DATA STORAGE, PROCESSING AND RECOVERY

PHASES ONE AND TWO

PROJECT 9

REPORT 0/1

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This first progress report aims to provide a cross reference of data collected, stored and utilized by each of the sections of the division; to discuss the present and previously proposed methods of data storage. To nominate those methods that may be appropriate to the needs of the Division; and indeed other users of the data. Finally to propose an orderly timetabling for the implementation of any nominated systems.

The former Water Resources Branch conducted several studies into the storage of technical records. These reviews did not promote a reappraisal of the Branch's data collection and analysis techniques because each report was sectionally orientated and sought to justify the utilisation of a new or modified form of bulk, economical storage of the Branch technical records.

A secure technical record storage system must provide safe storage of the original data without the need for further removal from storage, and with minimal storage following its placement in storage. Security implies long term storage for an appropriate future use, and therefore all technical records should be stored in a form that will maximise the utility function of the total technical record.

It is now obvious to many Division Officers and to the Auditor General that the basic records of the Division are not being adequately stored or fully utilized. Many of the failings of the present record storage and utilisation systems are the result of pressures imposed to the Division.

Division has not attempted to develop a uniform nomenclature for monitoring structures and locations. Whatever the technical records are maintained in the current manual format it will remain difficult to jointly use data from more than one record store. The development of a single nomenclature system for the current manual data storage system is thought to be equally difficult.
The present methods of technical record storage do not:

1) Guarantee the security of the raw data
2) assist in the distribution of stored technical records
3) offer economical retrieval of stored data
4) assist in modification or updating of a stored record
5) enhance the utilization of the Division's technical records
6) allow efficient cross-referencing between different storage systems.

There are only two feasible methods for the secure storage of Divisional technical records. The recommendations of this report is that all Core Data, Hydrographic and Water Quality data should be stored in a digital media. Most other technical records should be micro-photographed. In addition this study has concluded that micro-photography should be examined for the storage and distribution of the Division's reports and data tabulations.

Based on 19/8/79 estimates a program to upgrade the security of the Divisional technical records may require up to 100 man-years, cost $4m and continue over a period of from four to ten years. These cost estimates do not include the purchase of any large computer facilities by the Division. In view of the Auditor General's concern it may be appropriate for the Division to seek the allocation of extra funds for the provision of temporary staff and equipment needed to complete the upgrading of technical record security. The recommendations and cost estimates contained in this report may only be valid for five years. If the upgrading of technical record security is not completed by 1985 it may be necessary to re-examine the findings of this report.

The development and operation of the above-mentioned systems would increase the rate of data analysis and enhance the Division's reputation as an efficient supplier of edited and analysed data. In addition, much of the data inconsistencies between the Division and other data storage organizations could proceed more efficiently.
## BACKGROUND

### FEATURES OF TECHNICAL RECORD STORAGE

6.1 Security of Storage  
6.2 Reproduction of the Record from Storage  
6.3 Distribution of Stored Data  
6.4 Retrieval of Stored Data  
6.5 Modification of the Stored Records  
6.6 Record Utilization

### INADEQUAICES OF PRESENT TECHNICAL RECORD STORAGE

8.1 Security of Stored Data  
8.2 Distribution of Stored Data  
8.3 Retrieval of Stored Data  
8.4 Modification of Stored Data  
8.5 Record Utilization  
8.6 Cross Referencing Between Storages

### PROPOSED FUTURE METHODS OF TECHNICAL RECORD STORAGE

10.1 Attempt Nothing New and Continue as Before  
10.2 Reproduce Copies of Selected Records  
10.3 Microphotographic Techniques  
10.4 Digital Storage

### APPENDIX

APPENDIX A  
APPENDIX B  
REFERENCES.
1. TERMS OF REFERENCE

On several occasions the Commonwealth Auditor-General has
stated his dissatisfaction with the insecurity of historic Water
Division technical records. This project was initiated to review the
current security and utilization of Water Division data and to
recognise and timetable those modifications necessary to adequately
meet the requirements of data security, availability, handling
and utilization. It is not intended for this project to examine the
justification for data collection.

To facilitate free discussion by all members of the Division it
was decided to conduct this project in a series of phases, each with
a definite end point. The adopted organisation of the project was:-

PHASE 1

Prepare listings of all original and/or derived data held by the
Water Division. The listings will recognize:-

- Type of data,
- Source of initiation,
- Period of collection,
- Responsibility for data collection, storage and
  retrieval,
- Source of data,
- Data users,
- General data integrity,
- Areas of data creation and storage in need of improvement,
- Current duplication of data store,
- Relative priority of improvements to the total data
  storage system.

PHASE II

Identify data storage systems that are capable of increasing the
record's security while still meeting the requirements set during
Phase 1; nominate a proposal for orderly progression toward the
ultimate "secure" data goal.
PHASE III

Design and commence operation of the adopted method(s) of data storage with only "primitive" means of data output. At the close of this phase all data storage requirements would be being met, though the requirements of efficient data retrieval to wide groups of people may not be achieved.

PHASE IV

Upgrade the storage systems developed in Phase II and III so that the data retrieval requirements and data security requirements are being equally met.

PHASE V

Continue operation of the data systems with gradual modification to the input/retrieval systems. This may include the provision of routine data analysis before input or upon retrieval.

It was understood that much of the work had previously been undertaken in a series of fragmented approaches by officers of the former Water Resources Branch; their findings were to be updated and summarised as appropriate.
2. **RECOMMENDATIONS**

2.1 That direction be given to further investigate and cost the data storage techniques outlined in this report.

2.2 Highest priority should be the development of co-ordinated digital (storage) of Hydrographic, Water Quality and Bore Data.

2.3 The Division proceed with photo reduction of Drafting records.

2.4 The Division further examine the applicability of micro-fiche for the storage and distribution of reports and data summaries.

2.5 The Division transfer original technical records to archival custody once the data has been edited and duplicated in a secondary data storage system.

2.6 The Division initially aim to have all digital storage systems operating in a "BATCH" mode within two years. It has been suggested that all current data in storage could be routinely (annually) "dumped" to microfiche. Duplicate copies of each micro-fiche could normally be distributed as required.

2.7 Within four years of the commencement of digital storage the Division should change from BATCH mode to INTERACTIVE mode. This should occur when most of the historic backlog has been cleared.

2.8 In view of the Federal Auditor General's disquiet with the present methods of technical record storage the Division should seek the allocation of additional staff and funds for an accelerated program. These allocations would reduce the time necessary for the implementation of the recommendations.
2.9 The Division should initially seek co-operation from the ADP Section in design and commissioning of digital systems, however if they are unable to assist the Division may need to approach outside computer agencies or alternatively develop its own computer facilities.

2.10 Each section of the Division should regularly review the quality of its raw and derived data.

2.11 Any new data storage system should enhance the utility of the record and reduce the man-handling of data outputting.
3. SUMMARY

3.1 This report presents the findings of the first two phases of a project to re-appraise the security of stored Divisional technical records. Phase I examined the previous attempts to securely store technical data and created a cross-reference of the status of record storage and utilization within the Water Division. Phase II nominated several methods that are capable of upgrading the security of technical records subject to constraints uncovered during phase I. In addition, phase II also nominated a proposal for the orderly progression toward the ultimate "secure" data goal.

If this project continues into phase III it should provide detailed estimates of development and operation costs for inclusion in the 1980/81 Estimates.

3.2 All findings of this report were based on the following assumptions:-

The Division has an objective statement.

All data collection activities are justified by the Divisional objective statement.

The Water Division is primarily responsible for all Water related functions no matter who performs those functions.

Thorough data analysis is the only way to assess the quality of any collected data.

A secure technical record storage system provides for secure storage of the original data with minimal need to remove it from storage. All routine users of technical records would only have access to duplicate copies of the raw data or to analysis results, both of which would be held on secondary storage systems.

The principal aim of this project is to arrange for the secure storage of all data in forms that will maximize the total utility of the stored records.

3.3 A secure technical record storage system would guarantee:-

Security of raw and derived data
Reproducibility of the stored data
Retrieval of the stored data
Distribution of the stored data
Easy modification of the stored data
Efficient record utilization.
3.4 Previous studies by the former Water Resources Branch had concluded that there were only five methods of data storage that could be used by the Division. These methods were:

- Attempt nothing new and continue as before
- Attempt little new but archive all original records
- Reproduce copies of selected technical records and archive all original records
- Microphotograph relevant technical records and archive all original records
- Digitally store relevant technical records and archive all original records.

3.5 The conclusions appended below have been developed within the main body of the report and are based upon the terms of reference and the assumptions listed above.

3.5.1 The Division was not achieving maximum benefit from its stored records. The major reasons for this included the methods of technical data storage and the Division's preference to be seen collecting, rather than analysing, raw data. Historically the Division may have allocated insufficient resources to the secure storage of technical records.

3.5.2 Current methods of data storage were inhibiting the use of the Division's technical records. Only a fraction of the data collected by the Division had ever been processed. It was estimated that the poor utilisation of currently held technical records resulted in an average annual loss to inventories of $7.7m; mainly through inappropriate design of physical structures. Slightly the current technical record stores systems were also

- Failing to provide sufficient security to the original data
- Hampering the distribution of the stored records
- Encouraging routine direct access to the original data
- Encouraging decentralisation of data storage
- Limiting the scope for utilization of the stored records
- Discouraging cross-referencing between data files.
3.5.3 All original field records should be archived as soon as the technical data has been duplicated onto a secondary data storage system. Based on interstate experience if future problems are to be minimised it is necessary to verify all data before it is duplicated onto a secondary data storage system and the originals archived.

If raw data is not verified and duplicated soon after it is collected it is possible for poor techniques to become standards. In addition the lack of data verification soon after collection may produce volumes of unprocessable field data.

3.5.4 The Assessment Group should allocate more resources to the acquisition of "standard map transparencies" that show the location of the Divisions monitoring structures. Maps stored in this form can be easily reproduced, quickly updated and more secure than previous location maps. The Drafting Section has already commenced a program to produce such a series of maps.

3.5.5 Coupled with the production of standard location maps the Division should expand its current field location program. Much of the current location information was poorer than the plotting accuracy and in need of upgrading.

3.5.6 As budgetary constraints allow, the Division should produce photo-reduced negatives of all drawings. These negatives would provide an efficient means of storage and distribution between offices whilst adding to the level of security afforded to the drafted records.

3.5.7 The use of digital storage by the Assessment Group would free officers from data retrieval and allow more data analysis to be performed.

3.5.8 The Division should continue the development of digital storage of hydrographic, water quality and Bore Data records as soon as budgetary constraints permitted. Digital storage of these records was recommended because it best fulfilled the requirements of storage and utilization at a cost acceptable to micro-photographic storage. In addition each of these storage systems require the use of a computer for data analysis.
3.5.9 The Hydrographic, Bore Data and Water Quality records should be integrated into one systematic Water Division DATA BANK. The need for such a data bank will increase as more multi disciplinary studies are undertaken.

3.5.10 All data stored in a digital form should be annually summarised in a micro-fiche "dumped" output. This would allow routine data distribution to people not having direct access to the computer facility.

3.5.11 Regarding non Drafting Office microphotography the Division should only purchase and use micro-fiche technology. Micro-film output from the present Division camera should be loaded into jacket covers. Such a system would allow greater flexibility than a microfilm system and also allow for future modification of the stored record.

3.5.12 It would be advantageous to examine the feasibility of distributing reports and data summaries on micro-fiche. Such a Division policy would save space while reducing postage and storage costs.

3.5.13 All work associated with data security should be rigidly controlled by the Water Division. With the possible exception of digital storage all work should be performed in-house. In the case of digital storage the Division should initially seek cooperation from the ADP Section. If they are unable to assist it may be necessary to approach external computer agencies or alternately to develop in-house computer facilities.

3.5.14 Based on 1976/77 estimates the program to upgrade the security of Divisional technical records could require up to 100 man-years. In view of the Auditor General's concern the Division should seek extra funds for the provision of necessary staff and equipment. The estimated all up cost of the upgrading of security is $4m spread over four to ten years. This cost does not include any allocation for the purchase of full scale in-house computing facilities.

3.5.15 Interstate experience has indicated that the first year upgrade should not have any immediate data analysis requirements if system bugs are to be logically eliminated without compromising the integrity of the data system.
1. INTRODUCTION

This first progress report examined proposals for the secure storage of technical records held by the Water Division and recommends the most appropriate forms of secure data storage bearing in mind the frequency of record usage. Several officers of the Division intended this project to recommend easy options for the improvement of the care afforded to technical records, while others hoped the project would examine the reasons for, and justify, current Division data collection. However, the project group initially realized that neither of these proposed goals had any relevance to this project.

The former Water Resources Branch had previously initiated pragmatic reviews of the security of data storage though none of these proposals had ever reached fruition. Much of the background data for this report was drawn from these earlier studies and updated as appropriate. Reactions to these earlier studies indicated it was undesirable for a small group in isolation to attempt to modify Branch policy on the collection, storage and utilization of data. A draft copy of this report had already been discussed with the appropriate section leaders of the Division, though the direction pursued during the next phase of the study is still to be finalised.

This progress report provides a cross-reference of data collected, stored and utilized by each section of the Division, and discusses the present and proposed methods of data storage. Based on discussions within the Division it nominates those methods of secure data storage suitable for internal and external data users. Finally the report has proposed an orderly timetable for the implementation of the recommended systems.
5. BACKGROUND

As previously mentioned the former Water Resources Branch conducted several studies into the storage of technical records. These reviews did not promote a reappraisal of the Branch's data collection and analysis techniques, because each report was sectionally orientated and sought to justify the utilization of a new or modified form of bulk, economical storage of the Branch's technical records. The present review attempts to consider all technical records generated and held by the Division and the cross referencing of historic data held may indirectly promote reappraisal of the Division's role in the collection and analysis of technical records.

In attempting to review the needs for secure technical record storage some assumptions have been adopted. These include:

A) The objectives of the Water Division are by definition, the assessment, development and management of water resources of the Northern Territory to ensure the maximum long term social benefit of this resource.

B) The Planning Group of the Division supervises the formulation and execution of all water resources assessment and development policies in such a way as to promote maximum efficiency.

C) Sections of the Division are only permitted to collect, store and analyse data that is perceived to be relevant to the efficient operation of the Division. This implies that the Planning Group together with the relevant Sections are routinely re-assess the role of data collection networks and data utilization functions within the larger Divisional and NTFS structures.

D) Lacking any clear statement on the objectives of area Managers the Water Division was deemed to effectively include all Water Division functions no matter who the functions was performed by.

E) Sections will always strive to collect and to analyse data to the highest practicable standard. Deficiencies in the quality of collected data do not become evident until that data has been fully analysed.
Most importantly that, though the secure storage of all technical records was important it could not be considered the total goal, as security implies long term storage for appropriate future usage. The total goal was therefore defined to be to securely store all technical records in ways that maximize the utility function of the total technical record.
6. DESIRABLE FEATURES OF A TECHNICAL RECORD STORAGE SYSTEM

There are several necessary and many desirable features that need to be considered when designing a particular technical record storage system. A secure technical record storage system must provide safe storage of the original data with minimal need for subsequent removal from storage, and with minimal handling following its placement in storage. This implies that original data needs to be reduced to secondary record systems prior to the safe storage of the original record.

The major requisites of a secondary record system will not be considered.

6.1 Security of Storage

Secondary Records up to several generations removed from the original data should be the basic record types routinely used by all data users. It is necessary to provide a reasonable level of protection to all secondary records if the original data is to remain securely stored. Duplication of secondary records or data summaries may afford sufficient protection to later generations of secondary records provided an early edition of the secondary record is stored in a secure manner.

6.2 Reproduction of the Secondary Record

The media used to store a secondary record should always adequately reproduce the original record. If the media fails to adequately reproduce the stored record then the security of the technical record system may be jeopardised when original data is removed from storage to recreate a secondary record.

6.3 Distribution of Stored Data

Some styles of technical record storage provide easier access to the record by people external to, or in different sections of, the Division. Whenever possible the system that most fully promotes easy distribution of raw and/or processed Divisional records to all groups in the Division should be adopted.

4.4 Retrieval of Stored Data

It is proposed that only systems that have proven cost effective retrieval modes should be employed by the Division. The increased usage of superior systems would free technical and professional officers from routine data retrieval and allow their time to be more productively utilized.
6.5 Modification to the Stored Records

When the Division collects more recent field data it is often necessary to modify the storage address of some types of original records, and to modify the data stored on a secondary record. The method of storing secondary records should allow for routine record modification and sequential updating. When a secondary record is updated or modified all current duplicate copies should also be updated. As a mechanical aid it is suggested that each secondary record contain the dates of the most recent record updates.

Record modification would be best achieved if, for each style of technical record, the Division established centralized data storage. It would be necessary to restrict the ability to modify each particular record type to small groups of technical specialists. The modified secondary record would be freely available for use by any interested groups within or outside the Division.

6.6 Record Utilization

The above requirements indicate that the forms of secondary record storage should not impinge upon the possible future uses of stored data, nor upon the ease of extraction of that data. It is often necessary for the Division to perform routine computation and analysis of selected technical records. The storage of these selected secondary records on a media that may be automatically loaded into a computer would facilitate analysis and minimize the ingestion of data errors.

