DOCUMENT RESUME

ED 108 657 IR 002 181

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TITLE Procedures for Salvage of Water-Damaged Library Materials.
INSTITUTION Library of Congress, Washington, D.C. Administrative Dept.
PUB DATE 75
NOTE 40p.

EDRS PRICE MF-$0.76 HC-$1.95 PLUS POSTAGE
DESCRIPTORS Archives; Books; Cleaning; Films; Libraries; *Library Materials; *Preservation; Repair
IDENTIFIERS *Water Damaged Materials

ABSTRACT

Procedures for salvaging water-damaged books, film, archives, and other library materials are outlined, from assessment of damage to final returning books to shelves. Advice is given on removing the materials, packing, freezing, drying, treating for mold, sterilizing, removing mud, forming a salvage team, evaluating losses, salvaging the catalog, keeping records, controlling humidity and temperatures in work and storage areas, and handling the chemicals necessary in the process. Initial emergency procedures are summarized. Appendixes list sources of assistance, services, supplies, and equipment. (LS)

PROCEDURES FOR

SALVAGE OF WATER-DAMAGED LIBRARY MATERIALS

PROCEDURES FOR SALVAGE OF WATER-DAMAGED LIBRARY MATERIALS

by

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LC Publications on Conservation of Library Materials

LIBRARY OF CONGRESS WASHINGTON 1975

Library of Congress Cataloging in Publication Data

Waters, Peter.
Procedures for salvage of water-damaged library materials.

(LC publications on conservation of library materials)
1. Books—Conservation and restoration. 2. Manuscripts—Conservation and restoration. 3. Photographs—Conservation and restoration. I. United States. Library of Congress. Office of the Assistant Director for Preservation. II. Title. III. Series: United States. Library of Congress. LC publications on conservation of library materials.
Z701.W37 025.8'4 75-1217
ISBN 0-8444-0151-X

Flood damage to collections in the basement of the National Library, Florence, Italy, November 1966

PREFACE

This document has been prepared to assist those faced with the need to salvage library and archival materials affected by floods or water from firefighting, broken water pipes, or other accidents resulting in severe water damage. The procedures suggested here are designed to save a maximum amount of material with a minimum amount of restoration and replacement. No general instructions, however, can take the place of an assessment of a given situation on site by a qualified, experienced library or archival conservator, and it is strongly recommended that such assistance and advice be sought at the earliest possible moment after a disaster. Individuals and institutions known to have had actual experience in dealing with these problems are listed in the append.. In addition, the Restoration Office of the Library of Congress stands ready to serve as an information center and, if need be, as a coordinating agency for emergency salvage efforts.

The author has set forth in the text the various considerations involved in the reclamation of water-damaged library and archival collections, but the following points cannot be over emphasized. The complete restoration of water-soaked documents, particularly items in bound form, can be a costly process even under favorable conditions. In the majority of cases, the high costs involved do not justify the salvage and restoration of books which are in print and/or replaceable. Vacuum or freeze drying is the most effective method yet discovered for removing the water from large numbers of books and other paper artifacts, but ordinarily it is not the final step in the reclamation process. In some cases, volumes which are only damp or which have suffered very minor physical damage before freezing will come from the drying chamber in such good condition that they can be labeled and sent directly to the shelves. In the vast majority of instances, however, drying must be followed by restoration and rebinding, which can be expensive.

Thus, librarians and others faced with the decisions which follow serious flooding or fires need to remember that replacement is nearly always much less costly than restoration. Nevertheless, the necessity of making sound, on-the-spot, cost-effective judgments is the best reason for seeking the advice of an experienced conservator or other person who can help in assessing the situation.

The author wishes to express his appreciation to colleagues of the Library's Preservation Research & Testing Office for their assistance with

several related testing projects. Of particular value was the work of Robert E. McComb of that office, who shared with the author the direction of salvage operations following the fire at the Klein Law Library, Temple University and also assisted with salvage operations at the Military Personnel Records Center in St. Louis, damaged by fire in July 1973. Such close cooperation between conservator and scientist, as joint technical directors in salvage efforts, is a source of great satisfaction to the Library of Congress and its Preservation Office. It is hoped that collaboration with administrators of collections will become the rule rather than the exception.

Peter Waters
Washington, D.C.
July 1974

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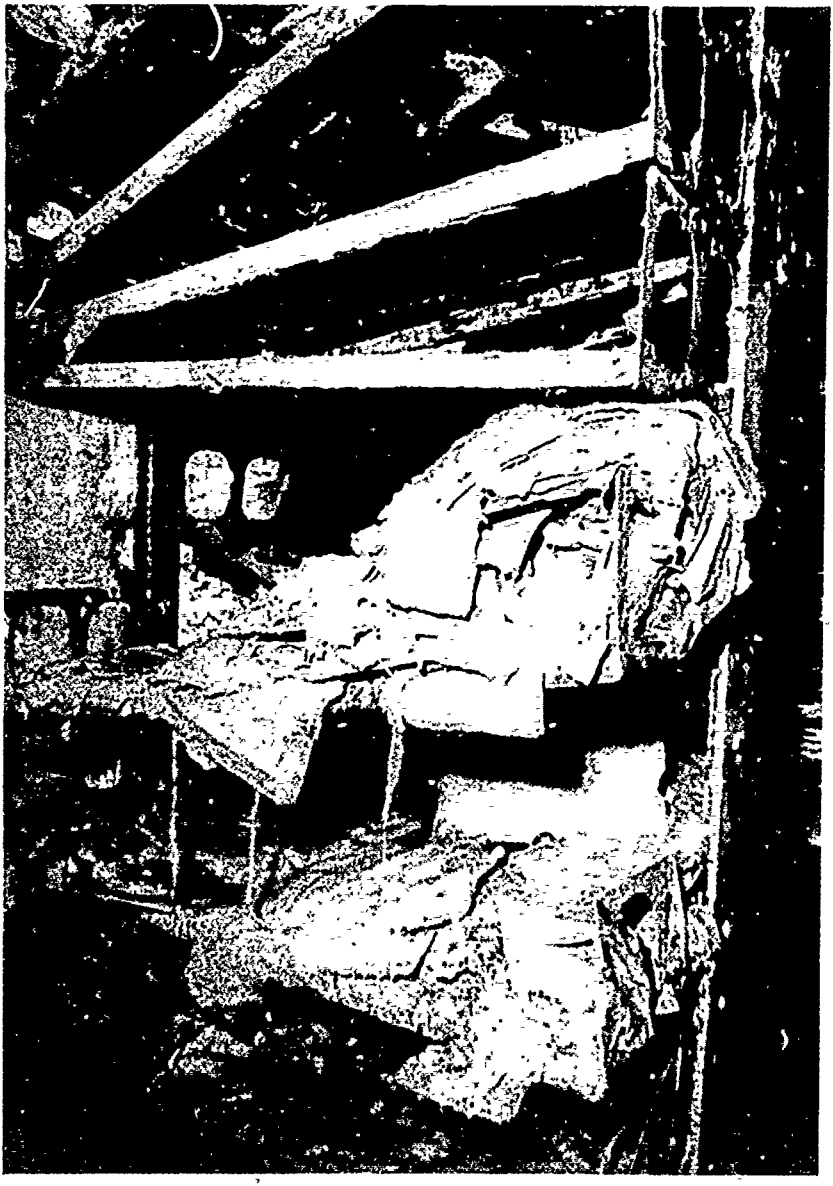

ASSESSMENT OF DAMAGE AND PLANNING FOR SALVAGE

Weather is the critical factor in determining what course to take after any flood or fire in which museum, archival, or library materials are damaged. When it is hot and humid, salvage must be initiated with a minimum of delay to prevent or control the growth of mold. When the weather is cold, more time can be taken to plan salvage operations and experiment with various drying procedures.

