sampling and gives a preliminary outline of the results obtained.

The questionnaire was prepared early in 1960. It asked 46 questions, on the following topics:-

a. Details of property, land use, water sources.

b. Numbers of dams and tanks; dimensions, construction details, costs, soils used and other details for each storage.

c. Details of the catchment areas, including soils, cover frequency of runoff.

d. Hydrologic details of the storages, such as frequency of drying out, spillway details, use of water.

e. Details of failures or inability of dam to meet the purpose for which it was intended.

The questionnaire form was designed so that most of these questions could be answered by simply ticking the appropriate column. The nature

of the replies suggests, however, that many people were frightened by the detail of the form and did not reply for this reason.

A pilot sample of 55 questionnaires was sent in September, 1960, to selected graziers who had attended the May School of the University of New South Wales in that year. 49 percent of these men replied to the questionnaire and the quality of their replies indicated that the form of the questionnaire was satisfactory.

The main sample was mailed in February, 1961, to 1,000 landholders, selected by a random process from the list of 20,288 names given in the "Pastoral Directory, 1957". The method of sampling is outlined in Appendix C. The sample was divided into 60 sub-samples based on pastoral districts, and the size of each sub-sample was proportional to the number of names in the district. This procedure is perhaps open to question on statistical grounds, and this problem is briefly discussed in Appendix C. It was, however, the only possible approach with the staff available.

In June, 1961, reminder letters were sent to those who had not replied to the first letter. In some cases, where a landholder had indicated that he was not willing to participate in the survey, a new form was sent to another landholder in the same district. A total of 192 "second-try" questionnaires was sent out in this way.

Table 3 summarises the response to the questionnaire as at 31st December, 1961. Of a total of 1192 contacts, 720, representing 60 percent, had not made any reply at all. 472, or 40 percent, had responded to the questionnaire in some way. Of these latter some 274, or 23 percent, returned replies which listed dams or tanks.

A detailed analysis of the returns has commenced. Whilst the proportion of returns obtained does not permit a proper state-wide statistical analysis for such tiems as number of dams per property, volume of water stored per 1,000 acres of pasture, etc., the questionnaire has shown itself to be of considerable value in indicating the state-wide distribution of dams and tanks, in locating high failure areas, in giving rough figures for catchment yield etc. It is anticipated that extremely useful results will become apparent as the analysis proceeds and a sound basis for the future research programme should result from it.

It is of interest to note the overall distribution of failures and the major causes of failure, as shown in Table 4. From a total of 1897 dams

# TABLE 3

## FARM DAM SURVEY

## SUMMARY OF RETURNS FROM MAIN SAMPLE

| Item | Number | Percent of total sample | Percent of useful replies |
|---|---|---|---|
| Original sample | 1000 | - | - |
| "Second try" questionnaires | 192 | - | - |
| Total main sample | 1192 | - | - |
| Replies with details of dams or tanks | 274 | 23 | 75 |
| Replies from parties with no dams or tanks | 91 | 8 | 25 |
| Total useful replies | 365 | 31 | 100 |
| Replies that did not wish to take part in survey | 107 | 9 | - |
| Total replies received | 472 | 40 | - |
| No reply of any sort | 720 | 60 | - |

## TABLE 4

## FARM DAM SURVEY: PRELIMINARY ANALYSIS OF CAUSES OF FAILURE.

| | | |
|---|---|---|
| Total number of dams for which details given | | 1879 |
| Total number classified as failures | | 384 |
| Overall failure rate | | 20 pc. |
| Major causes of failure as pc. of total failures | Inadequate catchment or storage volume | 36 pc. |
| | Seepage | 29 pc. |
| | Overtopping | 14 pc. |
| | Structural slumping or cracking | 4 pc. |
| | Others: Silting, tunnelling, etc. | 17 pc. |

some 384, or 20 percent, were considered by their owners to have failed. Of these failures, the high proportion of 50 percent were attributed to hydrologic causes, 36 percent being due to the catchment being too small or the volume of storage being inadequate and 14 percent being due to breaching as a result of insufficient spillway capacity. A further 29 percent were due to excessive seepage. The surprisingly low proportion of 4 percent were attributed to structural causes such as cracking and slumping, although it is suspected that many of the spillway failures might be traced in the first instance to excessive settlement. The remaining 17 percent of failures were due principally to excessive silting.

Details of dam costs have not been properly studied. It might be pointed out, however, that 1900 dams at an average cost of £500 to £600 represents an investment of roughly £1 million. If it can be assumed that this sample is representative, a direct extrapolation leads to the conclusion that the total investment in farm dams in New South Wales is of the order of £50 million. It might further be concluded that the total loss from dam failures over the last 10 years, say, has been of the order of £10 million which could represent an annual loss of £1 million. It must be emphasised that these figures are approximate estimates based on a cursory examination of the Survey returns, and they may be grossly in error. At the same time, and when considered in conjunction with the reasons for failure outlined above, they indicate that a considerable expenditure on farm dam research can be well justified.

An attempt will be made in February, 1962, to contact those persons who did not reply, using a short "yes-no" type form, in order to complete the more important statistics on a state-wide basis. It is apparent from an examination of the results received that a better response might have been obtained through personal contact. This approach was obviously impossible because of lack of staff. It is hoped, however, that as and when field staff become available the first survey might be supplemented by personal visiting within the more important districts indicated in the present returns.

### 2.33 Keyline Construction Study

The principal objective of the structural design and construction research programme is to produce a series of manuals containing specific design and construction data for representative districts of N.S.W. The first district to be so treated is the County of Cumberland, where dam construction for supplemental irrigation purposes is extremely active. Some soil testing and failure studies in parts of the County have been undertaken. It is proposed to extend these studies during 1962.

Because of the publicity associated with the construction methods advocated by Mr. P. A. Yeomans in connection with his Keyline Plan, it was felt desirable to include a study of these methods. The opportunity presented itself in April, 1960, when Mr. Yeomans commenced the construction of a large farm dam on his property "Yobarnie" at North Richmond, N. S. W., in typical County of Cumberland soil. Mr. Yeomans invited the participation of the University in a construction study, and the field work was undertaken by Mr. Fietz.

The objectives of the study were:-

a. To observe "Keyline" methods of dam construction.

b. To assess the general efficiency of "Bulldozer-only" construction in County of Cumberland soils.

c. To observe the behaviour of the embankment after completion and filling.

The dam has a height of about 20 feet. It was constructed using two bulldozers, a Caterpillar D6 and an Allis-Chalmers HD11. The compaction efficiency of the two bulldozers was gauged by taking insitu density tests during and after construction and correlating the results obtained with compaction tests carried out on the same soil samples in the laboratory. The settlement of the embankment due to post-construction consolidation was measured by establishing concrete plugs on the crest of the dam and checking their levels at regular intervals.

33 insitu density checks were made and to date 9 of the samples from these checks have been subjected to laboratory compaction tests. The following tentative conclusions are submitted by Mr. Fietz:-

a. In this case the soil was compacted at a soil moisture content close to optimum.

b. With Keyline construction (which means in effect a particular pattern of earthmoving through the borrow area and onto the wall), the compaction achieved by the D6 tractor was close to the maximum obtainable with the Harvard Compaction Test.

c. The Allis-Chalmers tractor was about 75 percent as efficient as the D6 for compaction purposes.

d. 7 months after completion the embankment had settled 3 inches in a wall height of 18 feet, i.e., a settlement of 1.4 percent. This figure indicates that thorough bulldozer compaction in County of Cumberland soils makes it unnecessary to provide the customary 10 percent allowance for settlement.

The most common method of construction in the County of Cumberland is to use a D6 or D8 Caterpillar tractor. This study (although admittedly based on one dam only) suggests that this technique is sound provided that soils are in a moist condition and that an adequate earthmoving procedure involving thorough compaction throughout the wall is employed.

Further settlement checks, 24 more Harvard Compaction Tests and some shear testing remains to be completed. As in other soil research projects, the lack of a soils technician during most of the period under review proved a serious handicap.

## 2.4 Seepage Control in Farm Ponds

### 2.41 General

Seepage control research at the University of New South Wales commenced in 1957, when the Water Research Foundation of Australia made the first of three annual grants for an investigation of dam sealing with plastic membranes. Expansion into other sealing techniques was made possible in 1958 when the Rural Credits Development Fund made a general seepage investigation grant. To date the investigation has considered three principal methods of seepage control; the use of impervious membranes, the stabilisation of soils with trace chemicals, and the incorporation of impervious soil additives. Earlier activities in these three fields have been reported in "Research in Soil and Water Conservation Engineering - Progress Report No. 1, 1957-1960".

During the period under review the principal activity was in the field of trace chemical stabilisation. A number of chemicals other than sodium tripolyphosphate were examined: these included sodium hexametaphosphate (Calgon), trisodium tetraphosphate (Tetron) and sodium carbonate, together with two proprietary sealing chemicals, SS 13 and AM 9. The effects of these chemicals on soil properties were tested in the laboratory and their relative sealing characteristics were examined by means of standard soil samples. A series of evaluation tests for determining the best material to use for sealing a given soil were developed.

Some plastic membrane testing was continued in order to finalise the current programme of plastic membrane studies. These tests for the most part were concerned with wind damage and outdoor exposure, and included weathering and plant damage tests at Manly Vale and Griffith, N. S. W., and a study of the stability of various cover materials under wave action.

Some limited bentonite testing was also carried out. A mixing machine for bentonite slurry research was obtained from America.

Whilst in the United States Mr. Burton investigated current developments in seepage control and visited a number of laboratories and field stations. These included the Utah Agricultural Experiment Station and the California Agricultural Experiment Station in connection with plastic membrane studies; the South-West Research Station of A. R. S. at Tempe, Ariz., the University of Arizona at Tuoson, Ariz. and the Massachusetts Institute of Technology in connection with trace stabilisation; Colorado State University and the laboratories of the American Colloid Co. in connection with bentonite sealing and the headquarters of the Agricultural Research Service in Beltsville, Maryland, the Soil Conservation Service in Washington, D. C. and the Bureau of Reclamation in Denver, Colorado in connection with general seepage control studies.

It was found that American conditions differ in some ways from those experienced in Australia, and the University of New South Wales programme created considerable interest. Useful liaisons with the principal American investigators were established for future exchanges of information.

### 2. 42 Seepage Control with Plastic Membranes

No funds for seepage control with plastic membranes were granted during the period under review. Limited work aimed at finalising the current investigation was undertaken using the available balance in the Water Research Foundation grant and some University funds.

In view of the continuing lack of outdoor exposure data, new field exposure racks were set up at Manly Vale and the Commonwealth Research Station at Griffith, N. S. W. Samples under test comprise black polythene and an olive-green outdoor vinyl formulation. Some buried samples have also been exposed, using three inches of soil cover on a membrane set at a slope of 1 in 3. At Manly Vale rainfall has removed the cover in a period of three months, indicating that a straight soil cover is of limited value in high-rainfall areas.

At both Manly and Griffith integrating photometers are set up to measure solar radiation over the period of the test. It is proposed that these samples remain in position for approximately 5 years, with periodic tensile and other physical testing as a check on progressive deterioration.

At Manly and Griffith a number of samples have been buried under various grasses in order to check on root penetration, reported in the United States as a possible source of damage in buried membranes.

Further wave damage tests have been conducted at Manly Vale. The purpose of these tests is to determine the best material for covering buried membranes. It has been shown that the slope stability figures published by the Utah Agricultural Experiment Station are extremely optimistic when tanks are subjected to wave action, and on normal tank slopes sand or soil covers will be removed by wave action in a very short time. The most suitable material appears to be $1\frac{1}{2}$ inch or 3 inch round river gravel, which remains stable on a 2 to 1 slope under accelerated wave action equivalent to one year of field exposure. Handling tests aimed at determining the damage sustained when dumping this material have shown that vinyl film is undamaged, whilst the heavier gauge polythenes show very little damage if the material is dropped from a height of less than 2 feet or onto a thin sand cushion. A technique for dropping the cover from a travelling chute with a drop height of less than one foot has been briefly investigated.

Further permeability tests have been conducted using an overlapping polythene membrane with no physical seal at the joint. It has been shown that round gravel cover reduces seepage losses for normal tank heads to a point where the additional cost of heat welding is not justified. Installation problems with loose film strips need some further investigation.