6.7 Easy Access to Multiple Record Stores

The efficient operation of several technical record storage systems that use different nomenclature requires the development and implementation of suitable cross-referencing codes. It may not be necessary for all storage systems to use the same primary nomenclature, although the use of a standard secondary nomenclature, e.g. Australian Map Grid co-ordinates, is needed even if the present technical record storage systems persist into the future.
7. PRESENT METHODS OF TECHNICAL RECORD STORAGE

The status of each current Division technical record storage system has been summarised in appendix A. The current storage systems do not meet the level of record security developed in section 5. The storage systems of the Assessment Group offer the poorest levels of security to the original records. Original records held by this Group are still routinely accessed, only a limited number of partial secondary records have been created, and only a fraction of the secondary records are currently being utilized.

A comparative cost/benefit analysis for each Divisional technical record has been summarised in Table 1. During this analysis it has been assumed that:

A) Where data collection and storage systems overlap all value and costs of the specific data have been assigned to the section that is primarily responsible for that type of data. For example water quality data may occasionally be stored in any of the Groundwater, Hydrographic, Water Quality or Operations data systems, however all costs and benefits of this data have been lumped into the Water Quality technical records.

B) The present value of any raw stored data is at least the current costs of data collection minus any revenue or subsidy collected for the provision of a service while the data was being collected. The estimates in column 2 may therefore underestimate the true value of the stored record.

C) The operations group includes the commercial and public utility management functions.

D) The rates of return from data usage (columns (3) and (4)) by each section is the average net annual return from their technical records. The concept is subjective, though the assessments may be considered as the sum of annual savings produced within the Territory by analysis and distribution of collected data.

E) The current cost of data storage includes the salaries of record filing clerks, floor space rental, depreciation of data storage equipment and any additional costs associated with preserving the original and secondary records.

F) The annual increase in data value (column (7)) represents the current rate of Territory expenditure in the area of responsibility of a Functional group.
### TABLE 1

ESTIMATED COMPARATIVE VALUES OF DIVISIONAL TECHNICAL RECORDS.

**CURRENT COSTS**

*(JULY 1978)*

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Current Value of Data</th>
<th>Rate of Annual Return From Data Usage</th>
<th>Cost of Data Storage</th>
<th>Annual Increase in Data Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Groundwater</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
</tr>
<tr>
<td>Hydrographic</td>
<td>75</td>
<td>1.0</td>
<td>5.0</td>
<td>0.025</td>
</tr>
<tr>
<td>Survey/Drafting</td>
<td>30</td>
<td>1.0</td>
<td>3.0</td>
<td>0.050</td>
</tr>
<tr>
<td>Water Quality (and Laboratories)</td>
<td>10</td>
<td>1.0</td>
<td>1.0</td>
<td>0.025</td>
</tr>
<tr>
<td>Operations</td>
<td>15</td>
<td>1.0</td>
<td>1.5</td>
<td>0.025</td>
</tr>
<tr>
<td>Library</td>
<td>1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.070</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>141</strong></td>
<td><strong>4.5</strong></td>
<td><strong>12.2</strong></td>
<td><strong>0.175</strong></td>
</tr>
</tbody>
</table>
Table 1 grossly simplifies the true situation in that much of the data collected and stored by the Operations function group is of interest to that group for only a brief interval following collection. A reasonable suite of operational data may be required by the Assessment Group when reviewing an impact on the environment, or investigating the need for a water supply augmentation. When the Assessment Group is not provided with adequate operational data it is difficult and/or more expensive to answer the appropriate questions. Other types of operational data such as maintenance reports and consumer accounts may have value to only the Operations Group for only a finite time period.

The technical record storage systems currently employed by the Division only allow 30% of the possible nett value of the stored data to be extracted. The shortfall of $7,700,000 (column (4) - column (3)) is felt most by the Territory Taxpayers but is also lowering the morale of the Division because data needed to answer an enquiry is easily extracted from the current storage systems.

From Table 1 it can be seen that the Division and its predecessors have outlaid considerable sums of money to collect raw data. At the same time financial consideration may have impeded several attempts to improve the methods of data storage and data utilisation. This has precipitated the present problems in which less than 20% of the stored data has been analysed.

Historically the Assessment Group has placed more emphasis on record collection than on record verification and subsequent storage. Neither the Hydrographic, Bore Data or Registered Sampling Point (RSP) systems have the location of all their monitoring structures recorded on a series of maps. In each system the local knowledge of Division Officers is often used to resolve queries, however little of this local knowledge has been transferred to the technical record systems. In the future the value of these records must gradually reduce as knowledgeable officers retire if more data is not placed in the relevant technical storage systems.

If data is copied to a secure storage without being verified and checked there must be greater problems in the future when data users inadvertently assume that all data in the secure record store has been previously verified. Some present users of Division technical records are currently assigning too much reliance to the validity of recorded data when attempting to utilize stored data without further checks on its integrity.

The Division has no common nomenclature of monitoring structures and locations. As an example the Groundwater Section uses two naming conventions. These are the Registered Number (RN) of a bore or well, which is simple unique chronological number that is related to the time the bore was registered, and the Index Number (IN) of the bore or well which is a complex number.
The IN is composed of a sheet number that has arbitrarily been assigned to every 1,250,000 map of the Northern Territory, followed by an oblique and then the chronological bore number for that sheet. The advantage of the index system is that all bores in a large area may be located by the IN however, the system has failed when –

1) the 1,250,000 map ceased to be the primary scale map of the N.T. The 1,100,000 map is now adopted as the primary map series and

2) the number of indexed bores on any primary map is more than several hundred. Both the Darwin and Alice Springs 1,250,000 index sheets contain in excess of 1200 registered bores or wells (approximately 20% of the Territories registered bores or wells are on two maps that together represent about 2% of the land surface area).

Additionally many bores have been assigned a RSP number by the Water Quality Section. Further, it has been suggested by the Australian Water Resources Council that bores be known by a River Basin style number that would be similar to the present Gauging Station Numbers.

While over the technical records are maintained in the current manual formats it will be difficult to effectively use more than one naming convention and equally difficult to assign a single nomenclature system. With secondary records in a digital form it is possible to address any stored data. It has previously been suggested that if bores and wells were only referred to by their Registered Number a reduction in the general level of confusion would be possible.

If cross referencing is frequently required and the Registered Number is not appropriate, as with the RSP system, it may be best to develop specific secondary nomenclature based on the Australian Map Grid. When technical data has not been edited and analysed immediately after collection up to 25% of the total stored record may have little future utility because of poor field techniques, poor file reporting and badly located measurement structures persisting for much longer than is necessary to recognize the need for modifications. This in no way implies that 25% of the present data collection activities of the Division are wasted. Rather, the Water Division needs to routinely process all data as it is collected if data collection techniques and networks are to be constantly reviewed.
8. INADEQUANCIES OF PRESENT TECHNICAL RECORD STORAGES

The inadequancies of the present technical record systems may be summarized as below.

8.1 Security of Raw Data

The Water Division has not yet reduced many of the original data records to secondary forms. This has limited the analysis of the records and further entrenched the historic practice of routinely referring any request for data to the original technical record. While this system remains it is illogical to consider that the Division's raw data is securely stored.

8.2 Distribution of Stored Data

As mentioned above many of the original records have not been copied into secondary files and are not available for distribution outside the storage area. Several other types of technical records are distributed as a multitude of paper copies to secondary files. Neither system encourages the easy distribution of technical records because of the large volumes of stored records.

8.3 Retrieval of Stored Data

Most data is retrieved directly from the raw data. This is a dangerous process, because it will eventually destroy the original records. In addition it is also time consuming because of the present arrangement of the record storage systems.

8.4 Modification of Stored Data

In the few technical record systems where secondary files have been created they are unworkable. The difficulties centre about the inability to keep all secondary files up to date, especially where alterations need to be made to a portion of the historic record.

8.5 Record Utilization

The non-availability of records in a form convenient for further analysis has often resulted in the non-performance of the analysis. Often the goal of a project is to provide the best answer by a particular date. The poor storage of records has resulted poor answers because insufficient use was made of the historic records.
8.6 Cross Referencing between Storages

The cross-referencing of data files has not been encouraged within the Division. By way of example, Water Quality Data may be found on Bore Data, Hydrographic, RSP, Laboratory and Division files. Each data storage system has its own name for the results. These include Registered No., Gauge Station No., RSP No., Analysis No and Division File No.

It would be desirable to immediately investigate the Division nomenclature and modify the present sectional naming conventions to form a common Division Listing.
9. POSSIBLE FUTURE METHODS OF TECHNICAL RECORD STORAGE

All previous studies by the former Water Resources Branch have realized that there are only four methods for the storage of technical records by the Division. Not all of the methods will provide sufficient security to raw and secondary technical records. All four methods have been tried within the Division though to date it has not been necessary to reconstruct data from a secure data store. The methods may be summarized as:

A) Attempt nothing new and continue as before

B) Attempt little new advances; Reproduce copies of selected records.

C) Microphotography of relevant Division records.

D) Digitized storage on magnetic media of relevant Division records.

No alternative listing above can fulfill all the criteria of the Division's diverse technical records. It is now proposed to examine each method and to suggest areas of the Division's activities in which each may be appropriate.

9.1 Attempt Nothing New and Continue as before

In the past this approach has been applied to the broad range of Divisional Technical Records and perhaps the greatest benefit of this scheme was that the cost of record storage did not alter. This form of storage may be appropriate for technical reports, library books and magazines where other copies may be used if one copy is destroyed. If this method is continually used for the storage of raw data the original, and in some cases, only copy of the measurement will degrade with usage and eventually be destroyed. This alternative in no way constitutes secure storage.

9.2 Reproduce Extra Copies of Selected Records

The Alice Springs District Office of the Water Resources Branch used this approach with Bore-location Maps. It is more expensive than alternative however, a benefit is a copy of the original record. The original may now be securely stored in an archive while routine usage is made of the copy. In the event of a catastrophe or the degradation of the record copy of the original will have survived and can be used to reconstruct another copy of the record.
This approach is only a temporary and selective form for augmenting the security level of technical records. It is impractical to duplicate all historic records, because of the increased storage requirements, cost of duplication and lack of gain in the data utility function.

9.3 Microphotographic Techniques

Microphotography may be stored in one of two basis forms; micro-fiche or microfilm. The technical advantages/disadvantages of each microphotographic technique will not be discussed. Most technical journals and some technical books are now only available in micro-fiche and may never be commercially available on microfilm.

Microphotography provides a robust copy of the record that occupies a fraction of the volume of the original record. It is ideally poised to copy, securely store and disseminate large volumes of orderly records that do not need periodic alterations and/or updating. One disadvantage of conventional microphotography is the inability to update random sections of a record without either re-performing the microphotography or editing the alternation to a new microfilm or microfiche. It is possible to avoid an illogical and unordered record storage format by loading microfilm into fiche-jackets, and modifying records in the jacket as appropriate.

It was considered by the Water Resources Branch that all original field data should be micro-photographed. Since then it has been recognised that prior to microphotography it may be necessary to edit and highlight portions of the original field documents if a microphotography is to securely store a copy of the raw data.

It has been suggested that all transparencies currently held by the Drafting Office's should be duplicated on microphotographic media. The major disadvantage of complete microphotography of drafting records is that some fine detail and thin line-work may be lost from a drawing when the microphotography is re-converted. To overcome this problem while still achieving considerable reductions in plan room storage the following system was proposed by the Water Resources Branch Drafting Section. All currently registered drawings will be rescaled to produce 200mm x 125mm transparencies, and the duplicate copy of the negative held in archival storage. As new drawings are completed or amendments made to existing drawings these new sheets will in turn be rescaled to the 200mm x 125mm format and the redundant scaled negatives removed from storage and destroyed.
Such a storage scheme could be extended to provide routine destruction of selected full scale drawings that have not been amended or printed during the preceding two years. At least two copies of the rescaled negative would still be stored even though the original full size drawing may no longer exist. Such a system would reduce the space requirements of the Plan Storage Area and increase the level of storage security.

If the Division is given a choice between microfilm and microfiche technology then, based on external factors such as the availability of microphotographed copies of NTIS and ANCEL services, and computer output the only logical alternative would be to purchase microfiche reader/printers. It would be undesirable for the Division to purchase both microfilm and microfiche readers because of the high cost of the system hardware. It would however be advantageous for the Division to keep the rotary camera and to cut and load the microfilm into fiche-jackets prior to duplication, distribution and storage.

Microphotography is not suited to the efficient secure storage and recovery of currently collected raw data. Microphotography is economically and practically suited to the distribution of compiled or analysed data files. The New South Wales Water Resources Commissions Bore Data Storage System uses a computer to store and analyse the raw data. A micro-fiche output is made of all current data on an annual basis with quarterly updates of information added since the last annual output.

Their Bore Data filling system provides officers with access to the latest editions of microfiche output. They may only view the original records to resolve disputes caused by the input of incorrect data to the computer. Such microfiche data distribution systems allow dissemination in a compact form and should be examined closely by the Division and implemented if they are cost effective.

In summary microphotography is ideally suited to the duplication, secure storage and distribution of books, journals and reports and may be very useful for the distribution of updated compiled data records. It is not suited for secure storage of all raw data or drafted plans. Any future proposal to increase the Division's microphotographic techniques should be carefully weighed against the afore-mentioned detractions. Based on external factors only microfiche technology should be considered. The microfilm from the Division's camera should be loaded into fiche-jackets immediately after the film is processed.
9.4 Digital Storage

Depending on the computer configuration digital storage may be more or less attractive. In all forms digital record storage offers:

A) The facility to continually update or modify the stored record without the necessity to physically reschedule the record.

B) The ability to perform machine controlled data searches, releasing professional and technical officers for other work.

C) The capacity for data compilation and analysis on any of the stored record. This result may in turn be machine stored, tabulated on paper or microfiche output or drawn as machine-based graphics on paper or transparent materials.

D) The possibility of the Division operating a data base of all relevant information. These systems allow machine cross referencing of record files, and hence eliminate the need for manual cross referencing between technical records.

Based on these capabilities digital techniques are best suited to the storage of Divisional records that will require editing, compilation, computing and/or analysis. Within the Water Division all technical records of the Assessment Group fall into this category. The bore Data Files need continual editing and analysis together with cross referencing to the Registered sample point files, while the Hydrographic Data files need complex computation and analysis coupled with cross reference to the Registered Sample Point files. In addition to the need for cross referencing of RSP files, information on these files may be computed at the time of sample analysis and whenever results from temporally or areally distributed samples are being compared.

Survey/Drafting results often require future modifications and the British Government has developed a computer based map storage system that allows a map to be updated without the need to fully retrace the map. In this system an up-to-date map of any scale can be plotted by the computer as it is required. It is not proposed to further examine digital storage of survey data because it does not appear warranted.
The Operations Group may wish to store some data in a digital storage system. Not enough is known about the data collected by the Area Managers for the Operations Group of the Division. Some of the historic operational data may have been retained by the Federal Government at the time of transfer of powers.
10. PROPOSED FUTURE METHODS OF TECHNICAL RECORDS STORAGE

10.1 Attempt Nothing New and Continue as Before

It is possible to store every Division technical notebook in a secure manner if the original books are archived immediately after the raw data has been extracted and processed. This technique is applicable to

A) Survey Books. Survey data is used to compile survey plans. Any information that may be revised in a subsequent survey should be summarized either on the plans or in a Bench Mark Register.

B) Test Pumping Books. The raw data is extracted and analysed to predict values of aquifer parameters. Both the analysis and the results are currently stored on the relevant bore data file. The field books should be archived after the analysis is completed.

C) Drilling Return Books. A copy of this information is attached to the relevant bore data file and the butt copies still in the book should be archived.

D) Gauging Sheets. The gauging sheets record the field measurements and computation of storage-discharge relationship. The gauging results are also recorded in the gauging register. The gauging sheets should be archived.

10.2 Reproduce Copies of Selected Records

The Division has commenced a program to locate all measurement structures on transparent copies of the Australian Survey Office 100 000 maps. When this program is finalised all Bore, Gauging Stations and Sampling Locations maps could be duplicated as a paper print. This will save considerable time hand copying maps and will add security to the original of each map sheet.

In addition it is possibly still appropriate to dyline copy tide gauge charts and to then send a copy to all interested persons.

10.5 Microphotographic Techniques

The Division may choose to microphotograph some of the technical records it holds. Under no circumstances should microphotography be extended beyond the photo reduction of plans or Division reports and data tabulations.
The proposal for the Drafting Section to produce 200mm x 125mm transparent copies of all current drawings should be commenced as soon as possible. There is no urgency in suggestions to microphotograph all Division reports, though this should be commenced within the next five years.

10.4 Digital Storage

Following a consideration of the economic and practical results of digital record storage it is concluded that the 30re Data, Hydrographic and RSP files warrant computer based storage facilities. Based on the simple analysis presented in appendix B it would appear the maintenance costs would be low once the system is operational. A.D.P. has not commenced to charge users, and is unlikely to commence charging in the near future.

If these three file systems are digitized they should be created of sub-files in a total hydrologic data storage file. Such a system could allow free access for data extraction with data modification to a sub-file being restricted to a sectional group. After the original records are reduced to a digital form they should be securely stored under archival custody. The first generation of digital records would be copied to produce working editions of the records and would then be archived to further guarantee the security of the raw data record.

If such a system is adopted it will not be necessary to microphotograph the original record to further enhance its security.

Initially the Division should concentrate on duplicating raw data in a digital form so the raw data can then be archived. The first generation of the digital storage systems should provide annual bulk output of selected files as micro-fiche and the provision for operating batch jobs on the computer. As more data is added to the storage the Division may wish to change from a "batch" mode to an "interactive" mode with say a 30 second response time. Batch operation may provide machine graphics on a 5 day turnaround. When ADF purchases its own flat-bed plotter this will improve to a 1 day turnaround.