The first step is to establish the character and degree of damage. Once an accurate assessment of the damage has been made, firm priorities and plans for salvaging the damaged materials can be drawn up. These plans must include a determination of the special facilities and equipment required. Overcautious, unrealistic, or inadequate appraisals of damage can result in the loss of valuable materials. Speed is of the utmost importance, but careful planning is equally essential in the salvage effort.

Where water damage has resulted from fire-fighting measures, cooperation with the fire marshal is vital for a realistic appraisal of the feasibility of salvage efforts. Fire marshals and safety personnel will decide when a damaged building is safe to enter. In some cases, areas involved in the fire may require a week or longer before they are cool enough to be entered. Occasionally, parts of a collection may be identified early in the salvage planning effort as being especially vulnerable to destruction unless they receive attention within a few hours after the fire has abated. If the fire marshal appreciates such needs, he may be able to provide means of access to the area even when other parts of the building remain hazardous.

Once all entrances and aisles are cleared, the most important collections, including rare materials and those of permanent research value, should be salvaged first, unless other materials would be more severely damaged by prolonged immersion in water. Examples of the latter are books printed on paper of types widely produced between 1880 and 1946, now brittle or semibrittle. However, materials in this category which can be replaced should be left until last.

Salvage operations must be planned so that the environment of flooded areas can be stabilized and controlled both before and during the removal of the damaged materials. In warm, humid weather, mold growth may be expected to appear in a water-damaged area within 48 hours. In any weather, mold will appear within 48 hours in unventilated areas made warm and humid by recent fire in adjacent parts of the building. For this reason, every effort should be made to reduce high temperatures and vent

the areas as soon as the water has receded or been pumped out. Water-soaked materials must be kept as cool as possible by good air circulation until they can be stabilized. To leave such materials more than 48 hours in temperatures above 70°F and humidity above 70 percent will almost certainly result in heavy mold growth and lead to high restoration costs.

Damaged most by these conditions are volumes printed or coated stock and such highly proteinaceous materials as leather and vellum bindings. Starch-impregnated cloths, glues, adhesives, and starch pastes are affected to a lesser degree. As long as books are tightly shelved, mold will develop only on the outer edges of the bindings. Thus *no* attempt should be made in these conditions to separate books and fan them open. Archival files packed closely together on the shelves in cardboard boxes or in metal file cabinets are the least-affected.

As a general rule, damp books located in warm and humid areas without ventilation will be subject to rapid mold growth. Archival files which have not been disturbed will not be attacked so quickly by mold. Very wet materials, or those still under water, will not develop mold. As they begin to dry after removal from the water, however, both the bindings and the edges of books will be quickly attacked by mold, especially when in warm, unventilated areas. A different problem exists for books printed on coated stock, since if they are allowed to dry in this condition, the leaves will be permanently fused together.

HOW WATER AFFECTS BOOKS AND UNBOUND MATERIALS

Cellulose absorbs water at different rates depending on the age, condition, and composition of the material. Thus, some understanding of the mechanism of swelling action, as well as the development of mold, is essential to planning a successful salvage operation. In addition, when large collections are at stake, one must be able to calculate in advance the approximate amount of water which will have to be extracted in the drying process. Of equal importance is some knowledge of the length of time each type of material can be submerged in water before serious deterioration occurs.

Estimating Water Absorption. Generally speaking, manuscripts and books dated earlier than 1840 will absorb water to an average of 80 percent of their original weight. Since there is a greater concentration of proteinaceous material and receptivity to water in such early books, they are especially vulnerable to mold but will withstand longer periods of time submerged in water than will books printed on the less durable papers of more recent years. Modern books, other than those with the most brittle paper, will absorb an average of 60 percent of their original weight. Thus, in estimating the *original* weight of a collection, if one assumes an average of four pounds per book when dry for 20,000 books in each category, drying techniques must be set up to remove 64,000 pounds of water from the earlier materials and 48,000 pounds from the later.

The major part of all damage to bound volumes caused by swelling will take place within the first eight hours after they have been soaked. Since the paper in the text block and the cardboard cores of book covers have a greater capacity for swelling than the covering materials used for the bindings, the text block of a soaked book usually expands so much that the spine assumes a concave shape and the fore-edge a convex, thus forcing the case to become partially or completely detached.

Leather and vellum covers, especially those of the 15th, 16th, and 17th centuries, can usually be restored successfully if they are allowed to dry slowly. However, this should only be done under controlled environmental conditions by a trained conservator or under the supervision of a conservator. Unfortunately, modern manufacturing processes so degrade the natural structure of leather that, once water soaked, covers of these later materials are often impossible to restore. Some leather bindings will be reduced to a brown sludge, and others will shrink by as much as one-tenth of their original size.

Swelling of covering materials, such as cloth, buckram, and certain plastics is negligible. Cover cores, however, which are made of a highly absorbent cardboard, swell faster than an equivalent thickness of text block. Book covering materials which have already deteriorated will absorb water at about the same rate as the cores.

Once access to the collections is gained, the external appearance of each volume and group of volumes is a useful indication of the degree of water damage. Those volumes found, usually in heaps, in the aisles will be the most damaged. Not only will they have sustained the shock of falling, as rapid swelling caused them to burst from the shelves, but they will also have been immersed in water for a longer period than the volumes on the shelves above them. These will need the most extensive restoration. The appearance of such volumes can be a devastating shock, but one must not give way to panic; every volume can be saved, provided it is worth the cost of salvage and restoration, and provided the method of removal described here is followed.

Shelves which have been submerged will usually contain a mixture of wet and partially wet volumes. Misshapen volumes with concave spines and convex fore-edges can be immediately identified as belonging in the category of very wet. These will need to be rebound after they have been thoroughly dried. Others may still maintain their normal shape because they have absorbed less water. These stand the best chance of drying without distortion. Hand-bound volumes in this condition may only need recovering.

