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ASBESTOS-CONTAINING MATERIALS IN SCHOOL BUILDINGS

Guidance for Asbestos Analytical Programs

DRAFT REPORT

by

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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. At the end of this chapter a CHECKLIST FOR AN ANALYTICAL PROGRAM is displayed. Chapters 2, 3 and 4 then discuss, in detail, sampling procedures, laboratory quality assurance and laboratory analysis, and statistics.

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 rests. 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 as-

bestos 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 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 specific for the bulk analysis of asbestos-containing insulation and sprayed-on materials is being prepared and tested [3 and 4]. 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 the analysis of bulk samples for asbestos materials using polarized light microscopy should be considered for this service.

EPA is sponsoring a quality assurance program for bulk sample analysis. Fifty-two 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 parameters to be reported by the laboratory for each sample submitted for analysis. It is important that a 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 sixth 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 seventh 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.

CHECKLIST FOR AN ASBESTOS ANALYTICAL PROGRAM

		Dates 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	_____

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 Asbestos-Containing Materials in School Buildings: A Guidance 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 over-emphasized.

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 judgemental or convenience sampling method has led to biased and incorrect characterization of the material. In some cases, the asbestos was entirely missed. In other cases, it was significantly overestimated.

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 gymnasium and on the ceilings of first floor classrooms of an annex constructed six years after gymnasium construction. The friable material on the gymnasium 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) gymnasium 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. 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.

[redacted] Information noted in (a) (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 the Sampling Area contains friable material areas that are not adjacent (for example, areas on different floors of the school building), 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) Name and address of the school.

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

(3) Dates of inspection and diagram preparation.

(4) 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.)

(5) Brief description of the Sampling Area.

(6) Name of person preparing the diagram.

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

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 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

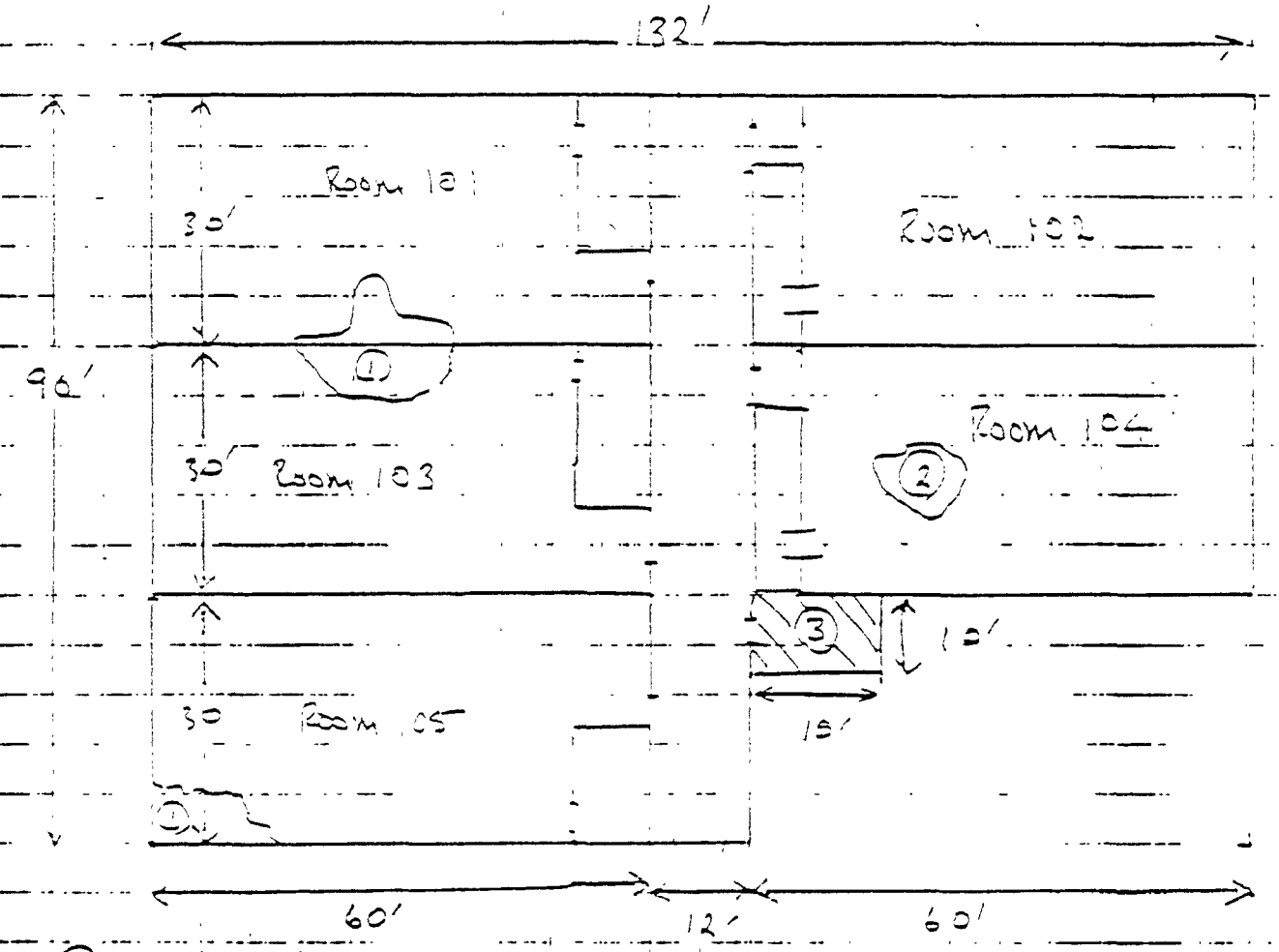
Selection of Sample Locations

After preparing the diagram(s) and determining the number of samples to be collected in each Sampling Area, determine the approximate

Classroom Annex (Constructed in [illegible])

Friable Ceiling Material of First Floor Classrooms
Gray textured spray finish
Stucco'd 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)

Scale: Square = 6' (meas. are inside dimensions)

School _____
Address _____

Program Coordinator _____
Telephone No. _____
Inspector _____
Date of Inspection _____

Figure 2.1: Example Sampling Area Diagram

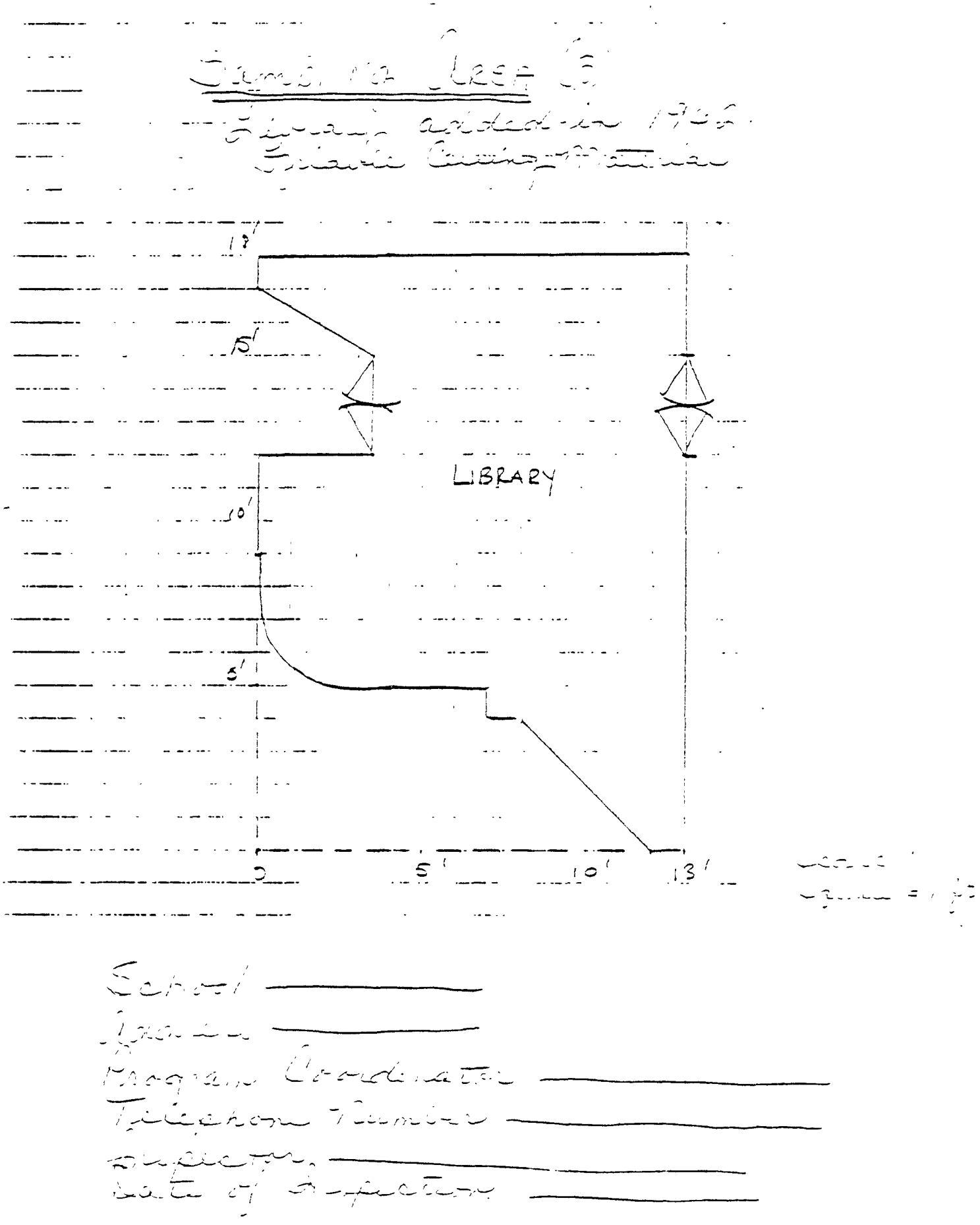


Figure 2.2: Example Sampling Area Diagram

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 considerable 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 locations.