If ADF are unable to provide logistical support to the Division it may be necessary for the Water Division to approach an outside computer Bureau or establish its own in-house computer facilities.
11. DEVELOPMENT TIMETABLE

It is a recommendation of this report that the Division immediately commence the development of a digital storage system for the combined technical records of the Bore Data, Hydrographic and RSP Systems. The development of such a storage system would require about 2 man-years from ADP and 1 man-year from the Water Division. It would then take at least 1 year to input enough data to establish an operational system.

The digital storage systems will require 3 to 4 man years to design and develop. It has been estimated that it will require 30 to 40 man years to place all the historic backlog of raw data into digital storage. If it is desired to commence raw data entry at the earliest date the initial system design should concentrate on data input and only achieve a primitive form of data output. More efficient System output and computation programs could be written as the raw data is being entered.

Under the present arrangements the Division will need to extract a considerable level of co-operation from the ADP section, if the recommendations are to proceed. Prior to approaching the ADP section the Division should prepare a concise job brief. This will help avoid repetition of the previous misunderstandings between ADP and the Division. If ADP are not able to assist then the Division should attempt to recruit expertise and hardware for its own usage.

The production of micro-fiche copies of Division reports and the 200mm x 125mm transparencies of all drawings should be commenced this financial year.

It may appear advantageous to initially develop all secure storage systems about the needs of the Uranium Region Projects. Some data, especially from external agencies such as ANDEL may be available in digital form. All the data collected in this region will need to be analysed and disseminated further than has previously been Divisional experience. The development and operation of the aforementioned systems would increase the rate of data analysis and enhance the Divisions reputation as an efficient supplier of edited and analysed data. Such a course of action should be weighted up with interstate experience that suggests the first area to be secured should be free of current data analysis requests.
## APPENDIX A

### DIVISION TECHNICAL RECORDS BY SECTION

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1. HYDROGRAPHIC SECTION

1.1 Raw Data Collected by the Hydrographic Section

The majority of raw data collected by the section may be summarized as measurements of the rate and depth of water movements within the hydrologic cycle. The major data networks measure rainfall, both as a rate and as a total depth, depths of surface water and stream discharge measurements, though the section also collects data on potential evaporation, temperature, wind speed, wind run and solar radiation.

1.2 Who uses this data?

Some of the raw data collected by the Hydrographic Section is processed within the section and then distributed to other data users. Daily rainfall data and peak stream-flow levels may be distributed without much computation. Other information such as stream discharge information and short duration rainfall data require very detailed computational procedures prior to distribution.

The raw and subsequently processed data is mainly used within the Water Division though a considerable volume of data is supplied to outside organizations, including consultants, universities, the Australian Water Resources Council, Bureau of Meteorology and the Northern Territory Port Authority. The present state of the data storage system, as will be discussed later, results in many requests for data not being fulfilled because of the lack of suitable information or the lack of staff to extract the data.

1.3 Size of Stored Data

As at the end of August 1978 it is estimated that the Hydrographic Section will be storing the following volume of data:

- BOOK AND STATIONS A10 and A25 Charts 3,750 station-years
- SOUNDER AND POMPEI Punched Tape 1,350 station-years
- GAUGE DISCHARGE MEASUREMENTS 12,000
- WATER BOOKS AND TECHNICAL BILLS 2,000
- WEATHER WEEKLY CHARTS AND MANUAL READINGS 500 station-years
- ADDITIONAL HYDROLOGIC DATA less than 500 station-years
With the completion of each water-year an additional 400 station-years of Leopold and Stevens A25 chart and up to 900 stream discharge measurements are added to the data store.

1.4 Level of Duplication of the Record

Of the total 5,600 station-years of stream-stage and rainfall pluviometer records only 662 station-years of streamflow data has been duplicated on magnetic tape and approximately 1,000 station-years of streamflow records have had daily flow computed from either the magnetic tape image or by hand from the original chart record.

The station inspection reports could provide a value of stream gauge height every six to seven weeks; though these reports would not be capable of regenerating the chart records if they were destroyed.

Other data held by the section, notably the results of chemical or sediment analysis of surface runoff are fully duplicated on the East Point Laboratory Register and also in the Water Quality Section's Registered Sampling Point files.

1.5 Present Method of Data Storage

All original data together with a copy of the magnetic tapes and any computations are stored in a compactus and other cabinets on the top floor of the Mitchell Street Office. Duplicate copies of the magnetic tapes are held by CSIRO in Canberra and, as mentioned previously copies of some analyses may be kept in other Division filing systems around Darwin.

1.6 Requirements of Users of Hydrographic Data

In the past the Hydrographic Section tried to publish and distribute annual and five yearly stream discharge reports. The latest annual report, for the 1973/74 water year, has only just been published and it is hoped to be able to publish the first five yearly stream discharge report within the next eighteen months. These stream flow reports are able to provide most information required by data users from outside the Division, though consultant or academic users may request more detailed information.
By far the greatest user of the hydrographic data are officers of the Water Division, especially those in the Investigation Branch. This group of data users has very diverse requirements, though normally they would prefer not to extract information they require from the original chart. Instead they prefer access to a corrected and edited version of the field record. In other State Water Resource Authorities such access is provided via computer manipulation of a magnetic data image.

It is often claimed that once a suitable chart image has been created and edited most data users have no requirement to peruse either the original charts, the original field inspection reports or the chart computation reports and that all this original data should be preserved in an archive without the need for further reproduction.

1.7 Possible Methods of Providing Adequate Data Security

Basic security of original data can only be guaranteed if following original reproduction, a very small group of people are allowed to examine the original records. In past studies of the security of technical records two possible reproduction technologies have been proposed, each capable of several slight variations. The two available techniques may be lumped as:

A. Microfilming: Proposals to microfilm records of the Hydrographic Section appear to have grown out of the work of the 1974 Working Group. Several people have stated that microfilming would provide the section with a fast method of initial data duplication and this is discussed further in later sections.

B. Digitization: Since 1968 the Hydrographic Section has tried to develop a computer technique to facilitate economic and safe storage of the field data while allowing speedy and efficient methods of data analysis and report production. As mentioned in Section 1.4 the section has already duplicated some 662 station-years of records onto magnetic tape.
It is important to note that this progressive duplication of data onto magnetic tape has not advanced further because of the following reasons:

i. A general lack of performance by the old A.D.P. Section of the Department of the Northern Territory, especially during the interval 1969 to 1977. It is conceded that some progress has been made since 1977 though a lot more cooperation will be needed between A.D.P. and Hydrographic Staff.

ii. Due mainly to (i) above the Hydrographic Section was allowed to commence digitization and computer analysis of stream flow records on the CSIRO computer system in Canberra. A lack of adequate funding by both Water Resources Branch and the A.D.P. Section severely handicapped progress and in fact the Hydrographic Section has never kept abreast of, nor got on top of the backlog of historical data. There has been no trip to Canberra since early 1975 and it has been proposed by the A.D.P. Section that the Hydrographic Section no longer use the CSIRO facility, and instead use the Darwin facilities of A.D.P. During the last eighteen months A.D.P. have not reported any progress with the conversion of programmes from CYMSR to IBM compatibility.

iii. The analogue to digital chart converters (PMDUs) have progressively deteriorated due to damage received during Cyclone Tracy. It is reported the machines will have their first post cyclone service later this year. The servicing delay, it is claimed, is the result of divided priorities within the old Water Resources Branch which resulted in no funds being made available for this important work.
iv. During the five years 1977 the Hydrographic Section had a succession of Senior Engineers and prior to the arrival of Ralph Ash in 1977 had not been led by a senior engineer for three years, and no engineering staff during one six month period. This resulted in a loss of priorities within the section and further removed the section's operational activities from the vision of senior management.

v. Partly as a result of (iv) and also because of several other reasons the Hydrographic Section field staff are not performing enough preliminary computation of their field work. This situation will continue to exist for as long as the high density of field stations in each area and the small numbers of field staff remain the same. Historically it could be claimed the section has collected an excessive volume of useless records because too much emphasis was placed on the production of field data; any field data, without that data being subject to even preliminary procession or analysis.

1.8 Results and Implications of Secure Data Storage

1.8.1 Microfilming of all Basic and Derived Data

If Division policy dictates that all original and/or derived data will be microfilmed then a separate policy governing the quality of the record to be copied will need to be established. If we only consider the security of all analogue charts produced by Lepold and Stevens Recorders the following issues may need clarification.

i. Are original charts to be microfilmed in their present raw state or is somebody going to chart analyse those records and "touch up" all the chart annotations.
ii. Will all inspection reports be copied, and if so will they be "touched up" prior to copying.

If only the charts are to be microfilmed in an "as is" condition then the 3,750 station-years (chart length approximately 70 kilo-metres) could probably be microfilmed in 15 to 20 weeks. To microfilm the inspection and annual reports would probably take an additional 15 to 25 weeks. (There is estimated to be a minimum of 100,000 pages to individually microfilm).

The two options above would only secure a chart image and not guarantee the quality or readability of the resultant microfilm. It has been estimated that to chart analyse all Leopold and Stevens charts prior to microfilming could take between 6 and 10 man-years. If we assume 6 people could be spared to chart analyse and check all historic data prior to microfilming then the total time required to produce a secure usable microfilm copy of the data would be about 2 to 2½ years (allowing for holidays).

Previous examination of Division microfilming do not appear to have examined the applicability of duplicating the 1350 station years of records held on Fischer and Porter punch tape. Indeed it is not even known if it is technically possible to microfilm a punched tape. It is possible to produce a readable microfilm copy of the 1350 station years of record (tape length approximately 135 kilometres) would take 25 to 50 weeks to microfilm. It would require an additional 8 to 12 weeks to microfilm the inspection reports associated with these records.

Again it must be emphasised the above programme could only produce a chart image and in no way will it guarantee the quality or readability of the resultant microfilm image. It has been estimated that to chart analyse at the Fischer and Porter punch tapes prior to microfilming could take between 8 and 10 man-years. It takes much longer to verify Fischer and Porter tapes than Leopold and Stevens charts because of the type and variety of instrument malfunctions. Assuming the service of 4 people to analyse and microfilm these punched tapes it would take between 2½ and 3½ years to complete microfilming the record.
1.8.2 Digitization of Basic and Derived Data

Staff of the old Water Resources Branch have already commenced digitization of Leopold and Stevens analogue charts. Assuming similar staff availability as for section 1.8.1, a reasonable level of assistance from the A.D.P. Section and from the Water Division, it is estimated that the analogue-digital conversion would take a total of 3 to 4 years. If a punched tape reader can be suitably modified then all the Fischer and Porter tapes could be digitized in 2 to 3 years.

The above estimates are all mutually exclusive, and if all the historic backlog were to be digitized at the same time the job would take up to 4 years and require the use of two analogue-digital converters, two IBM’s are already owned by the Hydrographic Section; the use of three IBM 5100 or 5110 Portable Computers, the Hydrographic Section already has a 5100 and 5110, and lastly the provision of at least 6 new permanent/temporary technical staff in the ranges T02 and T42.

If only the existing Section staff and equipment are utilized the digitalization is estimated (conservatively) to require at least 8 years and more probably 10 years.

1.8.3 Duplicate Copies of all Instrument Charts.

If the only requirement is to produce a copy that may be used, if need be, at a later date then this may prove to be a viable alternative for the short term. It would take 12 months to produce copies of all existing Leopold and Stevens charts.

1.9 Implications of Securing Methods on Data Users

There is only one method mentioned under section 1.8 that offers promise of easy future use by a data user. This is the use of computer storage (digitization of the record). If this scheme were adopted all the original charts and inspection reports would be archived and probably never referred to again unless a translation error is detected.
With the other two methods of data duplication the ultimate data user will get no benefit from the copying process and may still require to see the original chart and inspection report; thus partially defeating the purpose of the duplication. In addition it will still be necessary to digitize the record if efficient use is to be made of all the collected data and this programme, if not attempted first, may never be completed because of the annual increase to the historic backlog and the general lack of support previously shown by the old Department of the Northern Territory and especially the A.D.P. Section.

Unless the long term security of all original data is totally commenced soon it will be too late to read some of the cyclone damaged records and too expensive to attempt to reconstitute this destroyed record from microfilm or other mediums. I strongly urge the Division to adopt a policy of extracting all useable information from the historic data, then storing the data in an "archive", but not trying to duplicate the archived original for any reason. If the archived original is lost or destroyed after the data has been extracted then the Division must be prepared to say "The loss of original data is unfortunate, but at least we have a working copy of all the original data we lost."
2. GROUNDWATER AND HYDROGEOLOGY SECTIONS

2.1 Raw Data Collected by the Groundwater and Hydrogeology Sections

The objectives of these sections may be summarized as the orderly collection and storage of all data related to the occurrence and variation of groundwater in the Northern Territory, and the application of this data to ensure that optimum use is made of this resource. These sections do not collect all the data they utilize, however they attempt to maintain a copy of all relevant data held within the Division.

The types of data collected by both these sections may be summarized as including the variations of geological, geophysical, geochemical, geohydrologic, geohydraulic parameters in space and or time. However, it must be stressed that other sections and departments also contribute to the store of information held in the "Bore Data System", viz water quality samples and analysed by the Division's Water Quality Laboratories and some geology samples have been logged by the Department of Mines and Energy.

2.2 Who Uses this Data?

The major users of all data held by the Groundwater and Hydrogeology sections are located within both sections. The most frequent users of the data is to provide advice on likely groundwater supplies to landholders and for the preliminary phases of all investigatory drilling programmes.

The Basin Management Section also uses the data to assess the quality and reliability of both the data collected and also of community and other water supplies.
2.3 Size of Stored Data

By the end of August 1978 it is estimated the Groundwater Bore Data System will hold information on approximately 1300 registered bores and wells in the Northern Territory. The contents of a bore data file may consist of a Regulation 8 form, Geologists log, geophysical logs, geochemistry analyses, pumping test results and analyses and/or geohydrologic data. Many files will contain little more than the Regulation 8 form though it is estimated the total bore data system may presently contain 300,000 sheets of paper.

The annual rate of increase is approximately 400 bores or wells or a total paper increase, including additions to previously registered bores, of 10,000 pages of original and derived data.

2.4 Level of Duplication of the Record

Information held within the bore data system may be duplicated in several other filing systems. The original copy of the Regulation 8 form is filed by ascending Registered Number in a filing cabinet on the top floor of the Mitchell Street office. This copy represents the primary reference file and may only be accessed in order to resolve inconsistencies in any of the operational bore data files.

A copy of the original Regulation 8 form is kept in the operational bore data files at both the Darwin and Alice Springs offices. These operational files also contain any additional relevant data on bores or wells located within the area of that office's responsibility. This additional data may include several or all of the following:

- Geologists logs
- Geophysical (wire-line) logs
- Pumping test data and analysis
- Bore completion report
- Access notes and aud maps
- Results of mineral and/or Water Chemistry analyses.
- Geohydrologic data
- Pump setting, pumping rate and hours of pumping
Some of the above information is duplicated by other data files of the Division; especially any results produced by the Division's laboratories, however results of analyses performed outside the laboratories may not be duplicated. All the above forms of information are, in a sense, non-replaceable historic data which should be better stored and better used.

2.5 Present Method of Data Storage

In Darwin all bore data is stored in filing cabinets on the top floor of the Mitchell Street Office. Most bore data files were damaged during Cyclone Tracy and several are now showing signs of deterioration. It is doubted if this filing system is capable of adequate performance for longer than the immediate short term.

In Alice Springs the bore data is housed in a central brick room which has fire prevention facilities. Again due to the excessive usage of the bore data files, the files are not expected to be operational outside the short term.

2.6 Requirements of Users of Bore Data

The bore data filing system contains all basic groundwater data and the predominant users of this data can be described as being either investigatory (selecting future bore sites) or managerial (assessing and reporting upon various aquifer characteristics). Both classes of users require suitable bore (or well) access for all registered bores and because of this need the Groundwater Section has previously attempted to locate all registered bores on approximately scaled maps.

Most of the present use of the bore data files is by people who require to sift out a small volume of data on a considerable number of registered bores in a given location. A manual data storage system is unable to provide any efficient search routines whereas computer data base storage of the bore data files would allow greater flexibility and efficiencies of data storage, retrieval and usage.
2.7 Possible Methods of Providing Adequate Data Security

The present duplication of bore data files in both the Darwin and Alice Springs offices does provide some additional security to certain classes of data; mainly geo-chemical assay and Regulation 8 sheets. However the inbuilt cost of this system is best illustrated by the following example. If a bore data file in either office is found to contain some wrong information (or to have been double registered etc.) it may seem easy enough to alter one or two data files, however data may also need to be corrected on such files as Registered Sampling Point, Pastoral, Original Regulation 8 file and also the addressing file in both Darwin and Alice Springs. There are other available techniques that have been investigated for use on the bore data system, and these may be grouped as below:

A. Microfilming: Proposals to microfilm the bore data records again appear to have developed from the 1974 Working Group. It is claimed that microfilming offers a fast method of initial data duplication and will be discussed further in a later section.

