The salvage and recovery of water-damaged library materials: a comprehensive guide

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The salvage and recovery of water damaged library materials: a comprehensive guide

by

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ABSTRACT

This thesis is a review of the literature available on the salvage and recovery of water damaged library materials. Majority views are expressed, current knowledge is presented and forthcoming research is indicated, where possible. It provides a practical guide to salvage operations and , where applicable, discusses alternatives for stabilisation and drying so that the library or archive will be able to make rational and informed decisions in the event of a disaster without having to wade through the wide volume of literature available on disaster planning. An extensive range of materials that could be found in any library or archive is covered, including books and other paper documents, maps, parchment and vellum, photographic materials, microforms, computer related media, sound and video recordings, compact discs and more unusual materials such as illuminated manuscripts, seals, papyrus, textiles, paintings, wood, bark, leaves, clay, metal, stone, and bone.

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CONTENTS

INTRODUCTION

The Florence floods of 1966 resulted in damage to an overwhelming number of valuable library materials and took the whole world by surprise. Unfortunately, at the time there was little information to be found on how to deal with large scale disasters and the worldwide efforts made during this unfortunate event laid the groundwork for future publications.

Since Florence, the literature has expanded enormously and considerable research has been undertaken into disaster planning, control, prevention, recovery and mass drying techniques. As is so often the case, the initial impetus came from America, where the importance of disaster planning has become a major concern. Consequently, a large amount of the literature available on the subject is American, and not always easy to obtain in this country. However, over the last few years, particularly since the publication of the "Ratcliffe Report" [1] which increased awareness of preservation as a whole, disaster planning has become a concern of British libraries too, and hence the literature is still growing.

The majority of the literature consists of disaster planning manuals and guides, post disaster narratives and technical reports on mass drying techniques. Although some practical salvage manuals do exist, of which Peter Waters' Procedures for the salvage of water-damaged library materials [2] is the most frequently cited, these largely concentrate on books and other paper based materials. Obviously paper comprises the major part of most library collections, but many other materials also exist in libraries and archives : photographic materials, computer related media, microforms, compact discs, as well as more unusual materials to be found in special collections such as parchment, vellum and papyrus. Although information is available in the literature on some, if not all of the materials that may be found in libraries, it is very widespread indeed, even for paper materials, which are more heavily documented. So, long literature searches and a lot of reading must be undertaken to gain the full range of advice available on the salvage and recovery of complete library collections. Hence, this project has been undertaken in an effort to save the librarian, who has little time to undertake such a task, from having to do so.

Water damage has been selected as the focal point of the project, since in most disasters that could occur it is water that will do the most damage. For example, even if fire is the cause of the incident, it is the water from the fire hoses or the in house sprinkler system that will damage those materials left salvageable after the fire itself, those materials that have been burnt being rendered largely unsalvageable anyway. Other possible disasters may be caused by freak weather conditions, causing floods, or burst pipes and leaking roofs, all of which will involve water as the major damaging force.

A large amount of literature has been reviewed in order to compile as comprehensive a guide as possible to the salvage and recovery of the different types of library material that may be involved in a disaster. The resulting thesis is intended as a manual of practice for the salvage of materials from the disaster area, their stabilisation and drying and offers alternatives where applicable; every effort has been made to present majority views. However, in some cases these intentions have not been fulfilled to the full, due to a lack of information available, in which case a summary of the present knowledge available has been given and where possible details of research known to be currently in progress have been given.

Unfortunately, there are some materials, particularly, the more unusual ones and the newer media, compact discs for example, for which there is a definite need for information. Unfortunately, such information can usually only be gained when a disaster happens which highlights previously unforeseen problems unless some specific research is undertaken. It is therefore important to realise that no guide or manual can be regarded as definitive and to keep up to date with salvage advice, literature searches should be undertaken periodically. Furthermore, if a disaster should happen, it is important to publish a report of the event so that any unusual problems encountered are disseminated for the benefit of those who may suffer a disaster in the future.

It is important to note that in the event of a disaster, circumstances will always be individual to the incident and therefore salvage methods may vary slightly depending on the conditions. Thus, a conservator should always be consulted for specific advice and guidance during the recovery efforts. Furthermore, although certain materials have been highlighted throughout this project that will require high priority treatment, such priorities will be individual to the institution according to the relative importance of the collections it holds. These priorities should be established as a part of the disaster planning process, so that in the unfortunate event of a disaster, salvage workers will know exactly where to begin. One general point of advice, however, though it may seem an obvious one, is to regard catalogues of collections as top priority as this will not only save a lot of time and effort in reconstructing the collection, but will also greatly assist in the evaluation of losses for the resulting insurance claim.

Finally, this manual is not intended to be used simply in the event of a disaster; it should be seen as a guide to the recovery section of a disaster plan. It should be read in order that the institution is aware of the methods and choices available in advance of a disaster, so that rational decisions can be made if/when it does happen. Though it may, of course, be referred to as a guide during the disaster, as Dr Fred Matthews said after the Dalhousie University fire, "if you haven't done your homework prior to the disaster there is no time to do it once disaster strikes" [3].

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P A R T   A

T R A D I T I O N A L

L I B R A R Y   M A T E R I A L S

A.1.

PAPER BASED MATERIALS

1. PAPER BASED MATERIALS

1.1 Effects of Water on Paper

Paper, the most common medium on which information is stored [1] is, unfortunately, naturally hygroscopic and although it will take more than forty-eight hours for any significant damage to be done only a few hours soaking is sufficient for the initial breakdown to begin [2]. This breakdown is basically a reversal of the paper-making process; paper is made by drying out an aqueous slurry of fibrous materials (wood, rags or rice etc.) and when paper is left in water for long enough this slurry can be reproduced [3]. The degree of damage sustainable, however, does relate somewhat to the quality and type of the paper.

Papers made before the middle of the nineteenth century have a great capacity for the absorption of water due to the use of water soluble sizing [4]. Such early papers will absorb approximately 80% of their original weight [5]. Papers made after the mid-nineteenth century were made with water resisting sizing [6] and will, therefore, only absorb approximately 60% of their original weight [7]. However, the early papers will actually survive total immersion in water for much longer than those of more recent years [8] which are generally much less durable due to their high acid content [9].

In general, however, water alone does not usually destroy paper [10] but when left damp for extended periods mould becomes active and, despite their durability, the greater concentrations of proteinaceous material in early papers means they are more susceptible to mould and microbiological infection than the more recent papers [11,12].

Coated papers, however, are an exception and these special papers often found in periodicals and art books, with their shiny finish, can be damaged quite considerably from even the slightest water damage [13]. Coated paper was designed to to produce an absorbent surface so as to provide the desired results for the quality of art reproductions. However, the coating also absorbs water very well and tends to dissolve producing a kind of glue so that when drying occurs the coated surfaces adhere to adjacent surfaces. These pages can be extremely difficult to separate without causing image loss [14]. More will be said about how coated papers can be salvaged later but it is sufficient, for now, to realise that important holdings on coated paper will require special attention during the recovery process.

In uncoated papers such adhesion is less of a problem. However, when a bundle of documents or a book is allowed to dry it will lose its water by capillary action from the inside outwards and water soluble materials such as acids and adhesives will move with it; this may cause the edges of the text block to stick together and become embrittled which can cause the acceleration of cellulose degradation in the paper in the long term [15]. However, this sticking is easier to release without text loss and the embrittlement can be corrected by a conservator.

To summarise : the significance of paper type and quality in deciding upon priorities for salvage will, of course, depend largely on the particular disaster situation but in general terms :

- coated paper will require the most urgent attention

- inferior acidic paper (c1880-1946) will need to be salvaged quite quickly [16] if it cannot be replaced but will otherwise not be worth the time it would take to identify.

- quality paper items will survive longest as long as the threat of mould is not imminent, however, rare items will often be on such paper and in this case will take priority.

1.2 Timing

Speed of action is of great importance for the salvage of water damaged paper records; the longer paper is left in the disaster area the more damage will be done to it and hence, the cost of salvage will proportionally increase.

After 24 hours pages will begin to stick together. After 48 hours some drying will have occurred in an uncontrolled way so that paper will be wrinkled, bindings and folders will have warped and coated stock paper will have permanently bonded [17]. However the greatest threat, as far as time is concerned, is mould.

After 60 hours bacterial and fungal growth will be evident [18] but, in the warm humid conditions created by the disaster, mould can be activated within 48 hours if the area is unventilated [19]. Eulenberg recommends that, if temperature and humidity cannot be reduced to below 60°F and 45% RH, water damaged books and other paper materials should be kept immersed in water until they can be dealt with but should never be left more than 72 hours [20]. Coated paper, however, should not be left more than 10 hours [21].

If mould does become visible Upton and Pearson recommend that no attempt should be made to remove mould from wet paper materials as this will only force the mould into the paper and increase staining [22].

It would clearly be preferable to remove records as quickly as possible so that the possibility of mould can be avoided; However time is not always on one's side especially in a disaster situation. As a general guideline try and have the disaster area cleared of paper within 48 hours and aim to have the whole situation stabilised within 72 hours [23]. Further information on inhibiting the possibility of mould in paper materials will be given in section 1.7.

1.3 Basic Do's and Don'ts for the removal of wet paper records from the disaster area

There is some disagreement about where to start salvaging paper records. Peter Waters recommends that the wettest materials be removed first as it is an essential step to lower the humidity level in the whole area and suggests that these will be the books and items on the lower shelves [24]. However, Eulenberg suggests that the wettest materials will either be those on the floor or those on the top shelves depending on the source of the water [25].

However, according to Anderson and McIntyre, submerged materials as you might find on the floor do not demand priority for salvage unless they contain water soluble inks or are suffering further damage by being trodden on [26]. They suggest that, where water damage has come from above, the top shelves should be cleared first as the books or records on these higher shelves will absorb the most water, swell and render it increasingly difficult to remove them without damage [27]. Indeed, during the disaster recovery at the Corning Museum of Glass, crowbars had to be used to dislodge swollen books resulting in the bookcases suddenly springing free and dumping their contents into muddy water [28]. Also, if items are removed from the lower shelves first then wet items higher up will cause the shelving units to become top heavy and may cause collapse [29].

However, as Anderson and McIntyre also point out, when the source of damage is at basement level and the upper shelves are not wet then then the lower shelves must be cleared first [30].

Clearly where removal should begin will depend upon the individual situation but it is important to have some idea of priorities before beginning to remove items as this will save time and money in the long run [31]

Once this decision has been made there are a few basic rules to follow to prevent unnecessary further damage, the main one being :

REMOVE PAPER RECORDS IN THE CONDITION IN WHICH THEY WERE FOUND

- Open books should be left open and closed books should not be opened [32].

- Single sheets should not be separated until they reach the sorting area [33].

- Do not disturb items in boxes envelopes or folders in the disaster area [34].

- Whilst taking records of items removed use soft pencil in case of accidental marking on paper and make no attempt to write on wet paper as this will tear [35].

- Do not press books and documents mechanically or stack wet records on top of each other as this may force mud into the paper and subject it to further structural damage [36,37].