Select sample locations according to instructions (1) through (9) below. It is very important to properly use the following random number procedure to select sample locations. A SELECTION OF SAMPLE LOCATION WORKSHEET for steps (2) through (9) below is provided in Figure 2.3.

(1) Construct on the Sampling Area diagram an imaginary rectangle enclosing the entire Sampling Area.

(2) Record the dimensions of this imaginary rectangle on the WORKSHEET: first the number of feet along the rectangle base and then the number of feet along the side or height.

(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. The second random number of the pair should be between 0 and the number of feet along the side 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 (i.e., inaccessible) random number pairs does not adversely affect

SELECTION OF SAMPLE LOCATIONS WORKSHEET

Sample Area No. (a) _____

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)*)

No.	RANDOM NUMBERS First	RANDOM NUMBERS Second	LOCATION FALLS WITHIN SA Yes	LOCATION FALLS WITHIN SA No	SAMPLE LOCATION Numbers	Unique Sample ID # 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

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 the required number (3, 5 or 7) of 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. This "blind" procedure helps prevent bias on the part of the analyst. Record these unique sample ID numbers (for laboratories) on the WORKSHEET. Choosing a number 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.

(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 all 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.

SELECTION OF SAMPLE LOCATIONS WORKSHEET

Sample Area No. (a) 2

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))

No.	RANDOM NUMBERS First	RANDOM NUMBERS Second	LOCATION FALLS WITHIN SA Yes	LOCATION FALLS WITHIN SA No	SAMPLE LOCATION Numbers	Unique Sample ID # For Lab
(1)	21	51	✓		201	217
(2)	71	45	✓		202	884
(3)	108	13		✓		
(4)	10	41	✓		203	072
(5)	119	76	✓		204	306
(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: _____

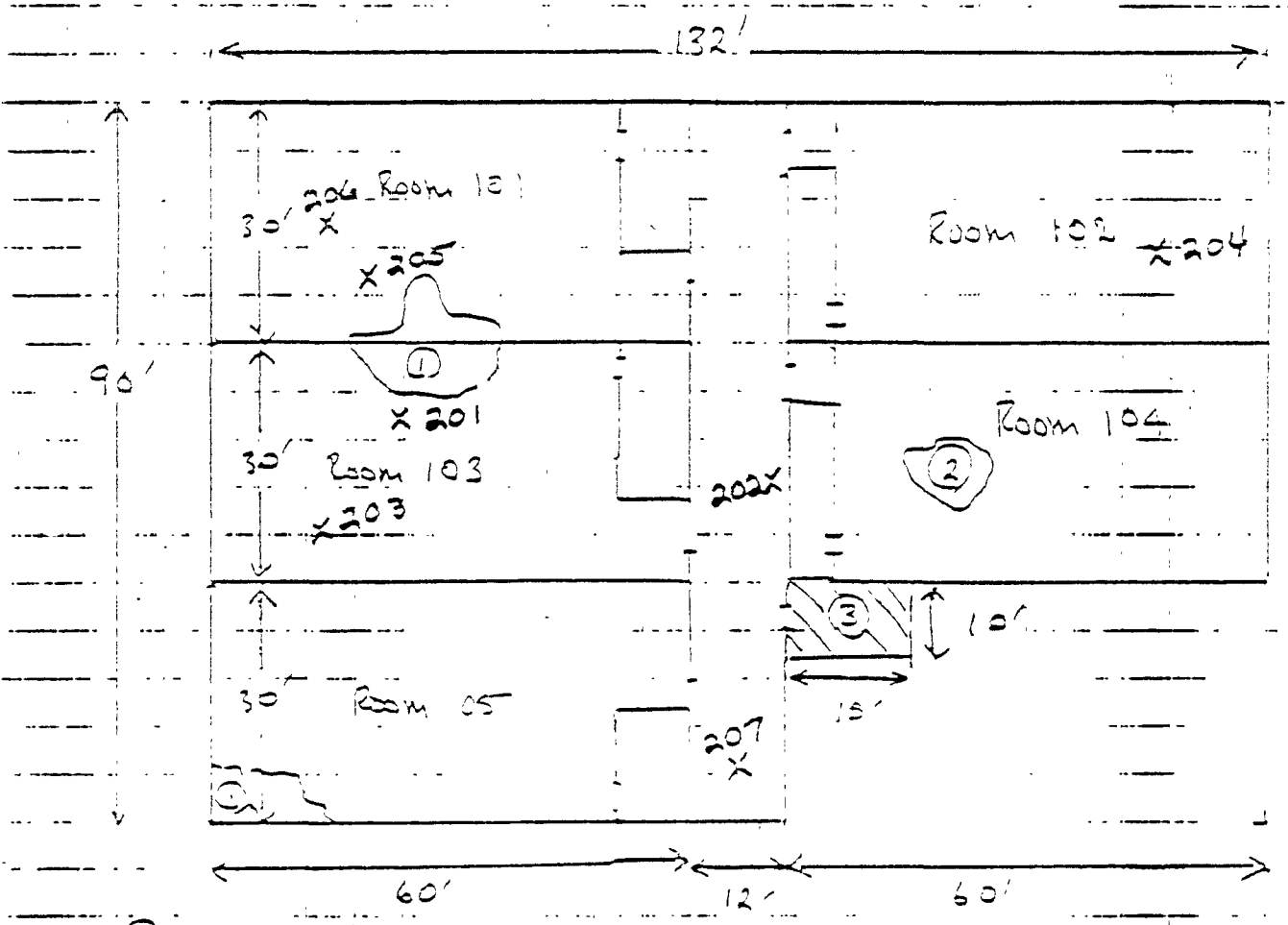
Date: _____

Figure 2.3: WORKSHEET

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)

Scale: Square = 6' (meas. are inside dimensions)

School _____
Address _____

Program Coordinator _____
Telephone No. _____
Inspector _____
Date of Inspection _____

Figure 2.4: Example of Sampling Area Diagram

TABLE OF RANDOM DIGITS

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	45573	34056	21625	16999	13085	22732
55363	07449	34835	15290	76616	67191	12777	21861	68689	03263
69393	92785	49902	58447	42048	30378	87618	26933	40640	16281
13186	29431	88190	04588	38703	81290	89541	70290	40113	08243
17726	28652	56836	78351	47327	13518	92222	55201	27340	10490
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	11062	56762	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	36613	76298	26678	89334	03908	95567	29080	75906	91807
37042	40318	57099	10528	09925	89773	41035	95244	29002	46450
53766	52873	15987	46962	67342	77592	57651	95508	80033	69823
90585	58955	53122	16025	84299	53310	67380	84249	25348	04332
32001	96293	37203	64516	51530	37069	40261	61374	05815	06714
62606	64224	46354	72157	67248	20135	49804	09225	64419	29457
10078	28073	55389	50324	14500	15562	64165	06125	71350	77569
91561	46145	24177	15294	10061	98124	75732	00815	83452	97355
13091	98112	53959	79607	52244	63303	10413	63339	74762	50289
73864	83014	72457	22682	03033	61714	88173	90835	00634	85169
56668	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	42351
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	63805	03032	94770
58268	57219	68124	73455	83236	08710	34234	65003	64171	42596
97158	03672	30685	01161	24262	19427	52106	34003	70685	74246
04230	16831	69085	30802	65559	09205	71329	06496	85650	03707
94879	56606	30401	02602	57658	70091	54986	41394	60437	03195
71446	15233	66715	28035	91513	70566	02383	79941	39684	54015
32886	05644	79316	09819	00813	58407	17461	73925	53037	91904
62048	33711	25290	21526	02223	75947	66466	06232	10910	75336
84534	42351	21628	53669	81352	95152	08107	98814	72743	12649
84707	15685	84710	35366	06446	86311	32648	88141	73902	69981
19409	40868	64220	80861	10360	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	83735	93388	07833	38216	31410	70555	03022	54147	06647
30014	25879	71763	96679	90603	99396	74557	74224	18211	91607
07265	69563	64268	33502	72264	66540	01782	08396	19251	83613
84404	88642	30263	80310	11522	57810	27627	73076	36240	48952
21778	02085	27762	46097	43324	34354	09369	14966	10156	76039

Table 2.1: TABLE OF RANDOM DIGITS Used for the Example SA

Example

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 with a tape measure and diagrammed as shown in Figure 2.4. Pertinent information such as 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 base and hieght 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' (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. (Keep in mind the number of random digits is the same as the number of digits in each dimension.) 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 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 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, 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 split-samples of suspect materials be taken. 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. Pack the two parts of the split-sample separately in a manner similar to other samples. Affix the unique sample ID number assigned at the time of sample location selection to the sampling container so the laboratory will not know which samples are split-samples.

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 program. 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. However, even if the laboratory is satisfactory, all split-sample results which do not agree must be resolved.

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

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.