B. Digitization: The old Water Resources Branch periodically examined the feasibility of digitizing all or some of the bore data files, but apart from several reports encouraging more effort nothing has been achieved. It may be of interest to note that at one stage the Water Resources Branch almost purchased an operational computerized bore data system from the Water Resources Commission of New South Wales. It is now doubted if such a purchase would be of much use to the Division.
2.3 Results and Implications of Secure Data Storage

2.3.1 Modifications to the Present Duplication System

It may be thought feasible and desirable, in terms of data security, to upgrade the volume of data that is duplicated in the bore data files. Already almost all field results of tests performed by officers of the Division are duplicated at least once within the office of origin of the data, however some people may see a need to duplicate all completion forms and location maps at the other office. Such moves to further duplicate the present bore data files should be resisted at all cost because of the possibility of introducing data errors and the difficulty of rationally removing any data errors after they have occurred.

2.3.2 Microfilming of all Basic and Derived Data

One of the problems presently plaguing the bore data filing system is the poor quality of much of the stored data. If short term expediency dictates that all data, regardless of authenticity, is to be microfilmed then the present data quality problems will be vastly magnified. Direct microfilming of the Groundwater technical records would take approximately twelve months (estimated on 250,000 sheets, 3,000 technical note books and 1,000 assorted tables and graphs of 43 or larger size). It is not possible to say what time would be required to first verify all the data, though it would possible take 6 to 10 man years (based on the present rate of data checking).

2.3.3 Digitization of all Basic and Derived Data

Most other State Water Resources Authorities have already commenced storing bore data on computer media. The major factors favouring computer storage are the possibilities of rapid cross-referencing or oblique name codes which can result in rapid retrieval and usage of any or all bore data, while the original data can be kept in government archives. Digitization of the bore data files would not be rapid, and would need to be subject to the same system of data checks proposed in 2.3.2.
Following discussions with D. Wolley of the New South Wales Water Resources Commission it is felt the historic backlog of registered bores in the Northern Territory could be decimated within three to five years if 4 suitably qualified staff were employed. Once the historic backlog was reduced the digitized data system would be capable of meeting all the Division's Groundwater data security goals and user flexibility goals.

2.9 Implications of Security Methods on Data Users

It is felt there is no easy way to solve all the problems inherent in the present bore data filing system, however a logical grouping of several mutually attainable methods will definitely improve the security and usability of the historic records.

It is felt that microfilming has little place as a stop-gap security measure because:

i. It is not easily added to at some future date.

ii. It will require a longish time to microfilm all the bore data files.

iii. Once the microfilms are available they in no way improve the usability of the present bore data system.

The only feasible solution is to spend time upgrading the technical quality of all bore data files and bore location maps so that the following aims will be achieved when the files are computerized:

i. The general record standard is improved.

ii. The data is adequately secured.

iii. Updated computer listings may be made available to any or all interested users.

iv. Only one single data file group need exist (reducing the problems caused by duplication).

v. All data may be retrieved in full or only in part - as required.
3. WATER QUALITY SECTION

3.1 Raw Data Collected by the Water Quality Section

The Registered Sampling Point (RSP) files operated by the Water Quality Section are supposed to function as a basic water quality data file and also as a clearing area between the laboratory where the samples are analysed and the sections of the Division or general public who have requested that analysis; either chemical or bacterial determinations.

Most of the results handled by the Water Quality Section have originated at one of the laboratories operated by the Water Division, though occasionally results are forwarded from other laboratories or in a very small number of cases from Division field staff who have used portable instruments to perform limited analysis of samples in the field, eg. drilling crews and test pumping crews occasionally check TDS, Nitrates and/or Fluoride concentrations.

3.2 Who Uses this Data?

There are three basic patterns of use of water quality data. These may be considered as:

i. The results are needed immediately and used immediately. For example, a drilling investigation hole will often be completed short of the target depth if the groundwater is excessively saline or contains excessive nitrates or fluoride. In these cases an early indication of the water quality can save a considerable footage and hence the finances of the investigation programme.

ii. Routine Water Quality data from a particular location may have been collected over several years and the task is now to analyse the time variation of any and all of the parameters measured. For example, a community water supply will be routinely monitored to ensure that the quality of the supply does not degrade with time.
iii. Occasionally the most recent Water Quality data may result in a check of all previous historic data. This is frequently happening where results from bacteriological tests indicate possible contamination of water supply. This group of actions is considered to be a composite of the two cases above and in no way is it unique.

3.3 Size of Stored Data

Approximately 2500 chemical samples and up to 2000 bacteriological samples are analysed by the Division’s laboratories each year. As at the close of August 1978 it is estimated that the RSP files will contain the results of 25,000 chemical determinations and an additional 12,000 bacteriological results.

3.4 Level of Duplication of the Record

If the RSP system is rigidly adhered to then all laboratory results should be duplicated at least once (i.e. in the laboratory register and also in the appropriate RSP file); though in addition many of the chemical results are duplicated on bore data files and both the chemical and bacteriological results should be duplicated in the water supply files of the Division’s filing system.

3.5 Present Method of Data Storage

At each laboratory the results for that laboratory are kept in an analysis index book. This book records all results in a yearly chronological order of analysis and also records where the sample originated from. All water quality analyses performed by the Division are also filed in the RSP system by order of the location’s RSP number and thus all analyses for a particular location will be kept together in the RSP system.
All water quality data is presently filed manually and so it is not convenient to cross reference all the multiple samples from say the Darwin Town Water Supply taken over the last 5 years. In addition, human errors may cause samples to be mis-named and hence the results are mis-filed. Under the present manual system it may be difficult and time consuming to correctly refile all the duplicate copies of the analysis results.

3.6 Requirements of Users of Water Quality Data

The present RSP filing system is not capable of adequately meeting the diverse demands placed upon it. The laboratory staff find the present data filing system time consuming and capable of introducing gross errors. Following analysis the results are normally checked by "empirical" calculations and then passed to the typist who copies the analysis results onto a pro-forma for subsequent distribution to the RSP and other appropriate filing systems. Unless each typed result sheet is closely examined it is possible for errors to be introduced by the typists.

A pool of competent staff is then needed to file the results on all the appropriate files and where appropriate to notify the sampler that the results of a particular analysis are now available.

Most project orientated users of water quality data would prefer to be able to collect and collate results from several locations and at several various temporal stages. Using the present manual system it is not possible to find out what analyses are available without first collecting all the files and processing the analysis reports; so that unnecessary and time consuming usage is made of the data files in the various technical filing system.
3.7 Possible Methods of Providing Adequate Data Security

Given the present level of duplication of water quality data, it is believed sufficient copies of all analyses performed by the Division exist and hence the data may be regarded as secure. However, it is of little use having secure data if it is difficult to utilize the data. Most people involved with water quality data appear to want a data filing system that is capable of providing speedy cross referencing and utilizing the few competent staff in a more efficient manner. Only one method of data storage appears to be capable of providing these diverse features, and that is digitization.

It has been proposed by the laboratory staff that the analysis name and results could be put into computer storage by the analyst. The computer would then compute any appropriate balance checks and if the results were satisfactory, store the results in a water quality file. If the analysis results were needed outside the Division a copy could be printed from the computer for distribution. For dissemination of results within the Division only the name of new analyses would need to be distributed from the computer to all appropriate sections; with a considerable saving in paper and time and producing a more efficient data storage system.

3.8 Results and Implications of Secure Data

If the present methods of data storage continue to be used then undeniably all the water quality data must be regarded as securely stored. However, the future use of any of the stored data will be reduced because of the difficulties likely to be encountered by people extracting and collating the data. This in no way belittles the quality or usefulness of the data, but instead reflects the possible shortcomings of the existing method of water quality data storage.
If, however, the water quality data were to be stored on a file in computer storage it would be possible to reduce the bulk of paper work presently being pushed through the Division and at the same time offer all interested (potential) users of the data freer access to all the records at no significant penalty.

3.9 Implications of Security Methods on Data Users

If a computer based data storage system is developed to include all water quality data then the laboratory staff and the Water Quality staff who previously maintained the RSP files should have additional time to spend on other routine activities. Another advantage of digitisation should be the more rapid distribution of results to people both inside and outside the Division, especially bacteriological analysis results being routinely sent to operators of community water supplies.

If digitization is not introduced it will still be possible to securely store all derived data, but the overall efficiency of the laboratory and water quality staff will gradually decrease as the annual rate of sample analyses increases. The size of the technical record store will hinder any effort to improve the manual system beyond the level of a cosmetic effect.
4. SURVEY SECTION

4.1 Raw Data Collected by the Survey Section

The Survey Section conducts engineering surveys at the request of other Sections of the Division. The results of all surveys are contained in field books and summarised as appropriate on Job Files, in Bench Mark Registers and on Survey Drawings. Although each regional office may operate independent survey sections it is assumed that all Division surveys will be conducted by officers of the Division from Darwin.

4.2 Who Uses this Data?

All jobs performed by the Survey Section are requested by another officer of the Division, and hence the results of any survey will be forwarded to the requesting officer. Most requests for engineering surveys are related to one of the following:

i. The location and situation of the Division registered structures and locations;

ii. Field topographic data related to a Water Resource project;

and as such some jobs requested in relation to a specific water resource project may also be of interest to one of the other Sections of the Division.

4.3 Size of the Stored Data

It is conservatively estimated that the Division has 1500 field books stored in Darwin and a further 1000 stored in Alice Springs. The annual rate of increase is thought to be approximately 250 field books per year. At present it is difficult to determine the numbers of job files etc. held by the Division, though these are not thought to be a major feature.
4.4 Level of Duplication of Record

All useful data from the field books should be summarised in bench mark registers, bore data files, gauging station files and survey job files. In addition all usable survey data is summarised in a survey drawing. There is no other known duplication of the survey records and it is thought the present system offers sufficient duplication of the important results.

4.5 Present Method of Data Storage

All original field books are stored by the Drafting Section. Relevant results are disseminated to various sections of the Division and following this the field books are not usually referred to again. Archival of the original field books would no more inconvenience data users than does the present system.

4.6 Requirements of Users of the Survey Data

Nearly all data users are satisfied to obtain survey results as a survey plan or occasionally to obtain a tabular summary of survey data for major points, e.g. levels on hydrographic stream gauge bench marks and RL's of gauge zero.

4.7 Possible Methods of Providing Adequate Data Security

The adequate archiving of all original field books once the desired data has been extracted should provide an adequate level of data security. Microfilming the original level books will in any way add to the level of data security, because many of the books would need to be edited and "touched-up" prior to copying.

4.8 Results and Implications of Secure Data Storage

It is doubted whether increased levels of raw survey data security would (or could) be detected by users of survey data.

4.9 Implications of Security Methods on Data Users

As mentioned above increased data security will have little or no impact on most users of survey data.
5. DRAFTING SECTION

5.1 Raw Data of the Drafting Section

The Division currently operates at least 4 drafting offices and the present comments may only be appropriate for the two drafting groups formally controlled by Water Resources Branch.

Between them these offices have been responsible for the production of over 5000 plans and are also responsible for the safe storage of new published topographic maps, geological maps and aerial photography photo negatives that will be used by the Division and original survey books.

5.2 Who Uses this Data?

A Drafting Section is a purely service group and all drafting is only performed as requested by another section of the Division. During a normal year all sections of Water Resources Branch would have requested some service from the Drafting Section.

5.3 Size of the Stored Data

The following tabular summary was based on only the Alice Springs and Darwin drafting groups of the former Water Resources Branch.

<table>
<thead>
<tr>
<th>Stored Plans and Drawings</th>
<th>5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topographic and Geological Maps</td>
<td>8000</td>
</tr>
<tr>
<td>Airphoto mosaics</td>
<td>700</td>
</tr>
<tr>
<td>plus assorted air photos and photo negatives</td>
<td>U/K</td>
</tr>
<tr>
<td>Survey Field Books</td>
<td>2500</td>
</tr>
</tbody>
</table>
Estimated annual rates of increase:

Plans and Drawings 450
Survey Field Books 250

5.4 Level of Duplication of the Records

All published maps and photos (air photo's and topographic maps etc) are widely distributed throughout Australia and hence there is no need for the Division to contemplate duplication of these records. Survey Field Books were discussed in the previous grouping and will not be discussed again here.

There is no systematic duplication of Division drawings - however at any time perhaps 20% of the drawings may have a paper print in existence in either the Darwin or Alice Springs office (mainly bore completion details or pumping test results on the bore data files).

5.5 Present Method of Data Storage

All plans and original drawings held by the Drafting Section are kept in horizontal plan draws in the respective drafting areas. The photo negatives and survey field books are kept in a locked filing cabinet. It has been proposed for several years to replace the horizontal plan draws with a vertical filing system which amongst other things would negate the possibility of water damage to the drawings.

5.6 Requirements of Users of the Drafting Data

Nearly all data distributed by the drafting group is in the form of paper prints made from a transparency, and this appears to be acceptable to most users of the survey data and also to all other data users.
5.7 Possible Methods of Providing Adequate Data Security

The Drafting Section have proposed photo reducing all transparent tracings to approximately 100mm x 75mm format. If this suggestion is followed through it will be possible to lodge a duplicate copy of the duplicates in a secure secondary storage and to use another copy to produce any necessary prints if the original became damaged or excessively aged. As mentioned in the main text this implies that original drawings not used for say 18 months could be destroyed.

Another method of plan security may appear to be to lodge all drawings in a central plan registry and never to remove the drawings from the safety of the central registry. This is effectively the approach of each drafting office, though it cannot operate remote from the drafting office.

5.8 Results and Implications of Secure Data Storage

Photo-reduction of all plan drawings should ensure that no irreplaceable drafting records are ever lost or destroyed. The effort required to reproduce a print from the photo-negative is slightly longer than the time required to produce a print copy from the original tracings, provided fine line details have not been lost during photo reduction.

5.9 Implication of Security Methods on Data Users

Any modification to data security methods will have little effect on data users because most data users rely on paper prints and not the original tracing.
6. OPERATIONS SECTIONS

6.1 Raw Data Collected by the Operations Sections

Most data collected by operations sections is related to the efficient supply of a service to the public. The records may include volumes distributed, fuel costs, maintenance schedules and operational performance data.

6.2 Who Uses this Data?

Most operation data is used almost immediately by the collecting section, however a small volume of data may be needed by the Assessment Group when they are analysing the response of the Source or investigating the need and potential for augmenting the service.

6.3 Size of the Stored Data

Little is known about the volume of operations data held by the Division.

6.4 Level of Duplication of the Record

Some operations data is duplicated between the Area Managers offices and the Operation Managers filing system. In addition some derived data may also be held by the Assessment Branch.

6.5 Present Method of Data Storage

Most of the details kept as graphical or tabulated summaries in the appropriate Division file.

6.6 Requirements of Uses of Operational Data

Most data needs can be adequately met by reference to the file summaries which quickly allow trends to be inspected and verified.
6.7 Possible Methods of Providing Adequate Data Security

The present practices of file duplication between the Area Manager's office and the Operations office provides a satisfactory level of security for most operations data. In fact much of the operations data could possibly be discarded once it has been held for some extended length of time, e.g. maintenance records. However, historic consumption data should be afforded a better, more secure form of storage, say microfilming of the tabulated summaries.

6.8 Implications of Security Methods on Data Users

There are few people outside the operations staff who will ever attempt to use historic operations data and all of their needs may be microphotographed copies of tabulated summaries.

The systematic culling of data files is not expected to inconvenience any data users at some time in the future.
APPENDIX B

COST - BENEFIT ANALYSIS

CONTENTS

COST BENEFIT ANALYSIS
COST-BENEFIT ANALYSIS

It was difficult to perform a valid economic analysis of the proposed methods for securely storing the Division's technical records. Part of the problem was that it was impossible to supply an economic value to various shades of record security. The Division has only two alternatives capable of providing adequate data security. These are micro-photography of the original which is then archived or digitization of the original data and subsequent archival of the original record.

Based on estimates by each section the apparent benefits of digitization over microphotography and the current manual systems are summarized in table B1.

TABLE B1
APPARENT BENEFIT OF DIGITIZATION OVER MICROPHOTOGRAPHY

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Average Annual time required to extract data - man-weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manual/Microphotography</td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
</tr>
<tr>
<td>Bore Advice</td>
<td>44</td>
</tr>
<tr>
<td>AWRC Requests</td>
<td>10</td>
</tr>
<tr>
<td>Project</td>
<td>5</td>
</tr>
<tr>
<td>Graphics</td>
<td>30</td>
</tr>
<tr>
<td>Hydrographic</td>
<td></td>
</tr>
<tr>
<td>Chart Processing (/Chart)</td>
<td>1.5</td>
</tr>
<tr>
<td>Data Extraction</td>
<td>30</td>
</tr>
<tr>
<td>Graphics</td>
<td>30</td>
</tr>
<tr>
<td>ZRP</td>
<td></td>
</tr>
<tr>
<td>Analysis (/location)</td>
<td>1</td>
</tr>
<tr>
<td>Graphics</td>
<td>20</td>
</tr>
</tbody>
</table>
Whilst the analysis is only very cursory it does reveal that
Digitization would:

A) Allow each section to operate 5 to 6 times more efficiently. This increase in efficiency would allow more work per person and would not reduce the staff requirements.

B) Allow the hydrographic section to process more charts per year than are currently being collected. This would allow the section to gradually reduce the historic backlog.

C) Allow the Assessment Group to better answer any requests for data by the AWRC.

If the data were stored on magnetic tape a total of 60 high density tapes would be required. If ADF were allowed to charge the annual rental of these tapes would be less than $800. At present ADF does not charge any system users.