- In general, handle quickly and with great care [38].

No attempt should be made to alter the state of water damaged paper records until they have reached the sorting area where conditions will be more favourable for making salvage decisions.

Further details will be given on the handling and salvage of different formats of paper records in section 1.7.

1.4 Cleaning paper records

Whatever drying or stabilizing method is to be chosen cleaning is always a preferable preliminary for paper records in order to remove excess mud and filth. However, it must be regarded as a luxury only to be applied if time, expert supervision and enough helpers are available [39]. Serious damage can be caused by such actions if the trained eye of a conservator is not available to assess whether items may contain water soluble components [40]. Therefore, if there is any doubt at all, cleaning should not be attempted.

There are several ways in which cleaning can be approached but which ever method, or combination of methods are employed, it must always be remembered that all actions should be gentle; no rubbing or brushing should be attempted as this may bruise the paper, will often start a tear and may merely result in pushing the dirt elsewhere, into the binding of a volume, for example [41]. Any persistent stains should be left [42] and even mud that proves stubborn will be best left until dry when it can be removed more easily [43]. The only cleaning action that should be employed is a very gentle dabbing action with a sponge [44,45,46].

Cleaning methods that may be used include :

1. Using a hand held water spray, to remove surface deposits with no rubbing or brushing [47] but gentle sponging as described above may be used.

2. Using clean, cold, gently running water; for treating closed volumes one at a time only [48]. This may be from a hose or even from a gently running tap; the cleaning action desribed above may be used.

3. Using four to eight large tanks of water which should be provided with a source of running water, via hose pipes, so that dirty water is constantly replaced. Large plastic dustbins would be suitable. Each book or stack of documents should be cleaned with the sponging action in the first tank and this should be continued in each tank until the last wash has been completed; Then the item can be rinsed by spraying with a fine stream of water. Any excess water can be gently squeezed out using the hands only; no mechanical methods should be used. [49,50]

It is also important to remember that closed books should still remain closed and documents should not be separated. Furthermore, Peter Waters suggests that the washing of opened volumes of any kind is not advisable [51].

If paper records have been subjected to fire damage the cleaning processes detailed are not intended to remove the carbon and smoke stains that may be apparent [52]. Such staining can be removed when dry. Eric Lundquist tells us that after the Dalhousie Library fire trials were carried out with chemical sponges, which proved to be very effective for the removal of even heavy smoke stains; Most of these books were then deemed reshelvable without further restoration work [53].

1.5 Deciding what to do next : freeze or dry?

How the drying or stabilization of water damaged paper records is approached, again, depends largely upon the extent of the damage that has occurred and the institution's individual situation as regards facilities and finance.

Freezing is now universally accepted as the best way of stabilizing water soaked paper against further deterioration and also allows valuable time in which decisions can be made as to how to dry and restore the damaged materials or indeed whether to discard them altogether. John Martin writes of experiences at the Corning Museum of Glass :

> Items which were beyond repair or those which were of current or ephemeral nature were discarded. This included part of the periodical collection - in the misguided expectation that it would be relatively easy to replace. The librarians later realised that everything should have been frozen so that decisions to save or discard could have

> been made more rationally at a less urgent time. [54]

Freezing has further advantages in that if time is against you, freezing can halt mould attack; although it will not destroy mould spores it will render them dormant and thus reduce damage that may otherwise have occurred [55]. Furthermore, it will stabilize soluble inks and dyes and prevent the adhesion of leaves of coated paper [56].

The alternative of air drying on site is very labour intensive and at first sight seems like an inexpensive option. However, as already stated, books and documents must reach a stabilized state within a 72 hour period if extensive damage is to be avoided and if large amounts of paper are involved this may not be practical. So, in the long term, restoration and replacement costs could prove very high indeed. After the Dalhousie fire both time and volunteers ran out before the operation of laying books out to air dry had been completed [57].

Julia Eulenberg comments that air drying is best used only when records are damp but not soaked, when no mildew damage is present and when the ratio of damaged records to available recovery staff allows completion within 72 hours after the disaster has occurred [58].

Although the immediate freezing of all paper materials is strongly recommended, if costs are a major concern or the disaster is small, it is acceptable to selectively keep back certain items for air drying. Tregarthen-Jenkins suggests that damp and partially wet items, and also wet modern books that can be easily replaced if things go wrong, can be air dried [59].

However if selection is taking place there are certain paper items that really MUST BE FROZEN:

- Items with soluble inks and dyes : freezing will stabilize these and prevent further feathering or migration

- Items on, or, containing coated paper : as detailed in section 1.1, such paper will adhere irrecoverably if allowed to dry and it must be frozen whilst still wet (Further details will be given in section 1.6.)

- Any items that may prove difficult to air dry e.g. folio volumes, due to their size.

Freezing at low temperatures is recommended though, as Sally Buchanan points out, there is slight disagreement about the ideal temperature, but temperatures well below freezing point should be aimed for; -20^{o} - $-30^{o}C$ is best

[60]. Blast freezing is reputed to be the best method as this freezes items very quickly and forms smaller ice crystals than slower freezing methods which tend to produce large needle like crystals. Thus, with blast freezing, there is less risk of damage to the structure of the paper [61,62].

Materials can be left frozen for almost indefinite periods; some collections have been left as long as six years and with little or no permanent damage on drying [63].

1.6 Packing paper records for freezing

There is some debate as to what receptacle is best suited to the packaging of paper records for freezing. The why's and wherefores will be briefly described here, but in the event of a disaster, no matter what amount of planning has been undertaken, it may well simply come down to a matter of availability.

Peter Waters highly recommends the use of plastic milk crates because they are strong, will not crush and can therefore be stacked to roof level in a freezer truck and will be equally compact in the freezer [64]. Thus transportation time and storage space is saved. Cardboard boxes, on the other hand, are seen as the poor alternative because wet books will make the boxes damp and heavy and cannot be stacked as high as milk crates without both the boxes and their contents being crushed [65]. However, Eric Lundquist favours the cardboard box because the milk crates not only tend to permanently imprint the water damaged materials with the design of the crate but, if mass drying is to be undertaken, they do not allow even heat distribution [66].

Lundquist suggests that the standard record centre box of one to one and a half cubic feet is the optimum size for ease of handling [67], though Waters suggests two cubic feet [68]. However, as England and Evans point out, it is simply important not to have very large boxes as wet documents and books are extremely heavy [69] and tired workers may mishandle them. Furthermore, boxes should not be filled completely; only three quarters full is recommended as not only does this facilitate easier handling but faster freezing [70].

Boxes should not be packed tightly but comfortably; i.e. close enough to provide support and minimise distortion but allowing enough room for the possibility of continued swelling of the paper [71,72]. England and Evans also suggest that putting crushed paper at the top and down the sides of crates or boxes will add extra protection and support [73].

Wrapping of damaged paper materials is recommended to prevent sticking during the freezing process [74-78] although this is to varying degrees and with varying materials. Lundquist, however, states that "it is far more important to get the damaged materials well packed and into a freezer, wrapping only if time permits."[79]. None of the books from the Dalhousie fire were wrapped and only a few are said to have remained glued together after vacuum drying [80]. However, stuck documents can be extremely difficult to separate without damage and there are other reasons for the wrapping of materials; it helps protect against the migration of acids and colours of the bindings causing a stain [81].

Acceptable wrapping materials include freezer paper, waxed paper, silicone paper [82], cling film and plastic bags [83,84]. Tregarthen-Jenkins recommends that each item be placed in a plastic bag or cling film with a label attached to each for later ease of identification [85]. The advantage of plastic keeping paper in "a state of damp equilibrium", is pointed out by Martin [86]. If one of the recommended papers is to be used it can be in one of several ways. Each item can be wrapped loosely around the spine or, if time is short, every other book can be wrapped [87]. England and Evans suggest that for special books a thin sheet of paper may be placed between the front/back paste down endpaper (the board paper) and the front/back free endpaper for extra protection [88].

Books should be packed spine down in a single layer to prevent text blocks from falling out and crushing [89].If this is not possible then they should be packed flat [90]. Books of the same size should be packed next to each other to provide support and prevent warpage [91].

Sally Buchanan emphasises the importance of careful packing; if books are placed in the freezer badly warped or distorted they are dried in that state and are then more difficult to rehabilitate. But if they can be gently straightened with regard to bindings, and carefully packed, then they will recover in a more satisfactory state. However if time is not available all is not lost; frozen books can be allowed to thaw slightly and then be reshaped and vacuum dried. Books so treated seemed to hold their new shape quite well because of their frozen condition. [92,93]

Books containing coated paper should be kept wet, until frozen, to prevent blocking; this can be achieved by packing them individually in plastic bags [94,95] or by packing them in boxes lined with plastic bin bags [96].

Folio volumes may not fit into boxes spine down so they may be placed in boxes flat with no more than two or three on top of one another, otherwise the weight will destroy the bottom one [97]. Or, if they do not fit into boxes or crates, they may be carefully wrapped individually and laid together flat in the transportation vehicle [98].

Books with special bindings, particularly those of vellum should be wrapped around with crepe bandages to prevent distortion : start at the lower edge winding the bandage round the boards, from spine to foredge to spine, with a small overlap each time, then wrap in cling film [99].

Open books should be be wrapped as they are found and placed on the top of crates or boxes preferably not weighed down by several other open books. Only one or two should be placed together with separating sheets placed between them. [100]

Loose documents should be wrapped in stacks of about 200 sheets or 2 inches thickness to make them into book like units. Eulenberg stresses the aim to facilitate ease of handling and suggests a wrapping method in which the extensions of wrapping paper on each side of the wet records can act as handles [101]. These can then be packed flat as Anderson and McIntyre suggest [102] or, as Buchanan suggests, by turning the box on its side, packing the material flat until the box is full and then turning it upright [103].

Records in boxes or folders are unlikely to have been saturated. However if the containers themselves are wet then they should be carefully removed and repacked in new ones or packed as suggested in the previous paragraph [104,105,106].

Records in ring binders, according to recent experiments by A.E. Parker of the Manuscript Conservation Studio at the British Library, may be left as they are if the binders are full to capacity; If they are not then records should be removed and packed separately before freezing, otherwise the folder cover creates a space into which the paper can distort [107].

1.7 Air drying on site

1.7.1 General information

Wet paper records that are to be air dried, rather than sent for freezing, should be taken to an area set aside for this purpose that is well away from the disaster area. A controlled environment is of central importance to the air drying process in order to avoid mould, mildew and excessive swelling [108]. Good air circulation is of primary importance so that evaporation is achieved and to discourage stagnant pockets of air where mildew might flourish ; thus keep air circulating with fans and open windows. Low humidity is also important, but because of the wet records this can be difficult to achieve, so temperatures should be kept under 21°C [109]. The use of dehumidifiers will be of great assistance as this will render the environment more controllable and speed up the drying process [110]. All surfaces to be used for drying should be protected with plastic sheeting [111].