Coated papers *must not* be permitted to begin drying until each volume can be dealt with under carefully controlled conditions. The period between pumping out the water and the beginning of salvage efforts is critical. It may be desirable to leave these volumes under water until a few hours before they are to be removed.

FREEZING

Stabilization by Freezing. The most generally accepted and proven method of stabilizing water-damaged library and archival materials is by freezing and storing at low temperature (-20°F). This buys time in which to plan and organize a controlled, carefully coordinated drying operation. Freezing gives the restorer time to dry individual items and collections in the knowledge that they will be in the same condition upon thawing as before they were frozen. Cold storage provides accessible and inexpensive space (about 50 cents per 100 pounds per month in 1974) in which large quantities of books can be stabilized in the condition in which they were found, preventing further deterioration by water and mold while awaiting treatment.

Freezing is not a drying method, nor will it kill mold spores, but it is highly effective in controlling mold growth by inducing the dormant state in the spores. The drying method chosen at a later date must be such that mold is kept dormant so that subsequent sterilization can achieve maximum benefit.

Stabilization by freezing also provides important advantages when it is not possible to assess immediately the value of the damaged materials or to determine which items can or cannot be replaced. In other words, such stabilization gives time in which to estimate recovery costs, to prepare adequate environmental storage conditions, and to restore the buildings affected. In some cases, it may be necessary to restore or rebuild the original facilities—a process which can require a long time.

Had the freezing technique been used after the catastrophic Florence flood in 1966, thousands of additional volumes could have been saved completely or would have suffered significantly less damage. The Florentine libraries which sustained the greatest losses contained mostly 19th- and 20th-century materials. In these collections, losses were heaviest among books printed on coated stock, whose leaves stuck together during drying and could not be separated afterward. These losses could have been largely prevented if the materials had been frozen while wet, and if drying methods now known had been used to prevent adhesion of the leaves.

Saturated volumes which have lost their shapes or have had their binding structures damaged by immersion will increase in thickness still more in freezing, but this additional increase in thickness has been found to contribute no further damage to already damaged volumes. In fact, studies conducted by the Research & Testing Office of the Library of Congress

have uncovered no evidence of any damage to cellulosic and proteinaceous materials caused by freezing.

Freezing as a salvage method has several advantages. It stabilizes such water-soluble materials as inks, dyes, etc. which may diffuse during conventional drying. Carefully controlled freeze-drying and vacuum-drying techniques cause the water to sublime, i.e., pass from the frozen to the vapor phase without going through the liquid phase. Under these conditions feathering of inks is negligible. Further, freeze drying reduces stains and reduces or eliminates the odor caused by smoke. Materials can be left frozen for an indefinite time if necessary. Some large collections have been kept in a frozen state for as long as six years before drying, with little or no permanent damage. Experience gained during the past 15 years has demonstrated that the most satisfactory method of stabilizing water-damaged books, manuscripts, maps, unframed prints and drawings, and archival collections is freezing.

Preparation for Freezing. Before freezing, it is preferable to wash away accumulated mud and filth, but this is rarely possible because of lack of time and the quantity of material to be handled. Washing should never be attempted by untrained persons as this may cause further damage, nor should time be taken for this purpose if so little help is available that any significant delay in freezing the bulk of the materials would result.

The washing of materials containing water-soluble components, such as inks, watercolors, tempera, dyes used in certain maps, and the like, should not be attempted in any circumstances. Experience has shown that such materials, as well as those that are fragile or delicate, can be seriously or irreparably damaged by untrained workers attempting to clean and restore on-site. Such materials need expert attention and hours of careful work if damage is to be kept to a minimum. The period of emergency action and "first-aid" is no time for the careful work required to restore materials to near-original state.

The general condition of the damaged materials will determine how much time can be spent in preparation for freezing. At the least, bound volumes should be wrapped in freezer paper, wax paper, or silicone paper to prevent their sticking together during the freezing process. Groups of sheet materials such as manuscripts, records, unframed prints and drawings, and the like should also be wrapped, the packages not to exceed about two inches in thickness. Each package should be marked to indicate type of material, its previous location, and its priority. However, if it is known that the damaged materials will be vacuum or freeze dried after freezing, the wrapping step may be avoided by substituting milk cartons (see below) as a means of limiting the materials to be frozen to small groups which are more readily handled.

When only a few items are involved, freezing can be accomplished in a home freezer. Naturally, if the collection numbers hundreds or thousands of volumes, larger facilities will be required. The temperature for freezing should be at least -20°F. Lower temperatures will do no damage. Rapid freezing produces the smallest possible ice crystals and is desirable for this reason, especially if the material is to be freeze dried at a later stage.

If freezing space is limited, priority should be given to the following types of materials: items which have already developed mold, leather- and vellum-bound volumes, manuscripts, art on paper, materials on coated stock, artifacts with water-soluble components (inks, watercolor, tempera, various dyes, etc.), and photographic prints.

Containers and Methods of Packing for Freezing. Interlocking plastic milk crates make excellent containers for packing wet materials. These measure one cubic foot, are easily lifted, and offer the most efficient unit for freeze or vacuum drying, if one or the other process is to be used at a later date. They will not crush and can be stacked on pallets to a level just below the roof of a refrigerated truck. They also provide compact and safe storage in a freezer plant.

If interlocking milk crates are not obtainable, strong cardboard boxes (approximately two cubic feet), similar in size to beer cases or boxes used by libraries for sending books to library binders, may be used. However, because wet books will make the boxes damp and abnormally heavy, cardboard boxes cannot be stacked as high as milk crates without both boxes and their contents being crushed.

Materials should not be packed tightly in either type of container. Faster freezing and subsequent drying will be accomplished if the cartons are packed approximately three-quarters full.

It should be possible to move the wet materials directly from library to freezing facility, preferably in refrigerated trucks which can be drawn up to the loading site. For small collections of books and documents, dry ice may be used to freeze the material for transport in unrefrigerated trucks to long-term freezing facilities. Gloves should be worn when handling dry ice to avoid "burning" the hands.

Drying Large Collections by Vacuum and/or Freeze Drying. If materials have been sent to freezing facilities, the next consideration is the choice of drying methods. By far the least expensive and most successful method for drying large collections is vacuum and/or freeze drying. Since the first edition of this manual, two very large collections have been successfully vacuum dried, one by the General Electric Company, Valley Forge Space Center, Valley Forge, Pa., and the other by the McDonnell Douglas Corporation, Saint Louis, Mo. These operations were successful in drying wet and frozen materials at far less cost than hand drying. In both cases, the

Preservation Office of the Library of Congress established the general guidelines to be observed, beginning with initial salvage procedures and following with technical advice during subsequent stages in the drying operation. The vacuum chambers used hold between 2,000 and 3,000 books at one loading, or the equivalent in records.