A series of research reports under the general title of "Seepage Control with Plastic Membranes" is in preparation. The following sections have been completed and reproduced as Water Research Laboratory Reports:-

Part 1: A Literature Survey.

Part 2: Available Plastic Films - Properties and Characteristics.

Part 3: Field Performance of Australian Dam Liners.

Part 4: Wind Damage to Polythene Dam Liners.

Part 5: Physical properties of Australian plastic films suitable for Dam Lining.

Two further reports are currently in preparation, as follows:-

Part 6: Fabrication and Installation of Plastic Dam Liners.

Part 7: Weathering and Durability of Plastic Dam Liners.

2. 43 Seepage Control with Trace Chemicals.

The principal research objective during the period under review was to develop relatively simple field and laboratory tests to determine:-

a. The suitability of a given soil for sealing with trace stabilisation.

b. The optimum stabilant chemical and the optimal stabilant application rate to employ.

c. The efficiency of the stabilant in reducing permeability.

d. The possible effects of using water drawn from ponds sealed with trace stabilants on the germination and growth of irrigated pastures.

The following methods of investigation were employed:-

(i) Suitability of soil for stabilisation, best stabilant to use:- in general, the approach has been to check the efficiency of relatively simple, inexpensive tests by comparing the results obtained from them with the results obtained when detailed laboratory testing has been carried out.

(ii) Efficiency of stabilant in reducing permeability - this can be properly assessed only through laboratory permeability tests. A special permeameter built for this purpose is described below. Detailed testing with this apparatus has not been completed.

(iii) Effect of water containing trace dispersants in irrigation - greenhouse plot tests were employed to measure the effect of contaminated waters on germination and plant growth.

The investigation has so far concerned itself only with "mixed blanket" stabilisation. All soil testing has been carried out using materials from the field trial at Nashdale, Orange, which was sealed with sodium tri-polyphosphate in 1959. This soil is extremely uniform

and is of such a nature as to be ideally suited for trace stabilisation.

Progress to date has been limited by the lack of a soils technician. Since one was appointed in August, 1961, the following work has been completed:-

a. Field tests for the general suitability of a soil for trace stabilisation have been developed and tested. They comprise:-

(i) Simple textural classification test or "jar test".

(ii) "Jar test" with addition of trace stabilant.

(iii) Simple pH test.

(iv) Examination of effect of stabilant on soil plasticity.

b. Laboratory tests for determining the suitability of a soil for trace stabilisation have also been established. They comprise:-

1. Chemical tests

(i) Slaking and dispersion of soil crumbs in water.

(ii) Slaking and dispersion of soil crumbs in calcium chloride solution.

(iii) Cation exchange capacity.

(To date only test (i) above has been applied to the Nashdale soil).

2. Engineering tests

(i) Grain size analysis.

(ii) Atterberg Limits.

(iii) Specific gravity.

(iv) Harvard compaction test.

(v) Soil permeability with and without stabilant.

(All of the above tests, with the exception of permeability testing, have been completed for the standard Nashdale soil. Permeability testing is still in progress).

"Screening" tests to determine in an approximate manner the type and quantity of stabilant best suited to a given soil have been investigated. Two such tests are recommended:-

(i) Fluidity test.

(ii) Hydrometer test.

The fluidity test is based on the standard Atterberg liquid limit test. The number of blows required to give a standard reading with this device are plotted against the percentage of stabilant used, and the test is repeated for various percentages of stabilant. It has been found that an optimal point is reached at which the stabilant develops maximum fluidity, addition of further stabilant causing a stiffening of the soil. Figure 1 shows a plot of fluidity tests for the Nashdale soil with 4 types of stabilant. Hydrometer testing has not been finalised. It is based on the fact that the most effective stabilant will keep colloidal material in suspension for the longest period. A thermostat-controlled constant temperature tank has been designed and built at Manly Vale for hydrometer testing.

"Performance" tests to give a measure of the effect of the trace stabilant selected on the physical properties of the soil and to determine the durability of the stabilisation achieved have also been studied. These tests are as follows:-

(i) Atterberg Limits.

(ii) Harvard Compaction.

(iii) Permeability.

(iv) Permeability following a series of wetting and drying cycles.

(v) Healing test.

(vi) Erosion test.

Compaction tests on the Nashdale soil have shown that the addition of various percentages of stabilant can be expected to increase the optimum density and decrease the O. M. C., but this effect is not so great as originally expected; it was earlier thought possible that the use of trace stabilants might permit field compaction at low in situ moisture contents. Typical results for the Harvard compaction test on Nashdale soil with Calgon and Tripolyphosphate are shown in Figure 2.

Permeability testing has not been completed. A special permeameter apparatus which utilises the compaction cell of the Harvard Compaction

Apparatus and thus makes possible a direct measurement of the permeability of compacted samples has been designed and constructed at the Laboratory. A schematic diagram of the apparatus is shown in Figure 3. It provides for:-

(i) Subjecting the soil specimens to a vacuum to remove entrapped air.

(ii) De-airing of the distilled water for the test.

(iii) Use of water heads from 0 to 20 feet for determining permeabilities in the range $1 \times 10^{-4}$ cm/sec. to $1 \times 10^{-8}$ cm/sec.

A small greenhouse has been constructed at Manly Vale and used to determine the effect of irrigation water drawn from dams sealed with trace stabilants and other sealing chemicals. Initially clover plants growing in unglazed clay garden pots were used, the only water applied to these plants being prepared from solutions of various trace chemicals, SS 13 and AM 9. Considerable difficulty has been experienced in keeping the pots moist during holiday periods, and the pots are now being replaced with large trays.

Further investigations will include the completion of the existing tests and a series of tests on soil samples from other areas. The healing and erosion tests remain to be worked out in detail. An unconfined compression testing machine has recently been obtained and it is proposed to measure the effects of stabilisation on shear strength in the near future. Some field and laboratory trials to determine the possibilities of applying stabilants in solution with tank water or by spraying the dry tank surface are also proposed.

2.44 Seepage Control - Other Methods.

During the period under review little research was accomplished with bentonite sealing or other seepage control methods. The sealing experiment at Alstonville, now converted to Class II HYDRA Station, has been under observation, and detailed testing of the Alstonville soil samples has been completed. Proposed field experiments at Baulkham Hills, in the Orange district and in Victoria have been postponed or abandoned for various reasons.

Whilst in the United States Mr. Burton spent some time investigating asphaltic sealing methods and discussed alternative methods of applying bentonite with various authorities. A bentonite mixer was sent back to

the University and detailed drawings for bentonite pumping machinery were obtained. If and when time and funds become available the possibilities of applying bentonite in slurry or suspension form will be briefly investigated.

## 3. Aministration of the Programme

### 3.1 Staff

Research activities during the period under review were again handicapped by staff shortage. In particular, inability to obtain a soils technician until August, 1961, caused considerable disruption of the soil mechanics aspects of the programme.

Mr. J. R. Burton, Lecturer in Civil Engineering, who is in charge of the research programme, was in the United States on extended study leave between 2nd September, 1960 and 2nd December, 1961. In his absence research activities were conducted, for the most part single handed, by Mr. T. R. Fietz. Mr. Fietz was appointed as a Research Fellow in February, 1960, and his salary has been met from Water Research Foundation and Rural Credits Development Fund grants. Early in December, 1961, Mr. Fietz was appointed a Lecturer in Civil Engineering at the University of New South Wales. Whilst he will still take part in the research programme his lecturing and administrative duties for the University will restrict the amount of time he can devote to conservation research, and in particular he will be unable to do extensive field travelling in connection with the HYDRA Scheme as was possible in the past.

Mr. D. Bennett was appointed as a laboratory assistant to undertake soils testing in August, 1961. He spent three weeks at the soils laboratory of the Water Conservation and Irrigation Commission before commencing duties at Manly Vale. His appointment has at last made possible a concentrated attack on the soils aspects of the research programme, and in particular has brought the seepage control research up to date. Mr. Bennett's salary is paid by the University of New South Wales.

Some temporary appointments were made during the period under review. At the beginning of the period Mr. G. Leach worked for 2 months as a laboratory attendant, his salary being paid by the University. During the summer of 1960-61 Mr. R. French, an engineering student was employed on soil testing, his salary being paid from research grants. In November, 1961, Mr. P. Yong and Mr. P. Rohan, an engineering student and an agriculture student respectively, were appointed for temporary summer employment. Their salaries also are paid from research grants.

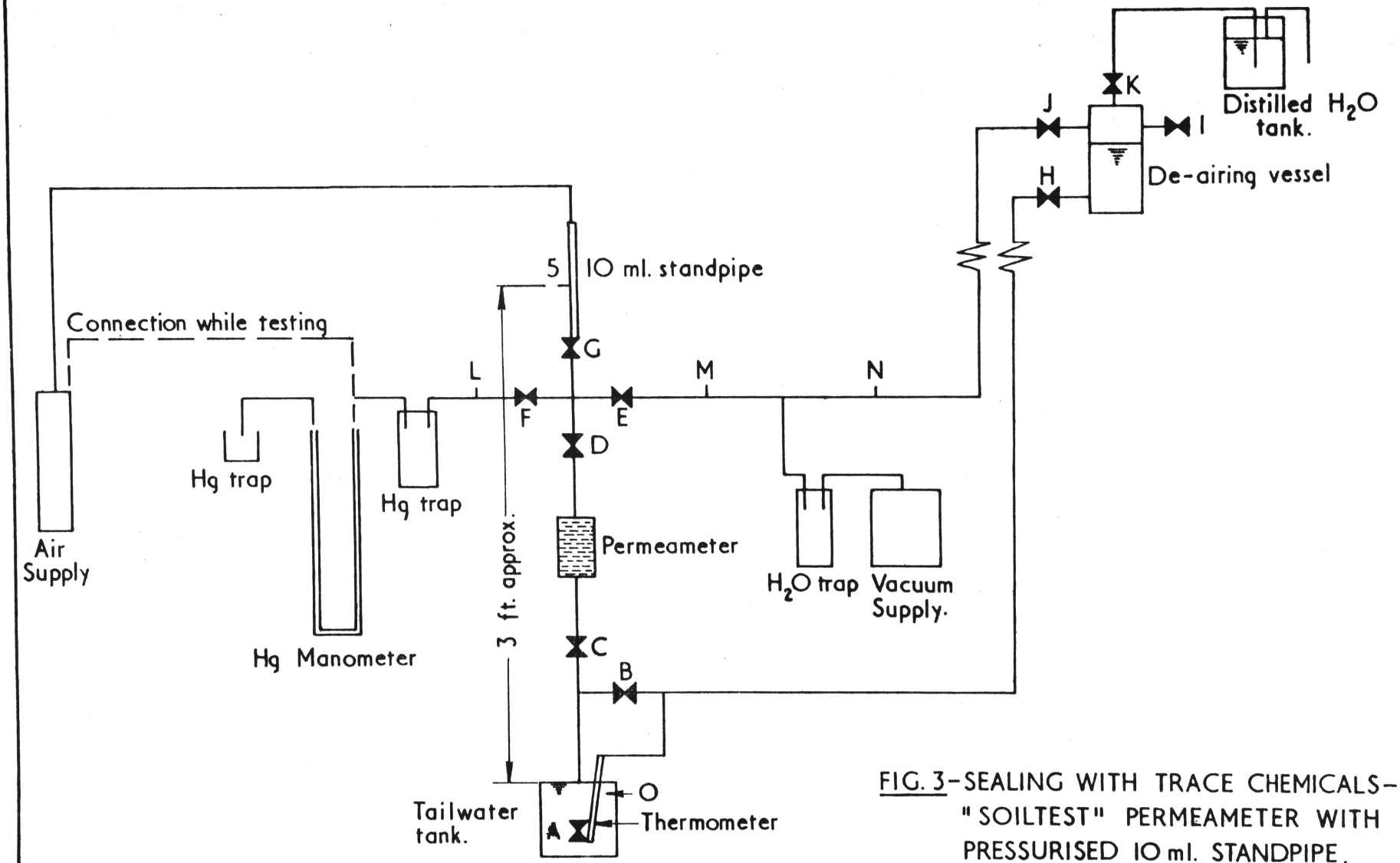


FIG. 3 – SEALING WITH TRACE CHEMICALS – "SOILTEST" PERMEAMETER WITH PRESSURISED 10 ml. STANDPIPE.