Interleaving is a commonly recommended practice in the air drying process. A clean, non abrasive, absorbent paper should be used e.g. unprinted newsprint, florists waxed paper, paper towelling, or white blotting paper [112].

Eulenberg comments that newsprint and other such acidic papers are not generally recommended for use with archival and permanent records, but says that significant acid transfer during the short contact of drying is far less likely than damage from mould or mildew which may occur if drying is delayed whilst enough acid free paper is found [113]. Several authors recommend the use of thymol impregnated interleaving papers [114,115,116] as this will inhibit mould in wet paper. Although its preparation can be messy and time consuming it is advisable, if the facilities are available, because the beginnings of mould formation can be difficult to detect. Lundquist points out that the glues in the spines of books can develop mould which cannot be detected without physically destroying the book [117].

To prepare thymol impregnated sheets, interleaving paper should be cut into several suitable sizes [118]. These sheets should be dipped into a 10-15% solution of thymol crystals in ethanol, acetone, trioclorethane [119] or industrial methylated spirits (not household as this contains a purple dye which may transfer to papers) [120]. These sheets should then be allowed to dry, which will be quite quickly, in a well ventilated environment (outside preferably) on a polythene covered surface [121]. When dry the sheets should be wrapped in polythene bags or aluminium foil and stored in a cool place until needed as thymol is a volatile substance [122]. Although thymol is recommended, because it is one of the least toxic fungicides and can be handled relatively safely by workers, during its preparation gloves goggles and respirators should be worn [123].

An alternative to impregnating sheets with thymol is outlined by Upton and Pearson and involves exposing the wet records to thymol as a vapour. The records to be treated should be placed in a cabinet or under a plastic tent with a tray of thymol crystals (60 grams of crystals for every cubic metre of space) placed over a light bulb for 24 hours. The heat from the bulb vaporises the crystals. [124]

The methods for drying and interleaving paper records are described in the following sections but there are one or two general points of advice that must be outlined first.

Drying is a continuous process that requires careful monitoring :

- Interleaving papers should be changed at regular intervals to speed up the drying process [125]. If these are not thymol impregnated they may be dried and reused

[126] but, if they are impregnated, then they must not be reused unless they have been reimpregnated with thymol [127].

- Check for and remove any dry records so that room will be given for more wet ones and the dry records can be placed in a more suitable environment [128].

- Test for dryness with lips as hands will be relatively poor indicators of moisture after working with wet records; if the paper feels cool, it is still damp, even if it looks dry [129].

- Check frequently for records that show signs of mould or mildew and remove them to avoid infecting others [130].

1.7.2 Air drying books

The following guidelines begin by assuming that the books are very wet as they would be after washing, for instance. For books which are slightly less wet, i.e. if the leaves are capable of being fanned without further damage, the first paragraph about draining may be ignored.

Wet books should be allowed to drain on several sheets of absorbent paper before they can be fanned or interleaved [131]. They should be stood, with their covers slightly opened, upside down on their head ends as this will compensate for the sag that books acquire during normal upright storage and which can otherwise be further aggravated by the weight of wet leaves [132,133]. Books which cannot stand alone (e.g. paperbacks) can be propped against each other or supported with Styrofoam, if possible, but may otherwise be placed spine down at a shallow angle of opening and resting on the unopened pages [134,135,136]. However if books are waterlogged they should not be forced open; they should be allowed to dry until the covers and pages separate naturally [137]. The covers of books usually contain the most moisture so, to prevent further wetting of the leaves, it is a good idea to isolate the covers with polythene between the boards and the pages of the book [138]. If books are tilted back on styrofoam the covers may be kept separate by using toothpicks [139]. Since the covers are the wettest they are usually the last to dry out and are therefore more susceptible to mould attack. Thus, at this early stage, it is advisable to place thymol impregnated sheets between the front and back covers and the flysheets [140]. The absorbent paper should be changed frequently and quite quickly pages will reach the point when they can be opened with care [141].

At this stage the drying of books can be assisted with interleaving, fanning out the pages slightly. Interleaving should be proceeded with very carefully; books should not be opened to more than a 30-45^{o} angle [142,143]. Sheets of interleaving paper, treated or untreated, should be placed as far into the gutter margin as possible and should extend a little beyond the foreedge and the top as this will help to wick the moisture out of the book and facilitate evaporation from the absorbent paper [144]. Absorbent paper should be placed at intervals of 25 leaves to begin with; as the book becomes drier it can be interleaved more closely but never to more than one third of the thickness of the book [145]. However, if drying conditions are not ideal and humidity is high, interleaving may be placed every five pages as the risk of mould outweighs the distortion that may occur [146]. Absorbent paper should be changed frequently at which point the book may also be inverted in order to reduce sagging of the text block [147]. Eulenberg recommends inversion of volumes every four to eight hours [148].

When books are dry to the touch they may have their interleaving papers removed and should be closed up and laid flat on a table. They can now be gently manipulated into their normal shape, with convex spine and concave foredge, and held in place with book presses or between covered boards with light weights, bricks or concrete blocks on them for several days. [149,150,151] Books must not be returned to the stacks until they are completely dry and it is certain that mould is not developing.

An alternative method of drying books which are not extremely wet is line drying; This method is, is especially good for pamphlets, and will help reduce distortion of the spine [152-155]. It involves hanging volumes on monofilament nylon lines of approximately one millimetre (1/32inch) in diameter which should be not more than two metres (six feet) long and strung extremely securely approximately 1½ centimetres (½inch) apart [156]. For a volume of four centimetres (1½ inches) thick, three lines are enough; more will be required for thicker volumes but no volume should be hung up if it weighs more than six pounds as this will cause the folds of the book to fracture [157]. A book is only deemed dry enough to hang if the paper only feels damp and the pages can be opened easily throughout; if a wet book is hung spine adhesives may migrate and cause staining and adhesion of leaves [158]. England and Evans warn that this method of drying volumes can cause serious damage if not done properly and should only be undertaken with the supervision of a conservator or as a last resort [159].

It has already been advised that coated paper should be frozen as it does not respond well to air drying. However, some volumes may have filtered through. If this is the case and air drying must be used every page must be interleaved, despite the distortion that will occur, and must frequently have their pages fanned gently to lessen the chance of adhesion [160].

1.7.3 Unbound paper records

Several techniques can be used to handle and air dry single sheet documents all of which are quite delicate operations. Thus, as Peter Waters recommends, if masses of single sheet documents are involved it is far better to freeze them, as they can then be vacuum or freeze dried, after which they will separate easily [161].

However, if air drying is to be undertaken, Eulenberg recommends that initial procedures should involve the opening of filing cabinets and storage containers to increase air circulation through the records followed by the removal of records in a systematic manner from all containers; even if records are dry inside containers they should be transferred to new ones and if records in filing cabinets are to be left for the time being they should be removed later to disinfect the cabinet [162].

Metal fasteners and paper clips should be removed from wet records, to prevent rust stains, as records are dealt with because this can cause as much damage as mould [163].

If records are very wet they will be extremely difficult to handle without tearing. Peter Waters recommends that the safest method of handling and drying these is to use polyester non woven fabric and film and even this he says requires great dexterity [164]. A sheet of polyester film should be dampened and laid on top of a wet pile of records which then adheres with the paper records due to the surface tension of water; several sheets can then be peeled away with the polyester film which should be placed, polyester side down, on a surface prepared with polythene sheeting. Then, to separate into single sheets, take another sheet of polyester film and place this on the newly formed pile and peel back again, this time lifting only one sheet, and place this polyester side down on the table. Then, to prepare the sheet for drying, take a sheet of dry polyester fabric and place this on the wet sheet, turn it over and remove the polyester film that has now appeared on top then replace it with another dry piece of polyester fabric. The process should then be repeated.

Each sheet, sandwiched in polyester fabric, can either be laid out separately on tables or on closely spaced nylon lines to dry. [165]. Sally Buchanan describes how these polyester sandwiches may also be hung from lines with clothes pins; as the wet sheet dries it gradually releases itself [166].

Eulenberg describes a similar process to separate wet records using mylar sheets to lift individual sheets from a pile and placing face down on to interleaving paper [167].

Less wet records may be interleaved at every fifth to twenty fifth page and placed in stacks no higher than eight inches; these stacks should be inverted every four to eight hours. As the top layers dry remove them but do not replace them with wet records as this will prevent the records in the middle from drying and encourage the development of mould. [168]

Rust proof screening that would be found in hardware stores can be attached to parallel walls to from a rigid surface on which drying records can be laid if drying space is limited [169]. Also, records that are only slightly damp may be hung directly on to lines to dry using rust proof clips [170]. These should be inverted periodically [171].

After drying single sheets may require some flattening. This may be done by placing sheets between clean blotters in a book press or between covered boards that are lightly weighted [172]. They may also be placed through rollers or can be carefully ironed, with moderate heat on a metal surface using a clean sheet of blotting paper to keep the document from actual contact with the iron (only minimal ironing is recommended, as excessive heat exposure may cause embrittlement) [173].

1.8 Drying paper records after freezing

There are quite a number of drying options available to the library which has given itself time to choose by freezing its water damaged records. The main methods will be described and discussed briefly below and some general conclusions will be made. But, in the event of such a decision having to be made, it will be necessary to consult with conservators and explore drying facilities in order to determine what method(s) are best suited to the individual library's needs and to discuss exact specifications.

1.8.1 Vacuum drying

Vacuum drying, sometimes known as freeze-thaw vacuum drying, uses a chamber into which frozen books are placed and air is removed to create a vacuum. Heat is introduced to create a temperature above freezing point; this thaws the materials and subsequently dries them by removing the moisture through evaporation. Since this is a wet process it is conceivable that items may be sent for vacuum drying direct from the disaster if the library has thoroughly planned for disaster in advance and the chamber is nearby and readily available. However it is still more advisable to freeze first. [174,175]

The use of a vacuum chamber can reduce the chances of mould growth and if any does appear a fumigant can be introduced to the chamber as a part of the process [176]. Vacuum drying is considered to be one of the best methods available for the mass drying of books and experts are satisfied that it does not damage the cellulose in paper [177].

However because the materials sit wet there are several drawbacks to vacuum drying that render it unsuitable for some types of paper record. Items with water soluble inks, adhesives etc. will continue to feather once defrosted [178]. The drying of early printed books is not recommended as the introduction of heat during the drying process causes the gelatin sizing contained in the paper of such books to move towards the edges of the book where it will then bake; Books may be lost altogether in the worst cases but in the best they will still be severely stained and enbrittled [179,180]. Furthermore, acid migration will occur if low acid content papers are mixed with those of high acid content [181]. However, Oxford University chose vacuum drying for their rare books and found the results quite acceptable with most of the damage being to the bindings rather than the paper which suffered only slight staining [182]. So it would appear there is some debate about this issue but the risk must be taken into account.