In summary a great improvement in staff efficiency could be achieved by digitization of the record and this process would not cost very much to maintain. Initial system costs are hard to evaluate, but they may be up to $100,000 in ADF wages and computer time. In addition it is estimated the project will require 100 man-years of Water Division staff time at a probable cost of $4m and extra sundary charges for computer rental. It is unlikely the project could be completed in less than four years, though it should ideally not run for more than ten years from now.
REFERENCES

LOHIMER et at. "Management Report on the Storage of Bore Data"
NSW WC & IC December 1970.

SX WRB Files:-
WA/2/8, WC/1/6, WH/6/1, WH/6/2, WH/6/3, WH/6/5
INTERIM REPORT

DATA STORAGE, PROCESSING AND MONITORING

PHASES ONE AND TWO

PROJECT 9

REPORT 9/1

R. REINHARD
November 1978
SYNOPSIS

This first progress report aims to provide a cross reference of data collected, stored and utilized by each of the sections of the Division; to discuss the present and previously proposed methods of data storage. To nominate those methods that may be appropriate to the needs of the Division; and indeed other users of the data. Finally to propose an orderly timetable for the implementation of any nominated systems.

The former Water Resources Branch conducted several studies into the storage of technical records. These reviews did not promote a reappraisal of the Branch's data collection and analysis techniques because each report was sectionally orientated and sought to justify the utilization of a new or modified form of bulk, economical storage of the Branch technical records.

A secure technical record storage system must provide safe storage of the original data without the need for further removal from storage, and with minimal storage following its placement in storage. Securely implies long term storage for an appropriate future use, and therefore all technical records should be stored in a form that will maximize the utility function of the total technical record.

It is now obvious to many Division Officers and to the Auditor General that the basic records of the Division are not being adequately stored or fully utilized. Many of the failings of the present record storage and utilization systems are the result of pressures external to the Division.

The Division has not attempted to develop a uniform nomenclature for monitoring structures and locations. Whichever the technical records are maintained in the current manual formats it will remain difficult to jointly use data from more than one record store. The development of a single nomenclature system for the current manual data storage systems is thought to be equally difficult.
The present methods of technical record storage do not:

1) Guarantee the security of the raw data
2) assist in the distribution of stored technical records
3) offer economical retrieval of stored data
4) assist in modification or updating of stored record
5) enhance the utilization of the Divisions technical records
6) allow efficient cross-referencing between different storage systems.

There are only two feasible methods for the secure storage of Divisional technical records. The recommendations of this report is that all Bore Data, Hydrographic and Water Quality data should be stored in a digital media. Most other technical records should be micro-photographed. In addition this study has concluded that micro-fiche technology should be examined for the storage and distribution of the Division's reports and data tabulations.

Based on 1978/79 estimates a program to upgrade the security of the Divisional technical records may require up to 100 man years, cost $4m and continue over a period of from four to ten years. These cost estimates do not include the purchase of any large computer facilities by the Division. In view of the Auditor General's concern it may be appropriate for the Division to seek the allocation of extra funds for the provision of temporary staff and equipment needed to complete the upgrading of technical record security. The recommendations and cost estimates contained in this report may only be valid for five years. If the upgrading of technical record security has not commenced by 1985 it may be necessary to re-examine the findings of this report.

The development and operation of the afore-mentioned systems would increase the rate of data analysis and enhance the Division's reputation as an efficient supplier of edited and analysed data. In addition much of the data transfers between the Division and other data storage organisations could proceed more efficiently.
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Appendix A  
Appendix B  
References
1. TERMS OF REFERENCE

On several occasions the Commonwealth Auditor-General has
stated his dissatisfaction with the insecurity of historic Water
Division technical records. This project was initiated to review the
current security and utilization of Water Division data and to
recognize and timetable those modifications necessary to adequately
meet the requirements of data security, availability, handling
and utilization. It is not intended for this project to examine the
justification for data collection.

To facilitate free discussion by all members of the Division it
was decided to conduct this project in a series of phases, each with
a definite end point. The adopted organization of the project was:-

PHASE I

Prepare listings of all original and/or derived data held by the
Water Division. The listings will recognize:

- Type of data,
- Source of initiation,
- Period of collection,
- Responsibility for data collection, storage and
  retrieval,
- Source of data,
- Data users,
- General data integrity,
- Areas of data creation and storage in need of improvement,
- Present duplication of the data store,
- Relative priority of improvements to the total data
  storage system.

PHASE II

Propose data storage systems that are capable of increasing the
record's security while still meeting the requirements set during
Phase I; nominate a proposal for orderly progression toward the
ultimate "secure" data goal.
PHASE III

Design and commence operation of the adopted method(s) of data storage with only "primitive" means of data output. At the close of this phase all data storage requirements would be being met, though the requirements of efficient data retrieval to wide groups of people may not be achieved.

PHASE IV

Upgrade the storage systems developed in Phase II and III so that the data retrieval requirements and data security requirements are being equally met.

PHASE V

Continue operation of the data systems with gradual modification to the input/retrieval systems. This may include the provision of routine data analysis before input or upon retrieval.

It was understood that much of the work had previously been undertaken in a series of fragmented approaches by officers of the former Water Resources Branch; their findings were to be updated and summarised as appropriate.
2. RECOMMENDATIONS

2.1 That direction be given to further investigate and cost the data storage techniques outlined in this report.

2.2 Highest priority should be the development of co-ordinated digital storage of Hydrographic, Water Quality and Bore Data.

2.3 The Division proceed with photo reduction of Drafting records.

2.4 The Division further examine the applicability of micro-fiche for the storage and distribution of reports and data summaries.

2.5 The Division transfer original technical records to archival custody once the data has been edited and duplicated in a secondary data storage system.

2.6 The Division initially aim to have all digital storage systems operating in a "BATCH" mode within two years. It has been suggested that all current data in storage could be routinely (annually) "dumped" to microfiche. Duplicate copies of each microfiche could normally be distributed as required.

2.7 Within four years of the commencement of digital storage the Division should change from BATCH mode to INTER-ACTIVE mode. This should occur when most of the historic backlog has been cleared.

2.8 In view of the Federal Auditor General's disquiet with the present methods of technical record storage the Division should seek the allocation of additional staff and funds for an accelerated program. These allocations would reduce the time necessary for the implementation of the recommendations.
2.9 The Division should initially seek co-operation from the ADP Section in design and commissioning of digital systems, however if they are unable to assist the Division may need to approach outside computer agencies or alternatively develop its own computer facilities.

2.10 Each section of the Division should regularly review the quality of its raw and derived data.

2.11 Any new data storage system should enhance the utility of the record and reduce the man-handling of data outputting.
3. SUMMARY

3.1 This report presents the findings of the first two phases of a project to re-appraise the security afforded Divisional technical records. Phase I examined the previous attempts to securely store technical data and created a cross-reference of the status of record storage and utilization within the Water Division. Phase II nominated several methods that are capable of upgrading the security of technical records subject to constraints uncovered during phase I. In addition phase II also nominated a proposal for the orderly progression toward the ultimate "secure" data goal.

If this project continues into phase III it should provide detailed estimates of development and operation costs for inclusion in the 1980/81 Estimates.

3.2 All findings of this report were based on the following assumptions:

- The Division has an objective statement.
- All data collection activities are justified by the Divisional objective statement.
- The Water Division is primarily responsible for all Water related functions no matter who performs those functions.
- Thorough data analysis is the only way to assess the quality of any collected data.

A secure technical record storage system provides for safe storage of the original data with minimal need to remove it from storage. All routine users of technical records would only have access to duplicate copies of the raw data or to analysis results, both of which would be held on secondary storage systems.

The principal aim of this project is to arrange for the secure storage of all data in forms that will maximize the total utility of the stored records.

3.3 A secure technical record storage system would guarantee:

- Security of raw and derived data
- Reproducibility of the stored data
- Retrieval of the stored data
- Distribution of the stored data
- Easy modification of the stored data
- Efficient record utilization.
3.4 Previous studies by the former Water Resources Branch had concluded that there were only five methods of data storage that could be used by the Division. These methods were:

- Attempt nothing new and continue as before
- Attempt little new but archive all original records
- Reproduce copies of selected technical records and archive all original records
- Microphotograph relevant technical records and archive all original records
- Digitally store relevant technical records and archive all original records.

3.5 The conclusions appended below have been developed within the main body of the report and are based upon the terms of reference and the assumptions listed above.

3.5.1 The Division was not achieving maximum benefit from its stored records. The major reasons for this included the methods of technical data storage and the Division's preference to be seen collecting, rather than analysing, raw data. Historically the Division may have allocated insufficient resources to the secure storage of technical records.

3.5.2 Current methods of data storage were inhibiting the use of the Division's technical records. Only a fraction of the data collected by the Division had ever been processed. It was estimated that the poor utilization of currently held technical records resulted in an average annual loss to Territorials of $7.7m; mainly through inappropriate design of physical structures. Briefly the current technical record storage systems were also

- Failing to provide sufficient security to the original data
- Hampering the distribution of the stored records
- Encouraging routine direct access to the original data
- Encouraging decentralization of data storage
- Limiting the scope for utilization of the stored records
- Discouraging cross-referencing between data files.
3.5.3 All original field records should be archived as soon as the technical data has been duplicated onto a secondary data storage system. Based on interstate experience if future problems are to be minimized it is necessary to verify all data before it is duplicated onto a secondary data storage system and the original archived. If raw data is not verified and duplicated soon after it is collected it is possible for poor techniques to become standards. In addition the lack of data verification soon after collection may produce volumes of unprocessable field data.

3.5.4 The Assessment Group should allocate more resources to the acquisition of "standard map transparencies" that show the location of the Divisions monitoring structures. Maps stored in this form can be easily reproduced, quickly updated and more secure than previous location maps. The Drifting Section has already commenced a program to produce such a series of maps.

3.5.5 Coupled with the production of standard location maps the Division should expand its current field location program. Much of the current location information was poorer than the plotting accuracy and in need of upgrading.

3.5.6 As budgetary constraints allow, the Division should produce photo-reduced negatives of all drawings. These negatives would provide an efficient means of storage and distribution between offices whilst adding to the level of security afforded to the drafted records.

3.5.7 The use of digital storage by the Assessment Group would free officers from data retrieval and allow more data analysis to be performed.

3.5.8 The Division should commence the development of digital storage of Hydrographic, Water Quality and Bore Data records as soon as budgetary constraints permitted. Digital storage of these records was recommended because it best fulfilled the requirements of storage and utilization at a cost comparable to microphotographic storage. In addition each of these storage systems require the use of a computer for data analysis.
3.5.9 The Hydrographic, Bore Data and Water Quality records should be integrated into one systematic Water Division DATA BANK. The need for such a data bank will increase as more multi-disciplinary studies are undertaken.

3.5.10 All data stored in a digital form should be annually summarised in a micro-fiche "dumpee" output. This would allow routine data distribution to people not having direct access to the computer facility.

3.5.11 Regarding non Drafting Office microphotography the Division should only purchase and use micro-fiche technology. Micro-film output from the present Division concern should be loaded into jacket covers. Such a system would allow greater flexibility than a microfilm system and also allow for future modification of the stored record.

3.5.12 It would be advantageous to examine the feasibility of distributing reports and data summaries on micro-fiche. Such a Division policy would save space while reducing postage and storage costs.

3.5.13 All work associated with data security should be rigidly controlled by the Water Division. With the possible exception of digital storage all work should be performed in-house. In the case of digital storage the Division should initially seek co-operation from the ADF Section. If they are unable to assist it may be necessary to approach external computer agencies or alternatively to develop in-house computer facilities.

3.5.14 Based on 1978/79 estimates the program to upgrade the security of Divisional technical records could require up to 100 man-years. In view of the Auditor General's concern the Division should seek extra funds for the provision of necessary staff and equipment. The estimated all up cost of the upgrading of security is $4o spread over four to ten years. This cost does not include any allocation for the purchase of full scale in-house computer facilities.

3.5.15 Interstate experience has indicated that the first area upgraded should not have any immediate data analysis requirements if system bugs are to be logically eliminated without compromising the integrity of the data system.
4. INTRODUCTION

This first progress report examined proposals for the secure storage of technical records held by the Water Division and recommends the most appropriate forms of secure data storage bearing in mind the frequency of record usage. Several officers of the Division intended this project to recommend easy options for the improvement of the care afforded to technical records, while others hoped the project would examine the reasons for, and justify, current Division data collection. However, the project group initially realized that neither of these proposed goals had any relevance to this project.

The former Water Resources Branch had previously initiated pragmatic reviews of the security of data storage though none of these proposals had ever reached fruition. Much of the background data for this report was drawn from these earlier studies and updated as appropriate. Reactions to those earlier studies indicated it was undesirable for a small group in isolation to attempt to modify Branch policy on the collection, storage and utilization of data. A draft copy of this report had already been discussed with the appropriate section leaders of the Division, though the direction pursued during the next phase of the study is still to be finalised.

This progress report provides a cross-reference of data collected, stored and utilized by each section of the Division, and discusses the present and proposed methods of data storage. Based on discussions within the Division it nominates those methods of secure data storage suitable for internal and external data users. Finally the report has proposed an orderly timetable for the implementation of the nominated systems.
5. BACKGROUND

As previously mentioned the Former Water Resources Branch conducted several studies into the storage of technical records. These reviews did not promote a reappraisal of the Branch's data collection and analysis techniques, because each report was sectionally orientated and sought to justify the utilization of a new or modified form of bulk, economical storage of the Branch's technical records. The present review attempts to consider all technical records generated and held by the Division and the cross referencing of historic data held may indirectly promote re-appraisal of the Division's role in the collection and analysis of technical records.

In attempting to review the needs for secure technical record storage some assumptions have been adopted. These include:

A) The objectives of the Water Division are by definition, the assessment, development and management of water resources of the Northern Territory to ensure the maximum long term social benefit of this resource.

B) The Planning Group of the Division supervises the formulation and execution of all water resources assessment and development policies in such a way as to promote maximum efficiency.

C) Sections of the Division are only permitted to collect, store and analyse data that is perceived to be relevant to the efficient operation of the Division. This implies that the Planning Group together with the relevant Sections are routinely re-assess the role of data collection networks and data utilization functions within the larger Divisional and NTPS structures.

D) Lacking any clear statement on the objectives of Area Managers the Water Division was deemed to effectively include all Water Division functions no matter who the functions was performed by.

E) Sections will always strive to collect and to analyse data to the highest practicable standard. Deficiencies in the quality of collected data do not become evident until that data has been fully analyzed.
Most importantly that, though the secure storage of all technical records was important it could not be considered the total goal, as security implies long term storage for appropriate future usage. The total goal was therefore defined to be to securely store all technical records in ways that maximize the utility function of the total technical record.
6. **Desirable Features of a Technical Record Storage System**

There are several necessary and many desirable features that need to be considered when designing a particular technical record storage system. A secure technical record storage system must provide safe storage of the original data with minimal need for subsequent removal from storage, and with minimal handling following its placement in storage. This implies that original data needs to be reduced to secondary record systems prior to the safe storage of the original record.

The major requisites of a secondary record system will not be considered.

6.1 Security of Storage

Secondary Records up to several generations removed from the original data should be the basic record types routinely used by all data users. It is necessary to provide a reasonable level of protection to all secondary records if the original data is to remain securely stored. Duplication of secondary records or data summaries may afford sufficient protection to later generations of secondary records provided an early edition of the secondary record is stored in a secure manner.

6.2 Reproduction of the Secondary Record

The media used to store a secondary record should always adequately reproduce the original record. If the media fails to adequately reproduce the stored record then the security of the technical record system may be jeopardized when original data is removed from storage to recreate a secondary record.

6.3 Distribution of Stored Data

Some styles of technical record storage provide easier access to the record by people external to, or in different sections of, the Division. Whenever possible the system that most fully promotes easy distribution of raw and/or processed Divisional Records to all groups in the Division should be adopted.

6.4 Retrieval of Stored Data

It is proposed that only systems that have proven cost effective retrieval modes should be employed by the Division. The increased usage of superior systems would free technical and professional officers from manual data retrieval and allow their time to be more productively utilized.
6.5 Modification to the Stored Records

When the Division collects more recent field data it is often necessary to modify the storage address of some types of original records, and to modify the data stored on a secondary record. The method of storing secondary records should allow for routine record modification and sequential updating. When a secondary record is updated or modified all current duplicate copies should also be updated. As a mechanical aid it is suggested that each secondary record contain the dates of the most recent record updates.

Record modification would be best achieved if, for each style of technical record, the Division established centralized data storage. It would be necessary to restrict the ability to modify each particular record type to small groups of technical specialists. The modified secondary record would be freely available for use by any interested groups within or outside the Division.

6.6 Record Utilization

The above requirements indicate that the forms of secondary record storage should not impinge upon the possible future uses of stored data, nor upon the ease of extraction of that data. It is often necessary for the Division to perform routine computation and analysis of selected technical records. The storage of these selected secondary records on a medium that may be automatically loaded into a computer would facilitate analysis and minimize the ingestion of data errors.

6.7 Easy Access to Multiple Record Storage

The efficient operation of several technical record storage systems that use different nomenclature requires the development and implementation of suitable cross-referencing codes. It may not be necessary for all storage systems to use the same primary nomenclature, though the use of a standard secondary nomenclature, e.g. Australian Map Grid co-ordinates, is needed even if the present technical-record storage systems persist into the future.
7. PRESENT METHODS OF TECHNICAL RECORD STORAGE

The status of each current Division technical record storage system has been summarised in Appendix A. The current storage systems do not meet the level of record security developed in section 5. The storage systems of the Assessment Group offer the poorest levels of security to the original records. Original records held by this Group are still routinely accessed, only a limited number of partial secondary records have been created, and only a fraction of the secondary records are currently being utilized.