The part-time services of Mr. J. Clark, a University employee, are available for field trips. Mention should be made of his willingness and enthusiasm in many unpleasant field situations.

The current staff position is therefore as follows:-

Paid by University - J. Burton, Lecturer (part-time).
T. Fietz " ( " " )
D. Bennett, Laboratory Assistant.
J. Clark, Laboratory Attendant, half-time services available.

Paid by Research Grants - P. Yong, Temp. Lab. Attendant ) vacation em-
P. Rohan, Temp. Lab. Attendant) ployment only.

The present staff is adequate for laboratory research but does not allow of extensive field investigations. The appointment of a field engineer to develop and supervise the HYDRA Scheme and to undertake field construction testing is now necessary. Clerical assistance with the correspondence and filing associated with the HYDRA Scheme and the Farm Dam Survey is also desirable.

3. 2 Finance

The Conservation Research Programme is financed from three sources:-

a. General University Funds.
b. Water Research Foundation of Australia benefactions.
c. Rural Credits Development Fund benefaction.

Details of the benefactions are given below. Financial statements are given in Appendix A.

1. Water Research Foundation

(i) Water Research Foundation - Commonwealth Bank Grant: topic, "Improved Methods of Design and Construction of Small Dams Under Australian Conditions"; annual grant; first grant dated December, 1956; total grant to date £ 4700 with a further £ 1700 approved.

The money from this grant is used for purchase of equipment, for travelling expenses, and for salary payments. Salaries paid from this grant have been for temporary laboratory assistance and part of stipend of Research Fellow T. R. Fietz.

(ii) Water Research Foundation - I. C. I. A. N. Z. Grant; topic "The Use of Polythene and Polyvinyl Chloride Membranes in the Construction of Waterproof Dams"; annual grant of £ 1000; first grant dated December, 1956; total grant £ 3000.

The money from this grant has been used for purchase of equipment, for travelling expenses, and for salary payments, including temporary laboratory assistance and part of stipend of Research Fellow T. R. Fietz. The grant has been discontinued.

2. Rural Credits Development Fund

Topic, "Seepage Control in Farm Dams"; annual grant; first grant dated November, 1958; total grant to date £ 3500.

The money from this grant has been used for purchase of equipment, for travelling expenses, for salaries of temporary laboratory assistants and part of stipend of Research Fellow T. R. Fietz.

It is difficult to assess the extent to which the University financially supports the conservation research programme. The following points should be noted:-

The University now pays the salaries of J. R. Burton, T. R. Fietz, D. Bennett and J. Clark; a total of about £ 7,000 per annum, of which perhaps £ 4,000 can be charged to conservation research.

The University has provided a vehicle for a mobile laboratory, and running and maintenance costs are met by the University.

Certain hydrologic instruments on experimental catchments, and survey instruments used for research purposes, are the property of the University.

Other University staff assist in hydrologic data collection; in repair and maintenance of instruments; in survey, photography, soil testing, workshop, etc.

It is estimated that the University financially supports the conservation research programme to the extent of about 60 per cent of total cost; the Water Research Foundation, about 30 per cent; and the Rural Credits Fund, about 10 per cent.

### 3.3 Equipment and Facilities

Early in 1960 the conservation research group moved to the Water Research Laboratory at Manly Vale and set up a temporary laboratory. A large storage shed was constructed and garage facilities were made available, together with the excellent workshop and general laboratory, clerical and drafting facilities of the Laboratory.

Recent expansion of the conservation team and corresponding development of the Water Research Laboratory have caused serious crowding at Manly Vale, and larger accommodations are urgently required for the conservation section.

In 1961 the University replaced the original Fargo mobile laboratory with a new Morris van, which has travelled approximately 2500 miles on conservation research.

Equipment obtained during the period under review included a microscope for seepage control research, resistivity and pH meters, and additional hydrologic instruments.

## 4. Publications

Publications originating within the group during the period under review were as follows:-

(i) T. Fietz - A Manual for HYDRA Operators. Duplicated.

(ii) J. R. Burton - Water for the Inland - A Review of the Bradfield Plan; Report No. 2, Water Research Foundation of Australia, 1961.

(iii) J. Burton and T. R. Fietz - Seepage Control with Plastic Membranes, Parts 1 - 5 inclusive: Manly Lab. reports, in press.

## 5. Conclusion

Research activities during the period under review have followed the lines previously established, and have included research in the hydrologic design of farm dams, the structural design and construction of small earth dams and seepage control.

Progress has been limited by the absence of Mr. Burton overseas and continued shortage of laboratory staff. Significant results have, however, been achieved in the Farm Dam Survey, seepage control with soil stabilants, and some expansion of the HYDRA Scheme.

Towards the end of the period under review the staff situation improved markedly. Four members of University staff are now engaged in conservation research, although only one of them is available full time. The field activities of these people are limited, however, and there is now need for a field engineer to develop and expand the HYDRA Scheme and to undertake construction testing.

A number of publications covering research progress in all topics are now in course of preparation. The issuing of these publications early in 1962 will mark the end of the first stage of the conservation research programme. During the remainder of 1962 it is proposed to concentrate research effort on the extension of the HYDRA Scheme as a long-range programme and on the preparation of design data for the improved construction of farm dams in representative areas of New South Wales.

John R. Burton,
Trevor R. Fietz.

Water Research Laboratory,
Manly Vale.

16th January, 1962.

# RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING

# PROGRESS REPORT NO. 2, 1960-61.

## APPENDIX A:

## FINANCIAL STATEMENTS FOR RESEARCH GRANTS.

A. Aggregate Statements 1st January, 1960 to 31st December, 1961.

a. Research Grant C.806
(W.R.F.S. Grant - "Improved Methods for design and construction of farm dams under Australian conditions".)

1. Receipts:

| | | |
|---|---|---|
| Grant 1961 | £1700. -. - | |
| Balance unexpended as at 31.12.59 | 1240.16.11 | £2940.16.11 |

2. Payments:

| | | |
|---|---|---|
| Salaries, etc. | £1264. 2. 3 | |
| Travelling expenses | 338. -. 5 | |
| Materials and Equip. | 773.11.11 | £2375.14. 7 |

Balance unexpended as at 31st Dec., 1961 £565. 2. 4

NOTE: An additional £1700 was approved by the Foundation late in 1961 but had not been received by 31st December, 1961.

b. Research Grant C.807
(W.R.F.S.Grant - "Sealing farm dams with plastic membranes".)

1. Receipts:

| | | |
|---|---|---|
| Balance unexpended as at 31.12.59 | £1747.10.11 | £1747.10.11 |

2. Payments:

| | | |
|---|---|---|
| Salaries, etc. | 1125.10. - | |
| Travelling expenses | 14.10. 5 | |
| Materials and equipment | 607.10. 6 | £1747.10.11 |
| Balance unexpended as at 31st Dec., 1961. | | -. -. - |

c. Research Grant C.809
(Rural Credits Grant: "Seepage Control in Farm Dams".

1. Receipts:

| | | |
|---|---|---|
| Grant 1961. | £1500. -. - | |
| Balance unexpended as at 31st Dec., 1959 | 1358.14. 7 | £2858.14. 7 |

2. Payments:

| | | |
|---|---|---|
| Salaries, etc. | £1145. 3.10 | |
| Travelling expenses | 66. 16. 7 | |
| Materials and equipment | 1593. 16. 4 | £2805.16. 9 |
| Balance unexpended as at 31st Dec., 1961. | | £52.17.10 |

B. Aggregate Statements for Entire Period of Conservation Research Programme. (1957-61).

a. C806: Water Research Foundation - Improved Methods Design and Construction.

Statement for period 26th November, 1956 - 31st December, 1961.

1. Receipts:

| | | | |
|---|---|---|---|
| Grants: | Dec. 1956 | £ 1000. -. - | |
| | July 1958 | 1000. -. - | |
| | Nov. 1959 | 1000. -. - | |
| | - 1961 | 1700. -. - | £ 4700. -. - |

2. Payments:

| | | |
|---|---|---|
| Salaries, etc. | 2192. 9. 5 | |
| Travelling Expenses | 514. 10. 9 | |
| Materials | 1427. 17. 6 | £ 4134. 17. 8 |
| Balance unexpended 31. 12. 61 | | 565. 2. 4 |

NOTE: Additional grant of £ 1700 from W. R. F. A. at end of 1961 will bring total grants to £ 6400 and balance unexpended to approx. £ 2265.

b. C.807: Water Research Foundation - Plastic Membranes

Statement for Period 24th November, 1956 - 31st December, 1961.

1. Receipts:

| | | | |
|---|---|---|---|
| Grants: | Dec. 1956 | £1000. -. - | |
| | July 1958 | 1000. -. - | |
| | Nov. 1959 | 1000. -. - | £3000. -. - |

2. Payments:

| | | |
|---|---|---|
| Salaries, etc. | £2114. 19. 7 | |
| Travelling expenses | 106. 18. 8 | |
| Materials and equipment | 778. 1. 9 | 3000. -. - |
| Balance unexpended at 31.12.61 | | -. -. - |

c. C. 809: Rural Credits - Seepage Control

Statement for period 11th November, 1958 to 31st December, 1961.

1. Receipts:

| | | | |
|---|---|---|---|
| Grants: | Nov. 1958 | £ 1000. -. - | |
| | Dec. 1959 | 1000. -. - | |
| | - 1961 | 1500. -. - | £ 3500. -. - |

2. Payments:

| | | |
|---|---|---|
| Salaries | £ 1257. 16. 11 | |
| Travelling expenses | 185. 17. 2 | |
| Materials and equipment | 2003. 8. 3 | £ 3447. 2. 2 |
| Balance unexpended at 31. 12. 61 | | £ 52. 17. 10 |

# RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING

## PROGRESS REPORT NO. 2, 1960-61

## APPENDIX B

## THE HYDRA SCHEME - DETAILS OF STATIONS AND SUMMARY OF STATION PERFORMANCES DECEMBER 1961.

# APPENDIX B

## THE HYDRA SCHEME - DETAILS OF STATIONS AND SUMMARY OF STATION PERFORMANCES DECEMBER, 1961.

The HYDRA Scheme is a scheme for hydrologic data collection from rural areas, with particular emphasis on those data which might be used for the design of farm reservoirs. It has been described in detail in Appendix F of "Research in Soil and Water Conservation Engineering - Progress Report No. 1, 1957-1960", to which the reader is referred.

The Scheme commenced late in 1958, and has been steadily expanded since that time. A total of 22 stations has been set up; some of these are no longer operating.

Tables A, B and C which follow briefly summarise the performance of each station from the date of its installation to 31st December, 1961.

These Tables are followed by 23 Evaluation Reports which give details of the location and instrumentation of each station, with commence on the records obtained from them and recommendations as to future action, if any.