Coated papers will tend to stick during vacuum drying also due to the fact that it is a wet process [183]. Although experiments undertaken after the Corning Museum of Glass disaster suggest that very carefully controlled freeze-thaw vacuum drying can produce relatively successful results with coated paper [184]. By measuring a random selection of books containing coated paper it was discovered that the majority of sticking took place when the temperature exceeded $10^{o}C$ and that sticking did not seem to occur when the temperature of the water in the book was below 4.4°C. Detailed specifications were developed so that the temperature during the liquid phase of drying would be kept close to 4.4°C and would not exceed 10°C. After drying 56% of the items containing coated paper suffered no sticking at all; the rest suffered various degrees of sticking but only 7% suffered 91-100% of their pages sticking. However, it was felt that much of the sticking was due to the history of the book i.e. whether it had been allowed to dry partially before freezing and they suggest rewetting of books containing coated paper before freezing and then vacuum drying. [185]. Again there is debate about the success of vacuum drying with this type of material and the risks must be weighed against the value of the materials.

More general experiments were conducted during the Stanford Library restoration project which discovered that books, in general, can be dried most quickly in the vacuum chamber if they are unwrapped and placed directly on the shelves in an upright position, rather than by leaving them in the boxes or crates in which they were frozen in [186].

Results, after drying books using this method, are generally seen as satisfactory and are considered to be better than those achieved by traditional air drying techniques [187]. It should also be noted that, after drying, books record a moisture content lower than that normally found in book paper and generally require a rehabilitation period which can be enhanced by the use of humidifiers in order to regain normal moisture content; before this there is a risk of damage to the bindings if opened [188].

1.8.2 Vacuum Freeze Drying

Vacuum freeze drying, which is sometimes also referred to as lyophilization, is a similar process to vacuum drying but with an important distinction; frozen materials do not thaw during this process. Water is removed by sublimation which means that ice is converted directly into water vapour without ever going through the liquid phase. [189,190,191]

The advantages of this are immediately apparent. Inks, adhesives, and other water soluble components do not feather or migrate any more than has already happened due to the water damage and coated paper runs less risk of adhering as long as it was still wet when frozen [192].

McCleary describes vacuum freeze drying as the the only practical way to restore coated papers at present [193].

A further advantage is that bound materials seem to distort less than with vacuum drying or air drying, although items which are in a distorted state when placed in the chamber will remain so [194]. Also, vacuum freeze drying seems to bring dirt to the surface more effectively than vacuum drying so that it may be more easily removed [195].

Sally Buchanan says this method is "at present the most successful way of drying large numbers of library or archival materials" [196]. It would certainly seem to be the safest method for items which contain unstable dyes or which are irreplaceable. After the disaster at the College of Physicians in Philadelphia which involved a high proportion of rare books, of which 423 were incunabula, this method of drying was considered the safest to choose [197]. After drying no damage which could be ascribed to the drying process could be detected, in fact Ruggere and Morse comment, "some of the books looked as if they had never been water damaged, frozen, or freeze dried" [198].

Flink and Hoyer found that freeze drying gave perfect results when they used the method on stacks of handwritten letters and documents; each page separated easily and none of the inks ran [199].

A.E. Parker has conducted some freeze drying trials on various types of paper in his work at the British Library. He found that, with loose letters, envelopes and stamps, where flood water had already effected the adhesives on these items, freeze drying reduced any adherence remaining and the items separated but, on items on where the water had not effected the adhesive freeze drying had no adverse effect. Other items tested included tissue lined papers such as might be found on items that had undergone restoration, for example; These had not suffered from separation and pages had not stuck. [200]

A.E. Parker is continuing to investigate freeze drying on many different types of material, so for updates on its uses and effects, his future publications should be of value.

1.8.3. Deep Freeze Drying

This is a method that requires only the use of a freezer and works on the principle of dehydration which is similar to the process of sublimation. Paper records are left in the freezer unwrapped and, as with food that is left in a domestic freezer for a long period, water vapour molecules are eventually drawn off into the freezer unit leaving the item dehydrated. However, as this method requires quite a long time, the technique has not caught on as a practical method for drying large numbers of water damaged records. [201]

1.8.4 Dielectric Drying

Dielectric Drying involves the use of electrical energy bursts when a book is placed between two electrodes in the drier. The current through the plate can be varied according to the size of the item being dried which in theory should be a great advantage. However, in practice, there have been several problems with the method. Charring of the paper occurs due to excessive drying and other associated materials, such as leather bindings adhesives and metallic lettering, also suffered charring. [202]. This method was used for drying some of the records involved in the Corning Museum of Glass disaster and it was found that any undetected metal, paper clips, staples etc., caused charring on the paper and also that for successful drying the covers of books should be removed because they contained much more water than the paper itself [203]. Martin also comments that it was uncertain whether the electrical burst could have caused any permanent damage to the paper such as premature aging [204]. Fischer conducted considerable experiments with this method of drying and concluded that the method was suitable for use only on materials which could be replaced, if charring did occur, and that it was not suitable for coated paper which stuck and, in some cases, pages ballooned and split as the water inside became a gas [205].

1.8.5 Microwave Drying

Microwave drying heats materials, from the inside outwards, in order to dry them. Unfortunately, no metals can be placed inside a microwave as these heat far more rapidly than any other materials and thus this drying method suffers from similar problems as dielectric drying which seriously limit its usage. [206]

Experiments by Thomas and Flink indicate that charring of paper can be prevented as long as complete drying is not undertaken but some success has been achieved with the complete drying of thin signatures or single leaves [207].

1.8.6 Solvent Extraction

This method of drying frozen paper materials involves submerging the materials in a precooled anhydrous solvent in a sealed container which is then stored in a freezer; water is gradually replaced by the solvent and books can then be air dried or vacuum dried. The object of this method is presumably to avoid the damage done by water in its liquid state during drying, i.e. the migration of inks adhesives etc.. However, the method is totally unsuitable for most modern books which use a printing that is highly soluble in solvents. [208]

1.8.7 Dehumidifying

This relatively new method of drying does not involve the pre-freezing of the water damaged items but, although still undergoing testing, shows great potential for the drying of materials in situ at the disaster site by bringing in large dehumidifiers. The relative humidity is lowered to such a level that the circulating air becomes very dry and evaporates the moisture from the damaged materials. [209]

1.8.8 Air drying after freezing

Once records have been frozen there is no reason why they should not still be air dried, if costs need to be kept to a minimum, and there will be the added advantage of being able to deal only with manageable sections of the damaged stock at a time. The procedures detailed previously can be followed but records will require thawing first. Books should be left lying flat on absorbent paper to defrost; this may be assisted with the use of fans but not heated ones [210]. Change the absorbent paper frequently until the book is thawed. The procedures detailed in section 1.7.2 may then be followed beginning with standing the book on its head to drain. Loose documents which have been frozen can be air dried with relative ease. Each bundle of documents should be laid out on blotting paper; again fans will assist thawing and evaporation. As the topmost document dries enough, so that it may be handled easily, it should be lifted off and placed on a fresh surface of absorbent paper to continue drying [211].

1.8.9 General conclusions

The most commonly preferred methods of drying records after freezing are vacuum and freeze drying because of the suitability of the facilities for mass drying operations which cut down costs. Although vacuum drying has been successfully used for the drying of rare books and to some extent with coated papers it would seem that, for such coated paper and valuable, special or irreplaceable items, particularly those with components that may migrate or feather, freeze drying is the least risky option. However, vacuum drying is extremely suitable for the large majority of the library's paper based materials.

In a study done by Fischer and Duncan, air drying was seen as the next most suitable method; followed by solvent extraction; with microwave and dielectric drying falling towards and at the bottom of the list respectively [212].

However it should once again be stressed that, before any decisions are made, there should be detailed consultation with conservators regarding the specific aspects of the collection of damaged materials to be involved in a drying operation.

1.9 Bindings

For the most part it is the paper, or more specifically the information on the paper, which is the priority during salvage operations. However, many bindings, particularly on older books are of interest, of intrinsic value to the book or, important in their own right. Furthermore, if the binding of a water damaged book can be saved, it can cut down the cost of restoration to some extent.

Unfortunately the binding of a book is extremely vulnerable to the effects of water damage, purely by virtue of the job it is designed to do; the paper it is designed to protect will swell in water and cause considerable strain on this mechanical device, particularly at its hinges, and splitting can often occur and the binding may detach itself from the book in the worst instances. An additional hazard is that book boards themselves are made from cardboard and can swell and distort quite badly when water damaged which can cause the material covering the boards to split, distort or stretch as well.

It is also unfortunate that because the bindings of books have never been the main concern of those involved with disasters, little information is available about successfully recovering them.

Peter Waters commented, after the Florence flood, that conservators were given a rare opportunity to examine in detail so many early bindings and that such a large number survived was mainly due to the high quality of the materials used in their production. He says that the bindings which survived the best were the limp paper and vellum bindings which had been constructed with little or no adhesives on the spine, but, the hard cover bindings were generally in a poor condition, particularly if they had been made with a lot of gelatine spine adhesives. [213]

Carolyn Horton, again regarding the Florence Flood, says that leather and vellum which are often used on book covers lose essential tanning agents when soaked in water and on drying become brittle and shrink badly. She reports that attempts were being made to restore these bindings using saddle soap and lanolin but could not comment on the success rate at the time of writing. [214]

Sally Buchanan reports similar findings with leather bindings after the Stanford Library flood - the leather on the bindings swelled when wet and then shrank when dried. It was found that exposure to 60% humidity for six to eight weeks and some pressing helped to recover some of them; out of approximately 3000 books 500 covers were completely lost and those that recovered in better condition were placed in handmade book boxes. [215]

The books that were water damaged at Oxford University were vacuum dried and it would appear that the only real damage that was done was to the bindings. Vellum covers were brittle, leather ones were torn and warped and it appears that only the more modern covers recovered well. However, it was felt that the damage caused to the bindings was as a result of the exposure to water rather than the drying technique used. [216]

So, what would seem to be the best approach to saving bindings? Anderson and McIntyre suggest that vellum bindings should be wrapped with bandages, before freezing in order to limit distortion [217] (see section 1.6. for details) so it would perhaps be advisable to practise this method with all bindings that are of special value in order to limit their damage. Freezing seems to be a safe option for leather and vellum bindings [218] but the next step is how best to dry them.

A.E. Parker conducted experiments on freeze drying at the British Library and produced satisfactory results on mottled calf bindings (1765-1794), paper bindings (1769-1958), full leather publishers' bindings (1781,1842), half leather publishers' bindings (1804-1817), full cloth publishers' bindings (1848-1961) and also more modern bindings including plasticised cloth bindings, imitation leather, plastic covered pocket guides, quarter cloth publishers' bindings and paperbacks though the latter type swelled considerably. However, he does point out that allowances had to be made for distortion caused by the flood water. [219]

In more recent experiments A.E. Parker has also investigated the freeze drying of vellum bindings. He discovered that the vellum shrunk away at the edges of the boards leaving the boards bare in places. He states that where the distortion caused by the water is minimal and recovering and rebinding would not be needed, freeze drying is an option, but where the distortion is to the extent that rebinding would be necessary then freezing followed by controlled thawing, pulling and rebinding is the better option. He also suggests an alternative; the cover could be removed, either after freezing or whist still wet, and then either dried conventionally or freeze dried as if it were a charter. The cover can then be relaxed and reused to cover the text block. [220]

It would seem however that for special bindings some distortion must be expected. However, as Carolyn Horton points out, a good idea is to take photographs of the original bindings so that when restoration work takes place there is a record of the original to plan new bindings from if the original cannot be saved [221]. Also, if during the salvage operation important bindings become detached from the text block or it is decided to detach it, it is important to make a record of the text the binding encased [222].