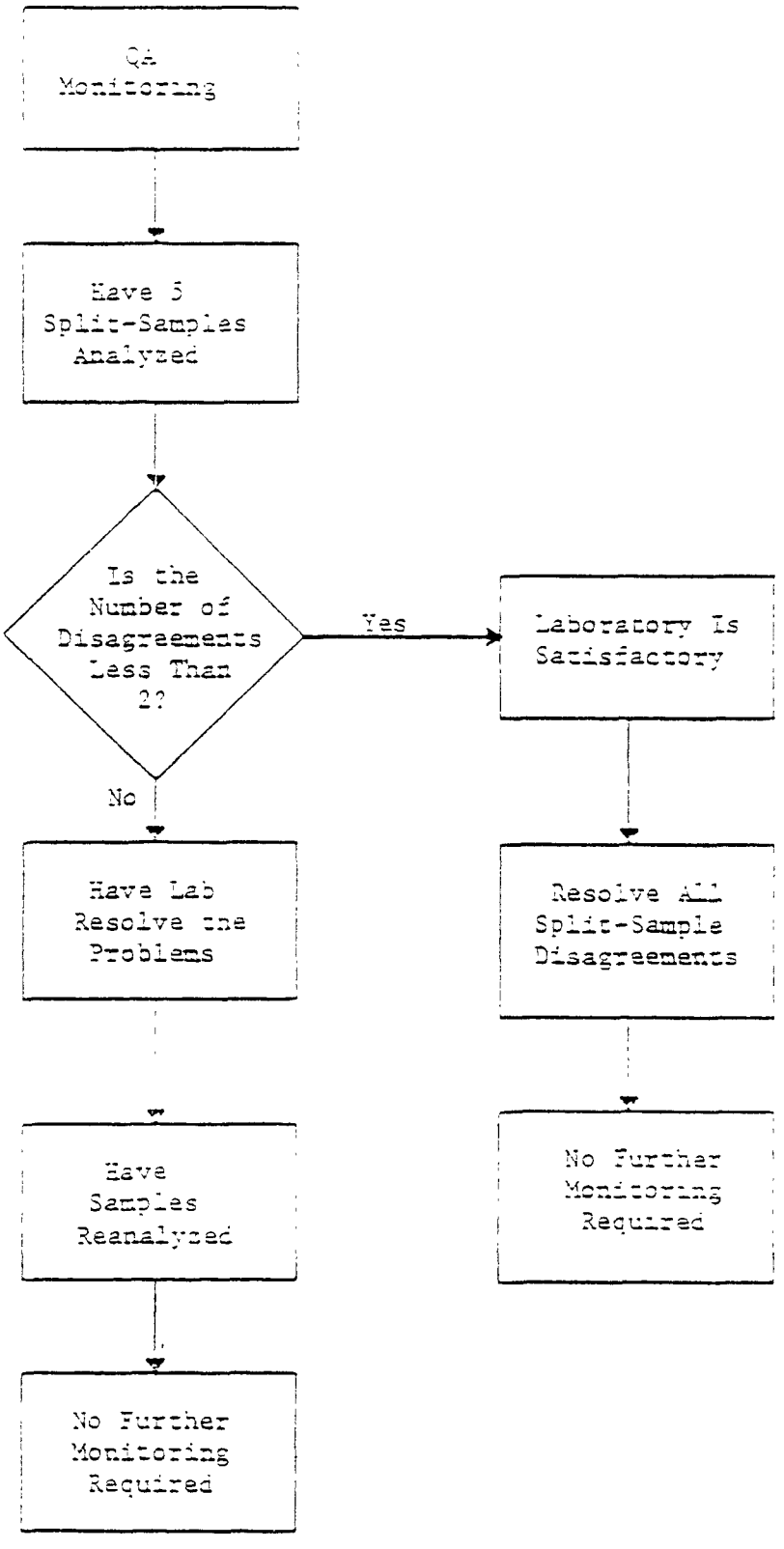


Figure 3.1 Case 1: School Systems For Which Fewer Than 25 Samples Will be Analyzed.

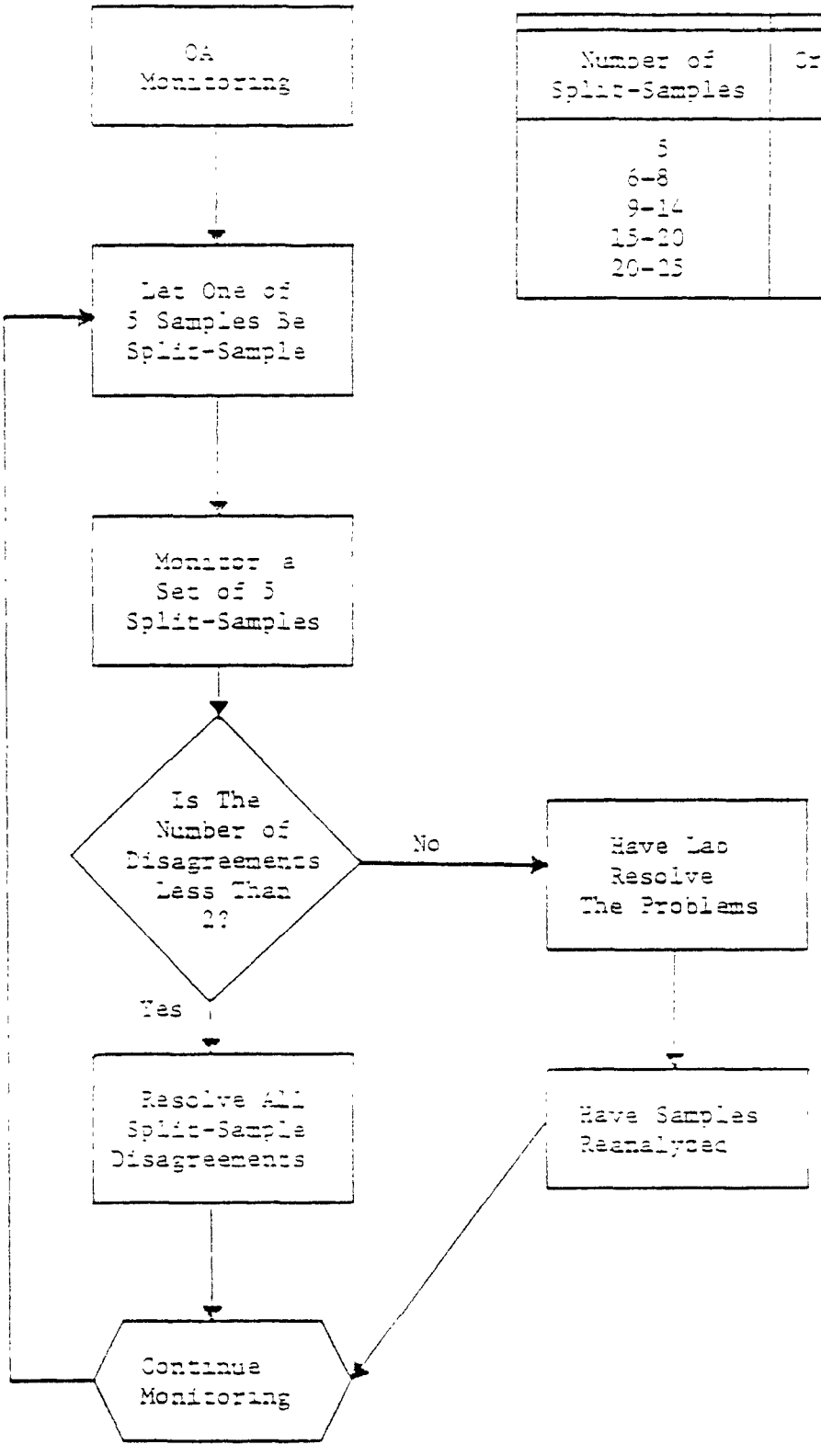
Figure 3.2

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	Critical Number
5	2
6-8	3
9-14	4
15-20	5
20-25	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

One out of every 5 samples among the first 100 samples should be a split-sample. For these split-samples, the result of each consecutive set of 5 split-samples should be monitored. If 2 or more disagreements are noted, the laboratory's 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 block of 20 split-samples should be monitored. If 5 or more disagreements are noted in the results of any block, the lab procedure may be suspect. All the samples analyzed during the period when the lab procedure was suspect should be reanalyzed after the laboratory resolves the problems.

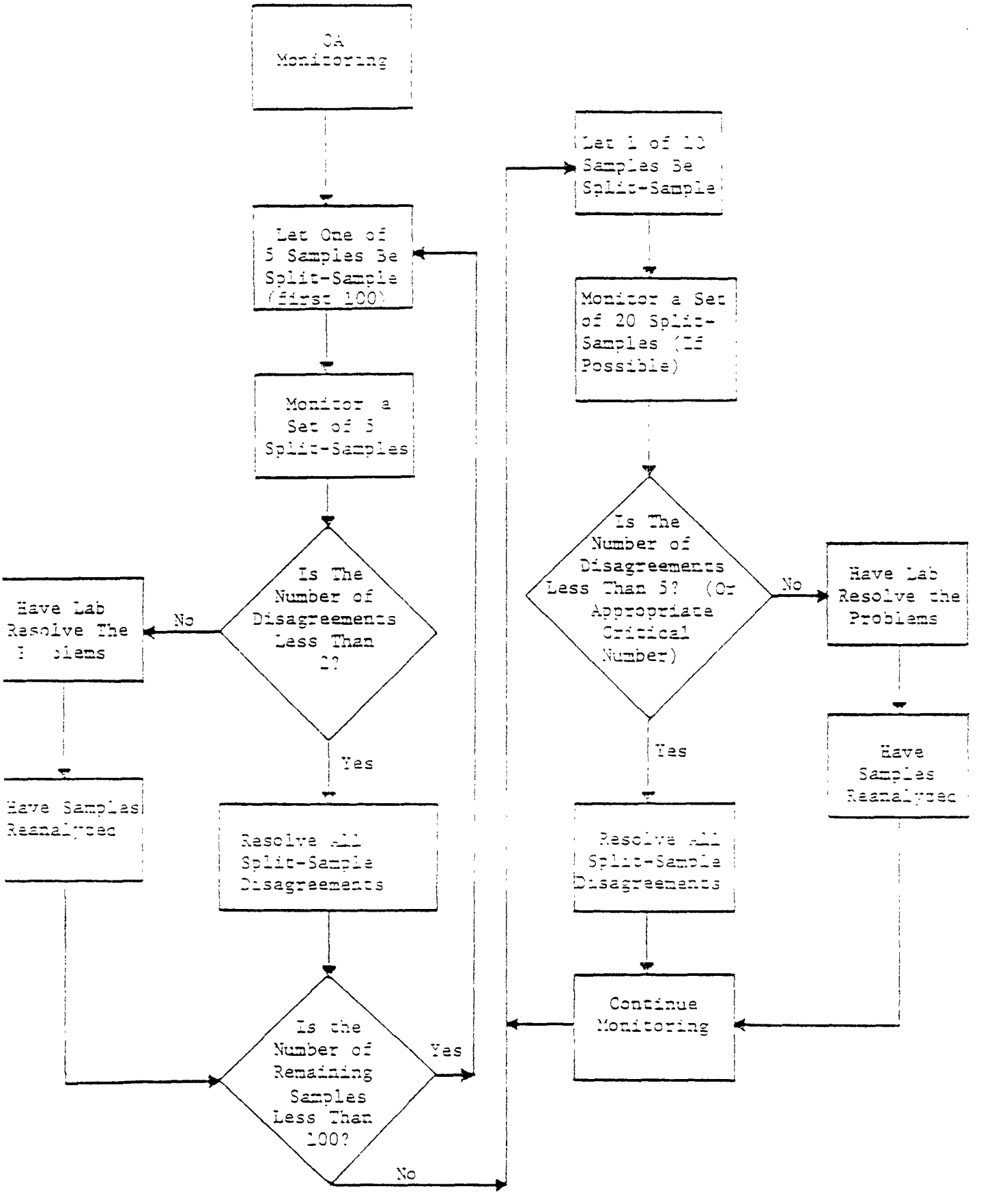


Figure 3.3 Case 3: School Systems With Expected Number of Samples Over 100.

