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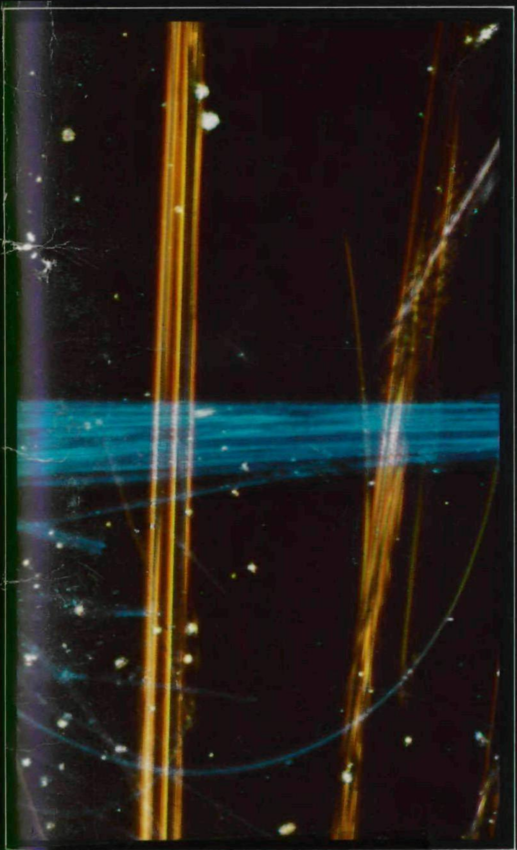
Asbestos - Containing Materials in School Buildings

Guidance for Asbestos Analytical Programs



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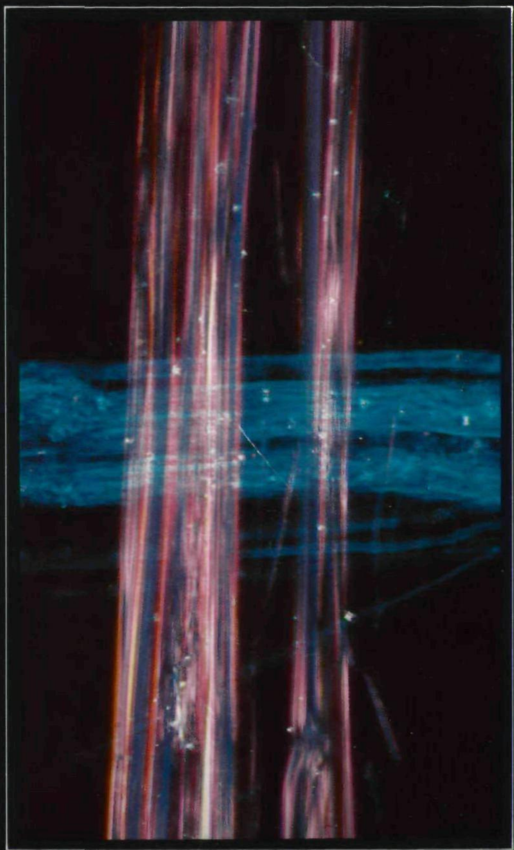

chrysotile

crocidolite

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ASBESTOS-CONTAINING MATERIALS IN SCHOOL BUILDINGS

Guidance For Asbestos Analytical Programs

December 1980

by

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DISCLAIMER NOTICE

PREFACE

This document is one in a series prepared in support of the EPA Asbestos-In-Schools Program. It was developed to provide guidance to local school officials and their staffs in determining the presence or absence of asbestos in school buildings. Data and information generated during the EPA Technical Assistance Program have been used to design a rigorous sampling and analysis scheme for bulk materials. Implementation of the enclosed sampling protocol will reliably document the presence or absence of asbestos in the bulk materials and provide an interval estimate of the asbestos content.

EPA has prepared rules which, when final, would require the examination of public school buildings for asbestos. The EPA Asbestos-In-Schools Identification and Notification Rule was proposed in September 1980 and is planned to be final in early 1981.

ACKNOWLEDGEMENTS

The authors greatly appreciate the helpful suggestions of Larry Longanecker and Joe Breen of the U.S. Environmental Protection Agency and Steve Williams and Martin Rosenzweig of Research Triangle Institute. Many thanks are also given to Carol Mitchell for the outstanding formatting and typing job and to Lynne Srba for the cover design and printing.

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CHAPTER 1: INTRODUCTION

The objective of this document is to provide guidance to local school officials and their staffs for the effective implementation of an asbestos analytical program that will generate adequate information for decision-making and yet not be too costly in terms of dollars and human resources.

Participants in the school asbestos program should be aware of some of the pitfalls associated with carrying out an asbestos analytical program. The proper implementation of a valid program to characterize suspected asbestos-containing materials requires an appreciation of the interdependence of the various elements of the overall process. The importance of random sampling, appropriate chemical analytical techniques, selection of a laboratory to do the bulk sample analyses, and an effective laboratory monitoring program are emphasized throughout this document.

The following paragraphs outline seven elements that are necessary in an asbestos program. Chapters 2, 3, and 4 then discuss in detail sampling procedures, laboratory quality assurance, laboratory analysis, and statistical analysis.

ASBESTOS ANALYTICAL PROGRAM COORDINATOR

The first element in the program is to identify an asbestos analytical program coordinator to be responsible for overseeing the entire asbestos program. In particular, the coordinator is responsible for supervising the sampling of suspected asbestos-containing materials, selecting laboratories to analyze the bulk samples for asbestos content, monitoring the laboratories' performance throughout the analysis period, and preparing a summary report. If possible, someone with a technical background, such as mathematics or science, should be designated coordinator.

SAMPLING OF MATERIALS SUSPECTED TO CONTAIN ASBESTOS

The second element in the asbestos analytical program, sampling of the suspect material, is considered the single most important step in the process. Proper sampling, that is, random sampling, is the basis upon which the validity of the subsequent laboratory analysis program and decision-making processes rest. If the suspect material is improperly sampled, the analyses that follow will be compromised.

Chapter 2 describes inspection for suspect material, identification of Sampling Areas, and the recommended sampling procedure. A simple random sampling procedure is employed to ensure the reliability of the results. To aid in this process, a SELECTION OF SAMPLE LOCATIONS WORKSHEET is provided in Chapter 2. The number of samples recommended provides a high chance of detecting asbestos in bulk materials, if present. For example, if a Sampling Area has 5% or more asbestos content, taking at least three samples would give greater than a 90% chance of detecting the presence of asbestos. (The assumptions underlying this statement are described in detail in a Statistical Background Document, [2]. These assumptions are based on data made available to EPA by the Bureau of Mines and the Battelle-Columbus Laboratories.) To achieve greater than 90% assuredness, the number of samples taken in each sampling area would have to be increased.

LABORATORY ANALYTICAL TECHNIQUE

The third element in the asbestos program is the appropriate choice of a laboratory technique to analyze the suspect materials. In view of the health and economic implications, accurate determination of the presence or absence of asbestos is critical.

The method of choice for the determination of asbestos in suspect materials is polarized light microscopy (PLM) with or without dispersion staining (DS), and with X-ray diffraction (XRD) as necessary to supplement the PLM analysis [1]. PLM is the only method that depends on the unique optical crystallographic properties of the sample. These properties uniquely identify the individual asbestos types: chrysotile, actinolite, amosite, anthophyllite, crocidolite, and tremolite. These crystal aspects coupled with the fiber shape will uniquely identify the asbestos present in the material being analyzed and will also characterize non-asbestos fibers present such as fiberglass and cellulose.

Another analytical technique used in asbestos analysis is phase contrast microscopy. This method was developed by the National Institute of Occupational Safety and Health (NIOSH) for use in occupational settings when a significant asbestos insult is known to exist. This technique is used to count fibers based solely on their shape and size and does not distinguish between asbestos fibers and non-asbestos fibers such as cellulose, hair, and fiberglass. Consequently, analysis of bulk samples for the determination of asbestos content by this laboratory technique is unacceptable.

A detailed analytical protocol for the bulk analysis of asbestos-containing insulation and sprayed-on materials is being prepared and tested [3]. This protocol should serve as an authoritative guide to any bulk sample analysis program using PLM and XRD as analytical tools.

LABORATORY SELECTION

The fourth element of the asbestos analytical program is the selection of a competent and reliable laboratory. The identification of asbestos in bulk samples involves expertise in optical crystallography and is not a routine laboratory procedure. Only laboratories actively engaged in using polarized light microscopy for the analysis of bulk samples for asbestos materials should be considered for this service.

EPA is sponsoring an analytical proficiency program for bulk sample analysis. Presently, 52 commercial and 23 non-commercial laboratories are participating on a voluntary basis. A brief description of this program, the results of round one, sample reporting, and a list of participating laboratories are provided in Appendix A. This is not a laboratory certification process; however, these laboratories have demonstrated proficiency in analyzing bulk samples using polarized light microscopy.

It is recommended that laboratories from this list be selected for school asbestos programs. If it is not possible to select a laboratory from this list, a procedure for evaluating the performance of an unknown laboratory is provided in Appendix B.

A laboratory proficient in NIOSH asbestos fiber-counting methodology using phase contrast microscopy may lack both the equipment and expertise for PLM identification of asbestos in bulk samples. As stated above, phase contrast microscopy is inappropriate for the differentiation of asbestos from non-asbestos fiber materials.

SPECIFIC INFORMATION TO BE REPORTED BY LABORATORY

The fifth element in the asbestos analytical program is to specify the information to be reported by the laboratory for each sample submitted for analysis. It is important that complete reporting of the analytical results be obtained from the laboratory.

The laboratory report should include: school's "blind" sample ID numbers, laboratory sample ID numbers (assigned by laboratory), analytical method, sample appearance, sample treatment, amount of material examined, type and percent of asbestos present, type and percent of non-asbestos fibrous and nonfibrous materials present, method of quantitation, laboratory quality control program, analyst's name and address, and the school system's return address. A LABORATORY DATA SHEET incorporating this information is provided in Chapter 4. Send this form to the laboratory with every set of samples.

QUALITY ASSURANCE MEASURES

Quality assurance is a term used to describe measures for determining and maintaining laboratory reliability. The selection of a competent laboratory for the analysis of bulk samples suspected of containing asbestos is an important step in the implementation of a successful asbestos program, and such a selection must be made prudently.

It is not, however, sufficient to carefully select a laboratory and then presume that all will run smoothly throughout the course of the asbestos program. The experiences of several state and local efforts in dealing with asbestos analysis strongly suggest that additional measures are not only recommended but even necessary if the program is to be successful. Thus, the <u>sixth</u> element in an asbestos program is laboratory quality assurance. Recommendations for a program of laboratory quality assurance are detailed in Chapter 3. Flowcharts are provided for three different situations depending on the number of samples taken.

RECORDKEEPING

The <u>seventh</u> and final element of the asbestos analytical program relates to proper recordkeeping of the analytical data collected during the program. Close attention must be paid to the accurate recording of the sampling process and the final disposition of the laboratory reports. The laboratory analytical reports should be inserted into the permanent file of the asbestos program. Reports of results from school surveys should be forwarded to the school district office. Additional recordkeeping details are presented in Chapters 2, 3 and 4.

The preceeding paragraphs have given an overview of a school asbestos program. Chapter 2 describes the recommended sampling procedure. A SELECTION OF SAMPLE LOCATIONS WORKSHEET is provided. Chapter 3 presents recommendations for a laboratory quality assurance program. Flowcharts outline the procedures to be followed. In Chapter 4, laboratory reporting and statistical analysis are discussed. A LABORATORY DATA SHEET and a STATISTICS COMPUTATION WORKSHEET are provided.

The following CHECKLIST FOR AN ASBESTOS ANALYTICAL PROGRAM provides a chronological list of events that normally comprise a thorough asbestos analytical program. This list is provided as a convenient reference for the program coordinator.

CHECKLIST FOR AN ASBESTOS ANALYTICAL PROGRAM

		Date Completed
1.	Appoint an Asbestos Analytical Program Coordinator	________
2.	Establish Program File	________
3.	Inspect For Friable Materials	________
4.	Follow Sampling Protocol [Use SELECTION OF SAMPLE LOCATIONS WORKSHEETS]	________
5.	Follow quality assurance protocol [Use flow charts]	________
6.	Send samples to laboratories [Use LABORATORY DATA SHEET]	________
7.	Interpret laboratory results [Use STATISTICS COMPUTATION WORKSHEET]	________
8.	Enter all information in program file	________
9.	Report to district office	________

CHAPTER 2: SAMPLING FRIABLE MATERIALS

Friable material is material that can be easily crumbled, pulverized, or reduced to powder in the hand. It may be an asbestos-containing material, or it may be a material that contains other fibers, such as cellulose and fiberglass. Since friable materials crumble easily, it is believed they have the potential to release fibers readily. For that reason, it is imperative to determine whether friable materials contain asbestos fibers and to take corrective action where necessary.

Friable material may be found on the ceilings of classrooms, corridors, auditoriums, cafeterias, machinery rooms, storage rooms, indoor pools, and gymnasiums. It may also be found on steel support beams and columns and, occasionally, on walls and pipes. Neither visual inspection of friable material nor checking building records can determine the presence or absence of asbestos. Such a determination must be made through proper sampling and analysis.

The sampling procedure outlined in this chapter is a refinement of the methodology presented in Chapter 5 of <u>Asbestos-Containing Materials in School Buildings: A Guid-</u>

ance Document, Part 1 [1]. It was developed using recently-available data and based on standard statistical theory. If a school sampling program has been completed prior to the release of this revised sampling procedure, EPA will not require additional sampling unless there still remains some question as to the presence or absence of asbestos in the friable material.

The recommended sampling procedure should be carefully followed. Improper sampling could result in incorrect decisions, even when the accompanying laboratory analysis and quality assurance programs are excellent. Incorrect decisions would lead either to costly, time-consuming, and unnecessary corrective action or to no action for potentially hazardous situations. Especially critical to a valid asbestos analytical program is the use of a random sampling technique. The importance of this aspect cannot be overemphasized.

Since it is clearly not reasonable to remove all the material from a ceiling to examine for the presence of asbestos, a few small specimens, a sample of the ceiling material, is taken. The basis for extending the results of the sample to the entire ceiling is statistical theory which assumes random sampling. This is easily explained by an example.

Suppose a handful of marbles are blindly withdrawn from a jar full of marbles. If the handful of marbles withdrawn is half white and half blue, it would be believed that the jar contains only white and blue marbles, and that the composition is approximately half of each color. Since the selection is random, the composition of the handful of marbles would be expected to reflect the contents of the jar. That is, if the jar contained mostly blue marbles, then selecting marbles purely by chance ought to produce a mostly blue sample.

On the other hand, if for convenience just the top layer of marbles are selected and 6 white and 6 blue marbles are found, not much can be said about the contents of the jar. It contained at least 6 blue marbles and 6 white marbles, but that is all that can be said. Thus, this purposively selected (chosen on purpose) or convenience sample, does not provide much information about the nature of the jar's contents. These ideas underlie the concept of statistical inference.

Given the wide variation in asbestos content observed in some ceilings, a similar judgmental or convenience sampling method has led to incorrect characterization of the material. In some cases, the asbestos was entirely missed. In other cases, it was significantly over-estimated.

SAMPLING PROCEDURE

The recommended sampling procedure includes the following steps:

- establish an asbestos analytical program file.
- locate all friable materials in the buildings of concern.
- identify and establish homogeneous Sampling Areas of friable material.
- diagram each homogeneous Sampling Area reasonably to scale on graph paper.
- clearly indicate all inaccessible areas and water-damaged areas in Sampling Areas on diagrams.
- determine the appropriate number of bulk samples to be taken.
- using a random selection process, select the locations within all Sampling Areas where bulk samples will be taken.
- collect the samples, using proper precautions.
- enter all pertinent data in the program file.