# HYDRA SCHEME - DETAILS OF STATIONS

## AS AT 31st DECEMBER, 1961.

## TABLE A - CLASS I STATIONS.

| Station No. | Location | Operator | Mean Rainfall (ins) | Remarks |
|---|---|---|---|---|
| HI/ 1 | Parkes (Central Western Slopes). | Grazier | 18 | Set up Jan., 1959. Inoperative, instrument installation not completed. |
| HI/ 2 | Dubbo | Grazier | 20 | Dam levels and rainfall data for 1958. No instruments installed. |
| HI/ 3 | Urana (Riverina) | Junior Farmer | 17 | Set up Nov., 1958. Operating satisfactorily. |
| HI/ 4 | Mathoura(Riverina) | Junior Farmer | 15 | Set up Nov., 1958. Inoperative, observer unwilling to continue. |
| HI/ 5 | Temora (South West Slopes) | Junior Farmer | 25 | Set up Nov., 1958. Operating satisfactorily. |
| HI/ 6 | Marrar (South West Slopes) | Junior Farmer | 22 | Set up Nov., 1958. Changed to Class II in April, 1961. |
| HI/ 7 | Humula (South West Slopes) | Junior Farmer | 30 | Set up Nov., 1958. Closed down 1960. Observer left district. |
| HI/ 8 | Merriwagga (Riverina) | Junior Farmer | 15 | Set up April, 1961. Operating satisfactorily. |
| HI/ 9 | Wentworth(Western) | Junior Farmer | 10 | Set up April, 1961. Operating satisfactorily. |
| HI/ 10 | Fowler's Gap (Western) | Conservation Dept. | 7 | Not yet operative - instruments on site but not installed. |
| HI/ 11 | Fowler's Gap (Western) | Conservation Dept. | 7 | Not yet operative. Instruments on site but not installed. |

## HYDRA SCHEME - DETAILS OF STATIONS

## AS AT 31st DECEMBER, 1961.

## TABLE B - CLASS II STATIONS.

| Station No. | Location | Operator | Mean Rainfall (ins) | Remarks |
|---|---|---|---|---|
| HII/ 1 | Richmond, N. S. W. | Farmer | 28 | Set up July, 1958, closed down 1960, of little value. |
| HII/ 2 | Lismore, N. S. W. | Dairy Farmer | 60 | Set up as HYDRA Station February 1960. Operating satisfactorily. |
| HII/ 3 | Orange N. S. W. | Orchardist | 34 | Set up 1959. Closed down. Little value. |
| HII/ 4 | Marrar, N. S. W. | Junior Farmer | 22 | Changed from Class I in April 1961. Operating satisfactorily. |

# HYDRA SCHEME - DETAILS OF STATIONS

## AS AT 31st DECEMBER, 1961.

## TABLE C - CLASS III STATIONS.

| Station No. | Location | Mean Rainfall (Ins) | Remarks |
|---|---|---|---|
| HIII/ 1 | Badgery's Creek, N. S. W. | 28 | Co-operative station with University of New South Wales. Records available since 1958. Operating satisfactorily. |
| HIII/ 2 | Mt. Vernon, N. S. W. | 28 | Co-operative station with University of New South Wales. Records available since 1958. Operating satisfactorily. |
| HIII/ 3 | Parramatta N. S. W. | | Co-operative station with University of New South Wales. Records available since June, 1960. Operating satisfactorily. |
| HIII/ 4 | Scone, N. S. W. | 25 | Co-operative station with Soil Conservation Service. Records available since 1958. Operating satisfactorily. |
| HIII/ 5 | Scone, N. S. W. | 25 | Co-operative station with Soil Conservation Service. Records available since 1958. Operating satisfactorily. |
| HIII/ 6 | Barcaldine, Queensland | 17 | Co-operative station with Western Queensland Local Authorities Association. Installed March, 1960. No runoff yet recorded. Operating satisfactorily. |
| HIII/ 7 | Harden, N. S. W. | 23 | Installed May, 1958 - Closed down Jan. 1961. Records of no value. |
| HIII/ 8 | Harden, N. S. W. | 23 | Installed May, 1958 - Closed down Jan. 1961. Records of no value. |

HYDRA SCHEME - STATION
EVALUATION REPORT
31st December 1961.

STATION NO. HI/1
(Class I)
(Not Operating)

## LOCATION DETAILS

Operator - W. R. Davies. Occupation - Grazier.
Address - Condobolin Road, Parkes, N. S. W.
Climatic district - Central Western Slopes.
Mean annual rainfall = 18 inches. Mean annual evaporation = 52 inches.
Station set up January, 1959.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge installed January, 1959. Gauge plates on property but never installed. Dam is rectangular tank about 100,000 gallons capacity. Catchment area roughly 100 acres.

## SURVEY DETAILS

No storage/ elevation survey or catchment survey has been undertaken.

## RECORDS OBTAINED

Satisfactory rainfall records have been received for Jan. to March, 1959.
No other records received.

## REMARKS

Davies has not been visited since the raingauge was installed in January, 1959, no trips to the Parkes district having been made since that time. Has obviously lost interest because of lack of University follow-up.

## RECOMMENDATION

It is desirable that we have a Class I station in this area. An attempt should be made to re-establish the station and maintain the observer's interest. This would involve a visit to the site of about 2 day's duration to instal gauge plates, carry out storage/ elevation and catchment area surveys and take soil samples.

HYDRA SCHEME - STATION EVALUATION REPORT, 31st December, 1961.

STATION NO. HI/ 2
(Class I)
(Not Operating)

## LOCATION DETAILS

Operator - C. G. Brown. Occupation - Grazier
Address - "Glen Ayr", Dubbo.
Climatic District - Central Western Slopes.
Av. annual rainfall = 20 ins. Av. annual evaporation = 52 ins.
Data obtained for 1958; no instruments installed.

## INSTRUMENTATION DETAILS

Dam is 62 million gallons. No University instruments yet installed. Landholder maintains raingauge and keeps reservoir inflow records.

## SURVEY DETAILS

Contour survey of damsite and catchment available.

## RECORDS

It is understood that reservoir in flow records from 1957 to 1961 are available.

## REMARKS

Landholder maintains rainfall and reservoir levels. No visit has been made for installation of gauge plates.

## RECOMMENDATION

The landholder is an enthusiast and apparently a good observer. Gauge plates should be set up as soon as possible and records collected.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/3
(Class I)
(Operating)

## LOCATION DETAILS

Operator - Robin Duncan. Occupation - Junior Farmer.
Address - "Doolinga", Urana, N.S.W.
Climatic District - Riverina.
Mean Annual Rainfall = 17 ins. Mean annual evaporation = 52 ins.
Station set up November, 1958. Instruments moved to new dam in April, 1960.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge and gauge plates set up November, 1958. Original dam changed to pumped storage and new dam instrumented in April, 1960, with old gauge plates. Evaporimeter (U.N.S.W. covered drum type) installed February, 1961. Dam has capacity of 160,000 gallons. Catchment area approx. 200 ac.

## SURVEY DETAILS

Approximate S/E survey for old dam made in Nov. 1958. Detailed S/E survey for new dam made April, 1960. S/E curve plotted. No catchment survey.

## RECORDS OBTAINED

Excellent rainfall records dating from Nov. 1958, with earlier records on non-standard gauge from Feb., 1950. Evaporimeter readings from Feb. 1961 to present. Inflow records available from Nov. 1958. Since April, 1960 these records include daily 9 a.m. readings during wet periods and some intermediate readings during periods of heavy runoff. The only Class I observer to have taken such readings.

## REMARKS

Station operating satisfactorily. Necessary to make catchment area survey so that records may be analysed.

## RECOMMENDATION

Continue operation. Make catchment survey as soon as possible.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/ 4
(Class I)
(Not Operating)

## LOCATION DETAILS

Operator - John Berryman. Occupation - Junior Farmer.
Address - "Collamon Park", Mathoura, N.S.W.
Climatic District - Riverina.
Mean annual rainfall = 15 ins. Mean annual evaporation = 53 ins.
Station set up November, 1958.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge installed Nov. 1958. Gauge plates installed in dam Nov. 1958. Dam is large rectangular tank fed by surface runoff from flat catchment. Catchment area about 400 acres. Full capacity of dam 500,000 gallons.

## SURVEY DETAILS

Storage/ elevation survey made March 1960, and S/ E curve plotted. No catchment survey.

## RECORDS OBTAINED

Satisfactory rainfall records November, 1958, to January, 1959. Dam level records over same period.

## REMARKS

Observer lost interest early when he married and assumed new responsibilities. Was visited at intervals by Junior Farmer Supervisor, but no University visit.

## RECOMMENDATION

The Junior Farmer Supervisor has located another Junior Farmer in the Mathoura district who is willing to become an observer. The site should be inspected and, if found suitable, the station re-established here.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/5
(Class I)
(Operating)

## LOCATION DETAILS

Operator - Baden Reinhold. Occupation - Junior Farmer.
Address - "Wilna", Cootamundra Road, Temora, N.S.W.
Climatic District - South West Slopes.
Mean annual rainfall = 25 ins. Mean annual evaporation = 50".
Station set up November, 1960.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge and gauge plates installed November, 1958.
Evaporimeter (U.N.S.W. covered drum type) installed Feb. 1961.
Dam is square tank fed by surface runoff from gently sloping catchment.
Total capacity of tank about 200,000 gals. Catchment area about 250 acres.

## SURVEY DETAILS

Storage/elevation survey made March, 1960.
S/E curve not plotted. No catchment survey.

## RECORDS OBTAINED

Excellent rainfall and dam level records from November, 1958 to date.
Evaporimeter records February, 1961 to date. Some 9 a.m. runoffs recorded.

## REMARKS

This dam has a large catchment and the bywash usually overflows when run-off occurs. No measure of the bywash loss has been possible, since the dam is located 2 miles from the homestead and is difficult to visit in wet weather. Apart from this, station operates satisfactorily.

## RECOMMENDATION

Investigate possibility of gauging spillway losses. Useful station if this can be done; otherwise consider an alternative location in the same area.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/ 6
(Class I)
(Now Class II, Operating)

## LOCATION DETAILS

Operator - F. Bussenschutt. Occupation - Junior Farmer.
Address - RMB 23, Marrar, N.S.W.
Climatic District - South West Slopes.
Average annual rainfall = 22 ins. Average annual evaporation = 52 ins.

Station set up November, 1958. Operated as Class I station until April 1961, when it was converted to a Class II Station (HII/ 4).

See Evaluation Report for HII/ 4 for further details.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/7
(Class I)
(Closed Down)

## LOCATION DETAILS

Operator - Noel Linsell. Occupation - Junior Farmer.
Address - "Romani", Humula, N.S.W.
Climatic District - South West Slopes.
Mean annual rainfall = 30 ins. Mean annual evaporation = 45 ins.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge and gaugeplates installed November 1958.
Dam small gully dam approx. 100,000 gallons capacity; catchment area about 40 acres.

## SURVEY DETAILS

Storage/elevation survey made April 1960, S/E curve not plotted.
No catchment survey.

## RECORDS OBTAINED

Rainfall and dam level records for period January 1959 to February 1960.
Gauge set too low and extensions left with operator never installed.
Several inflows not properly recorded as level over top of gauge.

## REMARKS

Operator left district. Arrangements have been made for Junior Farmer supervisor to collect instruments.

## RECOMMENDATION

The short record is of little value and the station should be abandoned. It is, however, desirable to establish a new station in this high-rainfall area as soon as possible.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/8
(Class I)
(Operating)

## LOCATION DETAILS

Operator - Brian Alty. Occupation - Junior Farmer
Address - "Fluxton", Merriwagga, N.S.W.
Climatic District - Riverina.
Mean Annual Rainfall = 15 ins. Mean annual evaporation = 52 ins.
Station set up April 1961.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge, gauge plates and evaporimeter (U.N.S.W. covered drum type) installed April 1961. Dam is rectangular half-tank, approximately 850,000 gallons capacity. Catchment area approximately 150 acres.

## SURVEY DETAILS

Storage-elevation survey made April, 1961. S/E curve not plotted.
No catchment survey.

## RECORDS OBTAINED.

Rainfall, water level and evaporimeter records April, 1961 to date.
Older rainfall records at property back to January, 1937.

## REMARKS

Dam is small in relation to catchment and spillway losses can be expected. To date station operated satisfactorily.

## RECOMMENDATION

Attempt to arrange gauging of bywash.

HYDRA SCHEME - STATION EVALUATION REPORT, 31st December, 1961.

STATION NO. HI/9
(Class I)
(Operating)

## LOCATION DETAILS

Operator - Orman McLoud. Occupation - Junior Farmer.
Address - "Kelso", Wentworth, N.S.W.
Climatic District - Western.
Mean Annual rainfall = 10 ins. Mean annual evaporation = 62 ins.
Station set up April, 1961.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge, gauge plates and evaporimeter (U.N.S.W. type) installed April, 1961. Dam is interconnected double tank, approximately 240,000 gallons capacity; catchment area mainly clay plans interconnected with catch drains. Total area approximately 40 acres.

## SURVEY DETAILS

Storage-elevation survey made April 1961. S/E curve not plotted.
No catchment survey.

## RECORDS OBTAINED

Rainfall, water level and evaporimeter records from April, 1961 to present.