Although there are potential dangers in both the freeze drying and vacuum drying processes, they are entirely safe under carefully controlled conditions. However, early manuscripts and rare printed books should not be mixed in with deteriorated or brittle materials, because of the possibility of acid migration from the latter to the former during the drying process.

Rehabilitation After Freezing and Drying. If maximum benefits are to be gained from stabilization by freezing, every effort should be made, first, to identify and assess the value, condition, and total numbers and types of materials damaged, and second, to draw up comprehensive lists of those materials which can be replaced and those which should be reclaimed and restored. *Replacement is nearly always cheaper than restoration.*

Volumes to be reclaimed will need to be evaluated in terms of the amount of restoration needed and probable costs. The best time to make such judgments is after the volumes have been dried and before they are returned to the library.

If the water-damaged material was infested by mold at the time of freezing, it should be sterilized. In vacuum drying, sterilization with ethylene oxide (mixed with either CO_2 or Freon) is easily accomplished at the end of the drying process, while the materials are still in the vacuum chamber. The results are well worth the small additional charge.

In addition, although the sterilized materials are safe until environmental conditions may again be favorable for mold growth, it is suggested that sterilization be followed by fogging the chamber with a solution of 12 percent thymol in trichloroethylene. This treatment acts as a temporary "fungicidal buffer" and confers a high degree of resistance to further attack, even when conditions are favorable for mold growth. This treatment also provides an additional safeguard in case sterilization was not thoroughly done.

It should be remembered that sterilized material can be reinfected by mold, especially if placed in an environment characterized by poor ventilation and high humidity. For this reason it is imperative to avoid mixing sterilized and unsterilized material. Under no circumstances should newly dried materials be packed in boxes and left without attention for more than a few days.

Ideally, all water-damaged materials should be sterilized. Where this is not possible, the following precautions should be observed:

1. All returned, dried materials should be placed on open shelving in a ventilated and air-conditioned "rehabilitation" area, well separated from the main collections. Such a rehabilitation area makes it easier to assess the condition of the dried materials, as well as to identify those that can be replaced and those that must be restored, and to plan for restoration. A carefully organized, random inspection for mold-infected materials can be conducted daily by personnel trained to carry out this important task in the rehabilitation process. Whether materials have or have not been sterilized during the drying process, it is necessary to monitor their behavior as a check against the effectiveness of sterilization and to identify any potential for mold growth before the return of these materials to the main collection.

We are concerned here with monitoring the dried volumes while they are in the rehabilitation area. It is good practice, however, to make a random selection of several volumes from such groups and to check them for possible development of mold following their return to the main stacks. This monitoring should be continued at regular intervals for at least a year after reshelving.

The rehabilitation area should be able to maintain a relative humidity of 35 to 45 percent and a temperature not exceeding 65°F. Both humidity and temperature controls must be adjustable. It is desirable to maintain the collection in the rehabilitation area under these conditions for a period of at least six months, if at all possible. At this time, temperature and humidity in the rehabilitation area can be gradually changed to duplicate conditions in the stack area to which they are to be returned. At the end of this time, if no mold growth has occurred, the volumes can be returned to the main stacks and monitored as indicated above. It is highly desirable but usually not practical to leave volumes in the rehabilitation area for an added six months as a check against later mold growth.

2. No materials should be returned to the main library shelves without very careful inspection by a qualified conservator, and preferably not before all neeessary restoration is complete.

FIRST PROCEDURES FOR SALVAGE

These procedures apply whether or not freezing is to follow.

1. In winter, turn off all heat in the building. In summer, reduce the temperature as much as possible through air-conditioning, if available.

2. Create maximum air flow through all affected areas by opening doors and windows. If electrical facilities are operational, use as many fans as can be acquired to create a current of air so directed as to expel the humid air from the building. If dehumidifiers are available they may be used with fans for small enclosed areas. The object is to avoid pockets of stagnant, moist air.

3. If house electricity is not available, hire portable generators to provide electricity for lights, fans, dehumidifiers, and other electrical services. For safety purposes, all electrical lines should be waterproofed and grounded.

4. Do not permit anyone to open wet books, to separate single sheets, to remove covers when materials are water-soaked, or to disturb wet file boxes, prints, drawings, and photographs. Such handling can result in extensive and often irreparable damage to materials that otherwise might be salvaged. *Reducing the cost of future restoration must be one of the top priorities of the salvage operation.*

5. Organize a disaster team and prepare a comprehensive plan of action, as well as plans for different contingencies.

6. Do not attempt to remove materials from the area until an overall plan with a schedule of priorities has been established and all personnel thoroughly briefed.

7. Canvass the community to locate freezing and storage space.

8. Seek the advice of specialists who can assist at the site of the disaster.

THE SALVAGE TEAM

Conducting a successful and efficient salvage operation after a major flood or similar disaster requires, in addition to a good supply of dedicated labor, a team of experts who should be assembled before practical work begins.

The leader should be a person who has had practical experience and understands the effects of different environmental conditions on water-soaked materials of all types, conditions, and ages. His team should consist of a librarian or archivist who knows the collection intimately, one or more archival conservators to assist, a building maintenance engineer, an electrician, a carpenter, a plumber, and a chemist if available. One or more persons familiar with national and local resources are highly desirable to assist in locating and procuring the special facilities, equipment, and supplies needed during the operation. They should be familiar with using the Yellow Pages to track down materials and equipment, able to seek out the key chemical supply companies in the country, if necessary, and generally able to cut through red tape.

The assembled team should be carefully briefed on the general procedures to be followed, various contingency plans which might have to be adopted, priorities to be observed, and their own specific responsibilities. The basic objectives are. 1) to stabilize the condition of the materials before removal by creating the environment necessary to prevent further damage, and 2) to salvage the maximum number of volumes from the damaged collections in a manner which will minimize future restoration and its costs.

The Catalog and Other Records of the Collection. High priority should be given to salvaging the catalog and other records of the collection. Salvage operations should avoid any action that might remove or deface identifying marks and labels. When part or all of the catalog or other bibliographic records have been lost, it may be necessary to make a chart of the flooded area and label each item as it is withdrawn to show its location. Such a procedure will assist later efforts to identify materials which have lost their call numbers. One or more persons must be assigned specific responsibility for making such records because the time and expense involved in subsequent identification and recataloging of damaged materials can be substantial.

Conveyor belts and "human chains" should be used to remove materials from each shelf and pack them in boxes or plastic milk crates numbered sequentially before being sent down the line. This system was used successfully in the removal of approximately 160,000 rare book items from the basement of the Klein Law Library, Temple University, after the fire of July 1972.

Manuscripts and other materials in single sheets create particularly difficult problems if they have been scattered. An indication of the approximate location in which they were found during the salvage operation may be extremely helpful at a later date. Materials should never be moved from the site in large batches or left piled on top of each other, either at the site or in adjacent temporary housing, since the excessive weight is very damaging.