The rest of this chapter presents this process in detail. Worksheets are provided to assist in the somewhat complicated steps necessary to ensure reliable results. A detailed example of the sampling process is provided at the end of this chapter.

ESTABLISHING AN ASBESTOS ANALYTICAL PROGRAM FILE

This step, though apparent, is listed here for emphasis. Maintain all worksheets and data forms in a permanent central file for future reference.

INSPECTING FOR FRIABLE MATERIAL

The next step in determining the presence or absence of asbestos is an inspection for friable material. Visually inspect all areas of the school building including student, administrative, maintenance, and custodial areas for friable material. Follow the guidelines for inspection given in Chapter 4 of Asbestos-Containing Materials in School Buildings: A Guidance Document, Part 1 [1]. If friable material is located during inspection, collect samples of the material for laboratory analysis according to the sampling procedure outlined below.

ESTABLISHING SAMPLING AREAS

Following the inspection for friable material, establish Sampling Areas. A Sampling Area is defined as a homogeneous area of friable material--that is, all friable material in a single Sampling Area is of the same type and was applied during the same time period. A decision as to the presence or absence of asbestos in the friable material is necessary for each Sampling Area.

The procedure for establishing Sampling Areas is described below. Their proper establishment is extremely important as incorrectly established Sampling Areas will yield results that do not accurately reflect the asbestos content of the friable material in the school building. This in turn may lead to very costly and unnecessary corrective action, or to no corrective action at all when it is needed.

Partition the total friable material area of the school building into Sampling Areas. The partitioning will be based upon visual inspection, knowledge of the school building's history, and building records, if available.

The following example should clarify the method of partitioning.

> Example: Suppose that friable material is found on the ceiling of a school's library and on the ceilings of first floor classrooms of an annex constructed six years after library construction. The friable material on the library ceiling appears to all be of one type, and the friable material on the ceilings of the annex classrooms appears to all be of a second type. In this situation, two Sampling Areas are required: (1) library ceiling and (2) ceilings of first floor classrooms of the annex. An estimate of the percentage of asbestos present will be obtained for each of these Sampling Areas, and separate decisions as to the necessity of corrective action will be made. If an unacceptably high percentage of asbestos is found only in Sampling Area (2), then corrective action needs to be considered only for that Sampling Area.

DIAGRAM PREPARATION

For each Sampling Area, prepare a diagram showing all friable materials in the Sampling Area. The diagram should be constructed on graph paper as follows:

(1) Clearly indicate the approximate dimensions of all rooms, corridors, or other school building areas included in the diagram. If these measurements are not readily available, rooms will need to be

measured using a tape measure or by pacing. Prepare the diagram to scale.

(2) Distinguish between friable material areas of the Sampling Area and areas in the diagram that are not contained in the Sampling Area.

(3) Draw on the diagram (to scale) any of the following features that are found within the Sampling Area.

(a) Damage caused by water or high humidity.

(b) Damage due to vandalism, rough use, or other factors.

(c) Patched or repaired material.

(d) Areas that are inaccessible for the purpose of sampling the friable material.

The reason for noting (a) water damage is that it is appropriate to take corrective action for all these areas regardless of asbestos content. Information noted in (b) may be useful in assessing the appropriate corrective action to be taken if asbestos is found to be present. Inaccessible areas (d) are marked so that no sample locations will be selected in these areas.

If one Sampling Area contains friable material areas that are not adjacent (for example, areas on different floors of the school building where the material is the same), sketch each separate area according to the above instructions. Place all sketches on the same graph, as close together as possible. The Sampling Area may contain areas that are not in the same plane (for example, a ceiling and a wall with the same type of friable material). In this case, sketch each flat surface according to the above instructions and place these sketches on the same graph, as close together as possible.

On each Sampling Area diagram, record the following information:

(1) Sampling Area identification (ID) number. (A number assigned by the school official to the Sampling Area that distinguishes the Sampling Area from all others of the school building.)

(2) Brief description of the Sampling Area.

(3) Area dimensions and scale.

(4) Name and address of the school.

(5) Name and telephone number of the asbestos analytical program coordinator of the school.

(6) Name of inspector and date of inspection.

(7) Name of person preparing the diagram and date prepared.

Include these diagrams in the program file. (Example Sampling Area diagrams are displayed in Figures 2.1 and 2.2.)

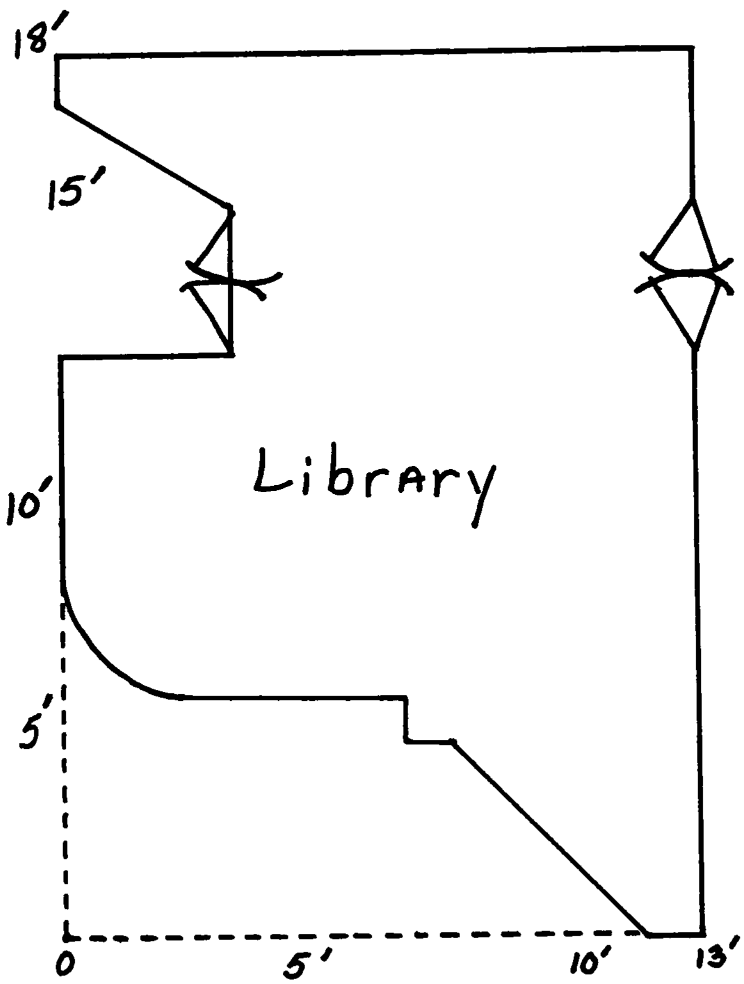
NUMBER OF SAMPLES TO TAKE

The number of samples to be collected will be based on the overall size of the Sampling Area. From the dimensions

Sampling Area

ID# 1

Description: Library — Friable Ceiling Material



Scale
square = 1 ft.

School ______
Address ______
Program Coordinator ______
Telephone Number ______
Inspector ______
Date of Inspection ______
Diagram Prepared by ______
Date ______

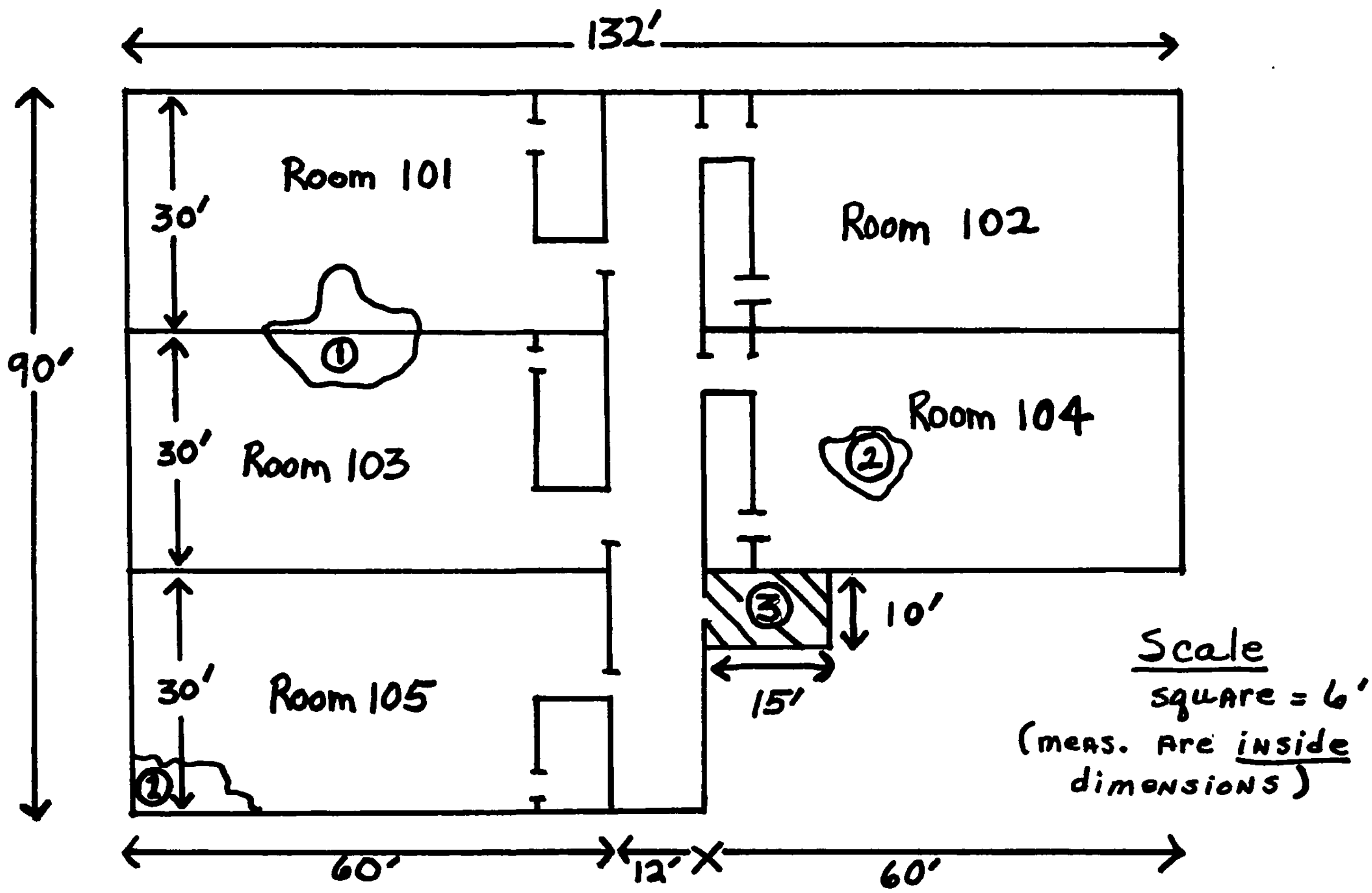
Figure 2.1: Example Sampling Area Diagram

Description: Sampling Area ID # 2

Classroom Annex (constructed in 1962)

Friable Ceiling Material of First Floor Classrooms
Gray textured spray finish
Stuccoed in appearance

All ceiling areas sketched below comprise Sampling Area (2), with one exception noted.



① Water damage
② Ceiling broken and falling
③ Stairwell ceiling not friable - not in Sampling Area (2)

School ______________ Program Coordinator ______________
Address ______________ Telephone No. ______________
Inspector ______________ Diagram Prepared by ______________
Date of Inspection ______________ Date ______________

Figure 2.2: Example Sampling Area Diagram

recorded on the Sampling Area diagram, compute the total square feet in the Sampling Area. Then from the table below, determine the number of samples to be collected.

If the size (square feet) of the Sampling Area is	Then the number of samples to be collected is
Less than 1,000	3
Between 1,000 and 5,000	5
Greater than 5,000	7

SELECTION OF SAMPLE LOCATIONS

After preparing the diagram(s) and determining the number of samples to be collected in each Sampling Area, determine the approximate location of each sample. The method for selecting sample locations described below utilizes a TABLE OF RANDOM DIGITS. This is designed to eliminate any inadvertent bias which would jeopardize the correctness of the final decision as to whether or not asbestos is present. Unfortunately, this method involves a certain amount of numerical work. No other method of site selection, though, can guarantee unbiased results. Following this step-by-step procedure carefully will give reliable, unbiased sample site selections.

Select sample locations according to instructions (1) through (9) below. It is very important to properly use the random number procedure to select sample locations. Refer to the SELECTION OF SAMPLE LOCATIONS WORKSHEET in Figure 2.3 for the following steps.

SELECTION OF SAMPLE LOCATIONS WORKSHEET

Sampling Area ID No. (a) ____________ Split-Sample ID No.(s) _______

Dimensions of rectangle covering the Sampling Area:

Base (b) ____________________ feet (*Choose* *first* *random number between 0 and no. in (b)*)

Height (c) __________________ feet (*Choose* *second* *random number between 0 and no. in (c)*)

	RANDOM NUMBERS		LOCATION FALLS WITHIN SA		SAMPLE LOCATION	Unique Sample ID #
	First	Second	Yes	No	ID Numbers	*(For Lab)*
(1)						
(2)						
(3)						
(4)						
(5)						
(6)						
(7)						
(8)						
(9)						
(10)						
(11)						
(12)						

School Name: ______________________________

District: ______________________ State: __________

Asbestos Analytical Program Coordinator: ____________________

Date: ______________________________

Figure 2.3: WORKSHEET

(1) Record the Sampling Area ID Number on the SELECTION OF SAMPLE LOCATIONS WORKSHEET (a).

(2) Construct on the Sampling Area diagram an imaginary rectangle enclosing the entire Sampling Area. Record the dimensions of this imaginary rectangle on the WORKSHEET: first the number of feet along the rectangle base (b) and then the number of feet along the side or height (c).

(3) From the TABLE OF RANDOM DIGITS, choose a pair of random numbers. Record the random numbers on the WORKSHEET. A TABLE OF RANDOM DIGITS and instructions for its use are provided in Appendix C. The first random number of the pair should be between 0 and the number of feet along the rectangle base (b). The second random number of the pair should be between 0 and the number of feet along the side or height (c) of the rectangle.

(4) The random number pair describes a location within the rectangle. The first number of the pair specifies the number of feet from the left side of the rectangle, and the second number specifies the number of feet from the bottom of the rectangle. The point should be plotted on the Sampling Area diagram.

(5) If the point described by the random number pair is within the Sampling Area and not within any

area designated on the diagram as inaccessible for the purpose of sampling, then that point is a sample location. Otherwise, the point is not a sample location. This elimination of inappropriate random number pairs does not adversely affect the random selection process so long as the pairs are chosen in continuous sequence. (If the random number selection process is done off-site, select some extra pairs of random numbers in case one or more are later found to be inaccessible. The SELECTION OF SAMPLE LOCATIONS WORKSHEET provides room to select 12 pairs of random numbers.)

(6) Continue using the above random number pair procedure until at least the required number (3, 5 or 7) of appropriate sample locations have been selected.

(7) All random number pairs should be recorded on the WORKSHEET. Beside each random number pair, indicate by a check if the location the pair describes is within the Sampling Area (and not within any area designated as inaccessible for the purpose of sampling) and is thus a sample location.

(8) Assign a sample location number to each of the sample locations. Any system of numbers that assigns a unique number to each sample location is satisfactory. Record these location numbers on

the WORKSHEET, and on the Sampling Area diagram.

