6.0 Survey Techniques

6.1 General Considerations

6.1.1 Survey Plans and Procedures

The survey should be conducted in accordance with documented plans and procedures. The survey plan describes the survey objectives, the design to meet those objectives, and the general approach to performing measurements and sampling; the quality assurance plan establishes the basis for assuring the adequacy and quality of the survey data. Specific survey techniques are detailed in procedures, which may be included in the plan or incorporated by reference. Flow charts for conducting surveys of buildings and site grounds are provided in Figures 6-1 and 6-2. Personnel conducting the survey should be trained and qualified in the procedures they will use. Changes in plans and procedures will frequently be necessary, based on unanticipated findings or conditions encountered as the survey progresses. The individual responsible for onsite direction of the survey should have authority to make such changes; deviations from plans and procedures should be documented.

6.1.2 Records

Records should be legible, thorough, and unambiguous. Records are prepared in indelible ink, signed, and dated; records should be adequate to enable an independent evaluation of the site status. Changes are made by striking through the item to be changed with a single line, entering the corrected information, and initialing the change. Where practical, survey data should be recorded on standardized forms; other information, for which forms are not appropriate, is recorded in a bound logbook. All data and supporting information, necessary to substantiate the survey findings, are considered permanent legal records and, as such, should be protected from damage or loss and retained for a time period appropriate for such records.

6.1.3 Cross Contamination

Minimal residual activity should be present at a site at the time of the final status survey. There is therefore usually little concern for direct exposure or personal contamination during the survey. However, prudent standard contamination control practices should still be followed to minimize the possibility of personal contamination and to prevent cross-contamination of samples. Instruments and equipment should not be allowed to come into contact with surfaces which might contain loose activity; if they do, they should be cleaned and monitored. Sampling equipment may retain deposits of the sample media. Visible material can be removed by wiping with a cloth or brush, followed by rinsing in clean water. Gloves are recommended for those operations where hand contamination is possible. Clothing, hands, and shoes should be periodically checked for contamination, and good personal hygiene should be practiced. Avoid eating drinking, or smoking in potentially contaminated areas; wash hands after activities that may have resulted in skin contamination.

6.1.4 Allow for the Unexpected

Regardless of the effort devoted to the development of the survey plan, all conditions, situations, and findings will not be as anticipated. Weather and site surface conditions may require changes in survey procedures, patterns, and schedules. Previously unknown areas of residual contamination, may be found. Radionuclides which were not expected to be present at significant levels may be identified. Be flexible and adaptable; be prepared to modify the plan, based on situations and findings as the survey progresses.

6.2 Instrument Selection

Choose instruments which are reliable, suited to the physical and environmental conditions at the site, and capable of detecting the radiations of concern. As a general practice the instrument and survey technique should be able to measure a level of radiation or radioactivity, i.e. have an MDA which is less than 25% of the guideline value for structure surveys and less than 75% of the guideline value for open land surveys, and, preferable, as low as 10% of the guideline value. The instrument must be calibrated for the radiations and energies of interest at the site; this calibration must be referenceable to an accepted standards organization such as NIST. Routine operational checks of instrument performance are conducted to assure that the background and response are maintained within acceptable ranges.

6.3 Establishing Background Levels

NRC guideline values for residual activity are levels above the naturally occurring background. It is therefore necessary to determine the site background levels of direct radiation and radionuclide concentrations in soil, to enable a comparison of site radiological conditions with the acceptable guideline values. Additional information on determining background levels is provided in Section 2.3.1.

6.4 Building Surveys

6.4.1 Preparations

Preparations for surveys of building surfaces involve accessing the surfaces of interest and establishing a survey reference system. Arrangements for movement of equipment and materials that may remain in the facility are necessary and other actions to obtain access to potentially contamination surfaces, e.g. removing wall and floor coverings, including paint and wax or sealer, and opening drains and ducts, should be initiated when required to enable representative measurements of the contaminant. If alpha radiation or very low energy beta radiation is to be measured, the surface must be free of overlying material, such as dust and water, which would attenuate the alpha particles. Preliminary measurement should be conducted to ensure that such preparation will not result in spread of contamination.

The reference grid is then established, where appropriate, based on the contamination potential classification of the area (Section 4.2.1). Grids may be marked by paint, chalk line, or markers at grid block corners. Consideration should be given to the physical condition and future use of the facility in choosing a grid marking system, such that major cleanup for its removal will not be required during restoration.

The final preparation step is to develop scale drawings of the survey areas, indicating facility features and superimposing the grid reference system.

6.4.2 Scanning

Before conducting any fixed measurements, surfaces are scanned to identify the presence of elevated direct radiation which might indicate residual gross activity or hot-spots. Scans are conducted for all radiations potentially present, based on the operational history. The scanning detector is kept as close as possible to the surface and moved across the surface at a slow speed. Nominally, the distance between the detector and the surface is maintained at less than two centimeters, with exception of alpha scanning for which the distance should be less than 1 cm. For particulate radiations (alpha and beta) which may have very limited ranges, the scan speed should not exceed 1 detector width per second; this speed should be reduced to as low as 1/3 detector width per second for those situations when relatively low count rates may be indicative of residual activity exceeding guideline values. For gamma radiation the scanning speed may be greater; the probe is typically moved in a serpentine pattern while advancing at a speed of about 0.5 m per second.