Finally, Eulenberg details a method of saving the bindings of paperback books or reports if they become detached. After drying the cover can be replaced by putting it on the book and heating it which may warm the glue on the book spine and cover enough to reattach them; this may be done using an electric iron or a thermal binder into which one to three paperback items may be placed for three to ten minutes. [223]

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A.2.

ANIMAL SKINS

A.2. ANIMAL SKINS

2.1 Leather

Leather is manufactured from the skin of any living creature and thus there are many different types. The original skin is modified by a process of tanning which replaces water and modifies the molecules of the skin to produce durability and flexibility and a certain amount of water resistance. [1]

The nature of leather is thus not, generally, adversely effected by water alone. In libraries it is usually found as a book binding material and damage is caused mostly by the distortion of the boards it covers. The effects of water damage on book bindings have already been discussed in section 1.9., and thus will not be reiterated here. However there may be unusual instances in which sheets of leather are present in a library's collection and thus some brief information will be given about the recovery of leather in its own right.

Leather may be frozen without any problems [2,3]. It can then either be air or freeze dried. Air drying must be carried out very slowly at room temperature and weights may be placed around its outer edges to provide some restraint against distortion [4]. Depending upon the extent of initial damage to the leather further restoration work may be required from a conservator in order to restore suppleness. Freeze drying can be carried out with little risk [5,6] and would therefore be a good option if any water soluble inks are present as decoration or writing on the surface of the leather.

2.2 Parchment and Vellum

2.2.1 Definition

Both parchment and vellum are the second most common material to be found in libraries and archives, after paper [7]. They are produced from animal skins which have been treated with lime and dried stretching on a frame [8]. Vellum is the finer of the two, being traditionally made from the skin of young calves whereas parchment was usually made from less delicate skins of sheep, ewes or lambs [9]. However, the terms are often interchangeably used and since their properties are very similar they will be examined, for the purposes of this study, as one. Thus, since most of the investigation that has been undertaken has been on vellum it can be assumed that parchment will behave in a very similar way.

2.2.2 Effects of water

Parchment and vellum are considered to be very strong and durable materials if kept under the right conditions. However, they are very susceptible to water damage and even damp conditions will have an adverse effect. Water is easily absorbed and in very extreme circumstances, parchment and vellum will hydrolyse into glue [10]. In experiments conducted by A.E. Parker a vellum sample was soaked for eight days and this did not turn into a gelatinous mass so it can be assumed that such severe degradation is unlikely to occur during the time it may be immersed in the average disaster situation [11]. However, soaking in water causes internal changes in structure which results in a swelling in thickness, an overall shrinkage in size and a decreased elasticity but this process is reversible [12,13].

2.2.3 Salvage and drying

The salvaging of parchment and vellum is problematic and since discovering the best way to treat such materials generally relies upon the unhappy event of water damage to actual documents experimentation has been limited. However, there have been disasters involving such documents and considerable research has been undertaken by A.E Parker at the British Library.

Since the effects of water are so severe it is desirable to stabilize manuscripts of parchment and vellum as quickly as possible before drying is considered, particularly as most documents of these materials will have water soluble inks associated with them. Freezing has been found to be appropriate for this purpose; it has no adverse effects on the damaged vellum; in fact freezing it at -25°C reduces the expansion that occurs when vellum is wet, although not to its original thickness, and of course holds the vellum in place while a drying method can be carefully chosen [14,15].

The drying of parchment and vellum documents has traditionally been done naturally between pieces of blotting paper. For example, after the Florence flood, parchments were air dried in this manner and it was found that writing did not transfer as much as expected but, translucent areas appeared at folds, which rendered the writing no longer visible and considerable shrivelling, shrinkage and curling occurred as it dried [16]. Carolyn

Horton recommends the use of weights around the edges of the documents to reduce this effect [17] but, Anderson and McIntyre point out that weights should never be placed on parchment and vellum documents as this will cause transparency [18].

A.E Parker has conducted experiments into the freeze drying of vellum documents, of many different formats [19]. This would clearly be a preferable option due to the nature of the process which drys by sublimation thereby causing less risk of further damage to the vellum itself by water and, in theory, the elimination of any further risk to inks and dyes on the documents. The results of A.E Parker's test are summarised below but a full account of his work is soon to be published in Library Conservation News.

Tests were conducted on several items including single sheets, charters, a roll and a full vellum text block with a limp vellum binding. It should be noted that all samples were soaked by immersion in a tank of water for 24 hours.

Freeze dried examples of single sheets were found, when compared to sheets of the same size dried between blotting paper, to have shrunk slightly more. However, Parker concludes that single sheets can be freeze dried and can later be dampened and flattened to resume a more normal thickness. He also discovered that, on drying, vellum becomes brittle and must be placed in a 60% RH atmosphere to recondition.

The charters that were treated had been left folded in their envelopes and put into polythene bags for freezing. After freeze drying the storage envelopes were found to have unstuck to varying degrees and the vellum generally felt stiff and rough. However Parker concluded that black and white charters can be bagged, packed and freeze dried as a part of a normal run along with other books and documents.

The roll, after soaking, was unravelled and the vellum was found to have detached itself from the linen cover and core attachment and the open end of the roll had shrunk slightly but the core end had not. It was then rerolled around the core and attached to the covers, placed in a polythene bag, frozen and later freeze dried. After freeze drying, the roll was found to be in a similar state but had shrunk slightly more. However Parker concludes that black and white rolls, like charters, can be satisfactorily bagged, frozen and freeze dried as a part of a normal freeze dry run.

The vellum text block with the limp vellum cover did not fare so well. After soaking the vellum folios were rearranged to present a more solid text block; it was then flattened and strapped, head to tail and spine to foredge, before freezing. It was noticed at this stage that some of the ground gold pigment in the text had offset (black ink and red pigment were also part of the text). The volume was opened 41 days after freeze drying. A white deposit containing mostly black but some red flakes was found to come off onto hands; the freeze dry process seemed to have weakened the adhesion of the pigments. 21 of the 32 folios were still complete or had suffered only a slight loss. The limp binding was stiff and the spine glues had crystallised and flaked off. There was also distortion of the whole volume and rebinding would be necessary. Parker concluded that a normal freeze dry run was too harsh for such volumes, due to the process of overdrying in the final stages, but suggests that a modified run of a gentler nature should work though experimentation has still to be carried out.

Thus it seems that freeze drying is suitable for single sheet documents, charters and rolls that contain only black and white inks but, as yet, the satisfactory drying of volumes of vellum and items containing coloured pigments is uncertain and requires further research. However, as the freezing of vellum is a satisfactory option, items can be stored until the method involves less risk.

It should be realised that perfect results cannot be expected with materials that are so susceptible to water damage. Some degree of shrinkage and distortion by wrinkling or curling must be expected. Such distortions can be removed later by a conservator. Single sheet parchments can be stretched over a frame and wrinkles can be removed by a variety of methods [20].

One such method can also be used to dry parchments but should not be attempted without the presence of a conservator as it is usually used to dry parchments that have undergone special treatment. Two glass plates should be degreased using talc. One surface is then sprayed with water and a sheet of polythene is placed upon it and rolled completely flat. The damp parchment is then placed on the polythene and covered with another sheet of polythene. This sheet should be rolled from the centre, outwards, to remove air bubbles and to render the parchment flat and smooth. The other sheet of glass should be placed on the top and the weight of this prevents the formation of wrinkles and as it is transparent it enables the monitoring of the inks on the parchment at all times. After 24 hours the upper layer of polythene can be replaced by a blotter and after a further 24 hours, the other polythene sheet can also be replaced by a blotter. These blotters should be replaced at regular intervals, until the document is dry. [21]

2.2.4 Illuminated manuscripts

When considering the salvage of vellum documents, in particular, the presence of illumination is a major concern. Unfortunately there is little or no published material on this subject although there is research being done on illuminations and disaster recovery by Chris Clarkson and Nicholas Hadgraft [22]. However, any results of this research will not be disclosed until publication [23].

Some success has been achieved by simply air drying using blotting papers; For example, Carolyn Horton comments regarding the recovery of illuminated documents involved in the Florence flood using this method that, "illumination had not transferred to the blotting paper as much as we would have predicted, perhaps because no weights had been placed on top" [24]. However, the necessary manpower or expert help is not always available in a disaster situation.

A.E. Parker, as a result of the experiments detailed in the previous section, offers some advice and information on the subject. He suggests that illuminated books and manuscripts should be removed from the water horizontally and if the books are still upright on the shelves they should be kept that way so that water will not flow onto fresh pigment. Volumes should not be pressed at all as this increases the risk of offsetting pigments. Then volumes should be frozen, laying them flat in stacking trays without any weight on them. [25]. There the volumes may stay until thoughts can be accumulated about drying them.

A.E. Parker comments that the vellum itself can be freeze dried but the cockled text could prove impossible to flatten without creating more risk to the pigments. On the example he tested, detailed in the previous section, pigments offset whilst the volume was wet but lost their adhesion after going through the normal vacuum drying process. He intends to follow up the possibility of drying such manuscripts further, in the hope that a suitable mass drying technique can be found perhaps by using a more gentle freeze dry method, when suitable samples can be found. However for the moment he suggests that illuminated material should be sorted from the rest and after freezing, a gentle method of drying can be investigated and suggests that just leaving the volumes in the freezer for a long time, until natural sublimation takes place, could be the best option. [26]. Therefore, it would seem that the freezer could be the best place for such volumes all round, at least until safer alternative methods of drying have been found and demonstrated.

2.2.5 Seals

Seals are another feature often associated with parchment and vellum documents that may be of concern when considering salvage. Again, there is little information available on the subject but a few comments have been lifted out of the literature on more general salvage techniques, where they have been found, which may be of some use.

Wax is generally resistant to water although high temperatures will cause softening; ordinary wax begins to soften at $40^{\circ}C$ but sealing wax is more resistant [27]. So, if the water damage that has occurred is due to the extinguishing of a fire, it is highly likely that wax seals will be lost anyway. However, if it is purely flood damage, temperatures are not likely to be accelerated to the extent that seals will melt.

John Lancaster says that wax or metal seals should not be frozen [28] so the salvage of some documents bearing seals could cause a dilemma since freezing is recommended for parchment vellum and paper. Therefore, if the seal is of great importance (i.e. more important than the document itself), documents may either be air dried or the seal could be removed, with the help of a conservator, to be reapplied at a later date. If time does not allow this, or expert help is not available, then photographs could be taken of the seals or an impression could be made so that any restoration work that may need to be done later will be made easier. If documents are being air dried then care should be taken to support pendant seals [29].