(9) At the same time, assign a non-systematic but unique sample ID number to each sample location. This ID number, not the sample location number, will be on the sampling container when it goes to the laboratory for analysis. Using unique non-systematic numbers will prevent the laboratories from knowing which samples come from the same Sampling Areas or the same buildings. This "blind" procedure helps prevent bias on the part of the analyst. Record these unique sample ID numbers (for laboratories) on the WORKSHEET. Choosing numbers from the TABLE OF RANDOM DIGITS is a quick and easy technique for assigning sample ID numbers.

SAMPLE COLLECTION

Sampling containers should be small, sealable tin, metal or plastic containers. Suggested sampling containers are plastic 35 mm film canisters or small wide-mouthed aspirin bottles. Prior to sampling, thoroughly clean a sufficient number of sampling containers.

Collect the bulk samples, i.e., samples taken from the friable material by penetrating the depth of the friable material, at the specified locations according to the following guidelines:

(1) Gently twist the open end of the sampling container into the material. A core of the material should fall into the container. A sample can also be taken by using a clean knife to cut out or scrape off a small piece of the material and then placing it in the container. Be sure to penetrate any paint or protective coating and all the layers of the material. If the sampling container cannot penetrate the material, consider whether the material is really friable or not.

(2) Tightly close the sampling container; wipe its exterior with a damp cloth to remove any material which may have adhered to it during sampling.

(3) Tape the sampling container cap to prevent the accidental opening of the container during shipment or handling. In addition, it is recommended that each container be placed in a sealed plastic bag because film canister caps, even when taped, may come off in transport.

(4) Record the unique sample ID number chosen in (8) above on a label and tape the label to the corresponding sampling container. Be sure to record the unique sample ID numbers on the WORKSHEET as part of the asbestos analytical program file.

(5) See Chapter 3 for laboratory quality assurance procedures.

Collect samples at (or as close as possible to) the selected locations and collect <u>all</u> samples. Exact measurements (i.e., by ruler) are not necessary for finding the sample locations. Quicker, easier techniques such as pacing may be employed.

PRECAUTIONS TO BE TAKEN DURING SAMPLING

To avoid causing unnecessary exposure to asbestos fibers, take the following precautions while sampling friable materials [1].

(1) Sample the material when the area is not in use.

(2) Have only those persons needed for the sampling present.

(3) Hold the sampling container away from the face during actual sampling.

(4) Do not disturb the material any more than necessary.

(5) Spray the material with a light mist of water to reduce fiber release during sampling.

(6) If a large number of samples are taken, NIOSH recommends that the sampler wear an approved respirator. Contact a NIOSH Regional Office for information on approved respirators [1].

(7) Wear a respirator if moving ceiling tiles or in any other way disturbing possible fallen asbestos or its debris.

(8) If pieces of material break off during sampling, wet mop the areas where they have fallen.

AN ILLUSTRATION OF THE SAMPLING PROCEDURE

The sampling procedure is illustrated by this example. A school was visually inspected for friable materials. Five classrooms in an annex were found to contain suspect ceiling materials. All the materials were believed to be the same and thus comprise one Sampling Area (SA).

Approximate room dimensions were obtained by pacing and diagrammed as shown in Figure 2.4. Pertinent information such as the location of damaged, non-friable, and inaccessible materials was diagrammed and labelled.

The total area of friable materials in the five classrooms determines the number of samples to be taken from the SA. The example SA is 10,080 square feet, as calculated by

$$\text{Area} = [60' \times 90'] + [12' \times 90'] + [60' \times 60']$$
$$= 10{,}080 \text{ square feet.}$$

Since this area is greater than 5,000 square feet, seven samples are required.

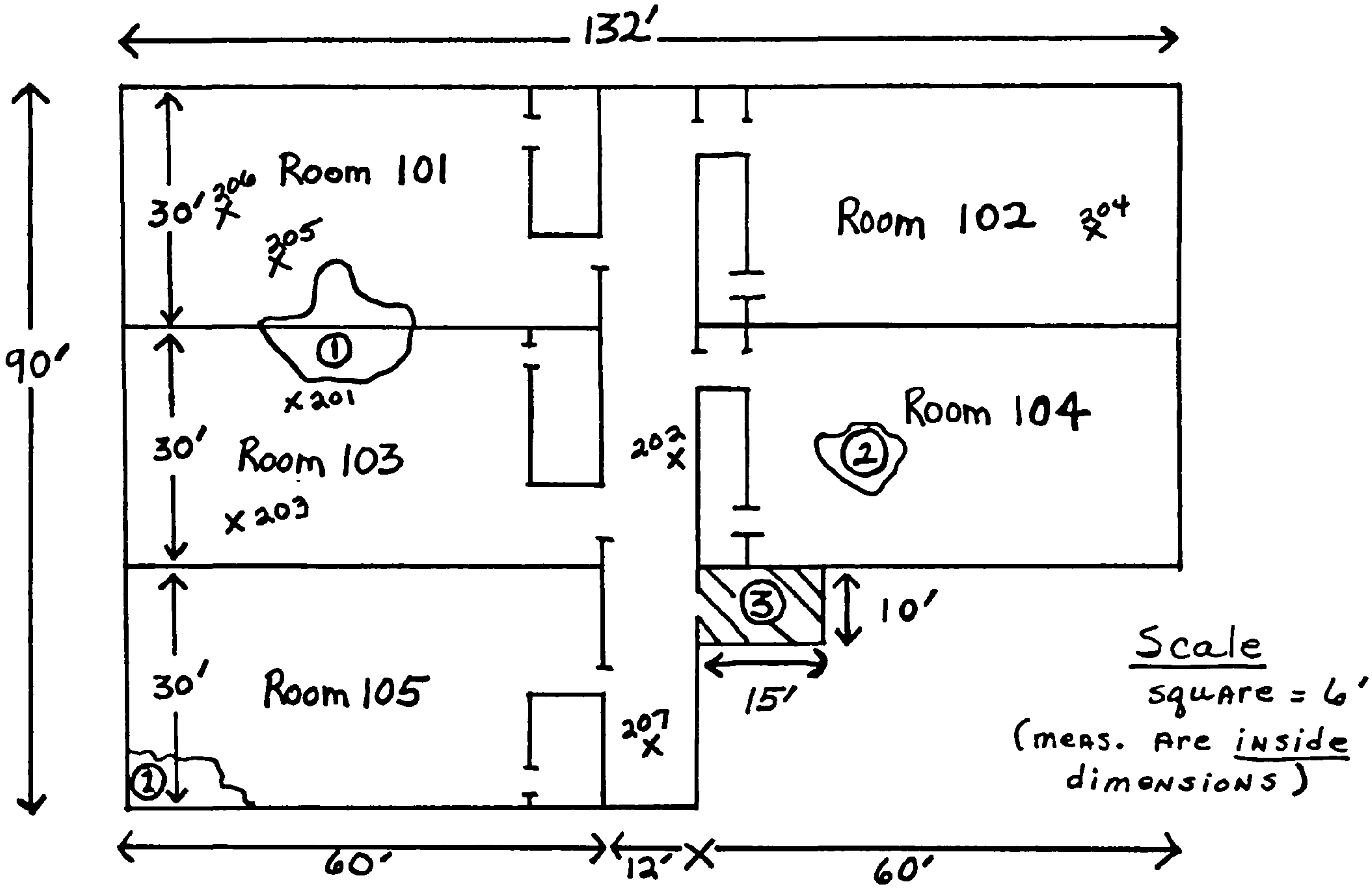
The SA ID number and the base and height of the SA were recorded on the SELECTION OF SAMPLE LOCATIONS WORKSHEET. The completed WORKSHEET is shown in Figure 2.5. The example SA's base is 132' (Note: 3-digit number) and height is 90'

Description: Sampling Area ID # 2

Classroom Annex (constructed in 1962)

Friable Ceiling Material of First Floor Classrooms
Gray textured spray finish
Stuccoed in appearance

All ceiling areas sketched below comprise Sampling Area (2), with one exception noted.



① Water damage
② Ceiling broken and falling
③ Stairwell ceiling not friable - not in Sampling Area (2)

School ______________ Program Cordinator ______________
Address ______________ Telephone No. ______________
Inspector ______________ Diagram Prepared by ______________
Date of Inspection ______________ Date ______________

Figure 2.4: Example Sampling Area Diagram With Sample Locations Marked

SELECTION OF SAMPLE LOCATIONS WORKSHEET

Sampling Area ID No. (a) 2 Split-Sample ID No.(s) ______

Dimensions of rectangle covering the Sampling Area:

Base (b) 132 feet (*Choose first random number between 0 and no. in (b)*)

Height (c) 90 feet (*Choose second random number between 0 and no. in (c)*)

	RANDOM NUMBERS		LOCATION FALLS WITHIN SA		SAMPLE LOCATION	Unique Sample ID #
	First	Second	Yes	No	ID Numbers	*(For Lab)*
(1)	21	51	✓		201	217
(2)	71	45	✓		202	884
(3)	108	13		✓		
(4)	10	41	✓		203	072
(5)	119	76	✓		204	300
(6)	22	66	✓		205	940
(7)	14	71	✓		206	572
(8)	67	12	✓		207	579
(9)						
(10)						
(11)						
(12)						

School Name: ______

District: ______ State: ______

Asbestos Analytical Program Coordinator: ______

Date: ______

Figure 2.5: WORKSHEET EXAMPLE

(Note: 2-digit number). The seven sample locations were chosen using the TABLE OF RANDOM DIGITS in Table 2.1. The first random number of each pair had to be between 0 and 132, and the second random number of each pair had to be between 0 and 90. Beginning in the upper left-hand corner of the random number table, the following 3-digit random numbers were crossed off as they are greater than 132: 632, 715, 998, 671, 744, and 511. Then the digits 021 were circled and used in the first random number pair since the number 21 is between 0 and 132.

To find the second random number of this pair, 2-digit numbers were considered. The digits 51 were circled since 51 is between 0 and 90. The first random number pair (21,51) was recorded on the SELECTION OF SAMPLE LOCATIONS WORKSHEET. This procedure was repeated until seven pairs of random numbers were selected.

After seven pairs of random numbers were selected and recorded on the SELECTION OF SAMPLE LOCATIONS WORKSHEET, these numbers were plotted on the SA diagram which was drawn to scale on graph paper (see Figure 2.4.). In the example SA, the first random number pair is (21,51). This designates the point 21 feet from the left side of the rectangle and 51 feet from the bottom of the rectangle. Since that point (21,51) is within the SA, it is a valid sample location and was marked on the diagram. If a random number pair designates a point within the rectangle that is not within

63271	59986	71744	51102	15141	80714	58683	93108	13554	79945
88547	09896	95436	79115	08303	01041	20030	63754	08459	28364
55957	57243	83865	09911	19761	66535	40102	26646	60147	15702
46276	87453	44790	67122	45573	84358	21625	16999	13385	22782
55363	07449	34835	15290	76616	67191	12777	21861	68689	03263
69393	92785	49902	58447	42048	30378	87618	26933	40640	16281
13186	29431	88190	04588	38733	81290	89541	70290	40113	08243
17726	28652	56836	78351	47327	18518	92222	55201	27340	10493
36520	64465	05550	30157	82242	29520	69753	72602	23756	54935
81628	36100	39254	56835	37636	02421	98063	89641	64953	99337
84649	48968	75215	75498	49539	74240	03466	49292	36401	45525
63291	11618	12613	75055	43915	26488	41116	64531	56827	30825
70502	53225	03655	05915	37140	57051	48393	91322	25653	06543
06426	24771	59935	49801	11082	66762	94477	02494	88215	27191
20711	55609	29430	70165	45406	78484	31639	52009	18873	96927
41990	70538	77191	25860	55204	73417	83920	69468	74972	38712
72452	36618	76298	26678	89334	33938	95567	29380	75906	91807
37042	40318	57099	10528	09925	89773	41335	96244	29002	46453
53766	52875	15987	46962	67342	77592	57651	95508	80033	69828
90585	58955	53122	16025	84299	53310	67380	84249	25348	04332
32001	96293	37203	64516	51530	37069	40261	61374	05815	06714
62606	64324	46354	72157	67248	20135	49804	09226	64419	29457
10078	28073	85389	50324	14500	15562	64165	06125	71353	77669
91561	46145	24177	15294	10061	98124	75732	00815	83452	97355
13091	98112	53959	79607	52244	63303	10413	63839	74762	50289
73864	83014	72457	22682	03033	61714	88173	90835	00634	85169
66668	25467	48894	51043	02365	91726	09365	63167	95264	45643
84745	41042	29493	01836	09044	51926	43630	63470	76508	14194
48068	26805	94595	47907	13357	38412	33318	26098	82782	42851
54310	96175	97594	88616	42035	38093	36745	56702	40644	83514
14877	33095	10924	58013	61439	21882	42059	24177	58739	60170
78295	23179	02771	43464	59061	71411	05697	67194	30495	21157
67524	02865	39593	54278	04237	92441	26602	63835	38032	94770
58268	57219	68124	73455	83236	08710	04284	55005	84171	42596
97158	28672	50685	01181	24262	19427	52106	34308	73685	74246
04230	16831	69085	30802	65559	09205	71829	06498	85650	38707
94879	56606	30401	02602	57658	70091	54986	41394	60437	03195
71446	15232	66715	26385	91518	70566	02888	79941	39684	54315
32886	05644	79316	09819	00813	88407	17461	73925	53037	91904
62048	33711	25290	21526	02223	75947	66466	06232	10913	75336
84534	42351	21628	53669	81352	95152	08107	98814	72743	12849
84707	15885	84710	35866	06446	86311	32648	88141	73902	69981
19409	40868	64220	80861	13860	68493	52908	26374	63297	45052
57978	48015	25973	66777	45924	56144	24742	96702	88200	66162
57295	98298	11199	96510	75228	41600	47192	43267	35973	23152
94044	83785	93388	07833	38216	31413	70555	03023	54147	06647
30014	25879	71763	96679	90603	99396	74557	74224	18211	91637
07265	69563	64268	88802	72264	66540	01782	08396	19251	83613
84404	88642	30263	80310	11522	57810	27627	78376	36240	48952
21778	02085	27762	46097	43324	34354	09369	14966	10158	76089

Table 2.1: TABLE OF RANDOM DIGITS Used For the Example

the SA, it is not used as a sample location and the next random number pair is used. In the example SA, the third random number pair selected (108,13) designated a point outside of the SA and was disregarded.

The plotting procedure was continued until a total of seven valid sample locations were specified on the diagram. Each sampling location was assigned a sample location number. (Any simple numbering system can be used so long as each sample location within a SA receives a unique number.) In the example SA, sample locations were numbered from 201 to 207. The unique non-systematic sample ID numbers for laboratory submission were randomly selected from a TABLE OF RANDOM DIGITS.

CHAPTER 3: LABORATORY QUALITY ASSURANCE

As previously stated, a rigorous quality assurance (QA) program is important to ensure the reliability of results from laboratory analyses. Once a laboratory is chosen from the list in Appendix A, or from subsequent laboratory lists provided by EPA, the implementation of split-sample techniques outlined in this chapter is recommended to monitor laboratory output on a regular basis. If it is not possible to choose a laboratory from this list, Appendix B contains a procedure for evaluating the performance of an unknown laboratory.

A quality assurance program need not be pursued on an individual school basis. In fact, measures described here would be much more effective and useful when applied by a school district or other collection of schools. By utilizing a coordinated quality assurance program, officials from many schools or districts could greatly improve their chances of receiving reliable and consistent laboratory results.