A comparative cost/benefit analysis for each Divisional technical record has been summarised in Table 1. During this analysis it has been assumed that:

A) Where data collection and storage systems overlap all value and costs of the specific data have been assigned to the section that is primarily responsible for that type of data. For example water quality data may occasionally be stored in any of the Groundwater, Hydrographic, Water Quality or Operations data systems, however all costs and benefits of this data have been lumped into the Water Quality technical records.

B) The present value of any raw stored data is at least the current costs of data collection minus any revenue or subsidy collected for the provision of a service while the data was being collected. The estimates in column 2 may therefore underestimate the true value of the stored record.

C) The operations group includes the commercial and public utility management functions.

D) The rates of return from data usage (columns 3 and 4) by each section is the average net annual return from their technical records. The concept is subjective, though the assessments may be considered as the sum of annual savings produced within the Territory by analysis and distribution of collected data.

E) The current cost of data storage includes the salaries of record filing clerks, floor space rental, depreciation of data storage equipment and any additional costs associated with preserving the original and secondary records.

F) The annual increase in data value (column 7) represents the current rate of Territory expenditure in the area of responsibility of a Functional group.
### TABLE 1

**ESTIMATED COMPARATIVE VALUES OF DIVISIONAL TECHNICAL RECORDS.**

**CURRENT COSTS**

*(JULY 1978)*

<table>
<thead>
<tr>
<th>Functional Group</th>
<th>Current Value of Data</th>
<th>Rate of Annual Return From Data Usage</th>
<th>Cost of Data Storage</th>
<th>0.5% of Max. Annual Data</th>
<th>Annual Increase in Data Value</th>
</tr>
</thead>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>Groundwater</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
<td>$m</td>
</tr>
<tr>
<td>Hydrographic</td>
<td>75</td>
<td>1.0</td>
<td>5.0</td>
<td>0.025</td>
<td>0.250</td>
</tr>
<tr>
<td>Survey/Drafting</td>
<td>50</td>
<td>1.0</td>
<td>5.0</td>
<td>0.030</td>
<td>0.150</td>
</tr>
<tr>
<td>Water Quality (and Labor)</td>
<td>10</td>
<td>1.0</td>
<td>1.0</td>
<td>0.025</td>
<td>0.050</td>
</tr>
<tr>
<td>Operations</td>
<td>15</td>
<td>1.0</td>
<td>1.5</td>
<td>0.025</td>
<td>0.075</td>
</tr>
<tr>
<td>Library</td>
<td>1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.070</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>141</td>
<td>4.5</td>
<td>12.2</td>
<td>0.175</td>
<td>0.610</td>
</tr>
</tbody>
</table>
Table 1 grossly simplifies the true situation in that much of the
data collected and stored by the Operations function group is of
interest to that group for only a brief interval following collection.
A reasonable suite of operational data may be required by the
Assessment Group when reviewing an impact on the environment, or
investigating the need for a water supply augmentation. When the
Assessment Group is not provided with adequate operational data it
is difficult and/or more expensive to answer the appropriate questions.
Other types of operational data such as maintenance reports and
consumer accounts may have value to only the Operations Group for
only a finite time period.

The technical record storage systems currently employed by the Division
only allow 20% of the possible nett value of the stored data to be
extracted. The shortfall of $7,700,000 (column (4) - column (3)) is
felt most by the Territory Taxpayers but is also lowering the morale of
the Division because data needed to answer an enquiry is easily
extracted from the current storage systems.

From Table 1 it can be seen that the Division and its predecessors
have outlaid considerable sums of money to collect raw data. At the
same time financial consideration may have impeded several attempts
to improve the methods of data storage and data utilization. This
has precipitated the present problem in which less than 20% of the
stored data has been analysed.

Historically the Assessment Group has placed more emphasis on record
collection than on record verification and subsequent storage. Neither
the Hydrographic, Bore Data or Registered Sampling Point (RSP) systems
have the location of all their monitoring structures recorded on a series
of maps. In each system the local knowledge of Division Officers is
often used to resolve queries, however little of this local knowledge
has been transferred to the technical record systems. In the future
the value of these records must gradually reduce as knowledgeable
officers retire if more data is not placed in the relevant technical
storage systems.

If data is copied to a secure storage without being verified and
checked there must be greater problems in the future when data users
inadvertently assume that all data in the secure record store has
been previously verified. Some present users of Division technical
records are currently assigning too much reliance to the validity of
recorded data when attempting to utilize stored data without further
checks on its integrity.

The Division has no common nomenclature of monitoring structures and
locations. As an example the Groundwater Section uses two naming
conventions. These are the Registered Number (RN) of a bore or well,
which is simple unique chronological number that is related to the
time the bore was registered, and the Index Number (IN) of the bore or
well which is a complex number.
The IN is composed of a sheet number that has arbitrarily been assigned to every 1:250 000 map of the Northern Territory, followed by an oblique and then the chronological bore number for that sheet. The advantage of the index system is that all bores in a large area may be located by the IN however, the system has failed when:

i) the 1:250 000 map ceased to be the primary scale map of the N.T. The 1:100 000 map is now adopted as the primary map series

and

ii) the number of indexed bores on any primary map is more than several hundred. Both the Darwin and Alice Springs 1:250 000 index sheets contain in excess of 1200 registered bores or wells (approximately 20% of the Territories registered bores or wells are on two maps that together represent about 2% of the land surface area).

Additionally many bores have been assigned a RSP number by the Water Quality Section. Further, it has been suggested by the Australian Water Resources Council that bores be known by a River Basin style number that would be similar to the present Gauging Station Numbers.

Whilever the technical records are maintained in the current manual formats it will be difficult to effectively use more than one naming convention and equally difficult to assign a single nomenclature system. With secondary records in a digital form it is possible to multi address any stored data. It has previously been suggested that if bores and wells were only referred to by their Registered Number a reduction in the general level of confusion would be possible.

If cross referencing is frequently required and the Registered Number is not appropriate, as with the RSP system, it may be best to develop specificsecondary nomenclature based on the Australian Map Grid. When technical data has not been edited and analysed immediately after collection up to 25% of the total stored record may have little future utility because of poor field techniques, poor file reporting and badly located measurement structures persisting for much longer than is necessary to recognise the need for modifications. This in no way implies that 25% of the present data collection activities of the Division are wasted. Rather, the Water Division needs to routinely process all data as it is collected if data collection techniques and networks are to be constantly reviewed.
8. **INADEQUANCIES OF PRESENT TECHNICAL RECORD STORAGE**

The inadequancies of the present technical record systems may be summarized as below.

8.1 **Security of Raw Data**

The Water Division has not yet reduced many of the original data records to secondary form. This has limited the analysis of the records and further entrenched the historic practice of routinely referring to data in the original technical record. While this system remains it is illogical to consider that the Division's raw data is securely stored.

8.2 **Distribution of Stored Data**

As mentioned above, many of the original records have not been copied into secondary files and are not available for distribution outside the storage area. Several other types of technical records are distributed as a multitude of paper copies to secondary files. Neither system encourages the easy distribution of technical records because of the large volume of stored records.

8.3 **Retrieval of Stored Data**

Most data is retrieved directly from the raw data. This is a dangerous process, because it will eventually destroy the original records. In addition, it is also time consuming because of the present arrangement of the record storage systems.

8.4 **Modification of Stored Data**

In the few technical record systems where secondary files have been created they are unwieldy. The difficulties centre about the inability to keep all secondary files up to date, especially where alterations need to be made to a portion of the historic record.

8.5 **Record Utilization**

The non-availability of records in a form convenient for further analysis has often resulted in the non-performance of the analysis. Often the goal of a project is to provide the best answer by a particular date. The poor storage of records has resulted poor answers because insufficient use was made of the historic records.
3.6 Cross Referencing between Stores

The cross-referencing of data files has not been encouraged within the Division. By way of example, Water Quality Data may be found on Bore Data, Hydrographic, RSP, Laboratory and Division files. Each data storage system has its own name for the results. These include Registered No., Gauge Station No., RSP No., Analysis No and Division File No.

It would be desirable to immediately investigate the Division nomenclature and modify the present sectional naming conventions to form a common Division Listing.
9. POSSIBLE FUTURE METHODS OF TECHNICAL RECORD STORAGE

All previous studies by the former Water Resources Branch have realized that there are only four methods for the storage of technical records by the Division. Not all of the methods will provide sufficient security to raw and secondary technical records. All four methods have been tried within the Division though to date it has not been necessary to reconstruct data from a secure data store. The methods may be summarized as:

A) Attempt nothing now and continue as before
B) Attempt little new advances; Reproduce copies of selected records.
C) Microphotography of relevant Division records.
D) Digitized storage on magnetic media of relevant Division records.

No alternative listing above can fulfill all the criteria of the Division's diverse technical records. It is now proposed to examine each method and to suggest areas of the Division's activities in which each may be appropriate.

9.1 Attempt Nothing New and Continue as Before

In the past this approach has been applied to the broad range of Divisional Technical Records and perhaps the greatest benefit of this scheme was that the cost of record storage did not alter. This form of storage may be appropriate for technical reports, library books and magazines where other copies may be used if one copy is destroyed. If this method is continually used for the storage of raw data the original, and in some cases, only copy of the measurement will degrade with usage and eventually be destroyed. This alternative in no way constitutes secure storage.

9.2 Reproduce Extra Copies of Selected Records

The Alice Springs District Office of the Water Resources Branch used this approach with bore-location Maps. It is more expensive than alternative however, a benefit is a copy of the original record. The original may now be securely stored in an archive while routine usage is made of the copy. In the event of a catastrophe or the degradation of the record copy of the original will have survived and can be used to reconstruct another copy of the record.
This approach is only a temporary and selective form for augmenting the security level of technical records. It is impractical to duplicate all historic records, because of the increased storage requirements, cost of duplication and lack of gain in the data utility function.

9.3 Microphotographic Techniques

Microphotography may be stored in one of two basic forms: micro-fiche or microfilm. The technical advantages/disadvantages of each microphotographic technique will not be discussed. Most technical journals and some technical books are now only available in micro-fiche and may never be commercially available on microfilm.

Microphotography provides a robust copy of the record that occupies a fraction of the volume of the original record. It is ideally poised to copy, securely store and disseminate large volumes of orderly records that do not need periodic alterations and/or updating. One disadvantage of conventional microphotography is the inability to update random sections of a record without either re-performing the microphotography or adding the alteration to a new microfilm or microfiche. It is possible to avoid an illogical and unordered record storage format by loading microfilm into fiche-jackets, and modifying records in the jacket as appropriate.

It was considered by the Water Resources Branch that all original field data should be micro-photographed. Since then it has been recognized that prior to microphotography it may be necessary to edit and highlight portions of the original field documents if a microphotography is to securely store a copy of the raw data.

It has been suggested that all transparencies currently held by the Drafting Office's should be duplicated on microphotographic media. The major disadvantage of complete microphotography of drafting records is that some fine detail and thin line-work may be lost from a drawing when the microphotography is re-converted. To overcome this problem while still achieving considerable reductions in plan room storage the following system was proposed by the Water Resources Branch Drafting Section. All currently registered drawings will be rescanned to produce 200mm x 125mm transparencies and the duplicate copy of the negative held in archival storage. As new drawings are completed or amendments made to existing drawings these new sheets will in turn be rescanned to the 200mm x 125mm format and the redundant scaled negatives removed from storage and destroyed.
Such a storage scheme could be extended to provide routine destruction of selected full scale drawings that have not been amended or printed during the proceeding two years. At least two copies of the rescaled negative would still be stored even though the original full size drawing may no longer exist. Such a system would reduce the space requirements of the Plan Storage Area and increase the level of storage security.

If the Division is given a choice between microfilm and microfiche technology then, based on external factors such as the availability of microphotographed copies of WITS and ANSEL services, and computer output the only logical alternative would be to purchase microfiche reader/printers. It would be undesirable for the Division to purchase both microfilm and microfiche readers because of the high cost of the system hardware. It would however be advantageous for the Division to keep the rotary camera and to cut and load the microfilm into fiche-jackets prior to duplication, distribution and storage.

Microphotography is not suited to the efficient secure storage and recovery of currently collected raw data. Microphotography is economically and practically suited to the distribution of compiled or analysed data files. The New South Wales Water Resources Commissioners Bure Data Storage System uses a computer to store and analyse the raw data. A micro-fiche output is made of all current data on an annual basis with quarterly updates of information added since the last annual output.

Their Bure Data filling system provides officers with access to the latest editions of microfiche output. They may only view the original records to resolve discrepancies caused by the input of incorrect data to the computer. Such microfiche data distribution systems allow dissemination in a compact form and should be examined closely by the Division and implemented if they are cost effective.

In summary microphotography is ideally suited to the duplication, secure storage and distribution of books, journals and reports and may be very useful for the distribution of updated compiled data records. It is not suited for secure storage of all raw data or drafted plans. Any future proposal to increase the Division's microphotographic techniques should be carefully weighed against the above-mentioned detractions. Based on external factors only microfiche technology should be considered. The microfilm from the Division's camera should be loaded into fiche-jackets immediately after the film is processed.
9.4 Digital Storage

Depending on the computer configuration digital storage may be more or less attractive. In all forms digital record storage offers:

A) The facility to continually update or modify the stored record without the necessity to physically reschedule the record.

B) The ability to perform machine controlled data searches, releasing professional and technical officers for other work.

C) The capacity for data compilation and analysis on any of the stored record. This result may in turn be machine stored, tabulated on paper or micro-fiche output or drawn as machine-based graphics on paper or transparent materials.

D) The possibility of the Division operating a data base of all relevant information. These systems allow machine cross referencing of record files, and hence eliminate the need for manual cross referencing between technical records.

Based on these capabilities digital techniques are best suited to the storage of Divisional records that will require editing, compilation, computing and/or analysis. Within the Water Division all technical records of the Assessment Group fall into this category. The bore Data Files need continual editing and analysis together with cross referencing to the Registered sample point files, while the Hydrographic Data files need complex computation and analysis coupled with cross reference to the Registered Sample Point files. In addition to the need for cross referencing of MSP files, information on these files may be computed at the time of sample analysis and whenever results from temporally or areaally distributed samples are being compared.

Survey/Drafting results often require future modifications and the British Government has developed a computer based map storage system that allows a map to be updated without the need to fully redraft the map. In this system an up-to-date map of any scale can be plotted by the computer as it is required. It is not proposed to further examine digital storage of survey data because it does not appear warranted.
The Operations Group may wish to store some data in a digital storage system. Not enough is known about the data collected by the Area Managers for the Operations Group of the Division. Some of the historic operational data may have been retained by the Federal Government at the time of transfer of powers.
10. PROPOSED FUTURE METHODS OF TECHNICAL RECORDS STORAGE

10.1 Attempt Nothing New and Continue as Before

It is possible to store every Division technical notebook in a secure manner if the original books are archived immediately after the raw data has been extracted and processed. This technique is applicable to:

A) Survey Books. Survey data is used to compile survey plans. Any information that may be revised in a subsequent survey should be summarized either on the plans or in a Bench Mark Register.

B) Test Pumping Books. The raw data is extracted and analysed to predict values of aquifer parameters. Both the analysis and the results are currently stored on the relevant bore data file. The field books should be archived after the analysis is completed.

C) Drilling Return Books. A copy of this information is attached to the relevant bore data file and the butt copies still in the book should be archived.

D) Gauging Sheets. The gauging sheets record the field measurements and computation of storage-discharge relationship. The gauging results are also recorded in the gauging register. The gauging sheets should be archived.

10.2 Reproduce Copies of Selected Records

The Division has commenced a program to locate all measurement structures on transparent copies of the Australian Survey Office 100 000 maps. When this program is finalised all Bores, Gauging Stations and Sampling Locations maps could be duplicated as a paper print. This will save considerable time hand copying maps and will add security to the original of each map sheet.

In addition it is possibly still appropriate to dyeline copy tide gauge charts and to then send a copy to all interested persons.

10.3 Microphotographic Techniques

The Division may choose to microphotograph some of the technical records it holds. Under no circumstances should microphotography be extended beyond the photo reduction of plans or Division reports and data tabulations.
The proposal for the Drafting Section to produce 200mm x 125mm transparent copies of all current drawings should be commenced as soon as possible. There is no urgency in suggestions to microphotograph all Division reports, though this should be commenced within the next five years.

10.4 Digital Storage

Following a consideration of the economic and practical results of digital record storage it is concluded that the Rare Data, Hydrographic and ISP files warrant computer based storage facilities. Based on the simple analysis presented in appendix B it would appear the maintenance costs would be low once the system is operational. A.D.P. has not commenced to change users, and is unlikely to commence changing in the near future.

If these three file systems are digitized they should be created of sub-files in a total hydrologic data storage file. Such a system could allow free access for data extraction with data modification to a sub-file being restricted to a sectional group. After the original records are reduced to a digital form they should be securely stored under archival custody. The first generation of digital records would be copied to produce working editions of the records and would then be archived to further guarantee the security of the raw data record. If such a system is adopted it will not be necessary to microphotograph the original record to further enhance its security.