## REMARKS

This is only HYDRA station yet operative in Western district.
Catchment consists of isolated clay plans interconnected by ditches which pass through sandy areas. Seepage may be high in sandy areas, and station cannot be expected to give precise runoff totals. Useful as indication of frequency of occurrence of good runoff, and should be maintained. Operation of station otherwise satisfactory.

## RECOMMENDATIONS

Complete catchment survey.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/ 10
(Class I)
(Not Operating)

## LOCATION DETAILS

Operator - N. S. W. Department of Conservation.
Address - Rural Investigation Station, Fowler's Gap, N. S. W.
Climatic District - Western.
Average annual rainfall = 7 ins. Average annual evaporation = 75 ins.

## Warren's Tank Station

Warren's Tank is a 3. 2 million gallon tank having a catchment area of about 2, 300 acres. It is located on the Department of Conservation's research station at Fowler's Gap, 70 miles north of Broken Hill.

Mr. Fietz travelled to Fowler's Gap in April, 1961 to install instruments in this dam and another one on the same station. (Mandelmann's Tank - 2. 9 million gallons, 4, 900 acre catchment area). Heavy rain made it impossible to undertake any survey or to install instruments. Two sets of gauge plates, a raingauge, evaporimeter, Mort pluviometer and Bristol water level recorder were left at the Station for subsequent installation by the officer-in-charge. So far as is known this has not yet been done, and no records have been received.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HI/ 11
(Class I)
(Not Operating)

## LOCATION DETAILS

Operator - N. S. W. Department of Conservation.
Address - Rural Investigation Station, Fowler's Gap, N. S. W.
Climatic District - Western.
Av. annual rainfall = 7 ins. Average annual evaporation = 75 ins.

## Mandelmann's Tank Station

Mandelmann's Tank is an excavated tank having a capacity of 2. 9 million gallons and a catchment area of 4, 900 acres. Instruments have been taken to site but not yet installed. See Station No. HI/ 10 for further details.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HII/1
(Class II)
(Closed Down)

## LOCATION DETAILS

Operator - A. J. Horrex. Occupation - Vegetable and flower grower.
Address -
Climatic District - County of Cumberland.
Average annual rainfall = 28 ins. Average annual evaporation = 48 ins.
Station set up July, 1958.
Station closed down 1960.

## DETAILS OF STATION AND RECORDS

This station was set up originally as a seepage control field experiment. The dam has a capacity of 250,000 gallons (S/E curve and survey available) and is filled by pumping. There is also a surface catchment having an area of about 10 acres, on typical Richmond orchard country.

The tank was lined with a plastic membrane and the following instruments installed:- Bristol water level recorder, standard 8 inch raingauge, U.S. Type A landpan evaporimeter.

It was planned that after evaluation trials of the plastic membrane had been completed the dam would continue as a Class II station, with the objectives of measuring the yield of catchments typical of the Richmond orcharding country and measuring the water use of irrigated vegetable crops.

The membrane was destroyed on 11th October, 1958 and the instruments damaged. They were subsequently repaired and records taken over a period of 2 months early in 1959 with the dam in an unlined condition. The project was not satisfactory because owner abandoned dam and allowed to empty. The station was closed in 1960.

HYDRA SCHEME - STATION EVALUATION REPORT, 31st December, 1961.

STATION NO. HII/ 2
(Class II)
(Operating)

## LOCATION DETAILS

Operator - Harold Gibson. Occupation - Dairy Farmer
Address - Pearce's Creek, via Alstonville, N. S. W.
Climatic District - North Coast.
Mean Annual rainfall = 60 ins. Mean annual evaporation = 35 ins.
Station set up April, 1959.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge, gauge plates, U. S. Class Type A landpan evaporimeter and 0 - 20 ft. Bristol waterlevel recorder set up in March, 1959.

## SURVEY DETAILS

Storage-elevation and catchment surveys have been completed and plotted. Dam has capacity of 500,000 gallons; gully dam on fairly steep catchment, typical of North Coast Dairy districts. Catchment area 40 acres.

## RECORDS OBTAINED

Records on all instruments from April 1959, but only operated as HYDRA station since February, 1960. Some evaporimeter records are poor, remainder satisfactory.

## REMARKS

This station was originally set up as a seepage control field experiment when the dam was lined with bentonite in March, 1959. At completion of the experiment in February, 1960, it was made a HYDRA station. The original operator (Gibson) became rather unsatisfactory after February 1960, but arrangements have now been made with the Department of Agriculture in Lismore to maintain records.

## RECOMMENDATION

Operation to continue. Some consideration might be given to use of daily chart in place of existing weekly chart.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HII/3
(Class II)
(Closed Down)

## LOCATION DETAILS

Operator - Bruce Williams. Occuptation - Orchardist.
Address - "The Pines", Nashdale, N.S.W.
Climatic District - Central West.
Mean annual rainfall = 34 ins. Mean annual evaporation = 45 ins.

Station set up 1958
Station closed down 1959.

## DETAILS OF STATION AND RECORDS

This station was set up originally as a seepage control field experiment. The tank has a capacity of 50,000 gallons and is filled by pumping. Surface inflow is negligible. In 1958 the following instruments were installed; standard 8 inch raingauge, gauge plates, 0 - 1- ft. Bristol water level recorder, U.S. Type A landpan evaporimeter, water meter on inflow pump. After evaluation of the sealing experiment it was proposed to operate the station as a Class II station, primarily to measure evaporation and the water requirements of fruit trees. Owner decided to maintain tank as a fire storage and the station closed August, 1960. Records available for period of operation but of little value so far as HYDRA is concerned.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HII/4
(Class II)
(Operating)

## LOCATION DETAILS

Operator - F. Bussenschutt. Occupation - Junior Farmer
Address - RMB 23, Marrar, N.S.W.
Climatic District - South West Slopes
Mean Annual Rainfall = 22 ins. Mean annual evaporation = 52 ins.

Station set up November, 1958 as Class I station (See HI/6)
Changed to Class II station April, 1961.

## INSTRUMENTATION DETAILS

Standard 8 inch raingauge, gauge plates installed April, 1958. Mort Pluviometer installed February, 1961. Bristol water lever recorder installed April, 1961. Max. and min. thermometer installed May 1961. U.S. Class A landpan evaporimeter installed July 1961.

## SURVEY DETAILS

Storage-elevation survey made March, 1961. S/E curve not plotted.
No catchment survey. Catchment area about 400 acres.

## RECORDS OBTAINED

Rainfall from November, 1958. Water levels November, 1958 to date, supplemented by Bristol recorder charts from April, 1961.
Pluviometer charts from February, 1961 to date, temperature records May 1961 to date. Useful runoff data available.

## REMARKS

Operator is very keen and conscientious and makes first-class observations. Could possibly install flume here to make Class III.

## RECOMMENDATION

Complete surveys as soon as possible.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/1
(Class III)
(Operating)

## LOCATION DETAILS

Name of Station - Badgery's Creek.
Operated by University of New South Wales.
Located at McGarvie Smith Animal Husbandry Farm, Badgery's Creek, N. S. W. (University of Sydney).

Climatic District - Metropolitan.

Mean annual rainfall = 28 ins. Mean annual evaporation = 43 ins.
First set up 1957, flume operative 1958.

## INSTRUMENTATION DETAILS

This is a heavily-instrumented experimental catchment operated by the University of New South Wales - no Research Grant funds have been used for purchase of instruments. Catchment area is 15 acres. Instruments include Parshall flume with Leopold Stevens float recorder, Mort pluviometer, Casella pluviometer, D. S. I. R. intensity recorder, various evaporimeters and raingauges, gauge plates on dam (5 million gallon capacity) into which the Parshall Flume discharges.

## SURVEY DETAILS

Detail surveys of the catchment and dam are available. A detailed soil survey has been made and extensive infiltration studies have been undertaken.

## RECORDS OBTAINED

Runoff records, with accompanying records for other instruments and dam levels, available since 1958. Analysis to 1960 made by HYDRA staff.

## REMARKS

This station is operated by the University of New South Wales and is financed from the HYDRA Scheme. It is attended by University staff. Runoff records have been analysed and used in research for hydrologic design of farm dams.

RECOMMENDATION: Operation satisfactory. Some maintenance required and hydrograph analysis needs to be brought up to date.

HYDRA SCHEME - STATION EVALUATION REPORT, 31st December, 1961.

STATION NO. HIII/ 2
(Class III)
(Operating)

## LOCATION DETAILS

Name of station - Mount Vernon.
Operated by University of New South Wales.
Located at Mt. Vernon Creek, near Badgery's Creek, N. S. W.
Climatic district - Metropolitan
Mean annual rainfall = 28 ins. Mean annual evaporation = 43 ins.
First set up 1958.

## INSTRUMENTATION DETAILS

Bristol recorder in watercourse (ephemeral). Casella pluviometer and daily read raingauge. Catchment area 173 acres.

## SURVEY DETAILS

Catchment survey and rating curves for gauging site available.

## RECORDS OBTAINED

Pluviographs and hydrographs available from 1958 to date. Some analysis has been undertaken by HYDRA staff.

## REMARKS

This station is owned and operated by the University of New South Wales. No HYDRA funds have been used in its instrumentation. Analysis of records to end of 1959 has been made and used in research for hydrologic design of farm dams.

## RECOMMENDATION

Operation satisfactory.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/3
(Class III)
(Operating)

## LOCATION DETAILS

Name of Station - Hunt's Creek.
Operated by University of New South Wales.
Located at King's School, Pennant Hills Road, Parramatta, N.S.W.

Climatic District - Metropolitan.
Mean annual rainfall = 47 ins. Mean annual evaporation = 43 ins.
Date set up - June 1960.

## INSTRUMENTATION DETAILS

Mort pluviometer and 0 - 20 ft. Bristol water level recorder installed June 1960.

## SURVEY DETAILS

Partial contour survey of catchment available. Station being rated by University of New South Wales, full rating curve not yet available.

## RECORDS OBTAINED

Hydrographs and pluviographs available since June 1960. No analysis undertaken.

## REMARKS

The instruments for this station were purchased with HYDRA funds. It is located on land owned by the King's School and is serviced by the University of New South Wales. Extensive calculations for yield estimation based on Hunt's Creek rainfall records have been made as part of hydrologic design of farm dams study. Primary purpose of station is to evaluate the yield estimation procedures used.

## RECOMMENDATION

Operation satisfactory. Completion of rating curve necessary so that full analysis can be made.

HYDRA SCHEME -STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/ 4
(Class III)
(Operating)

## LOCATION DETAILS

Name of station - Flume No. 2, Catchment D.
Operated by N. S. W. Soil Conservation Service.
Location - S. C. S. Research Station, Scone, N. S. W.
Climatic District - Hunter.
Mean annual rainfall = 25 ins. Mean annual evaporation = 45 ins.
Set up as HYDRA station in February, 1960.
Catchment first instrumented early 1958.

## INSTRUMENTATION DETAILS

Type HL measuring flume with Esdaile (S. C. S. pattern) water level recorder. Negretti and Zambra pluviometer off catchment installed 1958. Mort pluviometer on catchment installed February, 1960. A First Class meteorological station operated by Soil Conservation Service.
Catchment area.

## SURVEY DETAILS

Catchment survey available. Soil and cover records kept. Rating curve for flume available.

## RECORDS OBTAINED

Hydrographs and pluviographs available since early 1958. Some analysis completed.

## REMARKS

This is a co-operative effort with the Soil Conservation Service in which the HYDRA Scheme has supplied a Mort pluviometer and in return the S. C. S. provides runoff and meteorological records.

## RECOMMENDATION

Operation satisfactory.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/5
(Class III)
(Operating)

## LOCATION DETAILS

Name of station - Flume No. 1. Catchment E.
Operated by N.S.W. Soil Conservation Service.
Location - S.C.S. Research Station, Scone, N.S.W.
Climatic District - Hunter.
Mean Annual rainfall = 25 ins. Mean annual evaporation = 45 ins.
Set up as HYDRA station in February, 1960.
Catchment first instrumented early 1958.

## INSTRUMENTATION DETAILS

Type HL flume with Esdaile recorder, Mort pluviometer.
See Station HIII/4 for other details.

## SURVEY DETAILS

Catchment survey and rating curve available.

## RECORDS OBTAINED

Hydrographs and pluviographs available since early 1958.
Some analysis undertaken.