SPLIT-SAMPLE TECHNIQUES FOR QUALITY ASSURANCE

To carry out a successful quality assurance program requires that a certain proportion of samples of suspect materials be split. Therefore, take each bulk sample in large enough quantity to allow it to be divided into two equivalent portions. The two portions are referred to collectively as a split-sample; that is, a split-sample is one sample that has been split into two equivalent parts.

The two portions of a split-sample must not differ from each other in any substantial way, and the amount of material taken for each part of the split-sample should be the same as for regular samples in the overall program. One simple method used for split sampling is to take two samples immediately adjacent to each other and use each as a portion of the split-sample. However, it is crucial that the two "splits" be equivalent material.

Pack the two parts of the split-sample separately in a manner similar to other samples. Affix a unique sample ID number to each sampling container so the laboratory will not know which samples are split-samples. Record the unique sample ID numbers so results can be accurately compared.

The two portions of a split-sample must be analyzed independently of each other, and the results from the two analyses should then be compared. The two samples might be analyzed by two different laboratories. One would be the laboratory that is to carry out the overall program and the second would be a qualified laboratory, either a commercial facility (perhaps a back-up laboratory in the event the other falters and proves unreliable) or a noncommercial facility that is willing to do a small number of samples on a limited basis but unable to handle a large volume. Alternatively, both parts of the split-sample may be submitted to the same lab.

If the two parts of a split-sample are not equivalent, then the results reported by the laboratories may correctly differ significantly one from the other and pose difficult interpretation problems for the school official. The failure of the laboratories to agree in their analyses of the split-samples may require that all samples (split-samples and non split-samples) be reanalyzed.

The laboratory reports for the split-samples will state whether asbestos is present or absent in that sample. It is this point of the analytical report - the presence or absence of asbestos - which should serve as the first focal point for the school official in deciding whether the laboratory performance is acceptable or not for the program.

To aid in this decision, the following procedure is recommended: The laboratory is performing satisfactorily if the number of disagreements (as to presence or absence of asbestos) between the results of the two portions of the split-samples is less than a predetermined critical number. This critical number depends on the number of split-samples analyzed. The following table, based on certain statistical considerations [2], gives the critical number of disagreements for different numbers of split-samples.

Number of Split-Samples	Critical Number of Split-Sample Disagreements
5	2
6 to 8	3
9 to 14	4
15 to 20	5
21 to 25	6

According to this table, if two or more disagreements are observed in five split-samples, or three or more disagreements are observed for six to eight split-samples, etc., then the laboratory's performance is suspect. On the other hand, if the number of disagreements is less than the critical number, the laboratory's performance is satisfactory. <u>However, even if the laboratory is satisfactory, all split-sample results which do not agree must be resolved</u>.

CONTINUING QUALITY ASSURANCE PROGRAM

As previously stated, the procedure for monitoring laboratory performance on an on-going basis includes a certain proportion of split-samples for the purpose of quality assurance. The number of split-samples with differences between the two parts of the split-sample will be monitored as described to determine whether laboratory performance is acceptable.

The number of split-samples that the school official will take will depend on the expected number of samples from the school system. If an unacceptable number of disagreements is noted, then there is reason to suspect the laboratory's performance. In such a situation, it is suggested that the school official ask the laboratory to investigate and correct the cause(s) for these discrepancies. All samples analyzed during the period the laboratory's procedure is suspect must be reanalyzed. Again, even if the laboratory is considered satisfactory, all split-sample results which do not agree must be resolved.

The split-samples in a school should be divided among the sampling areas. That is, all splits in a school should not come from the same Sampling Area, assuming that there is more than one Sampling Area in a school.

The following flowcharts summarize the split-sample procedures under situations with different total numbers of samples. Figure 3.1 (Case 1) is for school programs with less than 25 samples; Figure 3.2 (Case 2) is for school programs with between 25 and 100 samples; and Figure 3.3 (Case 3) is for school programs with greater than 100 samples.

Note, it should be clear in examining the figures that there are several advantages if there is one statewide authority for the purpose of quality assurance monitoring. The effort needed in monitoring will be considerably reduced.

Figure 3.1

Case 1:

Split-Sample Procedures For School Systems For Which Fewer Than 25 Samples Will Be Analyzed

Take a minimum of 5 split-samples for the purpose of monitoring. If the number of split-sample disagreements is 2 or more, the laboratory's performance is suspect. All the samples analyzed during the period when the laboratory's procedure was suspect should be reanalyzed after the laboratory resolves the problems.

If the number of split-sample disagreements is less than two, then the lab performance is considered satisfactory. However, all split-sample disagreements should be resolved. No further monitoring is required for that laboratory.

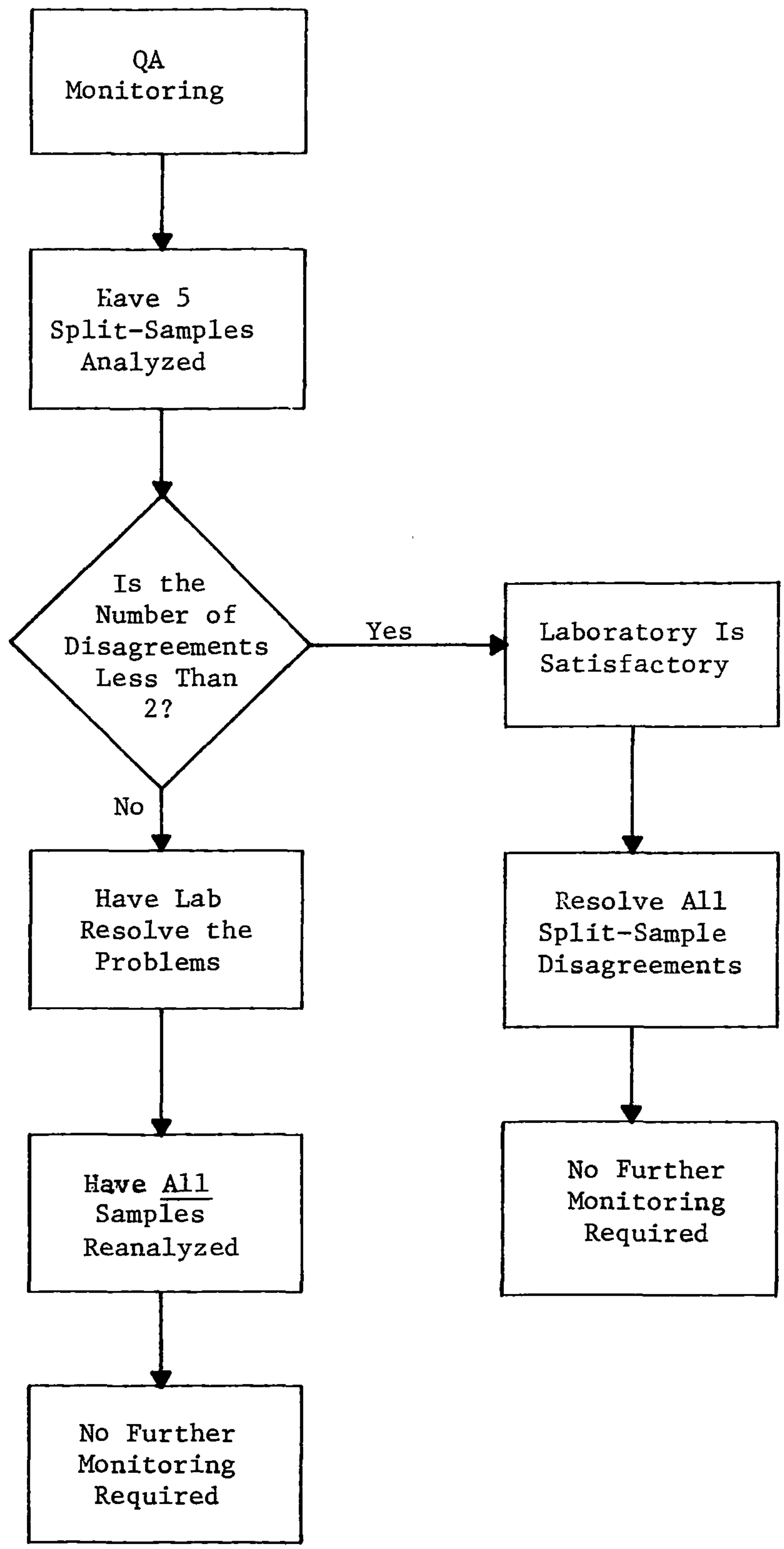


Figure 3.1 Case 1: School Systems For Which Fewer Than 25 Samples Will Be Analyzed

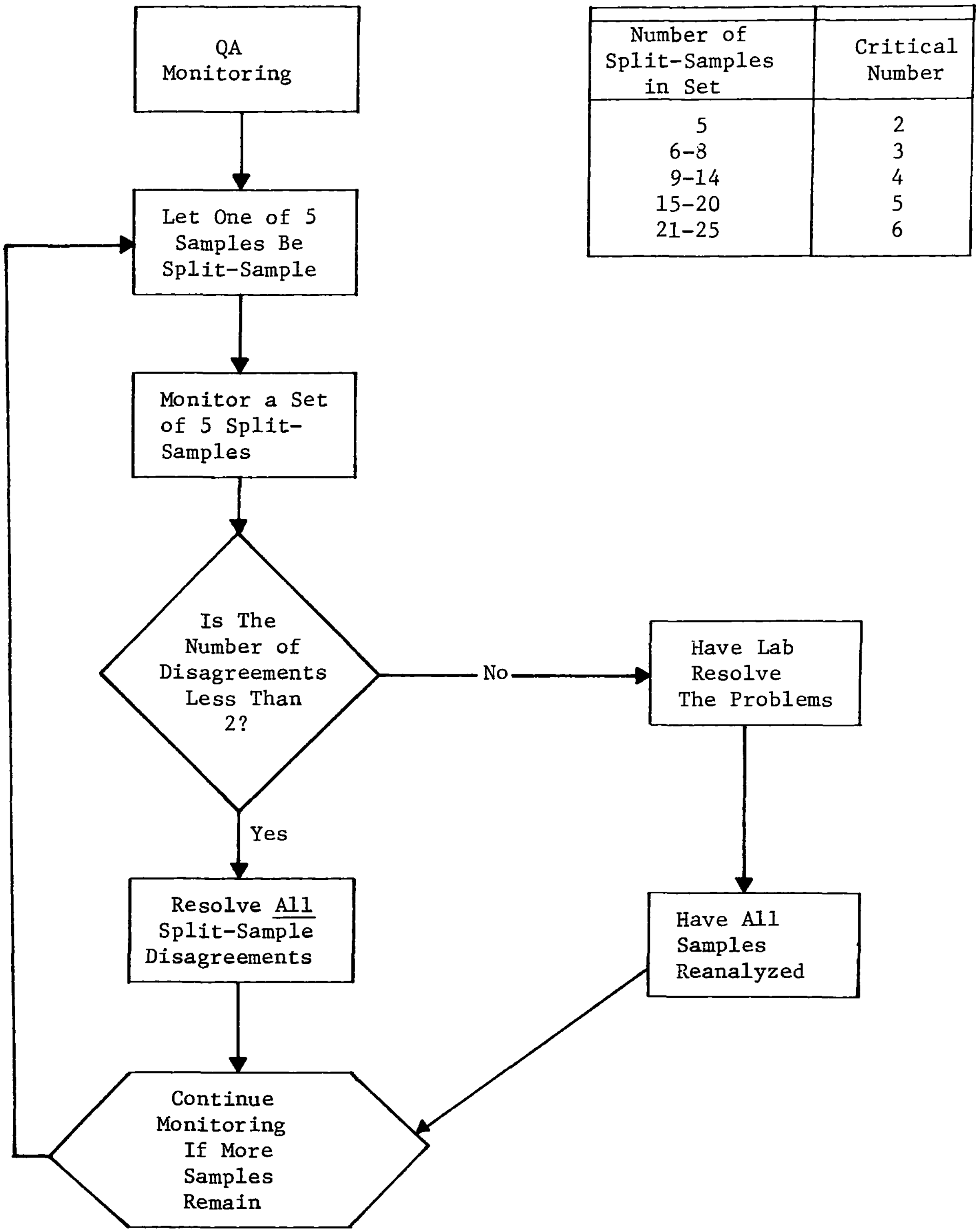
Figure 3.2

Case 2:

Split-Sample Procedures For School Systems With Expected Number of Samples Over 25 But Not Over 100

One out of every 5 samples should be split. The results of each consecutive set of 5 split-samples should be monitored. If 2 or more disagreements are noted, the laboratory must correct the problems and all samples analyzed during the period when the lab procedure was suspect should be reanalyzed.

Figure 3.2 assumes sets of 5 split-samples. If the number of split-samples in a given set is not a multiple of 5, then use the appropriate critical number in the table to determine the unacceptable number of disagreements.



Number of Split-Samples in Set	Critical Number
5	2
6-8	3
9-14	4
15-20	5
21-25	6

Figure 3.2 Case 2: School Systems With Expected Number of Samples Over 25 But Not Over 100

Figure 3.3

Case 3:

Split-Sample Procedures For School Systems With Expected Number of Samples Over 100

Among the first 100 samples, one out of every 5 samples should be a split-sample. For these split-samples, the results of each consecutive set of 5 split-samples should be monitored. If 2 or more disagreements are noted, the lab procedure is suspect. All the samples analyzed during the period when the lab procedure was suspect should be reanalyzed after the laboratory resolves the problems.

After the first 100 samples, the split-sample rate may be reduced to 1 in every 10 samples. Then the results of each consecutive set of 20 split-samples should be monitored. If 5 or more disagreements are noted in the results of any set, the lab procedure may be suspect. If less than 20 split-samples comprise a set, use the appropriate critical number in the table to determine the unacceptable number of disagreements. All the samples analyzed during the period when the lab procedure was suspect should be reanalyzed after the laboratory resolves the problems.