Initially the Division should concentrate on duplicating raw data in a digital form so the raw data can then be archived. The first generation of the digital storage systems should provide annual bulk output of selected files as micro-fiche and the provision for operating batch jobs on the computer. As more data is added to the storage the Division may wish to change from a "batch" mode to an "interactive" mode with say a 30 second response time. Batch operation may provide machine graphics on a 5 day turnaround. When A.D.P. purchases its own flat-bed plotter this will improve to a 1 day turnaround.

If A.D.P. are unable to provide logistical support to the Division it may be necessary for the Water Division to approach an outside computer bureau or establish its own in-house computer facilities.
11. DEVELOPMENT TIMETABLE

It is a recommendation of this report that the Division immediately commence the development of a digital storage system for the combined technical records of the Core Data, Hydrographic and ADP Systems. The development of such a storage system would require about 2 man-years from ADP and 1 man-year from the Water Division. It would then take at least 1 year to input enough data to establish an operational system.

The digital storage systems will require 3 to 4 man-years to design and develop. It has been estimated that it will require 30 to 40 man-years to place all the historic backlog of raw data into digital storage. If it is desired to commence raw data entry at the earliest date the initial system design should concentrate on data input and only achieve a primitive form of data output. More efficient System output and computation programs could be written as the raw data is being entered.

Under the present arrangements the Division will need to extract a considerable level of co-operation from the ADP section, if the recommendations are to proceed. Prior to approaching the ADP section the Division should prepare a concise job brief. This will help avoid repetition of the previous misunderstandings between ADP and the Division. If ADP are not able to assist then the Division should attempt to recruit expertise and hardware for its own usage.

The production of micro-fiche copies of Division reports and the 200mm x 125mm transparencies of all drawings should be commenced this financial year.

It may appear advantageous to initially develop all secure storage systems about the needs of the Uranium Region Projects. Some data, especially from external agencies such as ANZEL may be available in digital form. All the data collected in this region will need to be analysed and disseminated further than has previously been Divisional experience. The development and operation of the aforementioned systems would increase the rate of data analysis and enhance the Division's reputation as an efficient supplier of edited and analysed data. Such a course of action should be weighted up with interstate experience that suggests the first area to be secured should be free of current data analysis requests.
## APPENDIX A

### DIVISION TECHNICAL RECORDS BY SECTION

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<tr>
<th>CONTENTS</th>
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<td>1. HYDROGRAPHIC SECTION</td>
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<tr>
<td>2. GROUNDWATER AND GEOHYDROLOGY SECTION</td>
<td>A7</td>
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<td>3. WATER QUALITY SECTION</td>
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<td>5. DRAFTING SECTION</td>
<td>A17</td>
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<td>6. OPERATIONS SECTION</td>
<td>A19</td>
</tr>
</tbody>
</table>
HYDROGRAPHIC SECTION

1. Raw Data Collected by the Hydrographic Section

The majority of raw data collected by the section may be summarized as measurements of the rate and depth of water movements within the hydrologic cycle. The major data networks measure rainfall, both as a rate and as a total depth, depths of surface water and stream discharge measurements, though the section also collects data on potential evaporation, temperature, wind speed, wind run and solar radiation.

1.2 Who uses this data?

Some of the raw data collected by the Hydrographic Section is processed within the section and then distributed to other data users. Daily rainfall data and peak stream-flow levels may be distributed without much computation. Other information such as stream discharge information and short duration rainfall data require very detailed computational procedures prior to distribution.

The raw and subsequently processed data is mainly used within the Water Division though a considerable volume of data is supplied to outside organizations, including consultants, universities, the Australian Water Resources Council, Bureau of Meteorology and the Northern Territory Port Authority. The present state of the data storage system, as will be discussed later, results in many requests for data not being met either because of the lack of suitable information or the lack of staff to extract the data.

1.3 Size of Stored Data

As at the end of August 1979 it is estimated that the Hydrographic Section will be storing the following volume of data:

- LEOPOLD AND STEVENS: A10 and A25 Charts: 3 750 station-years
- FISCHER AND PORTER: Punched Tape: 1 350 station-years
- STREAM DISCHARGE MEASUREMENTS: 12 000 station-years
- LEVEL BOOKS AND TECHNICAL FILES: 2 000 station-years
- ASSORTED WEEKLY GRAPHS AND MANUAL READINGS: 500 station-years
- ADDITIONAL METEOROLOGIC DATA: 300 station-years
With the completion of each water-year an additional 400 station-years of Leopold and Stevens A25 chlor and up to 500 stream discharge measurements are added to the data store.

1.4 Level of Duplication of the Record

Of the total 5,600 station-years of stream-stage and rainfall pluviometer records only 662 station-years of streamflow data have been duplicated on magnetic tape and approximately 1,000 station-years of streamflow records have had daily flow computed from either the magnetic tape image or by hand from the original chart record.

The station inspection reports could provide a value of stream gauge height every six to seven weeks; though these reports would not be capable of regenerating the chart records if they were destroyed.

Other data held by the section, notably the results of chemical or sediment analysis of surface runoff are fully duplicated on the East Point Laboratory Register and also in the Water Quality Section's Registered Sampling Point files.

1.5 Present Method of Data Storage

All original data together with a copy of the magnetic tapes and any computations are stored in a compactus and other copies on the top floor of the Mitchell Street Office. Duplicate copies of the magnetic tapes are held by CSIRO in Canberra and, as mentioned previously copies of some analyses may be kept in other Division filing systems around Darwin.

1.6 Requirements of Users of Hydrographic Data

In the past the Hydrographic Section tried to publish and distribute annual and five yearly stream discharge reports. The latest annual report, for the 1973/74 water year, has only just been published and it is hoped to be able to publish the first five yearly stream discharge report within the next eighteen-months. These stream flow reports are able to provide most information required by data users from outside the Division, though consultant or academic users may request more detailed information.
By far the greatest user of the hydrographic data are officers of the Water Division, especially those in the Investigation Branch. This group of data users has very diverse requirements, though normally they would prefer not to extract information they require from the original chart. Instead they prefer access to a corrected and edited version of the field record. In other State Water Resource Authorities such access is provided via computer manipulation of a magnetic data image.

It is often claimed that once a suitable chart image has been created and edited most data users have no requirement to peruse either the original charts, the original field inspection reports or the chart computation reports and that all this original data should be preserved in an archive without the need for further reproduction.

1.7 Possible Methods of Providing Adequate Data Security

Basic security of original data can only be guaranteed if following original reproduction, a very small group of people are allowed to examine the original records. In past studies of the security of technical records two possible reproduction technologies have been proposed, each capable of several slight variations. The two available techniques may be lumped as:

A. Microfilming: Proposals to microfilm records of the Hydrographic Section appear to have grown out of the work of the 1974 Working Group. Several people have stated that microfilming would provide the section with a fast method of initial data duplication and this is discussed further in later sections.

B. Digitisation: Since 1968 the Hydrographic Section has tried to develop a computer technique to facilitate economic and safe storage of the field data while allowing speedy and efficient methods of data analysis and report production. As mentioned in section 1.4 the section has already duplicated some 662 station-years of records onto magnetic tape.
It is important to note that this progressive duplication of data onto magnetic tape has not advanced further because of the following reasons:

i. A general lack of performance by the old A.D.F. Section of the Department of the Northern Territory, especially during the interval 1969 to 1977. It is conceded that some progress has been made since 1977 though a lot more cooperation will be needed between A.D.F. and Hydrographic Staff.

ii. Due mainly to (i) above the Hydrographic Section was allowed to commence digitization and computer analysis of stream flow records on the CSIRO computer system in Canberra. A lack of adequate funding by both Water Resources Branch and the A.D.F. Section severely handicapped progress and in fact the Hydrographic Section has never kept abreast of, nor got on top of the backlog of historical data. There has been no trip to Canberra since early 1976 and it has been proposed by the A.D.F. Section that the Hydrographic Section no longer use the CSIRO facility, and instead use the Darwin facilities of A.D.F. During the last eighteen months A.D.F. have not reported any progress with the conversion of programmes from CYBER to IBM compatibility.

iii. The analogue to digital chart converters (FREQ'S) have progressively deteriorated due to damage received during Cyclone Trudy. It is reported the machines will have their first post cyclone service later this year. The servicing delay, it is claimed, is the result of divided priorities within the old Water Resources Branch which resulted in no funds being made available for this important work.
iv. During the five years 1977 the Hydrographic Section had a succession of Senior Engineers and prior to the arrival of Ralph Aikin in 1977 had not been led by a senior engineer for three years, and no engineering staff during one six month period. This resulted in a loss of priorities within the section and further removed the section's operational activities from the vision of senior management.

v. Partly as a result of (iv) and also because of several other reasons the Hydrographic Section field staff are not performing enough preliminary computation of their field work. This situation will continue to exist for as long as the high density of field stations in each area and the small numbers of field staff remain the same. Historically it could be claimed the section has collected an excessive volume of useless records because too much emphasis was placed on the production of field data; any field data, without that data being subject to even preliminary processing or analysis.

1.8 Results and Implications of Secure Data Storage

1.8.1 Microfilming of all Basic and Derived Data

If Division policy dictates that all original and/or derived data will be microfilmed then a separate policy governing the quality of the records to be copied will need to be established. If we only consider the security of all analogue charts produced by Leopold and Stevens Recorders the following issues may need clarification.

i. Are original charts to be microfilmed in their present raw state or is somebody going to chart analyse these records and "touch up" all the chart annotations.
II. Will all inspection reports be copied, and if so will they be "touched up" prior to copying.

If only the charts are to be microfilmed in an "as is" condition then the 3,750 station-years (chart length approximately 70 kilo-metres) could probably be microfilmed in 15 to 20 weeks. To micro-film the inspection and annual reports would probably take an additional 15 to 25 weeks. (There is estimated to be a minimum of 150,000 pages to individually microfilm).

The two options above would only secure a chart image and not guarantee the quality or readability of the resultant microfilm. It has been estimated that to chart analyse all Loopold and Stevens charts prior to microfilming could take between 6 and 10 man-years. If we assume 6 people could be spared to chart analyse and check all historic data prior to microfilming then the total time required to produce a secure usable microfilm copy of the data would be about 2 to 2½ years (allowing for holidays).

Previous examination of Division microfilming does not appear to have examined the applicability of duplicating the 1,350 station-years of records held on Fischer and Porter punch tape. Indeed it is not even known if it is technically possible to microfilm a punched tape. It is possible to produce a reusable microfilm copy of the 1,350 station-years of record (tape length approximately 155 kilometres) would take 25 to 50 weeks to microfilm. It would require an additional 6 to 12 weeks to microfilm the inspection reports associated with these records.

Again it must be emphasised that the above programme could only produce a chart image and in no way will it guarantee the quality or readability of the resultant microfilm image. It has been estimated that to chart analyse at the Fischer and Porter punch tapes prior to microfilming could take between 3 and 10 man-years. It takes much longer to verify Fischer and Porter tapes than Loopold and Stevens charts because of the type and variety of instrument malfunctions. Assuming the service of 4 people to analyse and microfilm these punched tapes it would take between 2½ and 5½ years to complete microfilming the record.
1.8.2 Digitization of Basic and Derived Data

Staff of the old Water Resources Branch have already commenced digitization of Leopold and Stevens analogue charts. Assuming similar staff availability as for section 1.8.1, a reasonable level of assistance from the A.D.P. Section and from the Water Division, it is estimated that the analogue-digital conversion would take a total of 3 to 4 years. If a punched tape reader can be suitably modified then all the Fischer and Porter tapes could be digitized in 2 to 3 years.

The above estimates are all mutually exclusive, and if all the historic backlog were to be digitized at the same time the job would take up to 4 years and require the use of two analogue-digital converters. Two PHR23S are already owned by the Hydrographic Section; the use of three IBM 5100 or 5110 Portable Computers, the Hydrographic Section already has a 5100 and 5110, and lastly the provision of at least 6 new permanent/temporary technical staff in the ranges T02 and T03.

If only the existing Section staff and equipment are utilized the digitalisation is estimated (conservatively) to require at least 3 years and more probably 10 years.

1.8.3 Dyaline Copies of all Instrument Charts

If the only requirement is to produce a copy that may be used, if need be, at a later date then this may prove to be a viable alternative for the short term. It would take 12 months to produce copies of all existing Leopold and Stevens charts.

1.9 Implications of Security Methods on Data Usage

There is only one method mentioned under section 1.8 that offers promise of easy future use by a data user. This is the use of computer storage (digitization of the record). If this scheme were adopted all the original charts and inspection reports would be archived and probably never referred to again unless a translation error is detected.
With the other two methods of data duplication the ultimate data user will get no benefit from the copying process and may still require to see the original chart and inspection report; thus partially defeating the purpose of the duplication. In addition it will still be necessary to digitize the record if efficient use is to be made of all the collected data and this programme, if not attempted first, may never be completed because of the annual increase to the historic backlog and the general lack of support previously shown by the old Department of the Northern Territory and especially the A.T.P. Section.

Unless the long term security of all original data is totally commenced soon it will be too late to read some of the cyclone damaged records and too expensive to attempt to reconstitute this destroyed record from microfilm or other mediums. I strongly urge the Division to adopt a policy of extracting all usable information from the historic data, then storing the data in an "archive", but not trying to duplicate the archived original for any reason. If the archived original is lost or destroyed after the data has been extracted then the Division must be prepared to say "The loss of original data is unfortunate, but at least we have a working copy of all the original data we lost."
2. GROUNDWATER AND HYDROGEOLOGY SECTIONS

2.1 Raw Data Collected by the Groundwater and Hydrogeology Sections

The objectives of these sections may be summarized as the orderly collection and storage of all data related to the occurrence and variation of groundwater in the Northern Territory, and the application of this data to ensure that optimum use is made of this resource. These sections do not collect all the data they utilise, however they attempt to maintain a copy of all relevant data held within the Division.

The types of data collected by both these sections may be summarized as including the variations of geological, geophysical, geochemical, geohydraulic, geohydrologic parameters in space and or time. However, it must be stressed that other sections and departments also contribute to the store of information held in the "Bore Data System", viz water quality samples and analysed by the Division's Water Quality Laboratories and some geology samples have been logged by the Department of Mines and Energy.

2.2 Who Uses this Data?

The major users of all data held by the Groundwater and Geohydrology sections are located within both sections. The most frequent users of the data is to provide advice on likely groundwater supplies to landholders and for the preliminary phases of all investigatory drilling programmes.

The Basin Management Section also uses the data to assess the quality and reliability of both the data collected and also of community and other water supplies.
2.3 Size of Stored Data

By the end of August 1978 it is estimated the Groundwater Bore Data System will hold information on approximately 15,000 registered bores and wells in the Northern Territory. The contents of a bore data file may consist of a Regulation 8 form, Geologists log, geophysical logs, geochemistry analyses, pumping test results and analyses and/or geohydraulic data. Many files will contain little more than the Regulation 8 form though it is estimated the total bore data system may presently contain 300,000 sheets of paper.

The annual rate of increase is approximately 400 bores or wells or a total paper increase, including additions to previously registered bores, of 10,000 pages of original and derived data.

2.4 Level of Duplication of the Record

Information held within the bore data system may be duplicated in several other filing systems. The original copy of the Regulation 8 form is filed by ascending Registered Number in a filing cabinet on the top floor of the Mitchell Street office. This copy represents the primary reference file and may only be accessed in order to resolve inconsistencies in any of the operational bore data files.

A copy of the original Regulation 8 form is kept in the operational bore data files at both the Darwin and Alice Springs offices. These operational files also contain any additional relevant data on bores or wells located within the area of that office's responsibility. This additional data may include several or all of the following:

- Geologists logs
- Geophysical (wire-line) logs
- Pumping test data and analyses
- Bore completion report
- Access notes and map maps
- Results of mineral and/or Water Chemistry analyses
- Geohydraulic data
- Pump setting, pumping rate and hours of pumping
Some of the above information is duplicated by other data files of the Division; especially any results produced by the Division's laboratories; however results of analyses performed outside the laboratories may not be duplicated. All the above forms of information are, in a sense, non-replaceable historic data which should be better stored and better used.

2.5 Present Method of Data Storage

In Darwin all bore data is stored in filing cabinets on the top floor of the Mitchell Street Office. Most bore data files were damaged during Cyclone Tracy and several are now showing signs of deterioration. It is doubted if this filing system is capable of adequate performance for longer than the immediate short term.

In Alice Springs the bore data is housed in a central brick room which has fire prevention facilities. Again due to the excessive usage of the bore data files, the files are not expected to be operational outside the short term.

2.6 Requirements of Users of Bore Data

The bore data filing system contains all basic groundwater data and the predominant users of this data can be described as being either investigatory (selecting future bore sites) or managerial (assessing and reporting upon various aquifer characteristics). Both classes of users require suitable bore (or well) access for all registered bores and because of this need the Groundwater Section has previously attempted to locate all registered bores on approximately scaled maps.

Most of the present use of the bore data files is by people who require to sift out a small volume of data on a considerable number of registered bores in a given location. A manual data storage system is unable to provide any efficient search routines whereas computer data base storage of the bore data files would allow greater flexibility and efficiencies of data storage, retrieval and usage.
2.7 Possible Methods of Providing Adequate Data Security

The present duplication of bore data files in both the Darwin and Alice Springs offices does provide some additional security to certain classes of data, mainly geo-chemical assay and Regulation 8 sheets. However the inbuilt cost of this system is best illustrated by the following example. If a bore data file in either office is found to contain some wrong information (or to have been double registered etc.), it may seem easy enough to alter one or two data files, however data may also need to be corrected on such files as Registered Sampling Point, Pastoral, Original Regulation 8 file and also the addressing file in both Darwin and Alice Springs. There are other available techniques that have been investigated for use on the bore data system, and these may be grouped as below:

A. Microfilming: Proposals to microfile the bore data records again appear to have developed from the 1974 Working Group. It is claimed that microfilming offers a fast method of initial data duplication and will be discussed further in a later section.