CHAPTER 4: LABORATORY ANALYSIS AND STATISTICS

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 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 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

(mg)

(6) Type and Percent of Asbestos Present

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

(7) Percent Total Asbestos Present in Sample

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

The non-asbestos fibrous materials should be identified 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 judgement 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

(10) Description of Method of Quantitation

(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

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*						
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 (description and percent)	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 Name: _____

Analyst 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 laboratories 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 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. 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

I. List the results of the laboratory analysis of the friable material. 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	11	11 x 11 = 121
2	2	2 x 2 = 4
3	5	5 x 5 = 25
4	—	—
5	—	—
6	—	—
7	—	—
	(A) 18 %	(B) 150

II. Enter the number of bulk samples taken. Should be 3, 5 or 7.

For Example: From above N = 3

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

For Example: $\text{Mean} = \frac{(A)\ 18}{N = 3} = (C)\ 6\ \%$

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

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

$$= \frac{1}{3-1}\left[150 - \frac{18 \times 18}{3} \right]$$

$$= \frac{1}{2}\left[150 - 108 \right]$$

$$= \frac{42}{2}$$

$$V = 21$$

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

For Example: SD = $\sqrt{(V)}$ = $\sqrt{21}$

SD = 4.58 %

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

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

For Example: HR = (SD) 4.58 % x (Q) 1.69

= 7.74%

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 = (C) 6 % - (HR) 7.74

= (LCB) -1.74 %

Upper Confidence Bound = (C) 6 % - (HR) 7.74

= (UCB) 13.74 %

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

For Example: 90% CI = ((LCB) -1.74 %, (UCB) 13.74 %)

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 (-1.74%, 13.74%) contains 1%, there remains uncertainty as to the presence or absence of asbestos.

STATISTICS COMPUTATION WORKSHEET

I.

No.	(A) Percent Asbestos	(B) Squares of Column (A)
1	11	121
2	2	4
3	5	25
4	—	—
5	—	—
6	—	—
7	—	—

Total (A) 18 % (B) 150

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

III. Mean = $\frac{(A)}{N}$ = $\frac{\text{Sum of Column (A)}}{\text{Total No. Observations}}$ = (C) 6 %

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

= $\frac{1}{2}$ [(B) 150 - $\frac{(A) 18^2}{3}$]

= 21

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

= 4.58 %

VI. The half-range (HR)

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

HR = (SD) 4.58 % x (Q) 1.69 = 7.74 %

VII. Confidence Bounds

Lower Confidence Bound (LCB) = Mean - HR
= (C) 6 % - (HR) 7.74
= (LCB) -1.74 %

Upper Confidence Bound (UCB) = Mean - Half-range
= (C) 6 % - (HR) 7.74
= (UCB) 13.74 %

VIII. The 90% Confidence Interval

90% CI = [(LCB), (UCB)] = [-1.74 %, 13.74 %]

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

☐ is above 1%. Conclude asbestos present.

☑ [illegible] 1%. [illegible]

STATISTICS COMPUTATION WORKSHEET

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 = $\frac{(A)}{N}$ = $\frac{\text{Sum of Column (A)}}{\text{Total No. Observations}}$ = (C) _____%

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

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

= _____

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

= _____%

VI. The half-range (HR)

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

HR = (SD) _____% x (Q) _____ = _____

VII. Confidence Bounds

Lower Confidence Bound (LCB) = Mean - HR
= (C) _____% - (HR) _____
= (LCB) _____%

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

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.

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.

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[3] Tentative Method for the Determination of Asbestiform Minerals in Bulk Samples by Polarized Light Microscopy. Environmental Monitoring Systems Laboratory, United States Environmental Protection Agency, Research Triangle Park, North Carolina, February 1980.

[4] Tentative Method for the Determination of Asbestiform Minerals in Bulk Insulation Samples by X-Ray Powder Diffraction. Environmental Monitoring Systems Laboratory, United States Environmental Protection Agency, Research Triangle Park, North Carolina. February 1980.

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APPENDIX A: EPA-SPONSORED QUALITY ASSURANCE ROUND ROBIN FOR ASBESTOS BULK SAMPLE ANALYSIS

APPENDIX A

EPA-Sponsored Quality Assurance Round Robin 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 a quality assurance 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 analys. . 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 material, 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 18, 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. Environmental Consulting and Testing Services of Cherry Hill, New Jersey and Princeton Testing Laboratory of Princeton, New Jersey, incorrectly identified mineral wool in Sample 1 as crocidolite and amosite, respectively. All other laboratories 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.

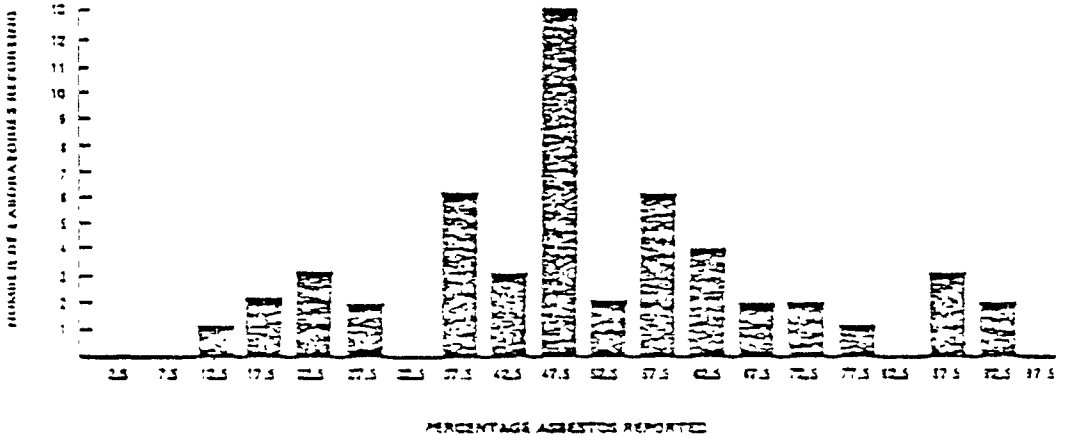
Reports were issued to individual laboratories on March 25, 1980 (commercial), and April 3, 1980 (noncommercial). Reports included the results of reference analyses, data reported by the individual laboratory, and summary data on quantitative estimates. An example of the reports to laboratories is shown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

ASBESTOS BULK SAMPLE ANALYSIS PROGRAM
RESULTS OF ROUND 1

Sample I.D. #:	220	301	273	354
Asbestos Present (%)				
Laboratory report	0	75 anthophyllite	0	96 chrysotile
Reference report	0	53 anthophyllite	0	96 chrysotile
Other Fibrous Material (%)				
Laboratory report	100 mineral wool	0	96 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 (4.2)	1.2 (2.1)

Distribution of Asbestos Quantitation

Sample I.D. #: 301



Sample I.D. #: 354

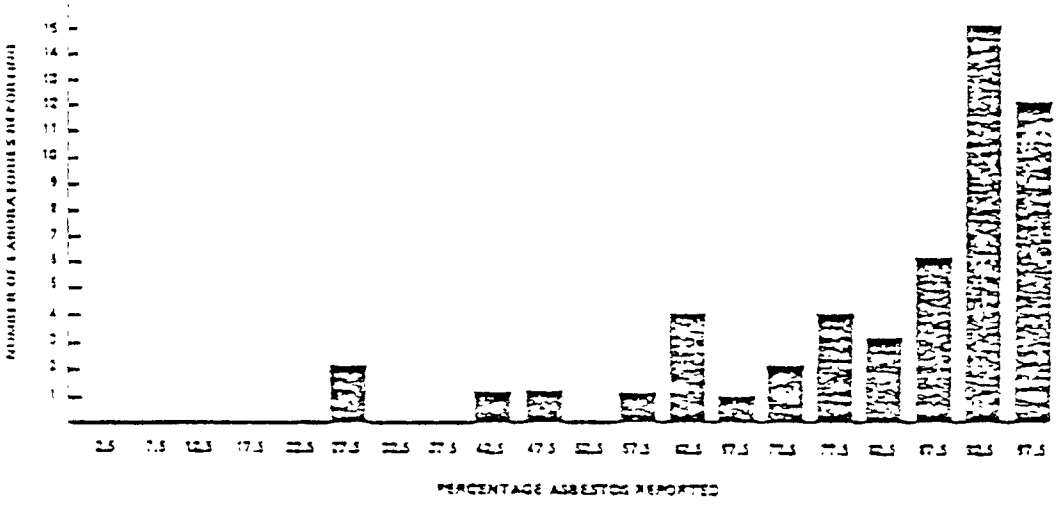


Figure A-1. Example of Reports to Laboratories

Laboratory's Participating in Quality Assurance Round Robin

Albuchemist, Inc.
715 San Mateo Boulevard, N.E.
Albuquerque, New Mexico 87108
Ms. Virginia Dugan
05 268-7367