Number of Split-samples In Set	Critical Number
5	2
6-8	3
9-14	4
15-20	5
21-25	6

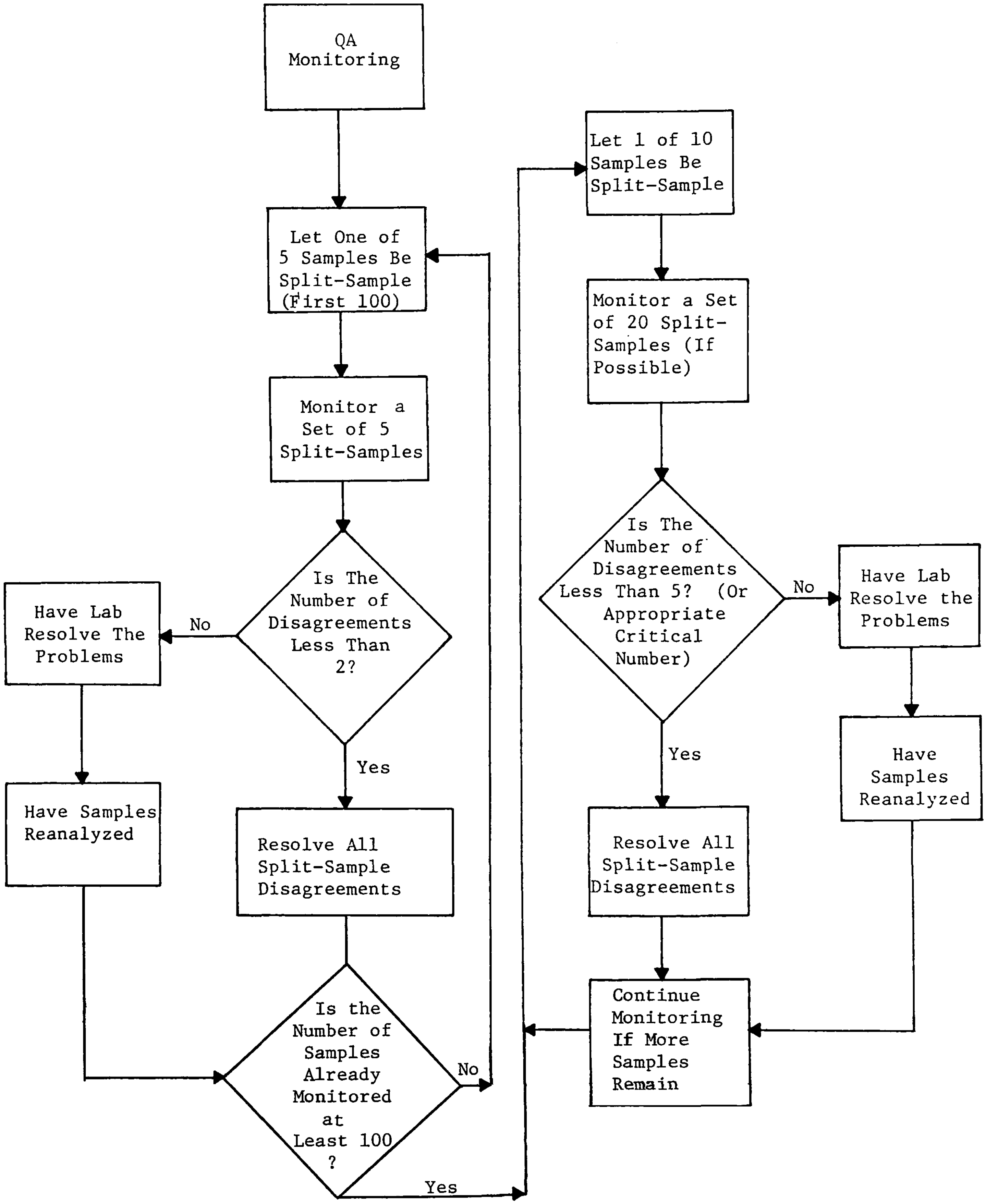


Figure 3.3 Case 3: School Systems With Expected Number of Samples Over 100

CHAPTER 4: LABORATORY ANALYSIS AND STATISTICAL ANALYSIS

Now that the asbestos analytical program is established and samples have been collected, the "blind" samples are sent to a qualified laboratory for analysis. To ensure completeness and consistency in the data received from laboratories, this chapter provides a LABORATORY DATA SHEET which should accompany all samples.

When the analytical results are received, the asbestos analytical program coordinator will need to interpret them. A simple statistical analysis technique is provided to facilitate this process.

The calculation of 90% confidence intervals as outlined below provides interval estimates of the asbestos content in each Sampling Area. The meaning of this estimate can be described as follows. If sampling is repeated 100 times and a confidence interval is calculated each time, then 90 of the 100 confidence intervals for the Sampling Area will contain the true average concentration of asbestos in that Sampling Area.

FORWARDING SAMPLES TO LABORATORY

It is very important to obtain complete and accurate information from the analytical laboratories. To ensure that goal, a sample laboratory reporting form is provided. Pertinent requested information includes:

(1) The Sample Identification Number

The analyst should not know whether he or she is running a routine sample or a sample which has been selected for split-sample analysis. To assure that all samples are run "blind", label the sampling containers with only the unique sample identification number assigned by the asbestos analytical program coordinator. Do not use sample location numbers.

(2) The Analytical Method(s) Used In the Analysis

The method of choice is polarized light microscopy with or without dispersion staining and X-ray diffraction as appropriate (see [3] and Appendix H of [1]).

(3) Sample Appearance

A comment should be made on the homogeneity of the sample and the steps taken to assure that proper analytical sampling was employed. If the analyst selects only fibrous-looking particles from the sample submitted for analysis, he or she is apt to miss small pea-like coated aggregates of asbestos which were formed during the spray-on procedure at the time of application. Improper sampling by the analyst may result in a false negative, i.e., reporting no asbestos present when it is in the sample. Several slides may be required for accurate analysis of the sample.

(4) Sample Treatment

Some analysts prepare the sample by grinding or washing prior to microscopic analysis. This process should be briefly described.

(5) Amount of Material Examined

The analyst should estimate the total number of milligrams of material examined.

(6) Type and Percent of Asbestos Present

The analyst should identify all asbestos fibrous materials and estimate the percent of each type present and specify associated precision.

(7) Percent Total Asbestos Present in Sample

The analyst should record the percent of total asbestos present (all types) in the sample.

(8) Type(s) and Amount(s) of Other Fibrous Materials

The non-asbestos fibrous materials should be identified by the analyst as to type(s) with an estimate of the amount of each type present. The precision to be associated with the percentage reported should also be specified. The basis for that judgment and characterization should be provided. Such verification may help to minimize the reporting of false negatives (i.e., reporting asbestos as cellulose) or false positives (i.e., reporting fiberglass as chrysotile).

(9) Type(s) and Amount(s) of Nonfibrous Material Present

The nonfibrous materials should be identified by the analyst with an estimate of the amount of each present.

(10) Description of Method of Quantitation

The analyst should briefly describe the quantitation technique employed.

(11) Description of Laboratory's Quality Control Program

The laboratory should give appropriate comments on their in-house "good laboratory practices" that provide quality control for their PLM analyses including the number of slides per sample and the number of splits per set.

LABORATORY DATA SHEET

Sample ID #								
Laboratory Sample ID #								
Analytical Method (enter number)	1. PLM 2. PLM + dispersion staining 3. X-ray diffraction							
Gross Sample Appearance (enter number; note color)	1. Homogeneous, fibrous 2. Homogeneous, nonfibrous 3. Heterogeneous, fibrous 4. Heterogeneous, nonfibrous 5. Heterogeneous, mixed							
Sample Treatment (enter number)	1. Homogenized 2. Untreated 3. Other, *specify*							
Total Amount of Material Examined (mg)								
Asbestos Present (enter number and percent)	1. Amosite 2. Chrysotile 3. Crocidolite 4. Other, *specify*							
Percent Total Asbestos Present in Sample								
Other Fibrous Materials Present (enter number and percent)	1. Fiberglass 2. Mineral Wool 3. Cellulose 4. Other, *specify*							
Nonfibrous Materials Present (enter description below by number and percent in columns)	1. 2. 3. 4. 5.							

(Continued: Please provide requested information on reverse side of this form.)

Description of Method of Quantitation

Description of Quality Control Program (e.g., # slides/sample, # splits/set)

Comments

Analyst's Name:

Analyst's Telephone Number:

Confirmation By:

Report Reviewed By:

Address Correction, Please:

Return Laboratory Forms to:

STATISTICAL ANALYSIS OF LABORATORY RESULTS

Because of the imperfection of the analytical techniques currently available for bulk sample analysis and the heterogeneous nature of these friable materials, it is not unusual to get a range of results reported by the laboratory on samples taken from within a single Sampling Area. It would be unusual for the asbestos concentrations for all three, five, or seven samples reported to be within a few percent of each other.

For that reason, a statistical analysis must be performed to compute a confidence interval for the average percentage of asbestos within a Sampling Area. The procedure outlined below was developed to be simple and easy-to-follow and is accompanied by a brief explanation.

Use the confidence interval to reach a conclusion as to the presence or absence of asbestos in the Sampling Area. If the entire confidence interval is below 1%, then conclude that asbestos is not present. If the entire confidence interval is above 1%, then conclude that asbestos is present. If the confidence interval contains the value 1%, then there is still some question as to the presence or absence of asbestos in the Sampling Area.

Note that the confidence interval's upper bound can be interpreted as a maximum probable value. To narrow the confidence interval, it would be necessary to take a second series of samples. In most situations, obtaining a more precise estimate when the maximum probable value is small would not normally warrant the additional expense involved in a second series of samples.

If it is concluded that asbestos is present in the Sampling Area, then the potential exposure of users of the building should be evaluated and a decision on corrective action should be made according to the guidelines presented in Asbestos-Containing Materials in School Buildings: A Guidance Document, Part 1 [1].

A STATISTICS COMPUTATION WORKSHEET and instructions are provided in this section. A completed WORKSHEET is also shown. In these calculations, use the value for percent asbestos from the line on the LABORATORY DATA SHEET titled "Percent Total Asbestos Present in Sample". Compute one confidence interval for each Sampling Area.

INSTRUCTIONS FOR STATISTICS COMPUTATION WORKSHEET AND EXAMPLE

I. List the results of the laboratory analysis of the friable material for the Sampling Area. There should be 3, 5 or 7 observations to enter in column (A). The order of entry is unimportant. In column (B) enter the square of the number in column (A). Sum both columns.

For Example:

No.	(A) Percent Asbestos	(B) Squares of Column (A)
1	15	225
2	30	900
3	25	625
4	25	625
5	35	1,225
6	0	0
7	22	484
	(A) 152 %	(B) 4,084

II. Enter the number of observations. Should be 3, 5, or 7.

For Example: From above N = 7

III. The mean is the sum of the observations divided by the number of observations.

For Example: $\text{Mean} = \frac{(A)}{N} = \frac{(A)\ 152\ \%}{N = 7} = 21.71\ \%$

IV. The variance (V) is a measure of precision and is calculated according to the formula below.

For Example: $$V = \frac{1}{N-1}\left[(B) - \frac{(A)^2}{N}\right]$$

$$= \frac{1}{7-1}\left[4{,}084 - \frac{152 \times 152}{7}\right]$$

$$= \frac{1}{6}\left[4{,}084 - 3300.57\right]$$

$$= \frac{783.43}{6}$$

$$V = 130.57$$

V. The standard deviation (SD) is the square root of the sample variance.

For Example: SD = $\sqrt{V}$ = $\sqrt{130.57}$

SD = 11.43 %

VI. The half-range (HR) depends on the number of observations, and is the product of the standard deviation (SD) and one of the following constants.

If N =	then HR = (SD) times
3	1.69
5	0.95
7	0.73

For Example: HR = (SD) 11.43 % x 0.73 (N = 7)

= 8.34 %.

VII. Confidence bounds are the upper and lower limits of the confidence interval and are found by subtracting the half-range from the mean to obtain the lower confidence bound, and adding the half-range to the mean to get the upper confidence bound.

For Example:

Lower Confidence Bound = (Mean) 21.71 % - (HR) 8.34 %

= (LCB) 13.37 %

Upper Confidence Bound = (Mean) 21.71 % + (HR) 8.34 %

= (UCB) 30.05 %

VIII. The 90% Confidence Interval (CI) consists of all the numbers between the upper and lower confidence bounds.

For Example: 90% CI = ((LCB) 13.37 %, (UCB) 30.05 %)

NOTE: Negative values can be achieved through this statistical analysis process. Since there obviously cannot be a negative concentration of asbestos in a ceiling, all negative values should be considered equivalent to zero.

IX.

If the 90% CI	Then Conclude
is below 1%	asbestos absent
is above 1%	asbestos present
contains 1%	uncertain

For Example: The 90% CI (13.37%, 30.05%) is completely above 1%, conclude that asbestos is present.

X. The maximum probable value equals the upper confidence bound (UCB), in this case, 30.05 %.

STATISTICS COMPUTATION WORKSHEET

SAMPLING AREA ID # ____

I.

No.	(A) Percent Asbestos	(B) Squares of Column (A)
1		
2		
3		
4		
5		
6		
7		

Total (A) __________% (B) ______________

II. No. of observations (3, 5, or 7), N = ______

III. Mean $= \frac{(A)}{N} = \frac{\text{Sum of Column (A)}}{\text{Total No. Observations}} =$ ______% = %

IV. Variance (V) $= \frac{1}{N-1} \left[(B) - \frac{(A)^2}{N} \right]$

$$= \frac{1}{\square} \left[\boxed{(B)} - \frac{\boxed{(A)}^2}{\square} \right]$$

= ________

V. Standard Deviation (SD) $= \sqrt{V} = \sqrt{\quad}$

= ______%

VI. The half-range (HR)

If N =	then HR = (SD) times
3	1.69
5	0.95
7	0.73

HR = (SD) ______% x ______ = ______ %

VII. Confidence Bounds

Lower Confidence Bound (LCB) = Mean - HR
= Mean ______% - HR ______%
= (LCB) ______%

Upper Confidence Bound (UCB) = Mean + Half-range
= Mean ______% + HR ______%
= (UCB) ______%

(continued)

VIII. The 90% Confidence Interval

90% CI = [(LCB), (UCB)] = [________%, ________%]

IX. The 90% CI ☐ is below 1%. Conclude asbestos absent.

☐ is above 1%. Conclude asbestos present.

☐ contains 1%. Uncertain.

X. Maximum Probable Value = (UCB) = ________%.

EXAMPLE STATISTICS COMPUTATION WORKSHEET

SAMPLING AREA ID # 2

I.

No.	(A) Percent Asbestos	(B) Squares of Column (A)
1	15	225
2	30	900
3	25	625
4	25	625
5	35	1,225
6	0	0
7	22	484

Total (A) 152 % (B) 4,084

II. No. of observations (3, 5, or 7), N = 7

III. $\text{Mean} = \frac{(A)}{N} = \frac{\text{Sum of Column (A)}}{\text{Total No. Observations}} = \frac{152}{7}\ \% = 21.71\%$

IV. $\text{Variance (V)} = \frac{1}{N-1}\left[(B) - \frac{(A)^2}{N} \right]$

$$= \frac{1}{\boxed{6}} \left[\boxed{(B)\ 4{,}084} - \frac{\boxed{(A)\ 152}^2}{\boxed{7}} \right]$$

= 130.57

V. Standard Deviation (SD) = $\sqrt{V}$ = $\sqrt{130.57}$

= 11.43 %

VI. The half-range (HR)

If N =	then HR = (SD) times
3	1.69
5	0.95
7	0.73

HR = (SD) 11.43 % x 0.73 = 8.34 %

VII. Confidence Bounds

Lower Confidence Bound (LCB) = Mean - HR
= Mean 21.71 % - HR 8.34 %
= (LCB) 13.37 %

Upper Confidence Bound (UCB) = Mean + Half-range
= Mean 21.71 % + HR 8.34 %
= (UCB) 30.05 %

(continued)

VIII. The 90% Confidence Interval

90% CI = [(LCB), (UCB)] = [13.37 %, 30.05 %]

IX. The 90% CI

- [ ] is below 1%. Conclude asbestos absent.
- [x] is above 1%. Conclude asbestos present.
- [ ] contains 1%. Uncertain.

X. Maximum Probable Value = (UCB) = 30.05 %.

REFERENCES

[1] Asbestos-Containing Materials in School Buildings: A Guidance Document, Part 1. Office of Pesticides and Toxic Substances, United States Environmental Protection Agency, March 1979.

[2] Lucas, D., A. V. Rao and T. D. Hartwell, Asbestos-Containing Materials in School Buildings: Guidance for Asbestos Analytical Programs. Background Document. Research Triangle Institute, Research Triangle Park, North Carolina, December 1980.

[3] Interim Method for the Determination of Asbestiform Minerals in Bulk Insulation Samples. Environmental Monitoring Systems Laboratory and Office of Pesticides and Toxic Substances, United States Environmental Protection Agency, June 1980.

[4] Brantly, E.P. Jr., and D.E. Lentzen, Asbestos Containing Material in School Buildings: Bulk Sample Analysis Quality Assurance Program. EPA-560/13-80-23. Office of Pesticides and Toxic Substances, United States Environmental Protection Agency, August 1980.