The final piece of information found about seals refers to freeze drying. During some freeze drying conducted by Flink and Hoyer some old wax seals were present on envelopes; after the process these were found to have softened, probably due to the elevated temperatures introduced during the process, and some transfer of the wax colour occurred onto the envelopes [30]. This may have some bearing on the decision to freeze dry certain important documents, with their seals on, as well as having obvious implications for the freeze drying of important seals in their own right.

The correct decision to make regarding seals will obviously depend on the seals' individual importance and the importance of the document they are appended to and it would be advisable to seek expert guidance in advance of any decision.

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A.3.

UNUSUAL MATERIALS

A.3 UNUSUAL MATERIALS

3.1 Wood and related materials

3.1.1 Wood

Wood of various types has been a popular writing material throughout history [1] but may also be present in the library or archive in the form of special bindings, woodcuts, or boxes and artefacts associated with older archival collections.

Wood, due to its cellular nature, is quite a porous material and can become waterlogged in extreme cases although, in a disaster situation, complete waterlogging is unlikely to occur. Drying wood is a delicate operation because, if drying occurs too rapidly, shrinkage and cracking will occur [2].

If the wetting is only superficial then the water can be removed with rags, paper towels or some other absorbent material, using a patting or blotting motion; it should not be rubbed [3]. If the wood has a painted surface that is of a delicate nature or a veneer, however, the surface should not be disturbed and expert advice should be sought [4].

If objects are thoroughly wet then they must be dried out very slowly, in a room that will not receive direct sunlight, at 50% relative humidity with good but not direct air circulation. Small items can be placed in polythene bags with small holes pierced in them to ensure that slow drying, in humid conditions, takes place. Larger items can be dried under sheets of polythene in a tent formation and the humidity can be maintained by either placing small dishes of water around the objects or by using a fine spray from a hose. To reduce the risk of mould formation a dish of thymol crystals may be placed under the tent. [5]

Some investigation has been done into the freeze drying of wood, although this has been related to waterlogged, ancient wood, that has been archaeologically excavated and has thus been waterlogged for an extremely long time. Some success was achieved, although these items were kept wet before drying and were treated with various chemicals to preserve them; one item which had previously been frozen suffered cracking. [6]. Thus, it is uncertain whether this method could be applicable to wooden library materials that had suffered relatively minimal water damage; it would seem that the method could be a little harsh, especially if freezing were to be involved.

3.1.2 Bark

Bark was a material often used for the sending of letters to Europe and America in the seventeenth century and was quite commonly used to make books in Central Asia and the Far East [7].

Bark is particularly vulnerable to water; when wet, leaves of bark books stick together, often roll up and become very fragile [8]. Thus such damaged materials should be handled with extreme care. When dried the leaves of bark books can split and powder when handled. As this is such a delicate material the expert advice of a conservator should be sort immediately, if damaged, and as it is essentially wooden in nature extremely slow drying, such as that described for wood, would seem to be the best policy. However, as bark can suffer quite badly from the effects of being dried, it would clearly be advisable to take strong precautions against this material ever suffering from water damage.

3.1.3 Palm Leaves

Palm leaves were commonly prepared to be written on, before the advent of paper in almost all South and South East Asian countries [9]. Such leaves were written on by either incising letters or illustrations using a stylus and then rubbing the surface with lamp-black or charcoal powder to make it visible, or by simply using a pen and ink [10].

The leaves themselves become very brittle and are easily broken with the passage of time [11]. In essence they are very similar in nature to the leaves of bark discussed above and should therefore be treated,with similar care. Again it would clearly be preferable to prevent these leaves from being subjected to water damage, due to their intrinsically delicate nature and, also, in view of the writing that appears on them which could quite easily be washed away completely with severe water damage.

If such items do become damp expert help should be called upon. Since these items are particularly vulnerable to fungal damage in a humid atmosphere [12] interleaving with thymol impregnated absorbent paper would be advisable.

3.1.4 Papyrus

Little has been discovered about this material except how it was made and, hence, any suggestions made here are nothing more than educated guesses. Clearly, again, the age and delicate nature of this material warrants expert help from a conservator if water damage occurs but preventative measures would really be the best option. This is particularly important since papyrus manuscripts were most commonly written on with lampblack bound with gum arabic [13] and gum arabic is soluble in water [14].

In the event of water damage occurring it is unknown whether freezing would have an adverse effect on the nature of the papyrus but it would clearly be a preferable option in terms of the gums. Nor is it known whether the process of freeze drying would be gentle enough for the material as no research has been published on this matter. Clearly expert advice should be sought on this matter before decisions are made.

Air drying papyrus would presumably be approached in the same way as single sheets of paper, but with a more careful eye because of the possibility of the inks feathering. Papyrus fragments, mounted in glass frames, would potentially be at less risk of severe water damage as they are to some extent protected. The glass frames would have to be removed if damage did occur, under the supervision of a conservator, and handling would be most safely done using the method described for single sheets of paper (see section 1.7.3.).

3.2 Clay and Ceramics

Unbaked clay is very fragile and must never be exposed to water [15]. However, when it is oven baked, fired or hardened in the sun, it becomes almost indestructible [16]. This process is irreversible and gives the clay a resistance to water that increases with firing temperature [17]. Thus, since most clay has been baked, library collections of this material are a low priority for salvage.

However if sunbaked clay tablets are present, for example and are in direct contact with water these should be removed before other low priority materials since their firing temperature was low and their resistance to water will be less strong and, more particularly, because of their historical significance.

Other ceramic materials can be regarded as safe in water, unless they have water soluble inks used on them, which is sometimes the case with ancient pot sherds or ostraka used to make notations on when no other medium was available. For the majority of cases, though, salvage is straightforward and ceramics can be air dried naturally [18]. Breakage is far more likely than water damage in a disaster situation.

3.3 Stone

Stone was most often used to convey information in the form of incised tablets or as sealstones [19]. Since stone is generally not greatly effected by the water it is not a priority for salvage operations and can be dried out naturally [20] and unless breakage has occurred it will require the minimum of attention. If breakage has occurred remember to keep all pieces together so that restoration work can be done at a later date [21].

3.4 Ivory and Bone

Ivory and bone are both fairly durable materials that are often used for decoration and sometimes as a writing medium [22]. If water damaged these materials should survive well but should be allowed to dry out gently and naturally [23]. The only cause for concern is if the ivory or bone has been written on or decorated with a water soluble ink or pigment in which case the material should be removed from the disaster area with greater priority.

3.5 Metals

Most metals will not deteriorate to the extent of creating a conservation problem after a short immersion in water and are therefore not a priority for salvage [24]. When they are salvaged they can be washed, if necessary, and wiped dry with an absorbent material [25]. Iron and copper (including its alloys), however, will begin to deteriorate to some extent and although this will not cause the metals themselves any serious problems it may cause staining to materials in contact with them [26]. Thus if iron and copper are appendages on a water damaged item the metals should be isolated or removed from the item whilst drying [27].

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A . 4 .

O T H E R   C O M P O N E N T S   O F

L I B R A R Y   C O L L E C T I O N S

A.4. OTHER COMPONENTS OF LIBRARY COLLECTIONS

4.1 Textiles

Textiles are hygroscopic in nature, those made of natural fibres being more so than synthetic ones and those containing cellulosic materials being more susceptible to fungal attack [1]. Thus, in a disaster situation, textiles should be removed from excessively humid conditions with some priority. Fortunately textiles can be frozen and thus stabilization can be achieved quite quickly to decrease the risk of deterioration [2].

Textiles can be air dried [3] and some recent experiments have shown that freeze drying does not damage such materials and may be included in a mass drying run along with other materials [4]. These experiments included samples of wool, wool slubbing, wool/cellulose mix, wool/terylene mix, nylon, silk/nylon mix, staple viscose rayon, cotton/viscose mix, and unmercerised cotton [5].

If textiles are to be air dried they should be gently formed into their appropriate shape and then laid out flat, in single layers, on support screens with wooden frames and fibre glass netting stretched across. If such screens are not available then they may be laid out on cotton mattress pads, towelling or sheeting. Large items, such as tapestries, should have as much water removed from them as possible and then be hung to dry; if excess water is not removed first, the extra weight may cause mechanical damage. If the formation of mould is feared thymol may be introduced as a vapour. [6]

4.2 Maps

Map cabinets should hopefully protect from excessive water damage as handling wet maps can be a troublesome task because of their size [7].

Modern maps can be safely air dried [8] but early maps often have potentially fugitive printing inks, handwritten notations or are handcoloured [9] and must therefore be sent for freezing and subsequent freeze drying [10].

Anderson and McIntyre recommend that maps of a size 40 inches by 50 inches or less should be laid flat and packed between boards for support and interleaved with polythene and blotting paper : polythene - blotting paper - map - blotting paper - polythene - blotting paper - map - and so on. The sandwich should then be strapped securely and sent for freezing with instructions for the boards to be laid flat. Larger items should be transported rolled in a polythene wrapping as should items that were already stored rolled. Any items that have become badly distorted should be left as they are, wrapped in polythene and sent for freezing. [11].

If maps are to be air dried flat on absorbent paper weights may be placed around the edges to keep them flat when they are almost dry. If the linen backing begins to peel off maps should be laid face down on absorbent paper or face up on polythene, to prevent the dissolved glue from causing sticking. [12]

The technique for handling single sheets described in section A.1.7.2. should be used for handling very wet maps.

4.3 Paintings

Ideally, all paintings should be dealt with by an expert conservator.

Framed prints, drawings and water colours should be unframed and preferably packed for freezing as for single sheets (see section A.1.6.), otherwise they should be air dried (see section A.1.7.3.) [13,14].

Oil paintings must not be frozen as this could cause irreparable damage [15]. Excess water should be drained and the paintings should be carried horizontally, if possible, to an area where they can be treated, most valuable first, followed by the least damaged and finally the most damaged [16]. If paintings cannot be carried horizontally they should be carried with the face towards the body and larger paintings should be carried by two people [17]. Distortion and loss of paint can occur so removal from the disaster area and treatment should be undertaken as soon as possible [18]

Structurally damaged paintings should be left to dry as they are, laid flat, and facing upwards [19]. Structurally sound paintings on canvas should be unframed but not removed from their stretcher but, paintings on cardboard must not be unframed [20].

Paintings on cardboard should be dried face upwards. The face of the painting should be protected with tissue and then sheets of absorbent paper placed on top followed by a sheet of masonite or glass which should be weighted down. Absorbent paper should be changed frequently to begin with. If the tissue paper sticks to the paint, leave it there, as this can be removed later by an expert. If the painting has impasto, a layer of sponge rubber should be placed underneath the glass to prevent this from flattening. [21]

Paintings on canvas, however, should be dried face downwards. Again the painting should be protected by tissue paper and it should be laid onto absorbent paper, the thickness of which will be determined by the relief on the painting. More sheets of absorbent paper should be placed on the reverse of the painting, inside the stretcher frame, and the masonite or glass and the weights should then also go inside the stretcher. [22,23]

4.4 Philatelic collections

Philatelic materials may be sent for freezing. When packing each item should be loosely wrapped in a polythene bag or cling film and volumes should be laid flat in crates. Care must be taken not to dislodge any stamps from their mounts. [24]

Freeze drying can be used; however, if stamps in the collection were previously stuck to envelopes and water has effected the adhesives, the freeze drying process will reduce any remaining adhesion causing the items to separate [25].