B. Digitisation: The old Water Resources Branch periodically examined the feasibility of digitising all or some of the bore data files, but apart from several reports encouraging more effort nothing has been achieved. It may be of interest to note that at one stage the Water Resources Branch almost purchased an operational computerised bore data system from the Water Resources Commission of New South Wales. It is now doubted if such a purchase would be of much use to the Division.
2.8 Results and Implications of Secure Data Storage

2.8.1 Modifications to the Present Duplication System

It may be thought feasible and desirable, in terms of data security, to upgrade the volume of data that is duplicated in the bore data files. Already almost all field results of test data performed by officers of the Division are duplicated at least once within the office of origin of the data, however some people may see a need to duplicate all completion forms and location maps at the other office. Such moves to further duplicate the present bore data files should be resisted at all cost because of the possibility of introducing data errors and the difficulty of rationally removing any data errors after they have occurred.

2.8.2 Microfilming of all Basic and Derived Data

One of the problems presently plaguing the bore data filing system is the poor quality of much of the stored data. If short term expediency dictates that all data, regardless of authenticity, is to be microfilmed then the present data quality problem will be vastly magnified. Direct microfilming of the Groundwater Technical records would take approximately twelve months (estimated on 250,000 sheets, 3,000 technical note books and 1,000 assorted tables and graphs of A3 or larger size). It is not possible to say what time would be required to first verify all the data, though it would possible take 5 to 10 man years (based on the present rate of data checking).

2.8.3 Digitization of all Basic and Derived Data

Most other State Water Resource Authorities have already commenced storing bore data on computer media. The major factors favoring computer storage are the possibilities of rapid cross-referencing or unique name codes which can result in rapid retrieval and usage of any or all bore data, while the original data can be kept in government archives. Digitization of the bore data files would not be rapid, and would need to be subject to the same system of data checks proposed in 2.8.2.
Following discussions with D. Wolley of the New South Wales Water Resources Commission it is felt the historic backlog of registered bores in the Northern Territory could be eliminated within three to five years if a suitably qualified staff were employed. Once the historic backlog was reduced the digitized data system would be capable of meeting all the Division's Groundwater data security goals and user flexibility goals.

2.5 Implications of Security Methods on Data Users

It is felt there is no easy way to solve all the problems inherent in the present bore data filing system, however a logical grouping of several mutually attainable methods will definitely improve the security and usability of the historic records.

It is felt that microfilming has little place as a stop-gap security measure because:

i. It is not easily added to at some future date.

ii. It will require a longish time to microfilm all the bore data files.

iii. Once the microfilms are available they in no way improve the usability of the present bore data system.

The only feasible solution is to spend time upgrading the technical quality of all bore data files and bore location maps so that the following aims will be achieved when the files are computerized:

i. The general record standard is improved.

ii. The data is adequately secured.

iii. Updated computer listings may be made available to any or all interested users.

iv. Only one single data file group need exist (reducing the problems caused by duplication).

v. All data may be retrieved in full or only in part - as required.
3. WATER QUALITY SECTION

3.1 Raw Data Collected by the Water Quality Section

The Registered Sampling Point (RSP) files operated by the Water Quality Section are supposed to function as a basic water quality data file and also as a clearing area between the laboratory where the samples are analysed and the sections of the Division or general public who have requested that analysis; either chemical or bacteriological determinations.

Most of the results handled by the Water Quality Section have originated at one of the laboratories operated by the Water Division, though occasionally results are forwarded from other laboratories or in a very small number of cases from Division Field staff who have used portable instruments to perform limited analysis of samples in the field, eg. drilling crew and test pumping crews occasionally check TDS, Nitrates and/or Fluoride concentrations.

3.2 Who Uses this Data?

There are three basic patterns of use of water quality data. These may be considered as:

i. The results are needed immediately and used immediately. For example, a drilling investigation hole will often be completed short of the target depth if the groundwater is excessively saline or contains excessive nitrates or fluoride. In these cases an early indication of the water quality can save a considerable footage and hence the finances of the investigation programme.

ii. Routine Water Quality data from a particular location may have been collected over several years and the task is now to analyse the time variation of any and all of the parameters measured. For example, a community water supply will be routinely monitored to ensure that the quality of the supply does not degrade with time.
All water quality data is presently filed manually and so it is not convenient to cross reference all the multiple samples from say the Darwin Town Water Supply taken over the last 5 years. In addition, human errors may cause samples to be mis-named and hence the results are mis-filed. Under the present manual system it may be difficult and time consuming to correctly refile all the duplicate copies of the analysis results.

3.6 Requirements of Users of Water Quality Data

The present NSW filing system is not capable of adequately meeting the diverse demands placed upon it. The laboratory staff find the present data filing system time consuming and capable of introducing gross errors. Following analysis the results are normally checked by "empirical" calculations and then passed to the typist who copies the analysis results onto a pre-forms for subsequent distribution to the NSW and other appropriate filing systems. Unless each typed result sheet is closely examined it is possible for errors to be introduced by the typists.

A pool of competent staff is then needed to file the results on all the appropriate files and where appropriate to notify the sampler that the results of a particular analysis are now available.

Most project orientated users of water quality data would prefer to be able to collect and collate results from several locations and at several various temporal stages. Using the present manual system it is not possible to find out what analyses are available without first collecting all the files and processing the analysis reports; so that unnecessary and time consuming usage is made of the data files in the various technical filing system.
5.7 Possible Methods of Providing Adequate Data Security

Given the present level of duplication of water quality data it is believed sufficient copies of all analyses performed by the Division exist and hence the data may be regarded as secure. However it is of little use having secure data if it is difficult to utilize the data. Most people involved with water quality data appear to want a data filing system that is capable of providing speedy cross referencing and utilizing the few competent staff in a more efficient manner. Only one method of data storage appears to be capable of providing these diverse features, and that is digitization.

It has been proposed by the laboratory staff that the analysis name and results could be put into computer storage by the analyst. The computer would then compute any appropriate balance checks and if the results were satisfactory, store the results in a water quality file. If the analysis results were needed outside the Division a copy could be printed from the computer for distribution, for dissemination of results within the Division only the name of new analyses would need to be distributed from the computer to all appropriate sections; with a considerable saving in paper and time and producing a more efficient data storage system.

3.8 Results and Implications of Secure Data

If the present methods of data storage continue to be used then undeniably all the water quality data must be regarded as securely stored. However, the future use of any of the stored data will be reduced because of the difficulties likely to be encountered by people extracting and collating the data. This in no way belittles the quality or usefulness of the data, but instead reflects the possible shortcomings of the existing method of water quality data storage.
If, however, the water quality data were to be stored on a file in computer storage it would be possible to reduce the bulk of paper work presently being pushed through the Division and at the same time offer all interested (potential) users of the data access to all the records at no significant penalty.

3.7 Implications of Security Methods on Data Users

If a computer based data storage system is developed to include all water quality data then the laboratory staff and the Water Quality staff who previously maintained the RCQ files should have additional time to spend on other routine activities. Another advantage of digitization should be the more rapid distribution of results to people both inside and outside the Division, especially bacteriological analysis results being routinely sent to operators of community water supplies.

If digitization is not introduced it will still be possible to securely store all derived data, but the overall efficiency of the laboratory and water quality staff will gradually decrease as the annual rate of sample analyses increases. The size of the technical record store will hinder any effort to improve the manual system beyond the level of a cosmetic affect.
4. **SURVEY SECTION**

4.1 **Data Collected by the Survey Section**

The Survey Section conducts engineering surveys at the request of other Sections of the Division. The results of all surveys are contained in field books and summarized as appropriate on Job Files, in Bench Mark Registers and on Survey Drawings. Although each regional office may operate independent survey sections it is assumed that all Division surveys will be conducted by officers of the Division from Darwin.

4.2 **Who Uses this Data?**

All jobs performed by the Survey Section are requested by another officer of the Division, and hence the results of any survey will be forwarded to the requesting officer. Most requests for engineering surveys are related to one of the following:

i. The location and situation of the Division registered structures and locations;

ii. Field topographic data related to a Water Resource project;

and as such some jobs requested in relation to a specific water resource project may also be of interest to one of the other Sections of the Division.

4.3 **Size of the Stored Data**

It is conservatively estimated that the Division has 1500 field books stored in Darwin and a further 1000 stored in Alice Springs. The annual rate of increase is thought to be approximately 250 field books per year. At present it is difficult to determine the number of Job Files etc. held by the Division, though these are not thought to be a major feature.
4.4 Level of Duplication of Record

All useful data from the field books should be summarised in bench mark registers, bore data files, gaging station files and survey job files. In addition all usable survey data is summarised in a survey drawing. There is no other known duplication of the survey records and it is thought the present system offers sufficient duplication of the important results.

4.5 Present Method of Data Storage

All original field books are stored by the Drafting Section. Relevant results are disseminated to various sections of the Division and following this the field books are not usually referred to again. Archival of the original field books would no more inconvenience data users than does the present system.

4.6 Requirements of Users of the Survey Data

Nearly all data users are satisfied to obtain survey results as a survey plan or occasionally to obtain a tabular summary of survey data for major points, e.g. levels on hydrographic stream gauge bench marks and RL's of gauge zero.

4.7 Possible Methods of Providing Adequate Data Security

The adequate archiving of all original field books once the desired data has been extracted should provide an adequate level of data security. Microfilming the original level books will in any way add to the level of data security, because many of the books would need to be edited and "touched-up" prior to copying.

4.8 Results and Implications of Secure Data Storage

It is doubted whether increased levels of raw survey data security would (or could) be detected by users of survey data.

4.9 Implications of Security Methods on Data Users

As mentioned above increased data security will have little or no impact on most users of survey data.
5. DRAFTING SECTION

5.1 Raw Data of the Drafting Section

The Division currently operates at least 4 drafting offices and the present comments may only be appropriate for the two drafting groups formally controlled by Water Resources Branch.

Between these these offices have been responsible for the production of over 5000 plans and are also responsible for the safe storage of now published topographic maps, geologic maps and aerial photographs photo negatives that will be used by the Division and original survey books.

5.2 Who Uses this Data?

A Drafting Section is a purely service group and all drafting is only performed as requested by another section of the Division. During a normal year all sections of Water Resources Branch would have requested some service from the Drafting Section.

5.3 Size of the Stored Data

The following tabular summary was based on only the Alice Springs and Darwin drafting groups of the former Water Resources Branch.

- Stored Plans and Drawings: 5000
- Topographic and Geologic Maps: 8000
- Airphoto mosaics: 700
- Assorted air photos and photo negatives: N/K
- Survey Field Books: 2500
Estimated annual rates of increase:

<table>
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<tr>
<th>Category</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane and Drawings</td>
<td>450</td>
</tr>
<tr>
<td>Survey Field Books</td>
<td>250</td>
</tr>
</tbody>
</table>

5.4 Level of Duplication of the Records

All published maps and photos (air photos and topographic maps etc) are widely distributed throughout Australia and hence there is no need for the Division to contemplate duplication of these records. Survey Field Books were discussed in the previous grouping and will not be discussed again here.

There is no systematic duplication of Division drawings - however at any time perhaps 20% of the drawings may have a paper print in existence in either the Darwin or Alice Springs office (mainly bore completion details or pumping test results on the bore data files).

5.5 Present Method of Data Storage

All plans and original drawings held by the Drafting Section are kept in horizontal plan draws in the respective drafting areas. The photo negatives and survey field books are kept in a locked filing cabinet. It has been proposed for several years to replace the horizontal plan draws with a vertical plan filing system which amongst other things would negate the possibility of water damage to the drawings.

5.6 Requirements of Users of the Drafting Data

Nearly all data distributed by the drafting group is in the form of paper prints made from a transparency, and this appears to be acceptable to most users of the survey data and also to all other data users.
5.7 Possible Methods of Providing Adequate Data Security

The Drafting Section have proposed photo-reducing all transparent tracings to approximately 100mm x 75mm format. If this suggestion is followed through it will be possible to lodge a duplicate copy of the duplicates in a secure secondary storage and to use another copy to produce any necessary prints if the original became damaged or excessively aged. As mentioned in the main text this implies that original drawings not used for say 18 months could be destroyed.

Another method of plan security may appear to be to lodge all drawings in a central plan registry and never to remove the drawings from the safety of the central registry. This is effectively the approach of each drafting office, though it cannot operate remote from the drafting office.

5.8 Results and Implications of Secure Data Storage

Photo-reduction of all plan drawings should ensure that no irreplaceable drafting records are ever lost or destroyed. The effort required to reproduce a print from the photo-negative is slightly longer than the time required to produce a print copy from the original tracings, provided fine line details have not been lost during photo reduction.

5.9 Implication of Security Methods on Data Users

Any modification to data security methods will have little effect on data users because most data users rely on paper prints and not the original tracing.
6. OPERATIONS, DEPARTMENTS

6.1 Raw Data Collected by the Operations Sections

Most data collected by operations sections is related
to the efficient supply of a service to the public.
The records may include volumes distributed, fuel
costs, maintenance schedules and operational performance
data.

6.2 Who Uses this Data?

Most operation data is used almost immediately by
the collecting section, however a small volume of
data may be needed by the Assessment Group when they
are analyzing the response of the source or
investigating the need and potential for augmenting
the service.

6.3 Size of the Stored Data

Little is known about the volume of operations data
held by the Division.

6.4 Level of Duplication of the Record

Some operations data is duplicated between the Area
Managers offices and the Operation Managers filing
system. In addition some derived data may also be
held by the Assessment Branch.

6.5 Present Method of Data Storage

Most of the details kept as graphical or tabulated
summaries in the appropriate Division file.

6.6 Requirements of Ease of Operational Data

Most data needs can be adequately met by reference to
the file summaries which quickly allow trends to be
inspected and verified.
6.7 Possible Methods of Providing Adequate Data Security

The present practices of file duplication between the Area Manager's office and the Operations office provides a satisfactory level of security for most operations data. In fact much of the operations data could possibly be discarded once it has been held for some extended length of time, e.g., maintenance records. However, historic consumption data should be afforded a better, more secure form of storage, say microfilming of the tabulated summaries.

6.8 Implications of Security Methods on Data Users

There are few people outside the operations staff who will ever attempt to use historic operations data and all of their needs may be microphotographed copies of tabulated summaries.

The systematic calling of data files is not expected to inconvenience any data users at some time in the future.
APPENDIX B

COST - BENEFIT ANALYSIS

CONTENTS

COST BENEFIT ANALYSIS
COST-BENEFIT ANALYSIS

It was difficult to perform a valid economic analysis of the proposed methods for securely storing the Division's technical records. Part of the problem was that it was impossible to supply an economic value to various shades of record security. The Division has only two alternatives capable of providing adequate data security. These are micro-photography of the original which is then archived or digitization of the original data and subsequent archival of the original record.

Based on estimates by each section, the apparent benefits of digitization over microphotography and the current manual systems are summarized in Table 3.1.

TABLE 3.1
APPARENT BENEFIT OF DIGITIZATION OVER MICROPHOTOGRAHY

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Average Annual time required to extract data - man-weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manual/Microphotography</td>
</tr>
<tr>
<td>Groundwater</td>
<td></td>
</tr>
<tr>
<td>Bore Advice</td>
<td>44</td>
</tr>
<tr>
<td>NHRC Requests</td>
<td>10</td>
</tr>
<tr>
<td>Project</td>
<td>5</td>
</tr>
<tr>
<td>Graphics</td>
<td>30</td>
</tr>
<tr>
<td>Hydrographic</td>
<td></td>
</tr>
<tr>
<td>Chart Processing (/Chart)</td>
<td>1.5</td>
</tr>
<tr>
<td>Data Extraction</td>
<td>30</td>
</tr>
<tr>
<td>Graphics</td>
<td>30</td>
</tr>
<tr>
<td>GIS</td>
<td></td>
</tr>
<tr>
<td>Analysis (/location)</td>
<td>1</td>
</tr>
<tr>
<td>Graphics</td>
<td>20</td>
</tr>
</tbody>
</table>
Whilst the analysis is only very cursory it does reveal that digitalisation would:

A) Allow each section to operate 3 to 6 times more efficiently. This increase in efficiency would allow more work per person and would not reduce the staff requirements.

B) Allow the hydrographic section to process more charts per year than are currently being collected. This would allow the section to gradually reduce the historic backlog.

C) Allow the Assessment Group to better answer any requests for data by the UWRC.

If the data were stored on magnetic tape a total of 60 high density tapes would be required. If ADF were allowed to charge the annual rental of these tapes would be less than $500. At present ADF does not charge any system users.

In summary a great improvement in staff efficiency could be achieved by digitisation of the record and this process would not cost very much to maintain. Initial system costs are hard to evaluate, but they may be up to $100,000 in ADF wages and computer time. In addition it is estimated the project will require 100 man-years of Water Division staff time at a probable cost of $1m and extra sundry charges for computer rental. It is unlikely the project could be completed in less than four years, though it should ideally not run for more than ten years from now.
LORIMER et. at. "Management Report on the Storage of Bore Data"

NSW WC & IO December 1970.

EX WAB Files:

WA/2/8, WS/1/6, WI/6/1, WH/6/2, WG/6/3, WM/6/5