## REMARKS

Co-operative effort in which HYDRA supplies pluviometer in return for runoff and meteorological records. See also Station HIII/4.

## RECOMMENDATION

Operation satisfactory.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/6
(Class III)
(Operating)

## LOCATION DETAILS

Name of station - Barcaldine.
Operated by C. H. Wilson, Consulting Engineer.
Location - "Dunblane", Barcaldine, Queensland.
Climatic District - Central Lowlands (Rainfall district 36).
Mean annual rainfall = 17 ins. Mean annual evaporation = 85 ins.
Station set up March 1960.

## INSTRUMENTATION DETAILS

5 foot V-notch weir with long earth wing walls; Ingram float recorder in concrete well; Mort pluviometer; raingauge. All instruments set up March 1960. Catchment area.

## SURVEY DETAILS

Catchment survey available.

## RECORDS OBTAINED

Records available since March 1960. No surface runoff has been recorded in this time, indicating severity of drought in western Queensland.

## REMARKS

This is a co-operative project; the flume construction was financed by the Western Queensland Local Authorities Association and the instruments were supplied by the HYDRA Scheme. The station is maintained by a group of consulting engineers in Barcaldine.

## RECOMMENDATION

Operation satisfactory.

HYDRA SCHEME - STATION
EVALUATION REPORT,
31st December, 1961.

STATION NO. HIII/7
(Class III)
(Closed Down)

## LOCATION DETAILS

Name of station - Cowang Creek.
Operator - The King's School.
Location - "Futter Park", Harden, N.S.W.
Climatic District - South West Slopes.
Mean annual rainfall = 23 ins. Mean annual evaporation = 45 ins.
Station set up May 1958.
Station closed down January, 1961.

## INSTRUMENTATION DETAILS

0 - 20ft. Bristol water level recorder installed in Cowang Creek; Mort pluviometer and daily read raingauge; instruments installed May 1958 and removed January, 1961.

## SURVEY DETAILS

Detail contour survey of catchment available.

## RECORDS OBTAINED

Pluviometer charts and Bristol charts available for period May 1958 to July 1959. Runoff records are useless since station was never rated.

## REMARKS

Station set up originally to measure yield and peak runoff rates in connection with proposed water conservation scheme. King's School decided in January 1961 not to go ahead with water scheme and expressed unwillingness to co-operate further in HYDRA Scheme. Station therefore closed and instruments removed.

HYDRA SCHEME - STATION EVALUATION REPORT, 31st December, 1961.

STATION NO. HIII/8
(Class III)
(Closed Down)

## LOCATION DETAILS

Name of station - Windmill Creek.
Operator - The King's School.
Location - "Futter Park", Harden, N.S.W.
Climatic District - South West Slopes.
Mean annual rainfall = 23 ins. Mean annual evaporation = 45 ins.
Station set up May 1958.
Station closed down January, 1961.

## INSTRUMENTATION DETAILS

Mort pluviometer, Bristol water level recorder. Installed May 1958 and removed January, 1961.

## SURVEY DETAILS

Detailed catchment survey available.

## RECORDS OBTAINED

Pluviometer and recorder charts May 1958 to July 1959. Runoff records useless as station never rated.

## REMARKS

See under Station No. HIII/7. Closed down January, 1961 at request of King's School.

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## APPENDIX C: THE FARM DAM SURVEY - A PRELIMINARY ANALYSIS.

# APPENDIX C -THE FARM DAM SURVEY - A PRELIMINARY ANALYSIS

## 1. SAMPLING PROCEDURE:

### 1.1 Pilot Sample Selection

Fiftyfive farmers and graziers who attended the special school in Rural Technology, conducted by the University of New South Wales in May 1960, were selected as the pilot sample. Because of their attendance at the Schcol these men were obviously interested in Water Conservation and were considered a good sample to criticise the survey form.

### 1.2 Pilot sample returns analysed and questionnaire form evaluated

The comments invited from the pilot sample were examined and it was decided that the questionnaire form and information sheet should remain substantially unaltered.

### 1.3 Main sample selection

#### 1.31 Population

A population list of 20, 288 stockowners in New South Wales was obtained from the 1957 edition of the "Pastoral Directory" published by the Pastoral Review Pty. Ltd. The advantages of selecting this population were:-

(a) The list was readily available.

(b) Probably the principal use (directly for drinking or indirectly for irrigation) of farm dams is for stock. Therefore stockowners would be expected to control the majority of farm dams in the State.

The disadvantages of selecting this population were:-

(a) Some good stock raising areas are not dependent on surface storage of water. These are usually intensely stocked i. e. smaller holdings, and carry the same weight (in the sampling procedure adopted) as less intensely stocked western properties (which depend on surface water storage). Consequently an appreciable proportion of the properties sampled were expected to have no farm dams.

(b) The use of farm dams for other purposes (i. e. horticulture, specialised crops, domestic supply only etc.) was automatically neglected.

1.32 Sampling Method

1.321 Initial Selection. The population listed in the "Pastoral Directory" was arranged alphabetically in each pasture protection district in New South Wales. The number of graziers in each district was found and the sample selected "at random" on a proportional basis, i.e.

$n = N \times \frac{p}{P}$ here n = number of graziers selected for survey in a district.

N = total number of graziers selected in N.S.W. (=1000)

p = total number of graziers (i.e. population) of the district.

P = total number of graziers (i.e. population) in N.S.W. (=20, 288).

This system was used to simplify the mechanical process of "picking numbers out of a hat".

1.322 Arbitrary Rules for Failure of a Particular return. When the questionnaire form was returned unanswered then the following arbitrary rules were employed:-

| Situation | Rule |
|---|---|
| (1) No dams on property | a. If considered representative of district then no action taken. |
| | b. If not representative and a reference to a landholder in close proximity was volunterred, then a form was sent to the latter. |
| (2) Grazier unwilling to complete form e.g. too busy. | Form sent to grazier listed immediately below in director. (If the unco-operative grazier was listed at the end of a district then the name immediately above was used). |
| (3) Grazier unable to complete form e.g. sold property. | Form sent to "The Landholder" on the particular property. |
| (4) Property subdivided | Form sent to the grazier listed immediately below in the directory. |

Arbitrary Rules for Failure of a Particular return (cont'd.)

| | | |
|---|---|---|
| (5) | Original letter returned unopened i. e. ficticious station name. | Form sent to the grazier listed immediately below in the directory. |
| (6) | No answer received at all | Reminder letter sent after 6 weeks. If no answer was received at the end of 3 months from date of sending then it was assumed that the landholder grazier was uncooperative and no further action was taken. |

Duplicate forms were given a suffix A, e. g. original form - 1000, duplicate form issued according to the above rules - 1000A.

1. 4 Details of areas sampled

Figure 1 shows the location of the 60 pastoral districts sampled. Table 1 gives the name of each district, the total "population" sampled and the size of each sample.

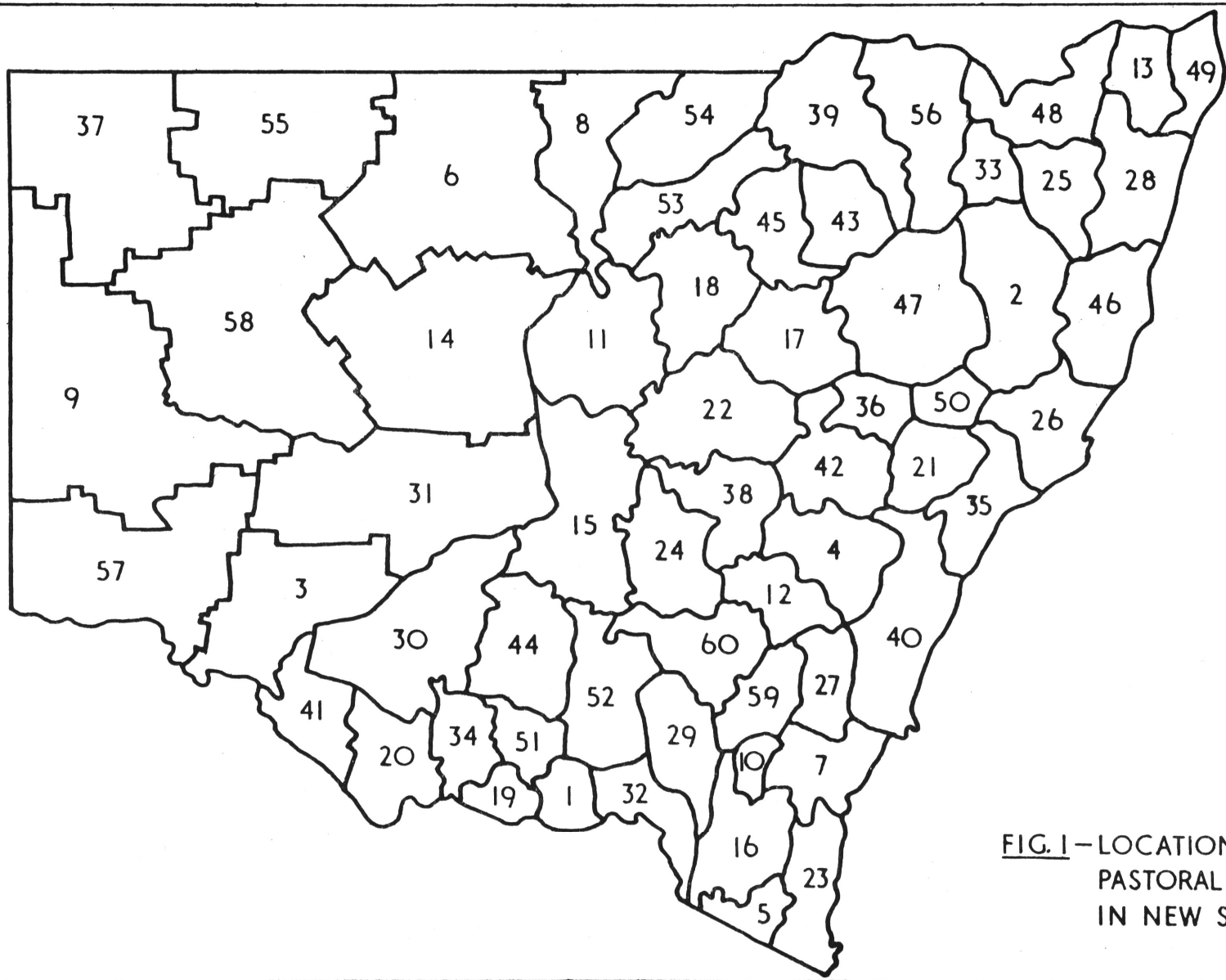


FIG. 1 – LOCATION OF PASTORAL DISTRICTS IN NEW SOUTH WALES.

# TABLE 1

## FARM DAM SURVEY 1960-61:

## SAMPLING DETAILS

| District Number | Pastoral District | Population | Sample |
|---|---|---|---|
| 1. | Albury | 260 | 13 |
| 2. | Armidale | 764 | 38 |
| 3. | Balranald | 145 | 7 |
| 4. | Bathurst | 526 | 26 |
| 5. | Bombala | 219 | 11 |
| 6. | Bourke | 231 | 11 |
| 7. | Braidwood | 252 | 12 |
| 8. | Brewarrina | 182 | 9 |
| 9. | Broken Hill | 141 | 7 |
| 10. | Canberra | 122 | 6 |
| 11. | Canonbar | 380 | 19 |
| 12. | Carcoar | 561 | 28 |
| 13. | Casino | 157 | 8 |
| 14. | Cobar | 208 | 10 |
| 15. | Condoblin | 829 | 41 |
| 16. | Cooma | 490 | 24 |
| 17. | Coonabarabran | 602 | 30 |
| 18. | Coonamble | 450 | 22 |
| 19. | Corowa | 261 | 13 |
| 20. | Deniliquin | 350 | 17 |
| 21. | Denman-Singleton | 121 | 6 |
| 22. | Dubbo | 907 | 45 |
| 23. | Eden | 42 | 2 |
| 24. | Forbes | 780 | 38 |
| 25. | Glen Innes | 290 | 14 |
| 26. | Gloucester | 73 | 4 |
| 27. | Goulburn | 407 | 20 |
| 28. | Grafton | 107 | 5 |
| 29. | Gundagai | 594 | 29 |
| 30. | Hay | 345 | 17 |
| 31. | Hillston | 205 | 10 |
| 32. | Hume | 328 | 16 |
| 33. | Inverell | 306 | 15 |
| 34. | Jerilderie | 199 | 10 |
| 35. | Maitland | 51 | 3 |
| 36. | Merriwa | 194 | 10 |
| 37. | Milpirinka | 59 | 3 |

TABLE 1 (cont'd.)