American Can Company
Safety & Industrial Hygiene Laboratory
U.S. Highway 22
Union, New Jersey 07083
Mr. James McVeigh
201/686-4500

American Microscopy Laboratory
D. 3410 12th Avenue E.
Tuscaloosa, Alabama 35405
Mr. M. A. Beg
205/349-2852

Analytical Center, Inc.
P. O. Box 15635
Houston, Texas 77020
Dr. W. C. Runnels
713/676-0141

Boeing Technology Services
9R-25
P. O. Box 3707
Seattle, Washington 98124
. Sherry Merritt
206/237-2722

Brandt Associates, Inc.
P. O. Box 81
Martins Creek, Pennsylvania 18063
Ms. Marlene C. Frey
215/258-2911

Brewer Analytical Laboratories
311 Pacific Street
Honolulu, Hawaii 96810
Mr. Wayne Nakagawa
808/533-4411

C.E.D., Inc.
Environmental Microscopy International
135 West Cutting Blvd.
Richmond, California 94804
Mr. Brig P. Tamayo
415/234-3761

Casalina Associates, Inc.
47-345 Manakaa Road
Kaneohe, Hawaii 967--
Dr. Sam L. Casalina
808/239-651-

Certified Testing Laboratories, Inc.
2905 East Century Boulevard
South Gate, California 90280
Mr. Stuart Salot
213/564-2641

Clayton Environmental Consultants, Inc.
25711 Southfield Road
Southfield, Michigan 48075
Mr. Bob Lieckfield
313/424-3860

Colorado School of Mines
Research Institute
P. O. Box 112
Golden, Colorado 80401
Mr. Jerome Krause
303/279-2581

Continental Technical Services
Environmental Health Division
9742 Skillman
Dallas, Texas 75243
Mr. David McNama
214/343-2025

Craig Testing Laboratories, Inc.
565 East Harding Highway
Mays Landing, New Jersey 08330
Mr. Jack Ferrell
609/625-1700

Department of Geological Sciences
SUNY, New Paltz
New Paltz, New York 12562
Dr. Martin Rutstein
914/257-2166

Department of Geology
Illinois State University
Normal, Illinois 61761
Dr. James Kirchner
309/436-8922

Dunn Geoscience Corporation
5 Northway Lane North
Latham, New York 12110
Mr. William E. Cutcliffe
518/783-8102

Eastern Analytical Laboratories
One "A" Street
Burlington, Massachusetts 01803
Mr. Robert L. MacDonald
617/272-5212

EMS Laboratories
12517 Crenshaw Boulevard
Hawthorne, California 90250
Ms. B. M. Tooper
213/973-6694

EMV Associates, Inc.
Microanalysis Laboratory
15325 Shady Grove Road
Rockville, Maryland 20850
Mr. John Wehrung
301/948-7400

Enviro-Med Laboratories, Inc.
414 W. California
Ruston, Louisiana 71270
Dr. Robert W. Flournoy
318/255-0060

Environment/One Corporation
2773 Balltown Road
Schenectady, New York 12301
Mr. Michael L. Mendelsohn
518/346-6161

Environmental Consulting & Testing Services
P. O. Box 3521
Cherry Hill, New Jersey 08034
Mr. Nathan R. Frenkel
609/779-1195

Environmental Health Services, Inc.
5206 Lindbergh Blvd.
W. Carollton, Ohio 45449
Mr. Alan W. Williams
513/293-0025

Erie Testing Laboratories
2401 W. 26th Street
Erie, Pennsylvania 16506
Mr. Mark R. Banister
814/833-4790

Erlin, Hime Associates
811 Skokie Boulevard
Northbrook, Illinois 60061
Mr. Bernard Erlin
312/272-7730

GCA Corporation
Technology Division
Burlington Road
Bedford, Massachusetts 01730
Dr. Charles Spooner
617/275-9000

Geoscience Consultants, Inc.
P. O. Box 341366
Coral Gables, Florida 33134
Mr. Jose Hennorez
305/446-5801

Goldblatt, Fay
407 N. Butrick St.
Waukegan, Illinois 60085
Ms. Fay Goldblatt
312/249-1745

Hager Laboratories
12000 E. 47th Avenue
Denver, Colorado 80239
Dr. Robert Hager, Jr.
303/371-1441

Hauser Laboratories
5680 Central Avenue
P. O. Box G
Boulder, Colorado 80306
Mr. D. Blair
303/443-4662

Health Science Associates
Suite B/C
10941 Bloomfield Street
Los Alamitos, California 90720
Ms. Kathy Jones
213/430-1031

Herron Testing Laboratories
5405 Schaaf Road
Cleveland, Ohio 44131
Mr. Bob Haddad
216/524-1450

IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616
Mr. Al Gaynor
312/567-4303

Industrial Analytical Laboratory
1523 Kalakaua Avenue
Suite 101
Honolulu, Hawaii 96826
Mr. Fred Hertlein
808/949-6191

Industrial Hygienics, Inc.
755 New York Avenue
Huntington, New York 11743
Mr. James Scnirripa
516/427-0950

Industrial Testing Laboratories, Inc.
2350 Seventh Blvd.
St. Louis, Missouri 63104
Mr. William A. Eddie
314/771-7111

Institute for Research, Inc.
8330 Westglen Drive
Houston, Texas 77063
Mr. Benjamin Mosier
713/783-8400

Inter-City Testing & Consulting Corporation
P. O. Drawer "O"
609 Middle Neck Road
Great Neck, New York 11023
Dr. Malcolm Newman
516 829-8762

Interscience Research
2614 Wyoming Avenue
Norfolk, Virginia 23513
Mr. Joseph H. Guth
804/853-8813

Jesse H. Bidanset & Associates, Inc.
P. O. Drawer "O"
609 Middle Neck Road
Great Neck, New York 11023
Dr. Jesse H. Bidanset
516/829-8763

Law Engineering Testing Company
3301 Winton Road
Raleigh, North Carolina 27619
Mr. Richard Hatfield
919/876-0416

LFE Corporation
Environmental Analysis Lab Division
2030 Wright Avenue
Richmond, California 94804
Mr. Yami Yaffe
415/235-2633

Maryland Mineral Analysis Laboratory
Department of Geology
University of Maryland
College Park, Maryland 20740
Dr. Ann Wylie
301/454-3548

MJH Associates
Mineralogical Consultants
13345 Foliage Avenue
Apple Valley, Minnesota 55124
Mr. Michael L. Boucher
612/432-8836

Northrop Services, Inc.
P. O. Box 12313
Research Triangle Park, North Carolina 2770
Mr. R. C. Jordan
919/549-0611

PEDCo Environmental, Inc.
11499 Chester Road
Cincinnati, Ohio 45246
Mr. Craig Caldwell
513/782-4700

Princeton Testing Laboratory
P. O. Box 3108
Princeton, New Jersey 08540
Mr. Gene Dennison
609/452-9050

R. J. Kurzvial & Associates
Meterology Consultants
12185 W. 29th Place
Lakewood, Colorado 80215
Dr. Robert J. Kurzvial
303/237-2566

Rossnagel & Associates, Inc.
23- Rt. 70
Medford, New Jersey 08055
Mr. Robert Busko
609/654-1441

Southwestern Laboratories
P. O. Box 10687
Dallas, Texas 75207
Mr. Gary Cude
214/688-0088

Southwestern Laboratories
P. O. Box 8768
Houston, Texas 77009
Mr. Bob Laws
713/692-9151

Spectric Corporation
7408 Fannin St.
Houston, Texas 77054
Mr. Donald Flory
713/790-1800

St. Paul Fire & Marine
Environmental Services Analytical Laboratory
494 Metro Square Building
7th and Robert Streets
St. Paul, Minnesota 55101
Mr. Donald J. Larsen
612/221-7043

Sunbelt Associates, Inc.
6961 Mayo Road
New Orleans, Louisiana 70126
Mr. Gary C. Allen
504/242-5026

Thomas A. Kubic & Associates
8 Pine Hill Court
Northport, New York 11768
Mr. Thomas A. Kubic
516/261-2117

Tri-State Laboratories, Inc.
54 Westchester Drive
Austintown, Ohio 44515
Mr. Frederick T. Posey
216/793-8800

Truescail Laboratories, Inc
4101 N. Figueroa Street
Los Angeles, California 90065
Mr. Karl Schiller
213/225-1564

United States Testing Company, Inc.
1415 Park Avenue
Hoboken, New Jersey 07030
Mr. Ray Robinson
201/792-2400

Utah Biomedical Test Laboratory
520 Wakara Way
Salt Lake City, Utah 84108
Mr. James Perkins
801/453-8267

Walter McCrone Associates, Inc.
2820 S. Michigan Avenue
Chicago, Illinois 60616
Mr. John Delly
312/842-7100

Wausau Insurance Companies
Environmental Health Laboratory
2000 Westwood Dr.
Wausau, Wisconsin 54401
Mr. Thomas Stavros
715/845-5211

Department of Chemistry
Attention: Dr. Joseph Bozzelli
New Jersey Institute of Technology
323 High Street
Newark, New Jersey 07102

APPENDIX 3: 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.