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PART B

MODERN MATERIALS

B . 1 .

P H O T O G R A P H I C   M A T E R I A L S

1. PHOTOGRAPHIC MATERIALS

1.1 General Information

Photographic materials are extremely vulnerable to the effects of water related disasters; they will not withstand high temperatures or humidity and the water itself will cause the softening of emulsion layers, which will result in sticking, and, after extended periods, separation of the various layers will occur. Recovery costs can be very expensive so prevention and the keeping of back up copies where possible, is highly recommended. [1,2]

Some processors and vendors offer recovery services; it is a good idea to have arrangements made in advance, as a part of a disaster plan. In the event of photographic materials being involved in a disaster, vendors and processors should be contacted immediately for specific advice and to make arrangements for materials to be sent to them. [3]

Prints should be salvaged first, as films appear to be more stable [4]. The next priority should be colour films as the dyes are not stable, followed by silver or emulsion films and lastly diazo and vesicular [5]. Also as a general rule, give higher priority to less damaged materials as these are more likely to be salvageable [6].

1.2 Prints

Photographic prints should be immediately immersed in clean cold water until they can be dealt with [7], but immersion time should be kept to a minimum [8]. Fungicide may be added to help prevent excessive swelling and inhibit mould growth [9].

They should ideally be air dried without prior freezing as this results in the least dimensional changes and the least loss of surface gloss [10]. However, since space may not always be available to spread out prints, freezing can be used as a method of preventing further deterioration as long as they have been soaked in water first [11]. If prints are frozen, they are best thawed in manageable batches and air dried; freeze drying can be used and will result in essentially unharmed photographs, but, the loss of surface gloss is most pronounced after this method of drying [12]. Freeze-thaw-vacuum drying is not recommended as this method causes the gelatin layers to stick together [13].

Before air drying, prints should be washed in plain cold water [14]. Black and white prints should be placed flat in a tray of water for 30 minutes; the water should be changed frequently and the tray should be gently agitated [15]. Colour prints should be washed in the same way, but the time must be reduced; however, without the proper chemicals fading is likely to occur [16]. Martin recommends that after washing, prints should be placed in a flattening solution, followed by a photoflo solution [17]. Then, to air dry, prints should be laid out individually, flat on absorbent paper with the emulsion side up, in an atmosphere that is as dust free as possible [18].

If photographs are contained in an album and are very wet then freezing followed by freeze drying is the preferred method, but if they are only damp then air drying should be chosen [19,20].

1.3 Negatives and film

The most important feature of salvaging photographic films, negatives or transparencies, is to keep them wet until they can be professionally dried and cleaned [21]. However, if colour film cannot be recovered (i.e.

professionally cleaned and dried) within 48 hours and silver or emulsion films, within 60 hours, then they should be frozen [22]. After this period, some image destruction will have taken place and freeze drying should then be considered [23].

Once the materials have been placed in water, the processor or vendor should be consulted to determine any further action that should be undertaken, whilst awaiting collection or transportation. This may include:

- the addition of formaldehyde to stabilize the emulsion layer of the film and inhibit mould formation (15 millilitres of formaldehyde to 1 litre of water) [24].

- the addition of salt to soft water to help strengthen the emulsion layer [25].

- the addition of ice to the water to keep the temperature low, reducing softening of the gelatin layer [26].

- washing the materials to remove mud or other contaminants [27].

During transportation film must also be kept wet, by using either containers filled with water, or by hosing the film down before, leaving for the laboratory and then at twenty minute intervals [28].

If professional help is not immediately available or it is decided to carry out treatment on the premises, the methods detailed below can be used, but processors should be consulted for specific advice if this is to be attempted.

Black and white films should be washed in cold water for about half an hour and gently swabbed to remove grit or mud. The film should then be dipped in photoflo solution or a mild detergent if this is not available, rinsed and dried without heat. [29]. Although drying can be done by laying out on absorbent paper [30], hanging on a line [31], as one would see in a photographic laboratory, would seem a more sensible option, as there would be less risk of surface contamination.

Colour transparencies and negatives should be washed in cold water, then placed in a 2% photoflo solution. They should then be rinsed for about five minutes. They should then be placed in stabilizer or hardener solutions as appropriate. [32,33,34]. They should then be dried as for black and white films.

Exposed film that has not been processed should be sent to the processing laboratory in the same way as other films. However, salvage is much more difficult and therefore costly, so unless the photographs taken are of particular value, it would be better to rephotograph at a later date and abandon the damaged film. [35]

Glass plate negatives and collodion positives, such as ambrotypes and tintypes are extremely difficult to salvage and should ideally be kept in a way that would completely protect from water damage, as of examples that have been tested, only half survived a 24 hour immersion and the rest barely survived [36]. However, if effected they should be washed and laid out for air drying, in an inclined position, if possible [37]. They should never be frozen or freeze dried as they will shatter [38].

1.4 Microforms

Silver halide microforms should be treated with the same priority as photographic film if they are security copies; they should be kept wet, and sent to the vendors or processors for salvage. If they are to be dealt with in house, they must be put through the entire developing cycle and once recovered new archival copies should be made [39]. Diazo and vesicular microforms, which are usually copies, can be treated with less priority [40].

Microforms should be placed in buckets of cold water; no attempt should be made to unwind microfilm nor should microfiche be separated [41]. At this stage, microforms should not be removed from their packaging, so that later identification will be easier; films in boxes can be secured with rubber bands [42,43].

Once, items of higher priority have been dealt with, diazo and vesicular microforms can be checked for readability. If blistering or delamination has occurred, the records should be discarded, remembering to take a note of the record title, and a new copy can later be made from the security copy [44]. If the damage is more minor, water spots and surface contamination, for example, the film can be recovered in house even if there are no microfilm processing facilities [45]. Film should be washed in a solution of cool to lukewarm water with a mild detergent, then rinsed in cool clean water [46]. As with photographic filmand negatives, the literature recommends drying can be done on blotters, paper towelling or lint free, non abrasive cloth [47,48], but, line drying would seem a preferable method, as it allows a free flow of air and cuts out any contact with the delicate emulsion surfaces.

There are formats of microform, which include other media as well as film and these will require different handling. Microfilm in plastic jacket sleeves must be removed from these, with sleeve cutters, as soon as possible, as mould can quickly form inside them and film will also stick to the jacket on drying [49]. Wash and dry the film, either in house or by sending to a processor and then insert into a new jacket [50,51]. Aperture cards, unfortunately cannot be easily salvaged and it is a time consuming job; film chips must be removed from their mounts, washed and then remounted [52].

All containers and folders should be replaced or sterilised before media are returned to them [53].

If time or facilities are short, microforms may be frozen and dried at a later date [54,55]. During the Stanford Library flood restoration project some microforms were tested to see if they could be vacuum dried [56]. Silver halide, diazo and vesicular film exhibited only minor spotting and no loss of text, but, the microcard tested, was ruined because the card disintegrated, although the film itself survived [57].

1.5 Slides

During the recovery operations at the Corning Museum of Glass, professional advice was taken concerning the colour slide collection. Slides were stored in tubs of water until they could be dealt with and were, one at a time, removed from their mounts (aluminium and glass), washed and hung up to dry on clothes lines using paper clips; the clips went through the sprocket holes on the side of the film and the mounts were hung to dry with the film for future identification. Unfortunately, the slides had become so degraded by the mud and water of the flood and their subsequent immersion, whist waiting to be treated, that they were eventually abandoned. [58,59]

Martin comments that the slides which were inadvertently sent to the freezer, were eventually salvaged with far less loss; he goes on to advise how to treat slides, in house, if the damage is not too extensive and when time allows [60]. This is summarised below :

1) Slides should be removed from their original containers and placed in a solution of 10 grams magnesium sulphate and 10 millilitres of 37% formalin per litre.

2) Disassemble mounts and gently clean slides with a camel hair brush using a solution of 10 grams sodium carbonate, 10 millilitres of dequest 2006 and 10 millilitres of 37% formalin per litre.

3) Soak Ektachrome films in an Ektachrome stabilizer solution.

4) Rinse slides in photoflo solution.

5) Air dry emulsion side up, in mount on paper towelling.

For glass mounted slides follow as above but after step 1) separate the film from the glass if the emulsion does not strip. If the emulsion adheres to the glass soak in the solution detailed in step 2), before final cleaning and drying. Dry emulsion side up on cloth, keeping the mount with the film and saving the glass in a separate container. [61]. Again, drying by laying on absorbent materials is recommended, but if hanging on a line is feasible, then it would surely be preferable.

1.6 Movie Film

Movie films on a reel should be stored by total immersion in cool clean water and have light excluded [62]. This may best be achieved by filling the film can itself with water and then placing it in a plastic bucket, lined with plastic bags [63]. They should then be sent to a film processor to be washed and dried [64,65]. If this is done quickly there should be no loss. After the Stanford Library flood movie film was frozen and later vacuum dried, rolled in a cardboard container and recovered quite well [66], so, freezing is an option if a processor cannot be reached quickly.

If the facilities are available, movie film may be recovered on site by storing in a solution of 10 grams magnesium sulphate and 10 millilitres of 37% formalin per litre, followed by reprocessing in white light. Film should be fed on rollers without emulsion contact, first into a prehardener solution followed by a solution of 10 grams sodium carbonate, 10 millilitres of dequest 2006 and 10 millilitres of 37% formalin per litre. The film should be run through a spray rack if possible. To complete the processing take up dry film on cores and reassemble on reels. [67]

It should be noted that if movie film is allowed to dry before recovery it may never be salvaged [68].

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B.2.

SOUND VIDEO AND INFORMATION MEDIA

B.2. SOUND, VIDEO AND INFORMATION MEDIA

2.1. Computer related media

2.1.1 General Information

Computer related media are extremely vulnerable to water damage [1]; they will deteriorate rapidly and should be a high priority for salvage, if recovery is to be attempted [2]. However, recovery is difficult, costly and holds no guarantees [3]. In fact, Eric Lundquist regards all such media as unsalvageable, with the exception of floppy discs [4,5]. As a general rule, the higher the the technology, the less recoverable the media [6]. Furthermore, should full recovery of such media be achieved, there is the risk of damaging the expensive equipment used to read them, to consider [7].

Thus, the key to recovering computer related material, is prevention and protection with backup copies. All media should have security copies, which should preferably be stored off site, but at least, in a different location to the working copies to ensure that they are not involved in the same disaster [8,9]. A daily backup routine is recommended for all data information banks, coupled with a regular routine for the transfer of all backup files to off site storage [10].