APPENDIX A: EPA-Sponsored Analytical Proficiency Program For Asbestos Bulk Sample Analysis

APPENDIX A

EPA-Sponsored Analytical Proficiency Program For Asbestos Bulk Sample Analysis

Growing public concern with the effects of exposure to asbestos fibers has resulted in a greatly increased demand for laboratory analysis to determine the content of bulk insulation samples. In the course of the Environmental Protection Agency school asbestos program, many differences have been noted in analytical services contracted for by public school systems. Discrepancies among laboratories may be attributed to variations in analytical methods, lack of appropriate reference standards, and inadequate reporting of analytical results.

Polarized light microscopy (PLM) is the EPA method of choice for detecting asbestos in bulk insulation samples [1]. EPA is sponsoring an analytical proficiency program directed at qualifying, to a limited extent, the services provided by commercial laboratories claiming capability in PLM analysis. Commercial and noncommercial laboratories were invited to participate in the program. Accepting laboratories were provided with four characterized samples and their analytical reports were compared with reference analyses. This was not an accreditation program and did not seek to certify or endorse participating laboratories. A performance rating based on a fairly lenient criterion was determined for each laboratory.

Laboratories had been notified at the start of the project that such a rating would be made. Participation in the program was required for laboratories to be included on the published listing.

Four bulk samples were sent to each laboratory. Two contained asbestos fibers, anthophyllite and chrysotile, and two were non-asbestos fiber materials, mineral wool and fiberglass, commonly found in insulations. The samples were doublebagged, coded, and packaged with a reporting form and instructions for analysis. Sample packages were mailed on December 28, 1979, to all laboratories on the source listing.

Seventy-one percent of the laboratories contacted reported results including 52 of 72 commercial labs and 23 of 34 noncommercial labs. Results included were received on or before January 25, 1980. For the 300 (75 x 4) samples analyzed, no false negatives and only two false positives were reported. Mineral wool (Sample 1) was incorrectly identified by one laboratory as crocidolite and by another laboratory as amosite. The other 73 laboratories correctly identified Sample 1 as either mineral wool, fiberglass or glass wool.

Anthophyllite-asbestos was frequently misidentified as either amosite (15 labs) or tremolite (10 labs). This was most likely due to unfamiliarity with anthophyllite-asbestos because no standard reference samples exist and it is not commonly found in insulation materials. Fiberglass was identified as fiberglass, mineral wool, or glass wool by all laboratories. Chrysotile was properly identified by all laboratories. Chrysotile is the most common asbestos fiber found in insulation materials.

The laboratories estimated the relative amounts of sample constituents. These estimates were averaged for each sample lot, disregarding errors in fiber identification. Means and standard deviations were included on reports to the laboratories. The distribution of quantitative estimates were recorded on histograms in 5 percent intervals. The histograms were included on individual reports to allow laboratories to place themselves within the distribution. Because of the lack of an accepted quantitation procedure, values reported were not used in rating laboratory performance.

Reports were issued to individual laboratories on March 25, 1980 (commercial), and April 3, 1980 (noncommercial). Reports included the results of reference analyses, data reported by the individual laboratory, and summary data on quantitative estimates. An example of the reports to laboratories is shown in Figure A-1.

A listing of laboratories which participated in the quality assurance program is included in this appendix.

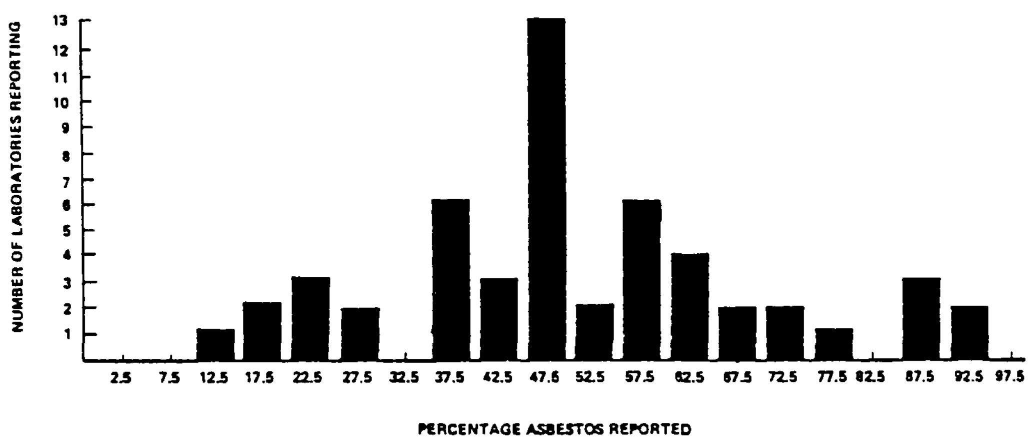
Updated lists of participants in subsequent rounds may be obtained by calling the EPA toll-free number for technical assistance, 1-800-334-8571.

ASBESTOS BULK SAMPLE ANALYSIS PROGRAM
RESULTS OF ROUND 1

Sample I.D. #:	220	801	273	854
Asbestos Present (%)				
Laboratory report	0	75 anthophyllite	0	95 chrysotile
Reference report	0	53 anthophyllite	0	95 chrysotile
Other Fibrous Material (%)				
Laboratory report	100 mineral wool	0	95 fiberglass	0
Reference report	98 mineral wool	0	98 fiberglass	0
Summary of Laboratories Reporting:				
Mean % (Standard deviation)				
Asbestos present	0 (0)	53.0 (19.3)	0 (0)	84.5 (17.4)
Other fibrous material	96.1 (5.4)	1.4 (7.1)	97.7 (4.0)	1.2 (3.1)

Distribution of Asbestos Quantitation

Sample I.D. #: 801



Sample I.D. #: 854

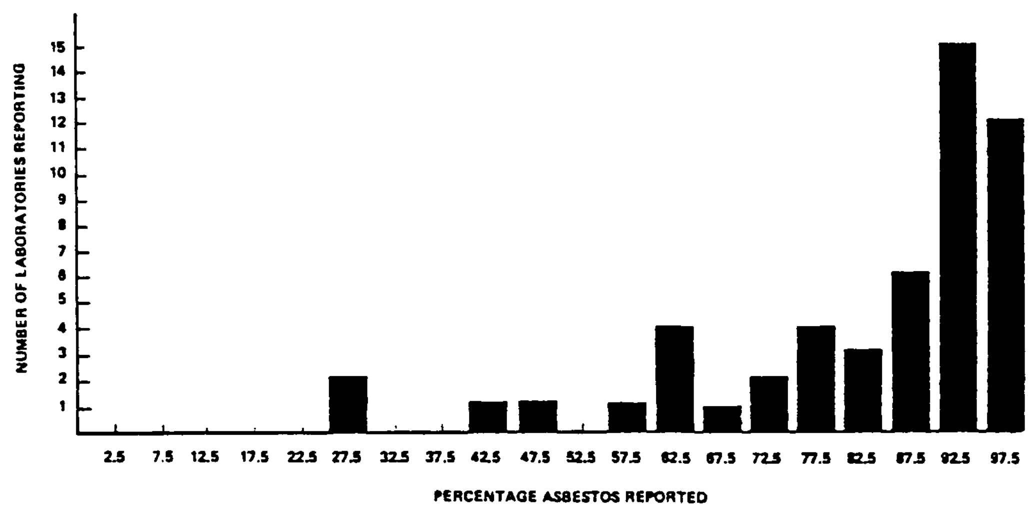


Figure A-1: Example of Reports to Laboratories

LABORATORIES PARTICIPATING IN THE ANALYTICAL PROFICIENCY PROGRAM

	# Correct/ 4 Samples
American Can Company Safety & Industrial Hygiene Laboratory U.S. Highway 22 Union, New Jersey 07083	4/4
American Microscopy Laboratory D. 3410 12th Avenue E. Tuscaloosa, Alabama 35405	4/4
Analytical Center, Inc. P. O. Box 15635 Houston, Texas 77020	4/4
Boeing Technology Services 9R-25 P. O. Box 3707 Seattle, Washington, 98124	4/4
Brewer Analytical Laboratories 311 Pacific Street Honolulu, Hawaii 96810	4/4
C.E.D., Inc. Environmental Microscopy International 135 West Cutting Boulevard Richmond, California 94804	4/4
Casalina Associates, Inc. 47-345 Mahakea Road Kaneohe, Hawaii 96744	4/4
Certified Testing Laboratories, Inc. 2905 East Century Boulevard South Gate, California 90280	4/4
Clayton Environmental Counsultants, Inc. 25711 Southfield Road Southfield, Michigan 48075	4/4
Colorado School of Mines Research Institute P. O. Box 112 Golden, Colorado 80401	4/4
Fay Goldblatt 407 N. Butrick Street Waukegan, Illinois 60085	4/4

	# Correct/ 4 Samples
Continental Technical Services Environmental Health Division 9742 Skillman Dallas, Texas 75243	4/4
Department of Chemistry New Jersey Institute of Technology 323 High Street Newark, New Jersey 07102	4/4
Department of Geological Sciences SUNY, New Paltz New Paltz, New York 12562	4/4
Department of Geology Illinois State University Normal, Illinois 61761	4/4
Eastern Analytical Laboratories One "A" Street Burlington, Massachusetts 01803	4/4
EMS Laboratories 12563 Crenshaw Boulevard Hawthorne, California 90250	4/4
EMV Associates, Inc. Microanalysis Laboratory 15825 Shady Grove Road Rockville, Maryland 20850	4/4
Environment/One Corporation 2773 Balltown Road Schenectady, New York 12301	4/4
Environmental Consulting & Testing Services P. O. Box 3521 Cherry Hill, New Jersey 08034	3/4
Environmental Health Services, Inc. 5206 Lindbergh Boulevard W. Carollton, Ohio 45449	4/4
Erie Testing Laboratories 2401 W. 26th Street Erie, Pennsylvania 16506	4/4
Erlin, Hime Associates 811 Skokie Boulevard Northbrook, Illinois 60062	4/4

	# Correct/ 4 Samples
GCA Corporation Technology Division Burlington Road Bedford, Massachusetts 01730	4/4
Geoscience Consultants, Inc. P. O. Box 341366 Coral Gables, Florida 33134	4/4
Hager Laboratories 12000 E. 47th Avenue Denver, Colorado 80239	4/4
Health Science Associates Suite B/C 10941 Bloomfield Street Los Alamitos, California 90720	4/4
Herron Testing Laboratories 5405 Schaaf Road Cleveland, Ohio 44131	4/4
IIT Research Institute 10 West 35th Street Chicago, Illinois 60616	4/4
Industrial Analytical Laboratory 1523 Kalakaua Avenue Suite 101 Honolulu, Hawaii 96826	4/4
Industrial Hygienics, Inc. 755 New York Avenue Huntington, New York 11743	4/4
Industrial Testing Laboratories, Inc. 2350 Seventh Boulevard St. Louis, Missouri 63104	4/4
Inter-City Testing & Consulting Corporation P. O. Drawer "O" 609 Middle Neck Road Great Neck, New York 11023	4/4
Interscience Research 2614 Wyoming Avenue Norfolk, Virginia 23513	4/4

	# Correct/ 4 Samples
Jesse H. Bidanset & Associates, Inc. P. O. Drawer "O" 609 Middle Neck Road Great Neck, New York 11023	4/4
Law Engineering Testing Company 3301 Winton Road Raleigh, North Carolina 27619	4/4
LFE Corporation Environmental Analysis Lab Division 2030 Wright Avenue Richmond, California 94804	4/4
Maryland Mineral Analysis Laboratory Department of Geology University of Maryland College Park, Maryland 20740	4/4
MJH Associates Mineralogical Consultants 13345 Foliage Avenue Apply Valley, Minnesota 55124	4/4
Northrop Services, Inc. P. O. Box 12313 Research Triangle Park, North Carolina 27709	4/4
PEDCo Environmental, Inc. 11499 Chester Road Cincinnati, Ohio 45246	4/4
Princeton Testing Laboratory P. O. Box 3108 Princeton, New Jersey 08540	3/4
R. J. Kuryvial & Associates Mineralogy/Microscopy Consultants 12185 W. 29th Place Lakewood, Colorado 80215	4/4
Southwestern Laboratories P. O. Box 10687 Dallas, Texas 75207	4/4
St. Paul Fire & Marine Environmental Services Analytical Laboratory 494 Metro Square Building 7th and Robert Streets St. Paul, Minnesota 55101	4/4

	# Correct/ 4 Samples
Sunbelt Associates, Inc. 6961 Mayo Road New Orleans, Louisiana 70126	4/4
Thomas A. Kubic & Associates 8 Pine Hill Court Northport, New York 11768	4/4
Tri-State Laboratories, Inc. 54 Westchester Drive Austintown, Ohio 44515	4/4
Truesdail Laboratories, Inc. 4101 N. Figueroa Street Los Angeles, California 90065	4/4
United States Testing Company, Inc. 1415 Park Avenue Hoboken, New Jersey 07030	4/4
Utah Biomedical Test Laboratory 520 Wakara Way Salt Lake City, Utah 84108	4/4
Walter McCrone Associates, Inc. 2820 S. Michigan Avenue Chicago, Illinois 60616	4/4
Wausau Insurance Companies Environmental Health Laboratory 2000 Westwood Drive Wausau, Wisconsin 54401	4/4

APPENDIX B: QUALITY ASSURANCE PROGRAM FOR INITIAL LABORATORY EVALUATION

APPENDIX B

Quality Assurance Program For Initial Laboratory Evaluation

A laboratory must document its experience with PLM and XRD prior to being used in a school's asbestos analytical program. All the laboratories on the list in Appendix A have demonstrated proficiency with these analytical techniques and should be utilized by school systems.

In the event that a state or school district selects a laboratory not on the list which does not have documented evidence of successful bulk sample analysis using PLM/XRD, the following laboratory evaluation procedure is suggested as a model for initial quality assurance.

Following the split-sample guidance offered in Chapter 3, use a minimum of twenty-five split-samples for judging the acceptability of a laboratory's performance. If the number of disagreements is more than 6, then the laboratory's performance is suspect. There may be situations in which it is not possible to have twenty-five split-samples, but the school official would like to have independent evidence of the performance of the laboratory. In such situations, analyze a minimum of five split-samples. If two or more disagreements are observed in these five split-samples, the laboratory's performance will be considered suspect.

The school official has two options. If the results of the split-sample analyses are unsatisfactory, reject the laboratory(ies) involved and identify other possible candidate laboratories. The second option is, encourage the laboratory to resolve the analytical problems surrounding the disagreements. When the laboratory has identified and corrected the problem, re-submit a new set of split-samples and again compare the analytical results in order to ensure that the problem has been resolved. Of course, if the official is still uneasy after sending several split-samples to a laboratory, he or she may opt to split every sample that they send to the laboratory.

In either case -- identifying new laboratories or resolving the problems at hand with previously selected laboratories -- the school official should not forward large numbers of samples for analysis until a laboratory has been determined to be acceptable in its analytical performance.

Figures B.1 and B.2 summarize the requirements for initial quality assurance under two different situations; namely, school systems with less than 25 samples and school systems with greater than 25 samples.

Number of Split-Samples	Critical** Number
5	2
6-8	3
9-14	4
15-20	5
21-25	6

All samples must be split-samples. (A minimum of 5 split-samples should be analyzed.) If the number of disagreements is equal to or greather than the critical number of disagreements, the lab is suspect. All samples must be reanalyzed either by the lab in question (after the problems are resolved) or by another lab.