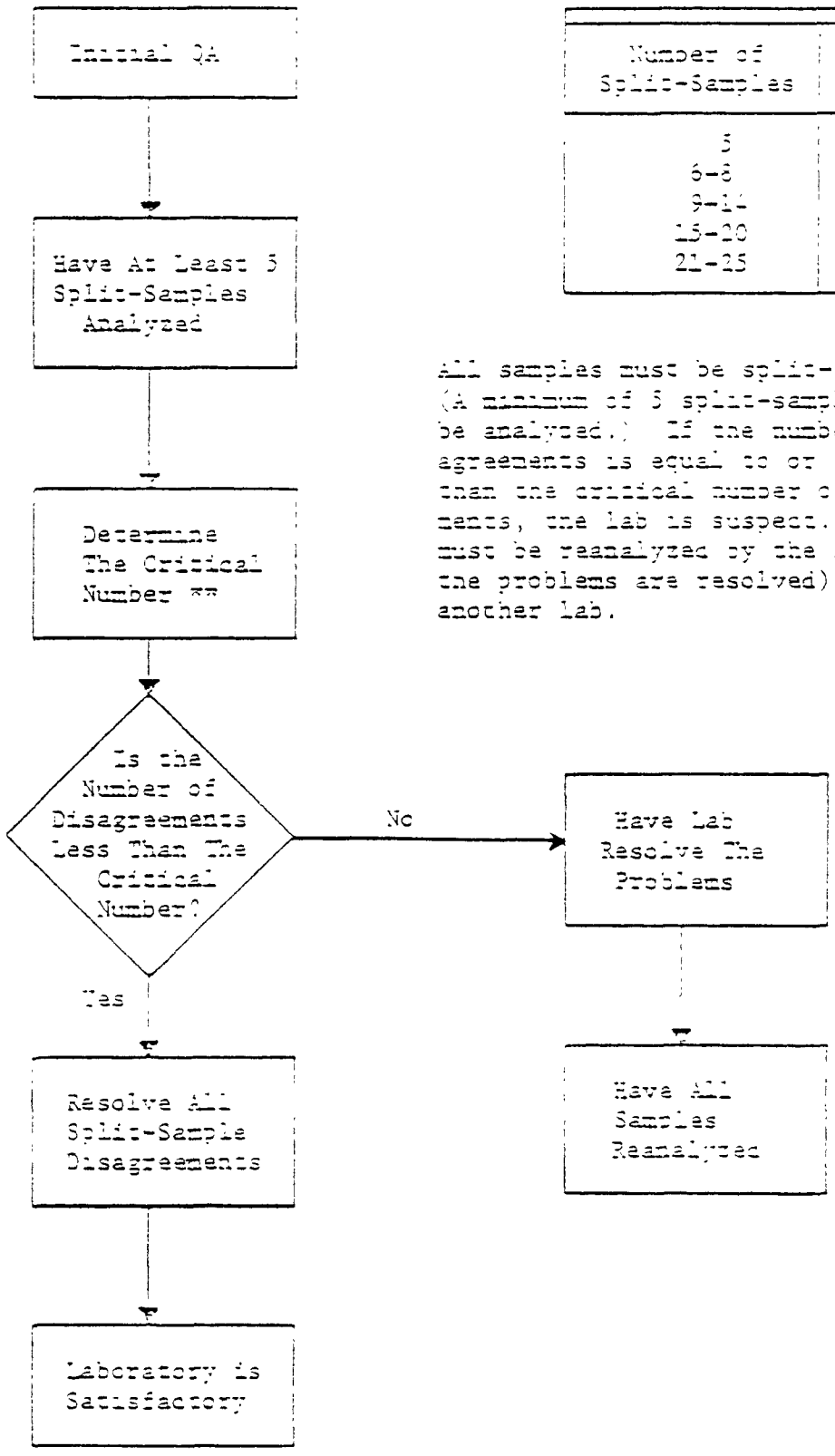
Following the split-sample guidance offered in Chapter 3, use a minimum of twenty-five split-samples for judging the acceptability of a laboratory's performance. If the number of disagreements is more than 6, then the laboratory's performance is suspect. There may be situations in which it is not possible 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 one or both of the laboratories 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 insure that the problem has been resolved. Of course, if the official is still uneasy after sending several split-samples to a laboratory, he may opt to split every sample that he sends 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 3.1 and 3.2 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 greater than the critical number of disagreements, the lab is suspect. All samples must be reanalyzed by the lab (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.

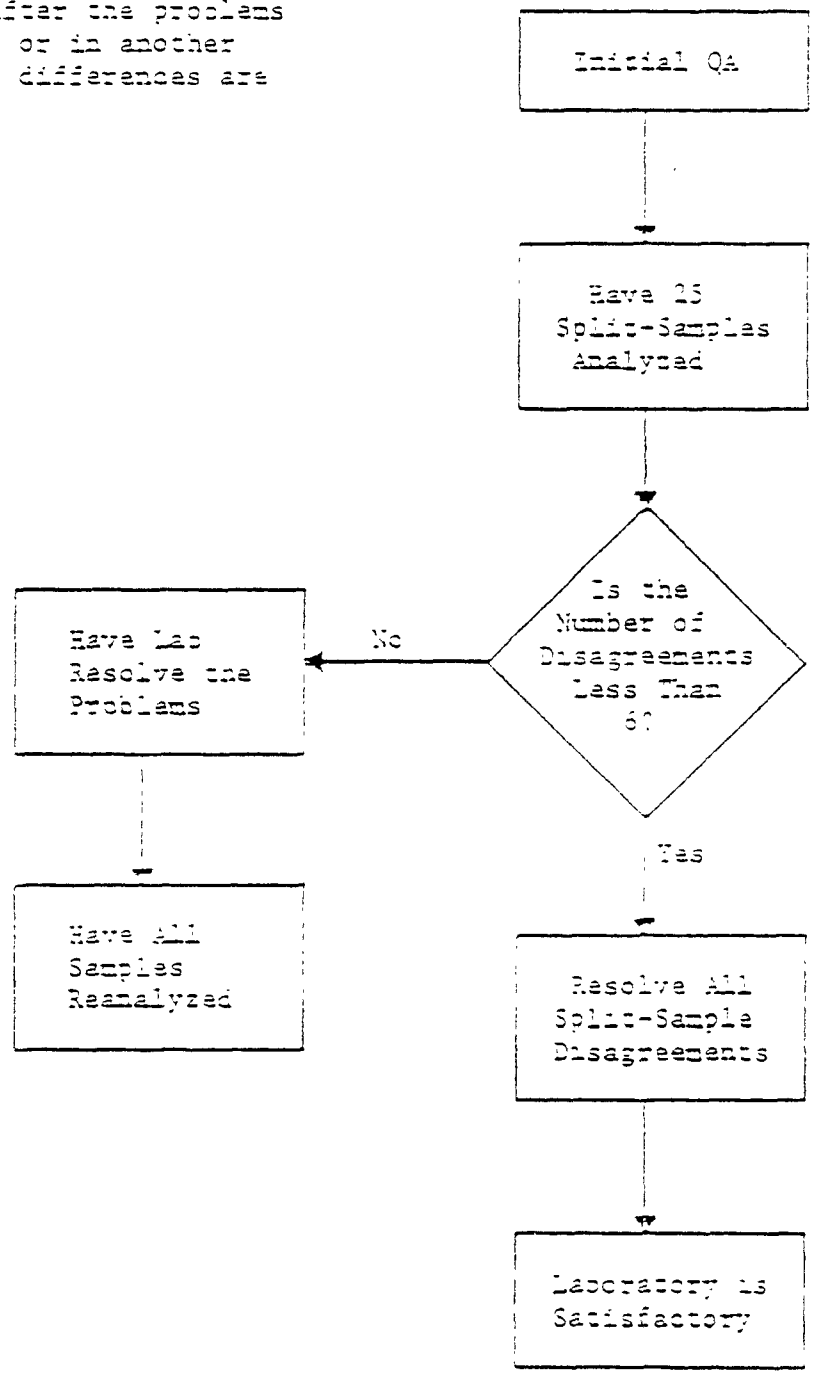


Figure B.2 Case 2: School Systems With Expected Number of Samples Over 25.

APPENDIX C: TABLE OF RANDOM DIGITS

The Table of Random Digits

(1) Always 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 <u>rectangle height</u>, 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 <u>height</u> 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
11734	55778	96963	77810	28022	82425	97392	39476	95151	72394
99467	43708	60959	40228	56188	98074	89262	31629	51108	67418
90320	11450	72504	86473	51064	47355	62408	78119	07511	78476
06734	40248	77132	05454	20024	26050	12507	27746	72340	77341
82283	16274	09896	94822	62222	86638	68735	71100	92155	42425
51551	55040	81301	37118	71410	00794	71918	36927	07989	49983
30123	39596	45464	86248	93148	44411	74090	79115	65126	47529
92577	88177	70879	86262	94259	94425	29510	64693	71494	76666
20634	56942	49147	06248	76430	05003	72932	14219	12357	07139
08361	25792	30352	54229	52236	94425	77004	05423	00344	73295
10302	02709	30614	30235	40006	04093	07178	41372	72597	22186
18222	53745	08060	08712	56392	87380	20034	55944	90350	53690
65099	27691	45346	50864	20147	42495	47582	03439	02451	92211
64120	99840	50925	29609	08126	56368	72380	28210	10877	87302
07785	11446	36829	00489	88258	32257	35044	28220	16018	63172
86522	81825	12175	64851	08704	39514	96470	08114	36112	48110
97368	79861	10561	68625	50525	67411	09184	24437	45222	55607
32442	94023	28821	42701	53581	19811	42181	61941	08487	31466
22031	84521	86988	73739	28505	42204	02517	77293	98604	94722
74697	72451	05019	10565	29075	09914	28312	75211	92115	42362
73913	04504	38179	33101	22620	53718	55562	98261	31001	29718
36212	47336	07554	52634	72295	42061	77629	49208	81319	00402
04034	34973	42422	99407	80696	99841	11789	08239	34200	92466
06738	25056	07062	41729	82225	35912	99622	80506	90053	17421
29556	67044	12000	41677	12570	05242	46663	48845	09251	20735
81332	00308	94354	40814	58271	51023	23225	28064	16580	15256
11899	40222	81608	95101	07853	48490	40089	52796	68081	34219
73536	25859	81910	42721	38146	27017	22664	90340	79871	44190
45257	95941	12175	59929	39556	86300	06350	46941	75486	26190
91745	99009	09540	05232	14596	05129	31070	57256	56462	44052
60150	41097	46375	37387	15919	50571	41519	82303	39215	59770
73706	82406	75400	52466	25128	21409	90490	92092	54212	59940
59656	00316	87543	64644	22366	93689	46717	53949	90949	64230
25122	09001	12244	93763	26217	68717	16136	02145	97902	50149
90048	70603	52174	06914	32766	52242	06632	90435	60126	70142
02444	92190	62427	55667	40864	17930	45671	23712	50460	76216
71285	96559	04405	68296	03070	67508	97855	21803	06861	32252
54442	26299	19385	73929	96552	86418	21529	95381	37457	50425
91806	60730	94109	13507	51182	31990	71202	02365	74616	99592
47900	04052	27184	67140	66033	21785	73033	01556	50675	21605
06884	46248	52972	53320	06251	46409	58129	21791	70982	71557
63232	28448	16119	73963	50564	32530	04139	15900	80466	82194
82603	53703	05848	89692	55194	23290	22232	00717	68939	49509
01007	03553	00990	03323	94805	76620	63754	19570	54337	42251
87049	98691	02240	81284	95851	50037	83905	65071	78121	12498
47465	74463	08384	91756	04492	36274	05605	85528	06472	40136
05479	75460	60621	05928	40280	65080	80680	11215	86705	28273
70796	63225	16039	54990	96073	02442	10670	80181	11517	81744
99193	15667	64280	75582	56897	81094	03620	74247	61702	65114