Fungicidal Fogging. Before removal begins, and during the entire packing operation, a constant watch should be kept for signs of mold development. With large collections, if access has not been permitted for several days, it may be necessary to use fungicidal fogging. However, this should never be attempted unless the operation is supervised by a competent chemist or conservator who will be responsible for the safety of personnel, the area, and the materials. Where fogging is necessary, a mixture of one pound of thymol to one gallon of 1,1,1, trichlorethane, for approximately 20,000 cubic feet, can be used. Areas to be fogged should be emptied of personnel, fans and dehumidifiers turned off, and then sealed as completely as possible. The best time to fog is between 9 and 10 p.m., since at least six hours should elapse before the area is vented and fans and dehumidifiers

turned on again. At least three more hours are necessary before salvage crews return to the building. It cannot be overemphasized that this procedure, when necessary, should never be attempted without supervision. *Appropriate safety precautions must be established and observed.*

Preliminary Steps. If the materials are to be frozen, prior arrangements should be made to ship the packed materials immediately to the freezing facilities. Packed materials must not be allowed to remain on or near the site for more than a few hours, since such delay will further increase the possibility of mold development. Finally, before actual removal of the water-soaked material begins, lighting, fans, dehumidifiers, and all possible venting should be fully operational.

All work surfaces should be covered with polyethylene sheeting. Areas selected for packing or drying should be prepared for the operation by emptying them of all unnecessary equipment and furniture. As much work surface as possible at a convenient height should be provided.

The Work Force. Safety of the materials and future restoration costs will depend largely on the competence and dedication of the salvage crews. The work will be arduous, dirty, and often frustrating. Team leaders should not hesitate to dismiss careless and thoughtless workers. Experience has shown that well-disciplined crews having brief rest periods with refreshments about every hour and a half are the most efficient. Working salvage crews to exhaustion pays no dividends.

Removal and Packing. The aisles between stacks and main passageways will probably be strewn with sodden materials. These should be removed first, separately, by human chain, in the exact condition in which they are found. Open books will be greatly swollen, but no attempt should be made to close them. Closing them will only cause further damage by tearing the leaves, since paper will not slide when wet. Instead, books should be passed undisturbed to an adjacent dry area where a team should be waiting to pack them, again without disturbing their shape. The packing team should have the same number of people as the team which passes the damaged material to them. This will avoid bottlenecks and stacking materials on the floor to await packing.

If a sufficient number of people and conveyor belts are available, the most efficient place to pack damaged materials will be on the site. Teams will have to be organized to assemble packing materials and supply them to the packers in a smooth flow. Use of a second human chain or conveyor will reduce bottlenecks and the likelihood of incoming supplies interfering with the flow of packed materials being passed out of the building.

Starting from the nearest point of access, pack the wettest materials first. This is an essential step in bringing down the humidity level in the whole area. Since books on the lower shelves are those most likely to be wet, these should be removed first, in horizontal sequence. As each line of shelves is emptied, an assistant should code each box and record the box number and its general contents in a notebook.

The contents of archival storage boxes are unlikely to be saturated with water if they were previously positioned close together. However, since certain types of boxes have a corrugated inside layer, they may be very wet, even though the major portion of the contents is only damp. In such cases, it is best to repack the contents in new boxes or in plastic milk crates. This will not only make each unit lighter to lift and prevent the

collapse of a wet box but will also speed the drying. When repacking it is important that the new boxes be properly identified as to contents.

Disposition of Remaining Drier Materials and Cleaning Affected Areas. After first removing the wettest materials, the very damp or partially wet materials should be removed. Only then should the balance of the collection be inspected. These volumes will usually be above the first four or five shelves and packed closely together. On no account should this third category be separated or spaced out during the earlier salvage of the wettest materials. Closely packed materials will *not* develop mold internally. However, since these will have been in a very humid atmosphere for several days, it is likely that the external parts will have been exposed to a far greater quantity of mold spores than is usual under ordinary circumstances.

During clean up of the area, it is not wise to leave these drier collections in place. They should be moved to a controlled environment while shelves, walls, floors, and ceilings are sterilized and necessary maintenance work is being done to return the site to its normal condition. If moved, materials should be stacked with air spaces between them. A good circulation of air should be provided, together with air-conditioning and dehumidification. If air conditioning is not available, fans and dehumidifiers should be used to keep air moving and to extract some of the moisture from the air.

The relative humidity of a drying area is no guide to the actual moisture content of cellulose materials. The normal water content of paper is between 5 and 7 percent by weight. Materials which feel relatively dry to the touch as they come out of a humid, flood-damaged area, may actually contain from 10 to 30 percent water.

Heat is one of the best means of drying, but since it increases the risk of mold development on humid books and documents, it should be used only if a good circulation of air and dehumidification can be established. Hygrothermographs for recording temperature and relative humidity should be installed to monitor the general area, and moisture-content meters are useful for measuring the moisture in the materials themselves.

Preparations for Drying. The following procedures should be attempted only by trained leaders and well-supervised staff. All drying rooms should be set up well away from the affected areas. They should have a controlled environment which will remove moisture-laden air and which can be maintained at a constant temperature. Additional heat may be supplied to these areas provided the air is well circulated at all times. Pockets of stagnant air should not be permitted, and cleanliness should be maintained by prompt removal of wet debris as soon as collected. Plastic bags designed for garbage or lawn clippings are ideal for this purpose. One or more persons should be assigned the task of keeping work areas and floors as clean as possible and free of wet material to reduce moisture and to avoid loss or damage to manuscript leaves and parts of documents mixed in the debris.

Wet materials should be separated into *small units*, either by loose packaging or individual wrappings, to permit a free flow of air around them and to prevent the crushing which occurs when materials collect in large piles.

Cleaning. If adequate assistance is available, mud deposits on books which will not be further damaged by water may be washed off in clean, running water. Closed books should be held, one at a time, under water and the mud removed with a sponge used with a gentle, dabbing action. Similar washing should *not* be attempted with opened volumes, manuscripts, art on paper, or photographs.

Rubbing and brushing should be avoided, and no effort should be made to remove oil stains at this stage. Anything which is hard to remove is better left until after drying, when techniques for removal can be worked out during the restoration stage. If necessary, printed books bound in cloth or paper can be left immersed in clean running water for as long as two weeks. Although this should be avoided if possible, it is preferable when the only alternative is leaving the books in warm, humid air while awaiting treatment.

Thorough Washing. A more thorough washing procedure, intended to remove as much mud and slime as possible from books, requires six to eight tanks big enough to accommodate the largest volumes in the collection.

This process is obviously wet and messy and ideally should be set up outdoors in fair weather or in a garage, large shed, or basement in bad

weather. Since large quantities of water are required, the area will be wet and dirty throughout the operation, and good drainage is therefore essential.