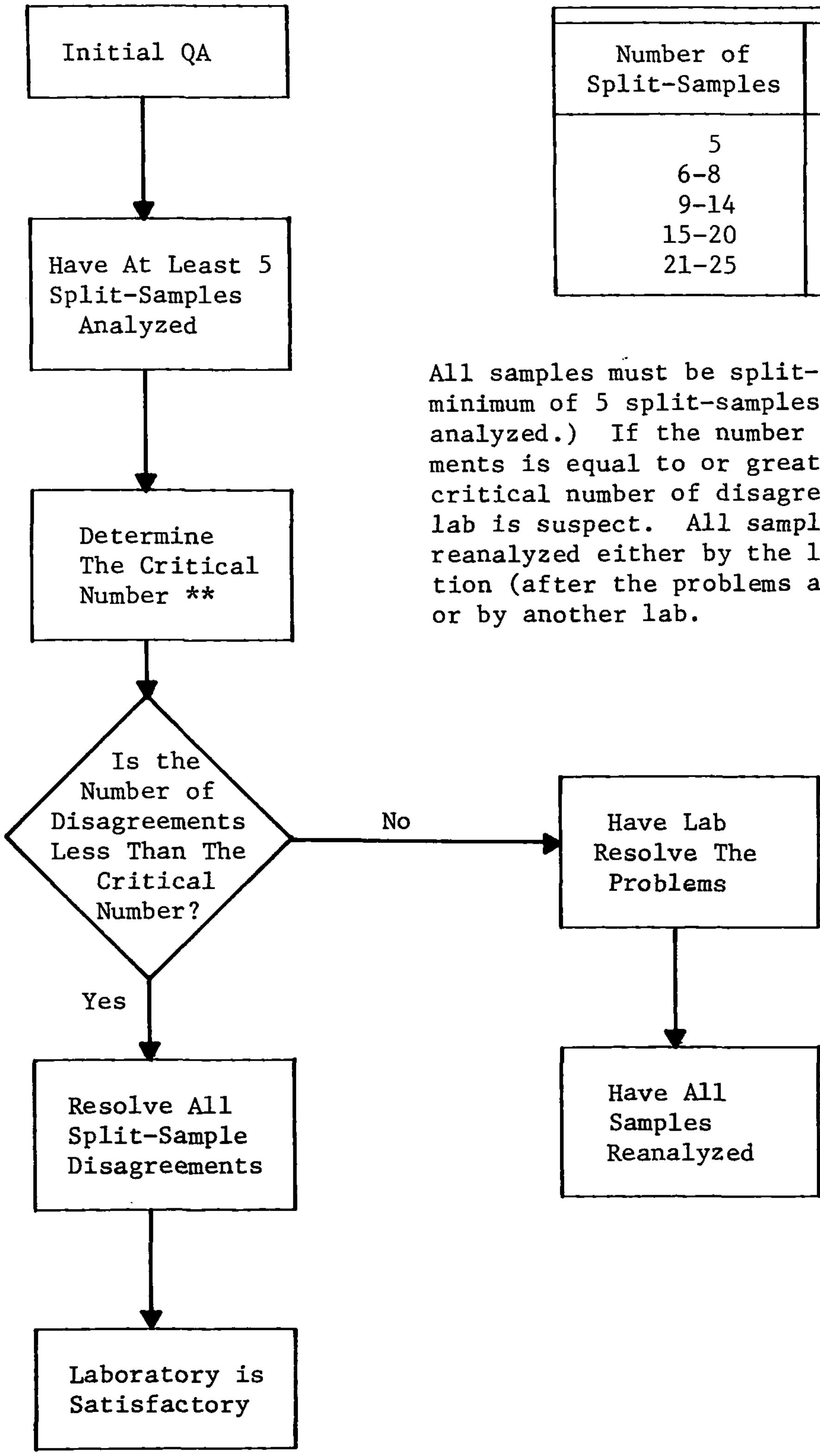


Figure B.1 Case 1: School Systems For Which Fewer Than 25 Samples Will Be Analyzed

Twenty-five samples should be split-samples. If 6 or more disagreements are observed in the results of these 25 split-samples, the laboratory's performance is suspect. In this case, reanalyze the samples in that lab after the problems are resolved, or in another lab until the differences are resolved.

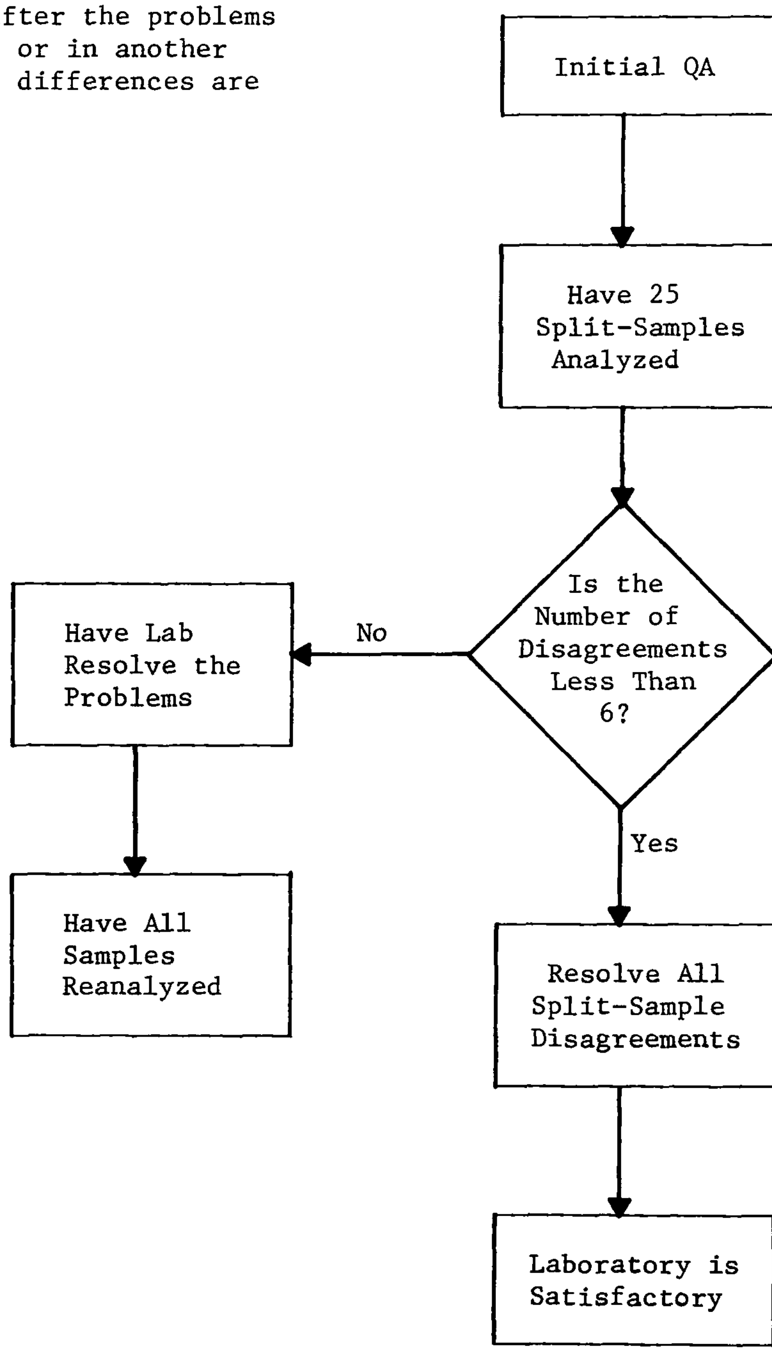


Figure B.2 Case 2: School Systems With Expected Number of Samples Over 25

APPENDIX C: HOW TO USE THE TABLE OF RANDOM DIGITS

APPENDIX C

Table of Random Digits

The Table of Random Digits

(1) Begin on the first line in the upper left-hand corner of the table.

(2) Proceed horizontally line by line as if reading a book.

(3) Cross off or circle each digit as it is used. This prevents using the same digit more than once and also is a marker that tells where the last digit used was located and that the following digit is the next digit to use.

(4) The first number of a random number pair is to be between 0 and the rectangle length, where the rectangle length is the number of feet along the base of the rectangle.

(5) If the length is less than or equal to 9, follow instruction (5)a. If the length is less than or equal to 99 but greater than 9, follow instruction (5)b. If the length is less than or equal to 999 but greater than 99, follow instruction (5)c. If the length is less than or equal to 9,999 but greater than 999, follow instruction (5)d.

a. Select a one-digit random number from the table. If the number is less than or equal to the length, then circle the digit and use the selected number. If the number is greater than the length, then cross the digit off the table and repeat instruction (5)a.

b. Select a two-digit random number from the table. If the number is less than or equal to the length, then circle the digits and use the selected number. If the number is greater than the length, then cross the digits off the table and repeat instruction (5)b.

c. Select a three-digit random number from the table. If the number is less than or equal to the length, then circle the digits and use the selected number. If the number is greater than the length, then cross the digits off the table and repeat instruction (5)c.

d. Proceed as in instruction (5)c, but select four-digit random numbers instead of three-digit random numbers from the table.

(6) The second number of a random number pair is to be between 0 and the rectangle height, where the rectangle height is the number of feet along the side of the rectangle.

(7) To select a random number between 0 and the rectangle height, follow instruction (5), using height wherever instruction (5) specifies length.

(8) Repeat instructions (4), (5), (6), and (7) until all sample locations have been selected.

TABLE OF RANDOM DIGITS

44582	46158	74093	59121	03692	64813	56617	72993	66590	38058
11784	55778	96965	77810	28022	82425	97392	39476	95151	72894
99467	43708	60959	43228	56188	98074	89262	81629	51108	67418
90320	11450	73504	86473	51064	47355	62408	78119	07511	78476
06734	40248	77182	05454	20024	26053	13507	27746	72340	77341
82283	16274	09896	94822	62222	66638	68755	71100	92155	42435
51551	55040	81801	37118	71410	00794	71918	36927	07989	49983
30133	39596	45464	86248	93148	44411	74090	79115	65126	47529
92677	88177	70879	86262	94259	94425	29510	64693	71494	76666
20634	56942	49147	06248	76430	05003	72932	14219	13357	07189
08361	25792	30352	54229	53236	94426	77004	05433	00344	78295
13302	02709	30614	30335	40006	04093	07178	41372	72597	22166
18222	53745	08060	08712	56392	87580	23034	55944	90350	53690
65099	27691	45346	50864	20147	42495	47582	03439	32451	93211
64133	99840	50925	39609	08126	56368	72383	28310	10877	67532
07765	11446	36839	00489	88258	32257	35044	28220	16318	63172
86522	81825	13175	64851	08704	89514	96470	08114	36113	48110
97368	79881	10561	68625	60526	67411	09184	24437	45333	55607
32443	94023	28821	42701	58581	19811	42181	61941	08487	31468
33031	64521	86988	73789	28505	42204	02517	77293	98604	94733
74697	72451	05019	10565	29076	09914	28512	75211	92115	43363
78918	04504	88179	33101	23620	53718	55562	98261	31001	29718
36213	47336	07554	52634	72398	42061	77639	49208	81819	00403
04034	34973	42422	99407	80696	99841	11789	08289	34200	92468
06738	25056	07063	41729	82225	35912	99622	80506	90053	17421
29556	67044	13303	41677	12570	05242	46668	48845	09351	20785
81832	00308	94554	40814	58271	51033	28225	28064	16880	15286
11699	40232	81608	95101	07853	48490	40069	82796	68081	34319
78536	25859	81910	42731	38146	27317	23664	93340	79871	44193
45357	95941	13175	59939	39556	86303	06350	46941	78486	26193
91745	99309	09543	38282	14598	28129	31073	87258	56462	44062
63150	41097	45876	87587	15919	53571	41519	82838	89215	59770
78706	82406	75403	52466	25138	21409	90490	92092	54212	59940
59656	00816	87648	64644	22866	98689	46717	58949	90949	64380
25122	39001	12244	93763	26217	68717	16188	02145	97902	50149
90048	70633	62174	06914	82768	62243	36682	93485	63136	70143
02444	92190	62427	85667	40884	17930	45671	28713	53460	76216
71285	96559	04405	68298	03070	87508	97855	21833	06881	32352
54442	26299	19385	79929	96552	86418	21539	95381	37457	50425
91806	60730	94109	13507	51182	31990	71202	32365	74616	99592
47900	04052	27184	67140	66333	21785	73333	01556	53675	21605
06884	46248	52972	63320	06351	46409	58128	21791	70982	71557
63232	28448	16119	73968	50564	32583	24189	15900	80466	82194
82633	53703	05848	89692	55194	28290	22382	00717	68939	49539
01007	38553	00993	33323	94835	76620	63754	19570	64557	42351
87049	98691	32243	81284	95851	50037	83905	65371	78121	12498
47465	74463	08384	91756	04492	36274	05635	85528	36472	40136
05479	75460	63621	05928	43283	65080	80680	11215	88705	28273
70796	68225	16339	64992	96378	02442	10670	80181	11517	81744
99193	15667	64280	75582	56897	81094	38630	74347	61703	65114

TABLE OF RANDOM DIGITS

56627	89443	89943	45868	04832	64523	14934	60455	05710	45757
05810	99759	57021	21715	69080	72643	10142	92591	83450	61043
89821	05097	12239	70006	03807	45385	68770	33824	00538	78897
74795	19802	44149	58632	04157	78258	14536	94714	53840	25035
03084	10365	69855	02042	30270	49892	71914	20928	71598	94787
10592	20389	24714	05413	14972	43781	43550	99496	21971	84332
55104	18126	71404	76804	59839	57359	84468	07251	32749	88488
57702	23085	31275	80363	88216	37966	32228	04721	68771	71920
12705	74357	83461	51295	02179	08139	62600	08093	89871	13790
71542	08402	60006	25569	55566	89610	71594	23893	15786	12227
22915	70587	46557	01760	11615	99346	92400	29472	60589	84236
55282	64458	33971	80916	75969	18812	70378	09583	40489	88956
21194	21729	74204	42410	40657	80693	42406	13049	49410	71809
28581	02659	86808	58957	43708	52585	79657	33885	05617	24783
06581	16639	01698	33379	43667	23579	81702	72391	26900	78616
24169	20306	21504	33688	49543	77966	75911	21129	41678	77126
94242	11143	98837	71924	04353	57665	36146	25962	45509	30276
22064	94868	20349	33047	12763	77184	42874	91559	40501	80582
35483	99930	24221	12262	50769	32705	81402	46572	63047	24256
38693	19511	95501	43606	36911	63597	76769	03700	44851	64002
87129	74119	47871	92109	92866	15117	77445	79735	44122	49203
00355	87686	30589	90363	99904	87015	33950	76535	09430	52527
13755	93590	98426	02615	31694	68531	82169	96693	48118	69197
64530	08357	53375	64358	22149	36431	14200	45329	75795	11705
77438	71193	80776	58326	77773	18577	23726	55381	63641	82235
06630	66615	54245	47822	19499	76229	45945	48395	18342	28652
04218	20098	09332	16093	49780	39373	67266	34104	05649	77246
54035	23575	77351	27694	40111	70949	52630	82284	75828	73896
37007	00509	09406	26693	16013	10380	65039	86530	43662	03513
98120	14199	94106	17951	30106	99747	59047	32848	75046	90435
28539	31469	95760	25687	76515	83987	72554	62189	05647	63969
12625	35935	03679	96762	19802	76493	35939	16105	45021	17328
75932	54154	55152	05819	83772	70113	28816	75194	65653	08365
54119	15877	61714	55847	69913	28748	31796	30689	76748	30283
92236	75184	44456	06416	95893	95836	76425	90192	42402	89408
36086	82355	75887	37395	05622	39763	48572	38715	22043	13062
50860	76490	13586	61583	53330	67945	07524	71677	11122	74120
65044	53596	24769	51227	44605	42879	30712	58219	22696	18305
33940	00785	77009	12605	05755	26706	68063	27324	20719	43279
01300	32373	80475	37957	60550	95824	38518	59896	10317	58221
35302	51965	48059	72212	13114	97556	81660	30668	65910	90048
55164	63088	34248	67068	99651	51387	21851	35714	15457	08299
49834	24686	09548	74846	33276	74292	38857	93825	67127	00611
73457	50641	77156	30478	95911	85434	45677	87215	13636	66906
55376	37603	68343	33754	44885	70128	04680	50994	45426	70685
91208	37322	13423	24895	61120	47571	12832	79322	53611	84159
14646	20965	34955	74655	04284	05374	74116	26931	44458	10575
77715	85702	51857	40755	47604	66135	07167	15892	27494	82112
30356	56178	04291	30972	25587	31805	96334	39109	23244	50481
36176	89348	94997	40154	34109	42126	34050	02873	05943	82698