TABLE OF RANDOM DIGITS

56827	69440	89942	45868	04802	64520	14934	60455	05710	45757
05810	99759	57021	21715	69030	72540	10142	92591	80450	61040
89821	05097	12239	70006	00307	45385	68770	00324	00506	73897
74795	19602	44149	56632	04157	73258	14536	94714	50640	25035
03084	10365	69855	02042	30270	49892	71914	20928	71596	94737
10592	20339	24714	05410	14972	40731	40550	99496	21971	54002
55104	18126	71404	75804	59839	57059	54463	07251	32749	58458
57702	23035	31275	80363	88216	37966	32228	04721	66771	71920
12705	74257	83461	51295	02179	08139	62600	03093	89571	13790
71542	06402	60006	25569	55566	89610	71594	23893	15736	12227
22915	70557	46557	01760	11615	99046	92400	29472	60589	34226
55282	54438	30971	80916	75969	18812	70273	09563	40439	53956
21194	21729	74204	42410	40657	30693	42406	13049	49410	71809
23581	02659	56808	53957	42703	52535	79557	30385	05617	24730
06531	18639	01698	00279	42667	20379	81702	72291	26900	73616
24169	20305	01504	03588	49543	77966	73911	21129	41673	77126
94242	11140	98807	71924	04253	57665	36146	25962	45509	30275
22064	94868	20249	33047	12763	77184	42374	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	79725	44122	49203
00355	87566	20539	90362	99904	37015	33950	75325	09430	52527
12735	93590	93426	02615	31694	68531	52169	96692	48118	69197
64520	08257	53375	54258	22149	36401	14200	45229	75795	11705
77438	71190	50775	58225	77773	18577	23726	55381	63641	62205
06630	66615	54245	47322	19499	76229	45945	48395	18342	25652
04218	20098	09322	18093	49780	39373	57256	34104	05649	77246
54025	23575	77051	27594	40111	70949	52620	32234	75828	73396
07007	00509	09406	26693	16010	10350	65039	66500	42662	02512
98120	14199	94106	17951	30106	99747	59047	02543	75046	90425
03529	01469	95750	25637	76515	30987	72554	60139	05647	50969
12625	05905	03673	96762	19302	76490	05809	15105	45021	17223
75902	54154	85152	05519	30772	70110	23816	75194	65632	03065
54119	15377	61714	55547	69913	23748	01796	00639	75745	00230
92226	75154	44456	06416	95393	95626	76425	90192	42402	39406
36086	82055	75837	07095	05622	09760	45570	03715	22040	10062
50860	76490	12586	61580	53000	67945	07524	71677	11122	74120
65044	50596	24769	51227	44605	42379	30712	53219	22696	18305
03940	00785	77009	12605	05755	26706	63063	07024	20719	40279
01300	32373	50475	37957	60550	95824	38518	59896	10317	53021
35302	51965	43059	72212	12114	97556	81660	30668	65910	90048
55164	60085	34243	67068	99651	51367	21851	05714	15457	03299
49834	24686	09548	74646	02276	74290	03857	90325	67127	00611
73457	50641	77156	20473	95911	85434	45677	57215	10336	66905
55375	37603	68342	33754	44385	70128	04680	50994	45426	70635
91203	07322	10420	24895	81120	47571	12302	79222	53511	34159
14646	20965	34955	74655	04254	05074	74118	25801	44453	10575
77715	85702	51357	40755	47604	66125	07167	15392	27494	32112
30256	56173	04291	30972	25537	01805	96224	39109	22244	50431
26176	89048	94997	40154	34109	42125	34050	02370	05942	82695

TABLE OF RANDOM DIGITS

96779	94885	00674	52860	09750	47056	59506	10552	26093	40520
06973	61200	00485	70079	02503	80120	36995	05706	71111	40425
22366	71553	64352	69107	08552	05495	85845	71500	21601	58600
07197	91054	45316	64212	60605	68992	02608	90110	21590	56027
15204	25530	10147	65273	07550	76431	62311	36104	89043	56110
75554	64074	07544	04860	06473	73081	53549	44207	19801	01040
47200	79000	08569	74977	06560	99653	07458	17425	08206	11027
30159	83599	72906	07561	13625	05611	03040	69904	55051	74144
28979	73275	87178	48764	58960	40528	14073	03812	90075	96905
65855	05534	44208	08900	19491	82126	66850	02340	54979	22212
95348	50091	44611	49700	54272	80200	76737	16562	18003	66995
41774	64236	05346	57070	74027	46196	05222	42958	84458	81297
03354	96795	86666	05222	08206	24650	39713	30864	03102	86269
88886	09860	77579	07972	20542	81125	54580	70122	12730	74558
48139	54216	64441	02520	06250	71271	90096	52357	50361	98260
29222	86060	34400	29290	29057	74102	18949	07051	90221	72949
57944	15790	46141	77291	54095	07292	71554	16467	07360	47556
26473	05895	03766	43263	09700	22819	40269	60159	08560	12548
90941	14121	02494	52627	65420	12249	66149	47064	51507	98475
15200	46466	66754	00111	29052	75579	92279	88993	69732	27541
03704	21488	20070	27179	73622	95506	85425	92275	97203	28716
06976	19232	77725	06152	82770	07364	02089	25244	20696	06246
56734	61149	39620	53225	08005	61411	29645	40186	35101	89935
92687	63644	29010	50475	45020	95679	44963	25562	51162	71790
68625	25907	60217	16001	05291	27832	49665	25975	06913	71625
25126	52256	21610	96745	14275	80274	08793	27121	02809	18003
10929	52366	77537	80150	95257	14191	09952	42701	69101	70946
98361	61960	02080	44679	30300	64194	41519	20487	22554	69494
34201	75039	40413	60325	01612	60375	27925	54277	20220	20997
94946	95050	19640	24501	53261	56204	12505	12350	97546	30746
92459	46807	00742	95068	05713	91914	30068	76530	01471	01379
01990	61536	21017	53126	81270	02479	53450	54158	15000	32447
56057	00811	04524	50456	55755	00120	02509	71750	49129	16246
05730	05002	71761	05852	40640	60600	26789	02557	44620	95577
58622	11796	28561	27091	93010	64909	94299	98240	57450	13672
00473	59017	00466	54460	02993	45625	90196	54866	90703	60701
15270	34614	07404	00656	51250	70950	50589	61018	73649	06700
09596	47504	59505	95170	59916	58014	03649	54255	14652	12456
71904	81590	94857	45573	76874	74548	36851	46630	77916	73922
05201	51012	78986	27000	60194	98096	93210	74891	55099	02679
16510	95406	39078	01468	42577	67990	11287	27068	07874	61734
82616	94852	73159	76120	05010	03090	62827	10725	34709	09578
19962	86026	99855	14146	28041	90570	04160	59620	14100	60287
66852	52292	02115	75977	50722	96562	19088	64446	73949	80323
84161	37020	79694	05717	73417	15617	90427	46951	94605	12415
58837	00960	54272	08907	27925	95400	51316	02202	11040	99905
12971	62671	57151	80924	06413	20579	51701	84000	65556	20152
21026	12175	77915	21973	78898	69569	22225	10040	49855	51515
54152	24555	54366	40704	02111	00490	50198	52017	77473	03052
50404	17800	99805	02819	71000	83674	84640	67470	60922	05920