Any rustproof receptacles may be used if they are large enough, but plastic garbage cans (20 or 30 gallons) are recommended. Each can should be equipped with a hose to provide low-pressure, continuous water flow to the bottom so that dirty water, as it overflows the rim, will be constantly replaced by fresh. Each hose should be fastened securely to prevent any damage to the books being washed. Wooden duckboards, rubber boots, and aprons are recommended for the protection of workers.

Keeping a book tightly closed, the worker should immerse it in the first can and remove as much mud as possible by gentle sponging *under* water. Workers should *not* use brushes and should not rub. Books should be passed from one can to the next and the same operations repeated until most of the mud has been removed. At the last can, books should be rinsed by spraying them gently with a fine stream of water. As instructed under "Cleaning," no effort should be made to remove mud which continues to cling after sponging under water. This is much better done when the books are dry. The remaining water should be squeezed from books with the hands only; *mechanical presses should not be used.*

It must be emphasized that the above procedure should be attempted only by a carefully instructed team. If there is any doubt about the ability of the team to follow directions, washing should not be attempted. There are many classes of books which should not be washed under any circumstances, and it is therefore imperative to have the advice of an experienced book conservator who can recognize such materials and who understands their treatment.

Mud. When materials have been exposed to mud-saturated river water, experience has shown that the best time to remove fine silt is before the materials have dried, but *not* on-site. All flood-damaged materials should be frozen so that each item can be properly treated later. If mud-saturated paper is allowed to dry before restoration, fine silt deposits are almost impossible to remove completely.

Conventional Drying of Wet Books with Covers Intact. One of the safest ways to determine the rate of water removal during drying is by weighing. Thus for small collections of very valuable items, it is helpful to weigh each book at the start of the drying period. For large collections this is generally impractical.

After the closed book has been washed it should be stood upright on the head end. The head is preferred since the book, in normal use, will have had a tendency to sag at the head end, a tendency that would be further

aggravated by the weight of wet leave. Turning the volume on the head will even the strain on the text block, i.e., the leaves of the book, without the covers.

Do not fan the leaves to make the volume stand up, merely open the covers slightly and let stand while draining. To provide further support for the book while it is draining, use Styrofoam, sponge rubber, or similar material three-sixteenths of an inch thick, cut into small pieces three-quarters of an inch wide and slightly longer than the thickness of the book block. Place a piece under the front edge of each book to keep it balanced in the upright position and tilted slightly backward. A toothpick placed under each cover about midway from front to back will keep the boards or covers in position while water is draining.

Washed books should be stood on several sheets of absorbent paper cut to the approximate size of each book. Newsprint stock, unprinted, is cheap and will work well for this purpose. It is important that these sheets be replaced frequently as they absorb water, and the wet sheets should be removed from the working area. Prepare thymol-impregnated sheets according to directions in the following section and place these between the front and back covers and the adjacent flyleaves. The covers of books are usually the last parts to dry out, and therefore the area between the board papers and flyleaves will be the first to be attacked by mold. Use of the thymol-treated sheets will reduce the possibility of mold damage to these areas. It is also useful to place a sheet of aluminum foil, polyester, or polyethylene film between the thymol-impregnated paper and the leaves of the book. The inner portion of the book will dry first, and the foil or plastic sheet will prevent the water held in the covers from migrating to the inside of the book.

Preparing Thymol-Impregnated Sheets for Interleaving. Thymol-impregnated sheets to be used as mold inhibitors will be needed in large quantities for the next steps in the drying process. To prepare these, cut unprinted newsprint stock into sheets of graduated size according to the sizes of the books to be treated. A few standard sizes such as 4 by 6 inches, 5 by 7 inches, 8 by 10 inches, and 10 by 12 inches should be adequate. Dip each sheet in a 10 to 15 percent solution of thymol crystals in ethanol, acetone, industrial denatured alcohol, or trichlorethane (1 pound per gallon of solvent). Because the vapors of these solutions are toxic and flammable, this operation must be performed outdoors. Rubber gloves, goggles, and a respirator of the type used by painters should be worn for the protection of the operator. Treated sheets should be air dried on polyethylene-covered tables. The treated sheets will dry quickly. They should then be gathered in bundles of convenient size and wrapped in aluminum foil or polyethylene and stored in a cool place until needed. Wrapping is necessary because of the volatility of thymol.

Thymol is not an effective fungicide for all types of mold, but it has been used successfully in major flood disasters. It is especially recommended because it is one of the least toxic of fungicides, can be handled with relative safety by workers, and is harmless to cellulosics.

Interleaving with Thymol-Impregnated Paper. A current of air and frequent changes of the absorbent paper lying under each book will quickly dry the books to the point at which, with care, they can be opened with little risk of damage. Proceed with great caution when first attempting to open a book which has been drying. Keep the opening shallow and do not open the covers to more than a 30-degree angle at the first attempt. As soon as the book can be opened safely, begin interleaving with sheets of treated newsprint stock or strong paper toweling at intervals of 25 leaves (50 pages), starting from the back of the book. It is highly desirable to keep books in the upright position during this first interleaving/drying stage.

Interleaving should be changed frequently, and care must be exercised not to interleave too much, otherwise, the spine will become concave and the volume distorted. If drying conditions are unfavorable because of high humidity, it may be necessary to interleave every five leaves, and to change sheets every two or three hours to dry the book with reasonable speed. Under these conditions, a distorted book is preferable to a moldy book. As the book becomes drier it can be opened flat on the spine and boards and interleaved more closely. Interleaving, however, should not exceed one-third the total thickness of the volume.

Some further details on the interleaving technique may be useful:

1. Used and damp interleaving sheets should not be reused unless first impregnated with thymol and dried.
2. Frequent changing of interleaving material is much more effective than allowing large numbers of sheets to remain in place for extended periods.
3. Newsprint should not be left in books after drying is complete.
4. A good grade of paper toweling is more effective than newsprint, but the cost is significantly greater, especially for a large collection.

Drying Distorted Books on Lines. Books tend to become distorted by the action of water swelling the leaves and by the interleaving. In such cases, the spine forms a concave shape when the book is closed. Hanging a partially dry volume on three or more short lines will help the spine return to its original shape as it dries. Such lines should be of monofilament nylon, not more than one thirty-second of an inch in diameter, not more than five or six feet long, and approximately one-half inch apart. Three lines are enough for a volume of ordinary thickness up to one and one-half inches. Thicker volumes will require more lines, but no volume should

be hung up if it weighs more than six pounds. The reason for this is that the inner folds of book sections are often thin and certainly fragile when wet, and hanging a heavy book in this condition will cause the folds to fracture.

Dampness will persist for some time in the inner margins, along the spine, and between boards and flyleaves. This is particularly true of volumes bound on oversewing machines.