TABLE OF RANDOM DIGITS

96779	94885	33674	52860	39750	47056	59836	10552	26093	40520
06973	61333	00465	70079	02538	83123	86995	05706	71111	40435
22366	71653	64852	69137	36552	25495	85845	71503	31631	58633
37197	91054	45316	64212	63635	68992	02608	93110	21593	56327
15234	35530	10147	65273	07553	78481	62311	36134	89043	56110
75554	64074	37544	34863	36478	79281	58549	44237	19801	31240
47230	79000	08569	74977	06680	99658	07458	17435	08308	11027
30159	83599	72906	07861	13625	35611	03043	69904	55051	74144
28979	73275	87178	48764	58960	40528	14378	03612	90075	96905
65855	05534	44208	08903	19491	82126	66860	32840	54979	22213
95348	50091	44611	49700	54373	80200	76787	16563	18303	66995
41774	64236	05346	57370	74027	46196	05323	43858	84458	81397
03354	96795	86666	35232	38206	24653	39718	80864	28193	86369
88886	09883	77679	07972	20542	81125	54583	70123	13780	74558
48189	54316	64441	32520	06350	71271	93086	52857	63361	98260
29323	88380	34403	29290	29057	74103	18949	37051	93231	73949
57944	15793	46141	77291	54098	37292	71554	16467	07860	47556
26473	35895	03768	48263	09733	22819	43269	63159	38560	13548
90941	14121	32494	52627	65420	12249	66149	47064	51607	98475
15200	48466	68764	30111	29052	75579	92279	88993	69782	27641
03704	21488	23373	27179	78622	98536	85425	92276	97238	28716
06976	19232	77725	26152	82770	07884	32089	25244	20896	06246
58784	61149	89620	88225	38005	81411	29645	40186	35101	89938
92687	63644	39013	63475	45033	98679	44963	28862	51162	71792
68635	28907	63317	16301	35291	27832	49665	26975	36918	71635
25136	53356	21610	96745	14276	83374	38793	27121	02809	18908
10939	52366	77537	80180	98287	14191	09983	42701	69101	73946
98361	61960	02082	44879	33803	64194	41519	20487	22554	69494
34201	75389	40418	63925	01612	60875	27928	54277	23320	23997
94946	95350	19640	24501	58261	86334	12535	12853	97546	80748
92459	46807	00742	98068	05715	91914	30368	76830	01471	31879
01990	61688	21317	58136	81372	32479	89450	54188	15032	52447
56357	03811	04824	53455	88755	30122	02839	71763	49139	06246
36783	05002	71761	35852	40640	62630	26769	02587	44623	95577
88822	11796	28561	27091	93013	64939	94299	98240	57450	18672
03478	89017	30466	54463	32998	45826	92196	84866	90728	60701
15272	84614	27404	33686	51283	72980	53589	61318	78649	06703
29596	47534	89805	95170	89816	58314	03649	64285	14682	12486
71904	81693	94887	45573	76874	74548	36851	48630	77916	78922
05201	51312	78986	27330	63194	98096	93212	74891	55099	02679
16510	95406	39078	31468	43577	67990	11287	27068	37874	61734
83816	94852	73159	76123	05010	08393	62827	13728	34709	39578
19962	86326	99855	14146	28341	93570	34163	59623	14103	63367
66852	52392	32115	75977	80723	96562	19388	64446	73949	83823
84161	37020	79694	35717	73417	15617	93437	46981	94838	12418
58837	30960	84272	38937	27926	95403	61816	32202	11343	99925
12971	62671	87151	80924	08413	22879	51701	84303	65556	20152
21036	13175	77916	31978	78898	69869	22225	13043	49858	81615
34152	24555	54366	40704	33111	00490	53198	52317	77478	38052
50434	17800	99805	32819	71033	83674	84640	67470	60922	25920

TABLE OF RANDOM DIGITS

49514	56977	61091	92612	26282	71434	09611	38514	22110	33105
92631	91973	05484	19712	21723	75125	33490	95926	01748	92453
40278	24410	94768	72614	30133	24250	19139	14774	19686	49597
81803	01934	67431	06570	68573	37985	63397	88439	29490	71102
06725	70141	56283	94081	68772	77224	71218	45373	42207	88661
03003	02041	43212	10780	87488	68377	59637	41731	97081	88146
96786	77447	36503	85678	29760	78551	57885	76095	46889	10514
13867	16828	74299	53165	91721	17584	03773	75051	83129	80955
60153	27028	68048	88563	30737	57731	62797	92327	86703	45231
03723	43680	40520	88434	76364	37846	60306	56808	68513	05431
70071	65642	85632	14420	76911	25034	62113	70957	59171	79161
85798	61647	84450	78632	92907	49621	00396	42732	31003	40448
03645	69342	80292	51763	21843	96110	69921	63435	77284	62427
36129	12616	76291	44000	80406	83704	74393	54442	56252	38487
67883	39077	21592	26234	40105	38901	68564	95491	48295	35200
35303	54831	27109	85724	80252	68075	56866	69977	15694	56340
65451	36814	24793	55271	22937	76975	23783	72291	37108	44979
97984	69925	21930	43520	42903	07952	22909	20514	22268	00017
98435	99382	72279	81923	92711	22859	73579	64006	32401	38988
52684	47602	92545	85307	27889	22652	94664	56700	09358	41365
71328	66786	05495	43089	30332	98484	57912	37416	05057	64606
06873	45241	68658	15507	61812	84899	24073	91467	37399	66597
61478	04063	32137	97949	28894	18848	43781	53423	68867	86084
20195	95679	18798	09786	95489	95477	52307	66635	13626	53577
82781	38482	38817	84125	14227	43948	54543	73141	85779	05960
76507	43573	73800	68958	25504	31547	36068	37290	58145	97945
73673	01651	36947	50655	18842	02009	10041	59211	76968	15850
82662	09745	20817	86570	01312	56188	06850	24880	50141	32037
59057	47915	45427	02391	14171	44789	60728	39158	18481	82991
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17377	75935	06637	44475	30935	58790	60159	05190	37755	06495
03973	99123	73738	23889	45586	52624	68847	03264	33298	45310
62945	41517	32909	38415	08517	18177	74068	17193	32115	17989
74341	11492	37721	82149	56743	24237	88066	47337	23687	84734
76481	59719	09182	68138	38681	71424	35332	93887	35799	73919
87994	93471	23310	60321	94807	28031	87369	14031	64574	31007
76542	43827	76797	38054	26127	86957	31770	06380	48235	93607
67803	33971	40771	56798	62945	35850	97353	45876	71431	12206
61450	33708	98687	68345	65812	57718	95158	87176	56817	86537
24626	08923	56849	98557	55227	38891	86332	85219	77847	02664
33885	02906	61019	47791	40655	52065	28583	52772	58993	22900
87145	85850	45170	98396	11448	18418	93095	80923	65885	00582
62761	59668	24486	32044	76952	55372	51677	48772	26826	64561
20334	07868	42065	07963	98165	92197	33502	57407	55643	36305
24130	28154	13623	81346	26267	91707	23440	54639	27918	89509
04179	24070	19024	08587	93957	13056	37274	78170	35724	50626
85691	65031	42942	15172	70876	05431	66260	18839	33916	95212
34157	75648	34808	89094	64196	03966	90926	63590	19298	75077
87159	03307	93587	93706	61341	36517	68751	97776	66750	75672
83231	85739	30743	47635	23682	86210	52789	32573	86446	07199

TABLE OF RANDOM DIGITS

02743	59982	92806	62853	39755	42550	31081	38860	35712	78632
74802	59354	91213	26293	18112	93831	01473	10798	18229	18642
06933	78651	45636	77509	28610	34307	68045	15107	62935	34149
40345	80092	50587	18535	19001	82179	12572	77589	33459	35130
70055	98685	10244	11760	21952	73985	68903	66934	42442	07608
34552	76373	40928	93696	97711	15818	31004	03263	05626	07460
45253	86947	42417	28778	14936	94099	90775	42001	86675	62770
71558	21692	84077	17814	33316	49494	31817	90127	39485	92302
95474	76468	12019	04274	01893	23930	88771	31142	65859	28948
34619	91898	28499	00279	35351	87736	83909	43736	19258	95068
44546	75524	68535	77434	18543	15479	58850	73802	10636	82735
22917	96024	04784	05809	52788	83577	02269	68632	23310	46261
33043	31433	47833	75234	74539	38529	57893	45997	71749	28666
99357	54593	21688	64216	85938	51742	12898	09737	61504	18946
01072	31679	80961	34029	56463	09594	11939	51777	64796	52452
90838	50179	42064	62987	13072	84227	24060	59438	05695	38136
35914	39441	90149	67957	16955	39960	26142	45600	75486	74103
87047	77284	12753	45644	47843	55781	06672	57548	84706	25453
93727	46613	48045	49685	28385	37200	98473	56808	86774	07305
37439	50362	44171	18495	57370	77691	28006	55318	39723	25299
98892	53633	33909	81674	91956	84531	60422	55574	31670	61059
95398	77381	21912	24873	26372	12044	43234	08503	86716	08095
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31303	70209	42174	10757	98531	35725	68208	61239	26705	43916
08457	10085	35741	79416	72457	59502	46986	09051	70963	19759
30698	80818	90073	78320	83675	78361	49929	70495	92247	04318
27142	41186	52273	81087	67396	16795	98542	83820	48765	24164
36775	63628	70856	43164	88426	51415	37514	24870	55665	05311
02560	51679	79600	23297	36434	17174	00109	02731	05909	58959
36744	66697	08331	50201	56303	09171	55995	60232	31305	30689
66482	04302	29770	46201	04588	42575	99318	84406	83405	21186
76375	41539	65940	57820	29283	94564	96598	00619	60468	97375
95772	72925	19454	63712	21401	96665	77750	21218	02990	50796
59013	81632	85000	39180	99975	73253	46534	59083	60243	27664
52392	04440	45628	34976	92012	16596	28596	15493	80754	48760
08027	07629	04339	77570	47155	77128	24498	67455	06320	82004
27284	39416	57313	03508	71443	42543	73335	68620	87559	77927
20513	38581	82309	69951	82658	60958	18290	60534	30741	89647
36076	12821	68723	37934	62818	64157	54590	98263	70109	06755
60679	43862	43675	03653	21060	81096	71332	28930	44207	08354
49416	58370	63738	87515	39290	87656	36130	23490	30963	57350
65757	39149	11780	92494	41335	35835	69882	56431	08091	01981
17379	77731	65133	44979	90939	29184	76634	58007	34873	83816
00757	13129	09648	07644	81689	68088	34882	04971	27565	66577
68276	79035	78273	83412	97328	81003	65938	85510	78367	29316
64716	91696	45448	92281	73854	67452	52145	41582	81549	82434
83695	11496	57066	48153	74754	56383	09253	65456	32438	96357
58275	66797	35380	41155	44389	94860	42074	31178	27967	12666
58005	84170	29999	23631	93032	41592	55688	78599	59902	21568
99993	80083	08810	07244	42067	76669	19686	64064	67141	80520

APPENDIX D: EPA REGIONAL ASBESTOS COORDINATORS

Region 1

Mr. Paul Heffernan, Asbestos Coordinator
Air & Hazardous Materials Division
Pesticides & Toxic Substances Branch
EPA Region 1
JFK Federal Building
Boston, Massachusetts 02203
(617) 223-0585

Region 2

Mr. Peter Flynn, Asbestos Coordinator
EPA Region II
Room 1015, 26 Federal Plaza
New York, New York 10278
(212) 264-4479

Region 3

Ms. Pauline Levin, Asbestos Coordinator
EPA Region III
Curtis Building
Sixth & Walnut Streets
Philadelphia, Pennsylvania 19106
(215) 597-9859

Region 4

Mr. Dwight Brown, Asbestos Coordinator
EPA Region IV
345 Courtland Street
Altanta, Georgia 30308
(404) 881-3864

Region 5

Mr. Anthony Restaino, Asbestos Coordinator
EPA Region V
230 S. Dearborn Street
Chicago, Illinois 60604
(312) 886-6003

Region 6

Mr. Larry Thomas, Asbestos Coordinator
EPA Region VI
First International Building
1201 Elm Street
Dallas, Texas 75270
(214) 767-2723

Region 7

Mr. Wolfgang Brandner, Asbestos Coordinator
EPA Region VII
324 East 11th Street
Room 1500
Kansas City, Missouri 64106
(816) 374-6538

Region 8

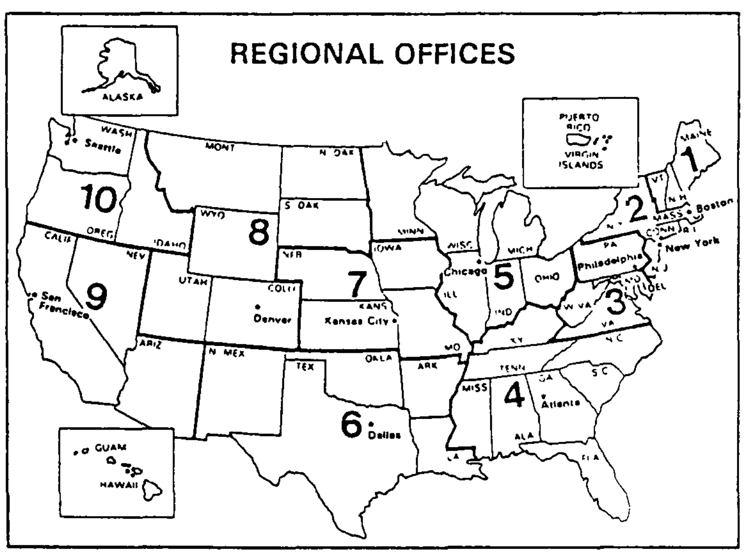
Mr. Steve Farrell, Asbestos Coordinator
Region VIII
1860 Lincoln Street
Denver, Colorado 80295
(303) 837-3926

Region 9

Mr. Kirby Narcisse, Asbestos Coordinator
EPA Region IX
215 Fremont Street
San Francisco, California 94105
(415) 556-3352

Region 10

Ms. Margo Partridge, Asbestos Coordinator
EPA Region X
1200 Sixth Avenue
Seattle, Washington 98101
(206) 442-5560



APPENDIX E: Toll-Free Information Number

APPENDIX E

Toll-Free Information Number

ENVIRONMENTAL PROTECTION AGENCY

The following number is to be used for general information on the EPA school asbestos program and to request copies of the guidance manuals and new documents:

800--424-9065

(554-1404 in Washington, D.C.)

This report is also available from:

National Technical Information Service

U.S. Department of Commerce

5285 Port Royal Road

Springfield, Virginia 22161