TABLE OF RANDOM DIGITS

49514	56977	61091	92610	26232	71404	09611	03514	00110	00105
92631	91970	05464	19712	01723	75125	00490	95926	01748	90450
40273	24410	94768	72614	00100	04250	19109	14774	19636	49597
61300	01904	67401	06570	85570	07985	60397	88409	29490	71102
06725	70141	56283	94081	66772	77024	71215	45070	42007	83661
03003	02041	40210	10730	87488	83077	59607	41701	97081	86148
96786	77447	06500	35673	29760	73551	57335	75095	46389	10514
13867	16828	74299	53165	91721	17584	03773	75051	83129	80955
60153	27028	68048	88563	30737	57701	62797	92227	86703	45231
00723	43680	40520	38434	76064	37846	60306	56308	68513	05431
70071	65642	85602	14420	76911	25034	62110	70957	59171	79161
85798	61647	84450	73632	92907	49621	00396	42702	31003	40448
03645	69342	80292	51763	21840	96110	69921	60405	77284	62427
36129	12516	75091	44000	80406	60704	74090	54442	56252	03487
67380	09077	01592	26204	40105	03901	68564	95491	48295	05200
05000	54801	07109	35724	80252	65075	56866	69977	15694	56040
65451	36814	24792	55271	22907	76975	20782	70291	37108	44979
97984	69925	21900	40520	42903	07952	22909	20514	22268	00017
98425	99082	72279	81922	92711	22859	70579	64006	02401	38988
52684	47602	92545	85307	27889	22652	94664	56700	09258	41365
71028	66756	05495	42089	00002	96484	57912	07416	05057	54606
06870	45241	68658	15507	61812	54899	24070	91467	07099	66697
61478	04060	02127	97949	28894	13548	43751	50420	68867	86054
20196	95679	18798	09736	95489	95477	52007	66635	10628	50577
82781	08482	03817	84125	14227	40948	54540	70141	85779	05960
76507	42570	70300	68956	25504	01547	06068	07290	58145	97945
70570	01851	06947	50655	18842	02009	10041	59211	76968	15850
82562	09745	20817	86570	01212	56138	06850	24860	50141	02007
59057	47915	45427	02291	14171	44739	60728	09158	18481	82991
30927	49665	55809	72006	26050	02878	88196	08501	09730	50992
17077	75905	06607	44475	00905	58790	60159	05190	07756	05495
02970	99102	70708	02889	48538	50824	58847	00264	00298	45010
82945	41817	02809	03413	08817	13177	74068	17190	02118	17939
74041	11492	07721	82149	56740	04207	83066	47007	20687	54704
75481	58719	09182	66108	08681	71424	05002	90387	05799	70919
87994	90471	00010	60021	94807	03001	87069	14001	54874	01007
76542	40327	76797	03054	26127	86957	31770	06080	45205	90607
67803	00971	40771	56798	62945	05850	97050	45878	71401	12206
61450	00708	98587	68045	65812	57718	95158	87176	56817	86507
24626	08923	56649	98557	55227	33891	86002	85219	77347	02664
00825	02906	61019	47791	40655	52065	23580	52770	58990	22900
87145	35850	45170	98096	11448	13413	90095	80920	65385	00552
52761	59668	24436	00044	76952	85072	51677	45770	25826	64561
20304	07868	42065	07960	98165	92197	03502	57407	55640	08005
24100	28154	13620	81246	26267	91707	00440	54639	07918	89509
04179	24070	19024	08587	90957	10056	07274	75170	05724	50026
85691	65031	42942	15172	70376	05401	86260	13609	02915	96212
34157	75648	34808	89094	64196	00966	90926	03590	19098	76077
87159	00507	90387	90706	61041	26517	68751	97776	66750	75672
82201	85709	00740	47625	20682	56210	60739	00570	86446	07199

TABLE OF RANDOM DIGITS

02740	59932	92306	62850	09755	42550	01031	08860	05712	78602
74802	58354	31210	26290	13112	93931	01470	10796	13229	18642
06930	73651	45636	77509	28610	04207	88045	15107	62905	04149
40345	80092	50587	18505	19001	82179	12572	77589	03459	35100
70055	98685	10244	11750	21952	72985	82903	66934	42442	07608
04552	76070	40908	93698	97711	15818	31004	00260	05626	07460
45253	86947	42417	28773	14936	94099	90775	42001	86675	82770
71558	21692	84077	17814	00316	49494	01817	90127	09485	92002
95474	76465	12019	04274	01890	23930	88771	31142	65859	28948
34619	91898	28499	00279	05051	87706	80909	40706	19056	95068
44546	75324	68505	77404	18543	15479	58850	70802	10636	82705
22917	96024	04784	05809	52738	82577	00289	68600	00310	46261
00043	01400	47803	75004	74509	08529	57890	45997	71749	08666
99257	54590	21688	64216	55906	51742	12898	09707	61604	18946
01072	01679	80961	84029	56460	09594	11909	51777	64796	52452
90806	50179	42064	62987	12072	84007	24060	59408	05695	36106
35914	09441	90149	67957	16985	39960	26142	45600	75486	74103
87047	77284	12753	45644	47540	55781	06672	57548	84706	25453
90727	46610	48045	49685	05035	07200	96470	56808	86774	07305
07409	50362	44171	16496	57370	77691	28006	55215	09723	25099
98892	53603	00909	81674	91956	84531	60422	55574	01670	61059
95398	77081	21912	24873	06372	12044	40204	08500	86716	08095
23982	24589	88896	01107	87512	00216	29665	06014	02919	17609
01300	70209	42174	10757	98501	05725	63205	61209	05705	40916
08457	10085	05741	79416	72457	59502	46956	09051	70963	19759
00698	80316	90070	73020	03675	78061	49929	70495	92247	04018
27142	41186	52273	81087	67096	16795	95542	80300	48765	24164
36775	63628	70656	42164	88426	51415	07514	24870	55665	05011
02560	51679	79600	00297	06404	17174	00109	00701	05909	58959
05744	56697	08001	50201	56300	09171	55995	60200	01205	00699
66482	04002	29770	46001	04588	42575	99018	84406	80405	21156
75075	41509	65940	67800	29080	94564	96595	00319	60468	87075
95772	70905	19454	60712	01401	96665	77751	01018	02990	50796
59012	81602	85000	09180	99975	70250	46504	59080	60240	27064
52092	04440	45625	04976	92012	18596	28595	15493	80754	46750
08027	07629	04009	77570	47165	77129	24495	67455	06000	82004
07284	09416	57010	02505	71440	42540	70005	66620	87559	77927
20510	08581	82009	69951	82658	60956	18290	60504	00741	59647
06075	12821	66722	07934	62318	64157	54590	96260	70109	06755
60679	43862	43675	03653	01060	81096	71332	28900	44207	08254
49416	58070	60708	87515	09290	87656	06120	23490	00963	57050
65757	09149	11750	92494	41005	05805	69882	55401	08091	01981
17079	77701	65100	44979	90909	29184	75604	58007	04470	80318
00757	10129	09646	07644	81689	66068	04882	04971	07565	66577
68276	79005	78270	80412	97028	81003	65908	85810	78067	29016
64716	91696	45448	92281	70854	67452	52145	41582	81549	82404
80695	11496	57056	43150	74754	56080	09250	65456	02408	96057
58275	66797	05380	41155	44089	94860	42074	01173	07967	12666
58005	84170	09999	03601	90002	41592	55686	73599	59900	21568
99990	80080	08810	07244	42067	76669	19686	64064	67141	80520

APPENDIX D: EPA REGIONAL ASBESTOS COORDINATORS

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

Region 2
Mr. Marcus Kantz, Asbestos Coor.
EPA Region II
Room 802,
26 Federal Plaza
New York, New York 10007
(212) 264-9538

Region 3
Mr. Fran Dougherty, Asbestos Coor.
EPA Region III
Curtis Building
Sixth & Walnut Streets
Philadelphia, Pennsylvania 19106
(215) 597-8683

Region 4
Mr. Dwight Brown, Asbestos Coor.
EPA Region IV
345 Courtland Street
Atlanta, Georgia 30308
(404) 881-3864

Region 5
Mr. Anthony Restaino, Asbestos Coor.
EPA Region V
230 S. Dearborn Street
Chicago, Illinois 60604
(312) 353-2291

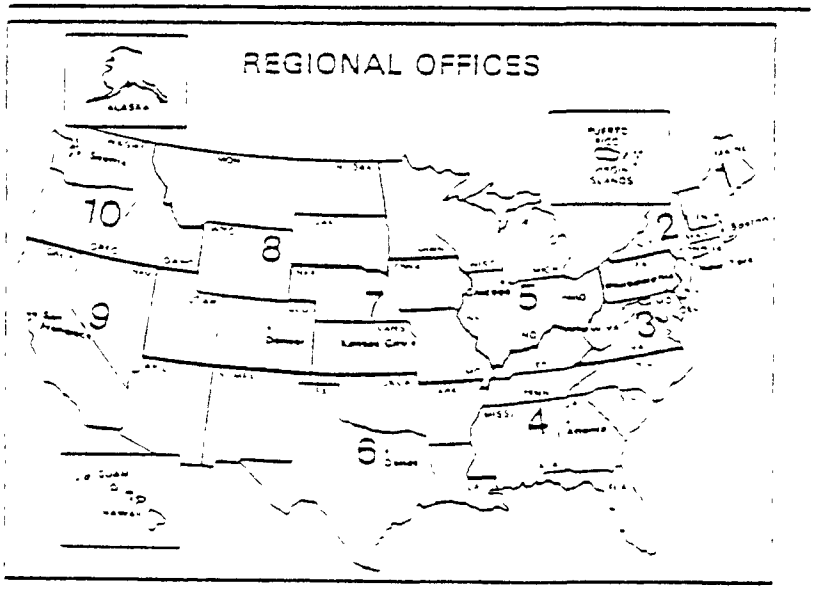
Region 6
Dr. Norman Dyer, Asbestos Coor.
EPA Region VI
First International Building
1201 Elm Street
Dallas, Texas 75270
(214) 767-273-

Region 7
Mr. Wolfgang Brandner, Asbestos Coor.
EPA Region VII
324 East 11th Street
Room 1500
Kansas City, Missouri 64106
(816) 374-6538

Region 8
Mr. Steve Farrell, Asbestos Coor.
Region VIII
1860 Lincoln Street
Denver, Colorado 80295
(303) 837-3926

Region 9
Mr. Kirby Marcise, Asbestos Coor.
EPA Region IX
215 Fremont Street
San Francisco, California 94105
(415) 556-3352

Region 10
Ms. Margo Partridge, Asbestos Coor.
EPA Region X
1200 Sixth Avenue
Seattle, Washington 98101
(206) 442-5560



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