If the volume was weighed while wet, it is possible to determine the extent to which it has dried by weighing it again during the interleaving process and finally by measuring the water content of the paper by a special moisture meter. When the volume has lost about two-fifths of its original wet weight, it may be hung on the nylon lines. If the volume was not weighed while wet, its stage of drying can only be guessed. However, if there is no water dripping from the book, if the paper feels damp but not wet, and if the book can be opened easily throughout, it is dry enough to hang or to be stood upright in the airflow from fans.

Under no circumstances should books be hung when saturated with water. In addition to the danger of mechanical damage, some spine adhesives, especially those made of gelatin, will migrate through a suspended, wet book and cause staining as well as adhesion of leaves.

Drying Wet Books with Soft Covers. The technique of wedging a wet book with pieces of styrofoam to enable it to stand upright for draining is not applicable for books with paper covers or those with covers missing. Such books may be stood on either head or tail, and if they will not stand alone, they may be allowed to support each other, with cardboard spacers placed between them. Experience on the site will suggest the best method.

Drying Books With Only Wet Edges. In the case of volumes in which only the edges are wet, the drainage procedure is omitted. Interleave from the back of the book, turning pages carefully. Thymol-impregnated sheets are preferred for this operation. Complete the interleaving by laying sheets of thymol-impregnated paper over sheets of clean blotting paper and placing these inside the front and back boards. Shut the book and place it on several sheets of absorbent paper without a weight. As drying proceeds, the interleaving sheets can be removed from the book to expose dry sections. Turn the book over each time it is interleaved. When the leaves are almost dry, a light weight may be placed on the book.

If the edges are only slightly wet, a book may be stood on its head and fanned open slightly in the path of a flow of heated air. Alternatively, lightweight books may be hung to dry. To hold distortion of the edges to a minimum, the volumes should be laid flat under light pressure (e.g., paper-covered bricks) just before drying is complete.

If an efficiently air conditioned room can be established with the capacity to maintain a constant relative humidity of 25 to 35 percent and temperatures between 50° and 65°F, books with only wet edges can be dried successfully in approximately two weeks without interleaving. No attempt should be made to dry books printed on coated stock by this method. In nearly every case, the only chance of saving such materials is to freeze them while wet and return to the dry condition by vacuum of freeze drying.

Final Stages of Conventional Drying. When books are nearly dry, they should be closed and laid flat on a table or other horizontal surface, gently formed into the normal shape, with convex spine and concave fore-edge, and held in place with a light weight.

Drying books should not be stacked on top of each other.

In no case should volumes be returned to the stacks until thoroughly dry; otherwise mold may develop, particularly along the inner margins.

In most cases, manuscripts, drawings, and handcolored prints should be frozen at once and their ultimate restoration left to experts.

No attempt should be made to sponge off mold, since this can be removed more easily when dry. If trained personnel and clean, cold running water are available, loose, single-sheet materials with no soluble components will benefit from washing before freezing.

Where single materials are found in masses, it is usually better not to attempt to separate, but freeze as they are. They will separate easily when vacuum or freeze dried.

Another precaution: do not turn drawers or manuscript boxes upside down to empty them. The wet contents may stick to the container and be torn if handled roughly. Containers and contents should be frozen as found.

Technique for Separating Single Sheets. Although it is usually inadvisable to attempt the separation of single sheets, there are circumstances where freezing is inconvenient or uneconomical. Under these conditions one may wish to separate a wet mass of single items for immediate hand drying. The safest method, which requires considerable skill and dexterity, takes advantage of the special properties of polyester nonwoven fabric and film. Separation is carried out as follows:

1. Dampen a sheet of polyester film (3 mil thickness), and lay it on top of a wet pile of single sheets. The surface energy of water makes it possible for an experienced worker to ease away several sheets at the corner of the pile and roll or peel these back with the polyester. This material and the attached sheets should then be transferred, *polyester side down*, to a nearby table covered with a large polyethylene sheet.

2. Next, place another piece of polyester on top of this newer pile of wet materials. You will find that by careful, gentle manipulation, you can roll the film back with a single wet sheet attached to it. Place this, polyester side down, on a table. Place a piece of dry polyester web over the wet sheet, turn the sandwich over, remove the polyester film and lay on a second piece of dry polyester web.

3. Repeat the entire process, separating wet sheets one at a time by means of the polyester film and interleaving with dry polyester web. If desired, the materials may be safely frozen or air dried at this stage. Note that film should be used for the initial separation. Final interleaving should be done only with web.

4. If the collection is small enough to make hand drying feasible, place each sandwich (web, wet sheet, web) separately on tables or closely spaced nylon lines to dry. By the time 100 of these have been processed, the first sheets will be dry. Be careful that fans do not blow directly on this material. Gentle, warm air may be used, plus good ventilation to remove excess moisture. Air-conditioners or dehumidifiers may also be employed to advantage in drying.

Photographic materials should not be frozen unless they cannot be professionally dried, since the formation of ice crystals may rupture the emulsion layer and leave marks on the film.

Monochromatic Materials. For emergency stabilization, wet, muddy black-and-white negative film and prints should be sealed in polyethylene bags and placed in plastic garbage cans (not metal) under clean, cold running water. Black-and-white negative film and prints can be left under such conditions for up to three days no longer—before the emulsion will separate from the film backing.

The Eastman Kodak Company provides emergency service for cleaning and drying black-and-white film of all varieties. Local film processors may be prepared to offer a similar service for microfilm and other film materials. Arrangements for cleaning and drying should be made as soon as possible, and the materials should be shipped to the laboratory in cold water. For a trip of several hours it may be necessary to add ice (not dry ice) to the water to keep it cold.

If professional drying cannot be arranged, photographic materials may have to be frozen. In this event, freezing should be as rapid as possible to keep ice crystal size to a minimum.

Color Slides and Color Negative and Positive Film. Unless color materials can be transported to a professional photographic service within 48 hours after immersion in water, colored layers will separate, and the dyes will become weak or will be lost altogether. After this time, the best way to save a large collection is to freeze it until special arrangements can be made.

EVALUATION OF LOSS

When a flood- or fire-damaged collection is covered by insurance, full settlement of a claim cannot be realized until the lost and damaged materials have been listed and their values have been established. The extent and success of possible restoration must also be determined. In the event that a claim is anticipated as a result of such damage, every item should be salvaged, frozen, and dried. After drying, the affected materials should be shelved in a specially equipped environmental storage area, isolated from the main stacks, and there inspected and monitored over a period of time. Such a policy is the best guarantee of sound judgments by custodians, consultants, and adjusters when they must calculate the degree of loss as a basis for compensation.