The effects of a disaster, can be minimised by protecting media and equipment with plastic containers or covers; this should certainly be undertaken if there is the threat of a disaster, due to adverse weather conditions, for example, and in the event of an unexpected disaster, plastic sheeting should be used to cover computer related media and divert the flow of water, if possible. [11].

Ideally, in the event of a disaster, the recovery of these media, should involve the removal of damaged records from the disaster area, the recording of the files effected, checking that backup copies exist, ordering new copies and then the disposal of the damaged records. However, as this is not an ideal world, there may be cases, in which backup copies do not exist, or are not up-to-date, and an attempt, at least must be made to salvage the media. Thus, the following sections deal with the possible procedures for the salvage of discs and magnetic tapes.

2.2.2. Discs

Floppy discs, as already mentioned, are the most durable of computer media, and salvage attempts, have quite a high rate of success. For example, the Laramie County Clerks Office salvaged over 100 discs with 100% success [12]. In fact floppy discs have been shown to be extremely durable, by Larry Osborne [13], who, after spilling a cup of coffee over a disc of extreme importance to him, and successfully salvaging it, experimented with a variety of substances, that included, coke, beer, whisky, WD-40, hamburgers and cat urine! The discs were washed, dried and tested and the only substance that actually resulted in data loss was the coke [14]. So it would seem that water damage, is unlikely to cause unsalvageable damage to floppy discs, when much more noxious substances have been found to cause no damage.

Wet floppy discs should be kept wet, preferably stored upright and without crowding, in containers of cool distilled water [15,16] until time is available to begin recovery. When recovery is to be carried out, remove the discs one at a time from the water. If the top and bottom of the disc itself is not easily identifiable, use a waterproof pen to mark the topside of the disc, very near to the centre hole [17]. With gloved hands, remove the disc from its jacket by slitting or cutting along the edge, using a pair of unmagnetised scissors [18,19]; some care is called for because ANSI standards only demand 0.125 inches of clearance between the disk and the inner edge of the jacket, so, slide the the disc gently away from the edge you intend to cut by pushing on the appropriate side of the centre hole [20]. Agitate the disc in several baths of distilled water to remove all visible dirt [21,22]; a mild detergent may be used if necessary [23]. Gently blot with a lint free towels and air dry on a lint free towel [24,25,26]; Larry Osborne air dried by stringing discs over a broomstick [27]. Forced air drying, using a hair drier on and air only setting (i.e. no heat) may also be used [28]. When the discs are dried and the main crisis of the disaster is over, remove the jacket from an undamaged but expendable disc and place the damaged disc into this; take care to place it the right way up [29]. Now copy the disc; if the computer rejects the disc, check that it has been placed in the jacket the right way up, before discarding it [30]. Verify the information has transferred and then discard the damaged disc [31]. The disc jacket can be reused to copy more the damaged discs [32], so be careful not to throw this away. The drive heads should be cleaned at frequent intervals, to minimise the risk of head damage [33].

This technique should salvage most floppy discs, unless the disc has suffered structural damage. However, Osborne comments that if you are recording on a higher than double density drive, the chances of recovery are lessened [34].

Hard disks and disk packs, that have sustained water damage might be cleaned, but, placing them back in equipment would almost certainly result in head damage and it is therefore advisable to replace these, rather than salvage, because of the potential cost of replacing the heads [35,36].

2.1.3. Magnetic tapes

Magnetic tape consists of a polyester with a bonded gelatin coating, which carries the magnetisable particles, thus due to this layered structure, it is susceptible to physical damage as well as loss of information [37]. Magnetic tape does not survive water exposure well [38] and should be removed from the disaster area as soon as possible, if salvage is to be attempted.

It is not worth attempting to salvage magnetic tapes if security copies are available; it should only be attempted if the security copy is not acceptable or one does not exist and a professional should be consulted for advice [39]. Stabilisation should be achieved within 48 hours [40]. Any magnetic tape that has been in the disaster area should be treated as wet, even if it does not look wet.

To dry tapes, first drain any excess water out of the reels; check the tape hubs and shake and rotate the reels [41]. If necessary, tapes can be gently washed, with clean water [42]. Then gently separate tape flanges with neoprene grommets, to allow air flow and prevent the tape from sticking to the container edges [43]. Hand dry the tape flanges with lint free cloths [44].

Once the tapes look dry, they should be cleaned using a tape cleaner, which will remove contaminants and finish the drying. A tape drive should never be used for this purpose as it will damage the item being worked on, the drive and any future items run on the drive. Remove the cleaning blades from the tape cleaner and place the blades in the cleaner and spin to remove as much of the remaining water as possible. Run the tapes over the wiping tissues six or seven times; if the tissues become waterlogged advance them manually. If the tape leaves an oxide residue on the tape cleaner, it means that the binding system has broken down; the tape should not be run on the machine and it should be sent to a professional for attempted copying.

Once the tape appears reasonably dry, the cleaning blades may be replaced and the tape should be run through the cleaner two more times. [45]

If tapes cannot be cleaned and dried within 48 hours, consider freezing and subsequent vacuum or freeze drying [46]. Computer tape has been successfully vacuum dried and freeze dried in one or two cases, without loss of information [47,48]. However it must be remembered that these drying processes only remove moisture and the tapes will require cleaning before they can be run on equipment [49].

Finally, any cassette case or cartridges can be regarded as irrecoverable, since most designs are irreversibly sealed by manufacturers; the tape inside will adhere and any contaminants inside will cause frictional pressures on the tape that will inhibit normal operation [50,51].

2.2. Sound and video recordings

2.2.1 Audio and video tapes

Audio and video tape are generally classed in the same category as magnetic computer tapes and hence, can also be regarded as highly vulnerable to water damage. Similar guidelines for keeping backup copies of important collections of these media must therefore be followed (see section B.2.1.1). However, some guidelines do exist for the salvage of these media.

Reel-to-reel audio tape, may be washed in lukewarm water while still wound on its reel, if its exterior is dirty. To air dry the tape, either support it vertically or lay it on absorbent paper. If the reels themselves are still dirty, they may be removed from the tape and washed separately in detergent and water or replaced. [52] There is no guarantee, however, that the tapes will not have suffered irreparable damage.

Copying is a good idea once the tapes have dried. After the Corning Museum of Glass disaster, damaged reel-to-reel tapes were cleaned once dry on an ordinary tape cleaner, which eliminated most of the mud that had contaminated them, but, differential stretching of the tapes' acetate base made playback extremely difficult, so materials from the reel-to-reel tapes was transferred to cassettes using a three head, four tack reel-to-reel recorder. It was found that periodic dropouts occurred due to tape warpage, but these could largely be eliminated by applying slight manual pressure to the pads holding the tape against the heads and usable audible recordings were achieved. [53]

Recently, some experiments have been conducted by A.E. Parker at the British Library to see if sound recordings can be freeze dried in bulk. Seven different types of ten inch reel-to-reel tapes were used for this experiment : Zonal 675, EMI Tape 4 (H77), AGFA Pem 468, BASF LGS 35, Zonal 676, BASF LR 56, BASF LGS 52. The tapes were soaked for 24 hours and then placed in polythene bags and blast frozen at -25^{o}C. They were then freeze dried, still in their plastic bags. They were left to equilibriate for over a week and then sent to the National Sound Archive to be tested for sound quality. [54]. Unfortunately though, the results of this sound test have not yet been reported, but will be worth looking out for in the future.

Cassette tapes are extremely difficult to salvage due to the way they are constructed. However, if master copies are not available, attempts should be made to dismantle the cassette, so that the tape may be dried like a reel-to-reel tape. They should then be copied. It is difficult to determine the condition of sealed tapes, but attempts should be made to copy them just in case, if replacements are not easily available. [55]

Video tapes, should also be dismantled and dried like reel-to-reel tapes, if duplicates are not available [56].

2.2.2. Records

Records are extremely vulnerable to warping, scratching and pitting, simply through handling and important collections should, therefore be well protected from and additional hazards. Their survival after a disaster, will largely depend on circumstances, for example, if fire is the cause of the disaster, then warpage is likely to have occurred anyway and fire-fighting equipment containing weak acids, will also cause damage; in these circumstances records can be regarded as unsalvageable [57]. However, in a flood situation, if water and dirt are the only contaminants, some degree of success will be achievable, as long as breakage and extensive scratching has not occurred.

Records effected should be removed from their sleeves and jackets, which can be air dried as for other paper documents. If the label at the centre of the disc has detached, it should be air dried separately, but identifying information should be marked at the centre of the record with a grease pencil [58]. Records should then be washed to remove any foreign matter deposited on the surface or in the grooves [59]; this may be done using either a 10% solution of photoflo solution in distilled water [60], or a 1% solution of non-ionic wetting solution, such as Lissapol TN450, in distilled water [61]. A very soft brush may be used to help dislodge particles in the grooves [62]. Discs should then be thoroughly rinsed in distilled water [63] before being air dried on supports that allow free air circulation [64], in a cool, dust free environment.

Some records have also been vacuum dried in their sleeves, on one occasion that has been recorded, without any discernible damage to the discs [65], but it is not stated whether they were previously frozen. The safest method, however would seem to be air drying, where records can be seen to be carefully handled and are not exposed to extreme conditions that may cause further damage.

2.3. Compact discs

Compact discs and CD ROM are one of the newest media to be found in libraries, and although some problems regarding their potential for archival storage have been highlighted, there is no information available in the literature to indicate how they would survive water damage.

The structure of compact discs would suggest that water damage is unlikely; they consist of a polycarbonate substrate, which holds the pits of information, coated with a thin metallic layer, which is then sealed in a layer of lacquer. However, the author decided to conduct a crude experiment, on an unwanted audio disc to see if these suspicions were correct. The disc was soaked in water for a 24 hour period and then dried by laying it out on absorbent paper. When dry, the disc had visible water spots on its surface, which were easily wiped off with a lint free cloth. A willing compact disc player owner was found and the disc was played. There was no discernible damage to the disc. However, it must be remembered that every byte of information on a data disc is important and that on an audio disc even one missing byte may not be noticed.

The author then wrote to manufacturers of CD ROM discs to find out their opinions on the matter. Kevin George of Philips Interactive Media Systems, confirmed suspicions that no study had been done on the effects of water on discs [66]. However, his opinion was that short term submersion would not damage the discs or cause any data loss, but that long term submersion may cause damage to the seal or the disc material if the water was heavily contaminated with solvents or other such types of material [67]. Phil Bradley of SilverPlatter Information Limited, also confirmed that there should be no problems of damage through water with a CD ROM disc, unless there is associated scratching [68]. He suggested that, compact discs could be regarded as low priority during salvage procedures and that all that would need to be done to dry the disc is to wipe it with a lint free cloth; no attempt should be made to dry a disc using a hair drier as this would be likely to cause warping [69].

Should any severe damage be caused to compact discs through scratching or warping, it would not usually be worth considering attempted recovery techniques since most discs are purchased with the information already on them and replacements will be available from the manufacturer or vendor. However, if compact discs are being used as an archival storage medium, which is rare due to uncertainties about their potential lifetime, backup copies should always be stored in a different location.

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