FARM DAM SURVEY 1960 - 61:

SAMPLING DETAILS

| District Number | Pastoral District | Population | Sample |
|---|---|---|---|
| 38. | Molong | 729 | 36 |
| 39. | Moree | 505 | 25 |
| 40. | Moss Vale | 121 | 6 |
| 41. | Moulamein | 236 | 11 |
| 42. | Mudgee | 467 | 23 |
| 43. | Narrabri | 328 | 16 |
| 44. | Narrandera | 428 | 21 |
| 45. | Pilliga | 240 | 12 |
| 46. | Port Macquarie | 67 | 3 |
| 47. | Tamworth | 1085 | 53 |
| 48. | Tenterfield | 270 | 13 |
| 49. | Tweed-Lismore | 18 | 1 |
| 50. | Upper Hunter | 174 | 9 |
| 51. | Urana | 168 | 8 |
| 52. | Wagga Wagga | 591 | 29 |
| 53. | Walgett | 251 | 12 |
| 54. | Walgett North | 220 | 11 |
| 55. | Wanaaring | 80 | 4 |
| 56. | Warialda | 646 | 32 |
| 57. | Wentworth | 113 | 6 |
| 58. | Wilcannia | 137 | 7 |
| 59. | Yass | 520 | 26 |
| 60. | Young | 756 | 37 |

## 2. THE QUESTIONNAIRE

The questionnaire form was a four-page printed form which asked 46 questions about farm dams and their use, together with details of property, location, stock carried, etc. For the most part questions were of the "Yes - No" variety, with answers given by ticking the appropriate box.

Table 2 summarises the questions asked and the form of answer required.

# TABLE 2

## FARM DAM SURVEY -

## SUMMARY OF QUESTIONNAIRE FORM

| Question Number | Question | Form of answer (See note below) |
|---|---|---|
| | Name of landholder | Written |
| | Address | " |
| | Name of Property | " |
| | Area of Property | " |
| | Shire | " |
| | Location in relation to nearest town | " |
| | (Brief description of property and main forms of land use. | " |
| | Number of dams and tanks now in use | " |
| | (Total number of dams and tanks on property, including failures, silted dams, etc. | " |
| | Other sources of water available | " |
| 1. | Type of dam or tank | ø |
| 2. | Present condition of dam or tank | ø |
| 3. | Capacity when full | figure |
| 4. | Designed by - | ø |
| 5. | Built by - | ø |
| 6. | When built | figure |
| 7. | Volume of Soil excavated | figure |
| 8. | Approximate total cost of construction | figure |
| 9. | Construction equipment used | ø |
| 10. | Construction methods | ø |
| 11. | Was a Core trench built under wall? | ø |
| 12. | Was top soil stripped before construction commenced. | ø |
| 13. | Dimensions of dam or tank | figures |
| 14. | Briefly describe soil in dam wall or floor and sides of tank | written |

TABLE 2
(cont'd.)

| Question Number | Question | Form of answer (See note below) |
|---|---|---|
| 15. | Area of catchment in acres | figure |
| 16. | Dam or tank filled from - (catchment, pump, irrigation channel, etc.) | ø |
| 17. | Briefly describe general nature of soil on catchment | written |
| 18. | Briefly describe general nature of cover on catchment | written |
| 19. | How often, on the average, do you get enough runoff to fill the dam to over-flow level? | ø |
| 20. | How often, on the average, does the dam become empty? | ø |
| 21. | How many times has dam been empty for- (3 months, 3-6 months, 6-12 months, 1-2 years, more than 2 years) | figures |
| 22. | Spillway and accessories in dam or tank. | ø |
| 23. | Major use of dam or tank | ø |
| 24. | Average number of stock watered in a year | figure |
| 25. | Approximate area irrigated | figure |
| 26. | Type of irrigation used | ø |
| 27. | Purpose of irrigation | ø |
| 28. | Do you consider dam or tank has ever failed? | ø |
| 29. | Do you consider failure was complete or partial? | ø |
| 30. | Type of failure | ø |
| 31. | If structural, how was it caused? | ø |
| 32. | Has wall been repaired? | ø |

TABLE 2
(cont'd.)

| Question Number | Question | Form of answer (see note below) |
|---|---|---|
| 33. | Is dam now in use? | ø |
| 34. | Date of failure | figure |
| 35. | Date of repair | figure |
| 36. | Cost of repair | figure |
| 37. | If seepage failure, where did seepage occur? | ø |
| 38. | Has seepage taken up? | ø |
| 39. | If so, was this due to<br>(a) Natural sealing,<br>(b) Artificial sealing. | ø |
| 40. | If artificial sealing, give method used. | ø |
| 41. | Approximate cost of artificial sealing. | figure |
| 42. | What is present seepage rate? | ø |
| 43. | If economic failure, give reason. | ø |
| 44. | Has an anti-evaporant chemical been used? | ø |
| 45. | How many times has dam or tank been desilted? | figure |
| 46. | Approximate total cost of desilting to date. | figure |

NOTE: ø Implies that answer given by putting tick in appropriate column.

"figure" - Implies answer given by single figure.

"written" - Implies that worded answer needed.

## 3. PRELIMINARY ANALYSIS OF RESULTS

Table 3 shows, for each of the 60 districts sampled, the number of dams, the number of dam failures, and a breakdown of the causes of failure.

Table 4 shows overall percentages of failure, broken down into five groups - failures resulting from hydrologic inadequacy, such as undersized catchment or too frequent emptying of dam; overtopping; seepage; structural causes, such as slumping, and miscellaneous causes, such as silting or tunnelling.

Table 5 shows a comparison between the 9 Western districts and 9 districts on the Central Tablelands and South-West Slopes.

Some interesting comparisons can be drawn from Table 5. The failure rate in the west is twice as high as that on the slopes and tablelands:- this is primarily due to the better runoff distribution, both in quantity and frequency, occurring in the east. For the same reason, overtopping failures are considerably more common in the higher rainfall districts. Silting is a major cause of failure in the west. In both areas (and in most other districts) seepage is a major problem. Most dams in the west are excavated tanks, accounting for the lack of structural failures. It is considered that a number of the failures in the slopes and tablelands which have been attributed to overtopping were due initially to excessive settlement, resulting from inadequate compaction.

Tables 4 and 5 serve to emphasise the importance of the three phases of the farm dam research programmes at the University of New South Wales - hydrologic design, improved construction and seepage control.

TABLE 3: FARM DAM SURVEY: PRELIMINARY ANALYSIS, JANUARY 1962.

| Dist. No. | District | Sample | | Replies Usable | Pc. replies usable | No. of Dams | No. of dams per property | No. of Failures | Pc. of Failures | Failure Analysis | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st try | 2nd try | | | | | | | Hydr Inad. | O/T | Seep. | Struct. | Other |
| 1 | Albury | 13 | 3 | 3 | 23 | 22 | 7.3 | 0 | 0 | - | - | - | - | - |
| 2 | Armidale | 39 | 5 | 14 | 36 | 30 | 2.1 | 6 | 20 | 2 | 0 | 2 | 0 | 2 |
| 3 | Balranald | 7 | - | 1 | 14 | 8 | - | 7 | - | 7 | 0 | 1 | 0 | 0 |
| 4 | Bathurst | 26 | 5 | 9 | 35 | 35 | 3.9 | 3 | 9 | 1 | 0 | 2 | 0 | 0 |
| 5 | Boubala | 11 | 4 | 5 | 45 | 22 | 4.4 | 3 | 14 | 1 | 0 | 2 | 0 | 0 |
| 6 | Bourke | 11 | - | 2 | 18 | 14 | 7.0 | 3 | 21 | 0 | 1 | 1 | 0 | 1 |
| 7 | Braidwood | 12 | 3 | 4 | 33 | 11 | 2.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Brewarrina | 9 | 1 | 5 | 56 | 28 | 5.8 | 6 | 21 | 3 | 0 | 0 | 1 | 2 |
| 9 | Broken Hill | 7 | 1 | 7 | 100 | 45 | 6.4 | 11 | 22 | 5 | 2 | 3 | 0 | 1 |
| 10 | Canberra | 6 | 1 | 2 | 33 | 3 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Canonbar | 19 | - | 5 | 26 | 59 | 11.8 | 31 | 53 | 22 | 0 | 2 | 0 | 7 |
| 12 | Carcoar | 28 | 6 | 12 | 43 | 60 | 5.0 | 10 | 17 | 0 | 1 | 6 | 1 | 2 |
| 13 | Casino | 8 | 1 | 2 | 25 | 4 | 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Cobar | 10 | 1 | 4 | 40 | 43 | 10.8 | 11 | 26 | 0 | 5 | 0 | 0 | 6 |
| 15 | Condobolin | 41 | 7 | 16 | 39 | 119 | 7.5 | 20 | 17 | 3 | 1 | 14 | 1 | 1 |
| 16 | Cooma | 24 | 7 | 13 | 54 | 11 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Coonabarabran | 30 | 9 | 11 | 37 | 8 | 0.7 | 3 | 38 | 2 | 1 | 0 | 0 | 0 |
| 18 | Coonamble | 22 | 3 | 10 | 45 | 62 | 6.2 | 20 | 33 | 14 | 4 | 1 | 0 | 1 |
| 19 | Corowa | 14 | 2 | 4 | 29 | 42 | 10.5 | 5 | 12 | 0 | 3 | 2 | 0 | 0 |
| 20 | Deniliquin | 17 | 1 | 9 | 53 | 60 | 6.7 | 8 | 13 | 0 | 0 | 8 | 0 | 0 |
| 21 | Denma-Singleton | 6 | 1 | 1 | 17 | 1 | - | 0 | - | 0 | 0 | 0 | 0 | 0 |
| 22 | Dubbo | 45 | 14 | 19 | 42 | 83 | 4.4 | 16 | 19 | 7 | 0 | 1 | 0 | 8 |

TABLE 3: (CONT'D) FARM DAM SURVEY: PRELIMINARY ANALYSIS, JANUARY 1962.

| Dist. No. | District | Sample | | Replies Usable | Pc. replies usable | No. of Dams | No. of dams per property | No. of Failures | Pc. of Failures | Failure Analysis | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st try | 2nd try | | | | | | | Hydr. Inad. | O/T | Seep. | Struct. | Other |
| 23 | Eden | 2 | 2 | 1 | 50 | 0 | - | 0 | - | 0 | 0 | 0 | 0 | 0 |
| 24 | Forbes | 38 | 8 | 21 | 55 | 147 | 7.0 | 36 | 25 | 18 | 2 | 7 | 1 | 8 |
| 25 | Glen Innes | 14 | 1 | 4 | 29 | 6 | 1.5 | 1 | 17 | 0 | 0 | 1 | 0 | 0 |
| 26 | Gloucester | 3 | 1 | 0 | 0 | - | - | - | - | 0 | 0 | 0 | 0 | 0 |
| 27 | Goulburn | 20 | 4 | 8 | 40 | 48 | 6.0 | 7 | 15 | 4 | 0 | 0 | 2 | 1 |
| 28 | Grafton | 5 | 1 | 2 | 40 | 15 | 7.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | Gundagai | 29 | 1 | 2 | 7 | 7 | 3.5 | 1 | 14 | 0 | 1 | 0 | 0 | 0 |
| 30 | Hay | 17 | 4 | 7 | 41 | 52 | 7.4 | 18 | 35 | 7 | 0 | 9 | 0 | 2 |
| 31 | Hillston | 10 | 2 | 4 | 40 | 9 | 2.3 | 3 | 33 | 0 | 0 | 1 | 0 | 2 |
| 32 | Hume | 16 | - | 6 | 37 | 33 | 5.5 | 7 | 21 | 2 | 0 | 4 | 0 | 1 |
| 33 | Inverell | 15 | 5 | 5 | 33 | 18 | 3.6 | 8 | 44 | 0 | 1 | 6 | 0 | 1 |
| 34 | Jerilderie | 9 | 3 | 2 | 22 | 7 | 3.5 | 3 | 43 | 3 | 0 | 0 | 0 | 0 |
| 35 | Maitland | 3 | - | 2 | 67 | 13 | 6.5 | 2 | 15 | 0 | 0 | 1 | 0 | 1 |
| 36 | Merriwa | 10 | 2 | 8 | 80 | 7 | 0.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | Milparinka | 3 | - | 0 | 0 | - | - | - | - | 0 | 0 | 0 | 0 | 0 |
| 38 | Molong | 36 | 2 | 13 | 50 | 65 | 5.0 | 10 | 15 | 2 | 5 | 3 | 0 | 0 |
| 39 | Moree | 25 | 1 | 7 | 28 | 32 | 4.6 | 8 | 25 | 4 | 2 | 1 | 0 | 1 |
| 40 | Moss Vale | 6 | 2 | 3 | 50 | 3 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | Moulamein | 11 | 4 | 3 | 27 | 5 | 1.7 | 3 | 60 | 2 | 0 | 1 | 0 | 0 |
| 42 | Mudgee | 23 | 9 | 8 | 35 | 43 | 5.4 | 8 | 18 | 0 | 3 | 3 | 0 | 2 |
| 43 | Narrabri | 16 | 4 | 8 | 50 | 6 | 0.8 | 2 | 33 | 2 | 0 | 0 | 0 | 0 |