SUMMARY OF EMERGENCY PROCEDURES

1. Seek the advice and help of book and paper conservators with experience in salvaging water-damaged materials as soon as possible.
2. Turn off heat and create free circulation of air.
3. Keep fans and air-conditioning on at night, except when a fungicidal fogging operation is in process, because a constant flow of air is necessary to reduce the threat of mold.
4. Brief each worker carefully before salvage operations begin, giving full information on the dangers of proceeding except as directed. Emphasize the seriousness of timing and the priorities and aims of the whole operation. Instruct workers on means of recognizing manuscripts, materials with water-soluble components, leather and vellum bindings, materials printed on coated paper stock, and photographic materials.
5. Do *not* allow workers to attempt restoration of any items on site. (This was a common error in the first 10 days after the Florence flood, when rare and valuable leather- and vellum-bound volumes were subjected to scrubbing and processing to remove mud. This resulted in driving mud into the interstices of leather, vellum, cloth, and paper, caused extensive damage to the volumes, and made the later work of restoration more difficult, time consuming, and extremely costly.)
6. Carry out all cleaning operations, whether outside the building or in controlled-environment rooms, by washing gently with fresh, cold running water and soft cellulose sponges to aid in the release of mud and filth. Use sponges with a dabbing motion, *do not rub.* These instructions do not apply to materials with water-soluble components. Such materials should be frozen as quickly as possible.
7. Do not attempt to open a wet book. (Wet paper is very weak and will tear at a touch. *One tear costs at least one dollar to mend!)* Hold a book firmly closed when cleaning, especially when washing or sponging. A closed book is highly resistant to impregnation and damage.
8. Do not attempt to separate single-sheet materials unless they are supported on polyester film or fabric.
9. Do not attempt to remove all mud by sponging. Mud is best removed from clothes when dry; this is also true of library materials.
10. Do not remove covers from books, as they will help to support the books during drying. When partially dry, books may be hung over nylon lines to finish drying. Do not hang books from lines while they are very wet because the weight will cause damage to the inside folds of the sections.

11. Do not press books and documents mechanically when they are water soaked. This can force mud into the paper and subject the materials to stresses which will damage their structures.

12. Use soft pencils for making notes on slips of paper but do not attempt to write on wet paper or other artifacts.

13. Clean, white blotter paper, white paper towels, *strong* toilet paper, and unprinted newsprint paper may be used for interleaving in the drying process. When nothing better is available, all but the color sections of printed newspapers may be used. Great care must be taken to avoid rubbing the inked surface of the newspaper over the material being dried, otherwise some offsetting of the ink may occur.

14. *Under no circumstance should newly dried materials be packed in boxes and left without attention for more than a few days.*

15. Do not use bleaches, detergents, water-soluble fungicides, wire staples, paper or bulldog clips, adhesive tape, or adhesives of any kind. Never use felt-tipped fiber or ballpoint pens or any marking device on wet paper. Never use colored blotting paper or colored paper of any kind to dry books and other documents.

Appendix 1 SOURCES OF ASSISTANCE

The following persons are known to have had actual experience in the salvage and preservation of flood-damaged materials:

Paul Banks
Conservator
The Newberry Library
60 West Walton Street
Chicago, Ill. 60610
(312) 943-9090

George Cunha
Director/Conservator
New England Document Conservation Center
800 Massachusetts Avenue
North Andover, Mass. 01845
(617) 686-9669

Carolyn Horton
Conservator
Carolyn Horton Associates, Inc.
430 West 22d Street
New York, N.Y. 10011
(212) YU 9-1472

Robert E. McComb
Physical Scientist
Research & Testing Office
Library of Congress
110 Second Street, SE.
Washington, D.C. 20540
(202) 426-5607

Robert M. Organ
Chief, Conservation-Analytical Laboratory
Museum of History and Technology
Smithsonian Institution
Washington, D.C. 20560
(202) 381-5592

Stella Patri
Book Conservator
68 Divisadero Street
San Francisco, Calif. 94117
(415) 626-8626

Willman Spawn
Conservator
American Philosophical Society Library
105 South Fifth Street
Philadelphia, Pa. 19106
(215) WA 5-9545 or 567-4566

Harold Tribolet
Consultant
R. R. Donnelley & Sons Co.
Larkspur, Colo. 80118
(303) 688-9101

Peter Waters
Restoration Officer
Library of Congress
110 Second Street, SE.
Washington, D.C. 20540
(202) 426-5634

Marilyn Kemp Weidner
Graphic Arts Conservator
612 Spruce Street
Philadelphia, Pa. 19106
(215) MA 7-2303

The Library of Congress will gladly act as an information source for technical advice where needed.

Appendix 2 SOURCES OF SERVICES, SUPPLIES, AND EQUIPMENT

One should check the Yellow Pages of the telephone directory for listings of area representatives of industrial chemical firms for the following products and for others mentioned in the text.

Newsprint (newspaper which has not been printed)
Available from local newspaper publishers or from paper suppliers in rolls or sheets. Purchase of cut sheets, when possible, will save time and labor. "Coarse paper" merchants, who sell shipping room supplies and the like, sometimes sell "stuffing newsprint." Because this is irregularly trimmed, it is not satisfactory for printing and is significantly cheaper than the newsprint sold by "fine paper" merchants.

Plastic garbage cans
Local hardware stores.

Plastic milk boxes
Local supermarkets; milk suppliers.

Polyethylene sheeting and bags
Local hardware stores and garden supply stores. In large cities, special suppliers of plastic films may be located in the Yellow Pages of the telephone directory under "Plastics."

Polyester film
Minnesota Mining & Manufacturing Co. (3M)
3M Center
St. Paul, Minn. 55101
(612) 733-1110

E. I. du Pont de Nemours & Co., Inc.
Fabrics & Finishes Department
Industrial Products Division
Wilmington, Del. 19898
(302) 774-2421

I.C.I. America Inc.
151 South Street
Stamford, Conn. 06904
(203) 327-3200

Polyester nonwoven web
E. I. du Pont de Nemours & Co., Inc.
Fabrics & Finishes Department
Industrial Products Division
Wilmington, Del. 19898
(302) 774-2421

Monsanto Company
Textiles Division
New York, N.Y. 10001
(212) 556-5100

Refrigerated trucks and freezing or cold-storage facilities
Consult the Yellow Pages of the telephone directory.

Recovery of photographic film and slides
In the event that necessary services cannot be located in the area, reprocessing of water-soaked photographic film and slides can be obtained from or through such organizations as those listed below. Arrangements must be made before shipment. Monochromatic film materials should be kept wet and shipped under cold water to the reprocessors as quickly as possible, preferably within 24 hours.

GAF Corporation
Charles Street
Binghamton, N.Y. 13902
(607) 729-6555

Minnesota Mining & Manufacturing Co. (3M)
3M Center
St. Paul, Minn. 55101
(612) 733-1110

Eastman Kodak Company
343 State Street
Rochester, N.Y. 14650
(716) 325-2000

Thymol, ethanol, acetone, industrial denatured alcohol
Chemical supply companies - consult the Yellow Pages.

GPO 885-461