TABLE 3:(CONT'D.) FARM DAM SURVEY: PRELIMINARY ANALYSIS, JANUARY 1962.

| Dist. No. | District | Sample | | Replies Usable | Pc. replies usable | No. of Dams | No. of dams per property | No. of Failures | Pc. of Failures | Failure Analysis | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st try | 2nd try | | | | | | | Hydr. Inad. | O/T | Seep. | Struct. | Other |
| 44 | Narandera | 21 | 6 | 8 | 38 | 56 | 7.0 | 8 | 14 | 1 | 1 | 4 | 2 | 0 |
| 45 | Pilliga | 12 | 1 | 3 | 38 | 6 | 2.0 | 1 | 17 | 0 | 0 | 0 | 0 | 1 |
| 46 | Pt. Macquarie | 3 | 2 | 1 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 47 | Tamworth | 53 | 17 | 27 | 52 | 74 | 2.7 | 23 | 31 | 0 | 8 | 9 | 6 | 0 |
| 48 | Tenterfield | 13 | 3 | 4 | 31 | 25 | 6.3 | 8 | 32 | 1 | 1 | 6 | 0 | 0 |
| 49 | Lismore-Tweed | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | Upper Hunter | 9 | 1 | 3 | 33 | 8 | 2.7 | 2 | 25 | 2 | 0 | 0 | 0 | 0 |
| 51 | Urana | 8 | 2 | 2 | 25 | 6 | 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 52 | Wagga Wagga | 29 | 5 | 13 | 45 | 92 | 7.1 | 9 | 10 | 2 | 3 | 4 | 0 | 0 |
| 53 | Walgett | 12 | 2 | 4 | 33 | 49 | 12.3 | 7 | 14 | 0 | 1 | 0 | 0 | 6 |
| 54 | Walgett North | 11 | 1 | 4 | 36 | 18 | 4.5 | 1 | 6 | 1 | 0 | 0 | 0 | 0 |
| 55 | Wanaaring | 4 | 1 | 2 | 50 | 10 | 5.0 | 3 | 33 | 2 | 0 | 1 | 0 | 0 |
| 56 | Warialda | 32 | 4 | 10 | 31 | 40 | 4.0 | 8 | 20 | 4 | 0 | 2 | 0 | 2 |
| 57 | Wentworth | 6 | 3 | 3 | 50 | 21 | 7.0 | 7 | 33 | 7 | 0 | 0 | 0 | 0 |
| 58 | Wilcannia | 7 | 2 | 3 | 43 | 25 | 8.3 | 6 | 24 | 0 | 0 | 2 | 0 | 4 |
| 59 | Yass | 26 | 3 | 10 | 38 | 51 | 5.1 | 5 | 10 | 0 | 3 | 2 | 0 | 0 |
| 60 | Young | 37 | 8 | 15 | 41 | 114 | 7.6 | 16 | 14 | 8 | 4 | 2 | 0 | 2 |

TABLE 4:

FARM DAM SURVEY-

CAUSES OF FAILURE ON STATE-WIDE BASIS.

| | |
|---|---|
| Total No. Dams for which data available | 1879 |
| Total No. of failures | 384 |
| Percentage reported as failures | 20 |
| Proportional distribution of failure causes: | |
| 1. Hydrologic inadequacy | 36 pc. |
| 2. Overtopping | 14 pc. |
| 3. Seepage | 29 pc. |
| 4. Structural | 4 pc. |
| 5. Others (primarily silting) | 17 pc. |

TABLE 5:

COMPARISON OF FAILURE CAUSES

WESTERN DISTRICTS
versus
CENTRAL TABLELANDS and S. W. SLOPES

| ITEM | WEST | CENTRAL AND S. W. |
|---|---|---|
| No. Dams per property | 6.7 | 5.0 |
| Failure rate | 29 pc. | 15 pc. |
| Failure causes:- | | |
| 1. Hydrologic inadequacy | 41 pc. | 29 pc. |
| 2. Overtopping | 41 pc. | 29 pc. |
| 3. Seepage | 17 pc. | 28 pc. |
| 4. Structure | 0 pc. | 5 pc. |
| 5. Others | 27 pc. | 14 pc. |

NOTES:

(a) Western districts comprise 37, 9, 57, 55, 58, 3, 31, 14, 6.

(b) Central and S.W. Districts comprise 38, 42, 4, 12, 60, 59, 29, 10, 27.

(c) High proportion of "hydrologic inadequacy" failures in Western districts due dams being dry for long periods, insufficient runoff, insufficient storage capacity.

(d) The majority of "other" failures in Western districts due excessive silting.

RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING

PROGRESS REPORT NO. 2. 1960-1961.

# APPENDIX D: YIELD ESTIMATES - U. S. D. A. METHOD.

# RESEARCH IN SOIL AND WATER CONSERVATION ENGINEERING

## PROGRESS REPORT NO. 2. 1960-1961.

## APPENDIX D: YIELD ESTIMATES - U. S. D. A. METHOD

### 1. INTRODUCTION

Research in the hydrologic design of farm dams has been handicapped by a lack of data regarding the yield from small ephemeral watersheds. The HYDRA Scheme has been established to overcome this lack of data; HYDRA, however, is a long term project, and useful design data cannot be expected from the Scheme for several years. In the interim period some method of estimating yield from rainfall data, which are readily available in most areas, is required for the design of small reservoirs.

A number of methods has been investigated and these have been reported in Progress Report No. 1. Because of the uncertain distribution of rainfall in most parts of N. S. W. it has been found that methods based on rainfall-runoff correlations on an annual or monthly basis, or on the use of water budget calculations, have not been successful. On the other hand, it has been shown that an analysis of the individual storms of the rainfall record may give a close approximation to the annual yield and, more importantly, a reliable picture of the runoff frequency and the length of dry spells to be expected.

The Soil Conservation Service of the United States Department of Agriculture has developed a method of yield estimation which is based on an analysis of individual storms. This method which appears with some modification to be suitable for Australian conditions is briefly outlined below. A new procedure for the estimation of annual yield is also described.

### 2. THE "DIRECT RUNOFF" PROCEDURE

This method is described in the U. S. D. A. S. C. S. National Engineering Handbook, Section 4 Supplement A - "Hydrology Guide for Use in Watershed Planning". The essentials of it have been reproduced in the recent U. S. B. R. publication "Design of Small Dams", now available in Australia.

The procedure is based on a rainfall-runoff equation for individual storms, and was originally intended for use in flood estimation, in order to determine the volume of flood runoff for synthetic unitgraph derivations. The basis for the equation used has not been published. It has been outlined in a personal communication from H. O. Ogrocky, Chief, Hydrology Branch, U. S. D. A. Soil Conservation Service.

The basic rainfall-runoff equation used is

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

where Q is the direct runoff in inches,

P is the storm rainfall in inches,

$I_a$ is the initial abstraction (i.e. initial loss) in inches and S is the maximum potential difference between P and Q, in inches, at the time of the storm's beginning. The semi-empirical constant S is difficult to define precisely; some explanation of its meaning is given in the references cited above. It depends upon the infiltration characteristics of the watershed, and is related to soil type, cover and antecedent moisture.

Research conducted on a number of watersheds in the United States has shown that the initial loss $I_a$ is equivalent to 0.2 S for all practical purposes. With this simplification the runoff equation becomes

$$Q = \frac{(P - 0.2\,S)^2}{(P + 0.8\,S)}$$

For convenience this equation is plotted for various values of S on a rainfall-runoff graph; given P, and knowing S, the amount of runoff, Q, can then be read directly from the graph.

The value of S to be used for a particular storm and catchment is determined according to the "hydrologic soil-cover complex" for the watershed. Soils are classified into four groups, according to infiltration characteristics. Watersheds are classified into groups according to land use, cover, and hydrologic condition. Antecedent moisture is classified into three groups. Tables and a nomograph are provided by which, for a given soil type, cover, land treatment

and antecedent moisture, the appropriate value of S is given and the appropriate rainfall-runoff curve is then selected and used to determine the runoff volume.

By taking the daily rainfall records and determining the value of S for each storm, the individual storm runoffs can be computed. The annual yield is the total of the storm runoffs thus obtained. The method is tedious and time consuming, especially if a long period of record is to be analysed. It could, however, be handled on a digital computer. Whilst this is hardly feasible for the design of a single farm dam, it offers an excellent opportunity for the developing of generalised yield maps on a state-wide basis. A FORTRAN programme for an IBM Computer has been written by Mr. Burton. If the general procedure can be shown to be suitable for Australian conditions, this programme will be used to analyse selected rainfall records for the major climatic districts in N. S. W. and thereby to prepare a set of watershed yield isopleth maps for the State.

A preliminary analysis has been made using this method for the experimental catchment on the Soil Conservation Research Station at Wagga, N. S. W. It has been shown that with some slight modification, principally through changes in the antecedent moisture ranges given by U. S. D. A. the procedure gives a good approximation to the annual yield and an excellent estimate of the runoff frequency distribution curve. Further testing against data from other experimental catchments is necessary.

## 3. THE "ES - 1014" PROCEDURE

"ES - 1014" is an in-service data sheet prepared by the Engineering Division of the U. S. D. A. Soil Conservation Service. It comprises a set of nomographs to permit the estimation of annual water yield from watersheds ranging in area from 10 to 2000 acres. The parameters are average rainfall, average annual temperature, watershed area, and cover. The chart gives average annual runoff and runoff probabilities in the range from 50 per cent to 90 per cent.

This chart was developed by V. Mockus of the Soil Conservation Service. The basis for its development has been outlined in personal communications from Mockus and Ogrosky.

"ES-1014" was prepared for national use throughout the United States, and for this reason has some shortcomings. It does, however,

provide data suitable for the approximate reservoir design method outlined in Bulletin No. 1 of the Water Research Foundation. It seems desirable that, if such an approach be used in Australia, it be based on smaller, more homogeneous areas than the whole of the mainland of United States. In such a form it would be of value to engineers engaged in farm dam design. It seems too complicated for the use of farmers and tanksinkers, who would more easily understand the runoff isopleths proposed above.

No attempt has yet been made to check this procedure against yield data from Australian watersheds. A considerable amount of research would be necessary to prepare such a set of nomographs for Australian conditions. Some consideration has been given, however, to the possibilities of a digital computer analysis, based on the results of the "Direct Runoff" procedure mentioned above.

## 4. ADOPTION OF THE U. S. D. A. PROCEDURES

Current indications are that the two procedures described above may, if suitably modified, be suitable for yield estimation on Australian watersheds. Further research is necessary to make the necessary modifications. It is anticipated that, if this research is successful, a manual of procedures for yield estimation based on these methods can be published in the coming year as an interim measure, pending the collection of new hydrologic data from the HYDRA Scheme.

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