For optimum detection sensitivity, changes in the instrument response are monitored via the audible output (use of headphones is recommended), rather than by observing fluctuations in the analog meter reading. This use of an audible signal negates concern for the time constant related to the meter response. Locations of direct radiation, discernable above the ambient level (typically 2 to 3 times the ambient count rate), are marked on facility maps and identified for further measurements and/or sampling.

An important factor in evaluating the potential effectiveness of scanning in identifying the presence of hot-spots is the detector sensitivity of the scanning techniques (see Section 5.2). The survey plan and final status report should include information on the sensitivity of the scanning technique.

6.4.3 Direct Measurements

To conduct direct measurements of surface alpha and beta activity, instruments and techniques providing the required detection sensitivity (Section 5.0) are selected. Experience has shown that a 1 minute integrated count, using a large area (100 cm^2) detector, is a practical field survey procedure and will provide detection sensitivities that are below most guideline levels. At the stage of the final survey little residual loose activity should be anticipated, and unless scanning has indicated the presence of gross activity, the probe can normally be placed in direct contact with the surface, without concern for contaminating the instrument.

All potential radiations should be measured. Some radionuclides or decay chains i.e. natural uranium and natural thorium, may emit more than one type of particulate radiation, i.e. alpha and beta particles. Although alpha radiation may provide a measure of the activity level of such materials, the alpha radiations may be attenuated by overlying dust and moisture, or due to imbedding in porous surfaces; in such cases the beta radiation associated with these same radioactive materials will be a better indicator of the true activity level. Because of the difficulties inherent in measuring alpha radiations on dirty or covered surfaces, reasonable efforts should be made to clean the surface or remove coverings prior to survey.

Surface activity measurements are performed at systematically and randomly selected locations (Section 4.2.3) and at locations of elevated direct radiation, identified by surface scans. If the measurement exceeds an action level, determined on the basis of the potential contaminant and the detector and survey parameters, the location is noted for further remediation or resolution. Localized scanning and measurements are repeated after any additional remediation.

Gamma exposure rate measurements are conducted at 1 m above the floor at systematically and randomly selected locations (Section 4.2.3) and at locations of elevated radiation, identified by area gamma scans.

6.4.4 Removable Contamination Measurements

Smears for removable surface activity are obtained by wiping an area of approximately 100 cm^2, using a dry filter paper, such as Whatman 50 or equivalent, while applying moderate pressure. A 47 mm diameter filter is typically used, although, for surveys for low-energy beta emitters, smaller sizes may be more appropriate because they can be placed directly into a liquid scintillation vial for counting. Small pieces of styrofoam are occasionally used for smears for tritium. A smear for removable contamination is obtained at each location of direct surface activity measurement.

For surveys of small penetrations, such as cracks or anchor-bolt holes, cotton swabs are used to wipe the area of concern. Samples (smears or swabs) are placed into envelopes or other individual containers, to prevent cross-contamination while awaiting analysis. Smears for alpha and medium- or high-energy beta activity can be evaluated in the field by counting them on an integrating scaler unit with appropriate detectors; the same detectors utilized for direct measurements may be used for this purpose. However, the more common practice is to return the smears to the laboratory, where analysis can be conducted using more sensitive techniques.

6.4.5 Samples

Samples from a variety of locations may be required, depending upon the specific facility conditions and the results of scans and direct measurements. Inaccessible surfaces cannot be adequately evaluated by direct measurements on external surfaces alone; therefore those locations which could contain residual radioactive material should be accessed for survey. Residue can be collected from drains using a piece of wire or plumbers "snake" with a strip of cloth attached to the end; deposits on the pipe interior can be loosened by scraping with a hard tipped tool that can be inserted into the drain opening. Particular attention should be given to "low-points" or "traps" where activity would likely accumulate. The need for further internal monitoring and sampling is determined on the basis of residue samples and direct measurements at the inlet, outlet, cleanouts, and other access points to the pipe interior.

Residual activity will often accumulate in cracks and joints in the floor. These are sampled by scraping the crack or joint with a pointed tool, such as a screwdriver or chisel. Samples of the residue can then be analyzed; positive results of such an analysis may indicate possible subfloor contamination. Checking for activity below the floor will require accessing a crawl space (if one is present) or removal of a section of the flooring. Coring, using a commercially available unit, is a common approach to accessing the subfloor soil. After the core, ranging in diameter from a few cm to 20 cm, is removed, direct monitoring of the underlying surface can be performed and samples of soil collected.

Coring is also useful for collecting samples of construction material which may contain activity, which has penetrated to below the surface, or activity, induced by neutron activation. This type of sampling is also applicable to roofing material which may contain imbedded or entrapped contaminants. The profile of the distribution and the total radionuclide content can be determined by analyzing horizontal sections of the core.

If residual activity has been coated by paint or some other treatment, the underlying surface and the coating itself may be contaminated. If the activity is a pure alpha or low-energy beta emitter, measurements at the surface will probably not be representative of the actual residual activity level. In this case the surface layer is removed from a known area - usually 100 cm^2 - using a commercial stripping agent or by physically abrading the surface. The removed coating material is analyzed for activity content and the level converted to units of dpm/100 cm^2 for comparison with guidelines for surface activity. Direct measurements are performed on the underlying surface, after removal of the coating.

6.5 Grounds Surveys

6.5.1 Preparations

Similar considerations and actions to those taken for building surveys are necessary for preparing for surveys of site grounds. Equipment and materials which restrict surface access should be relocated; heavy ground cover should be removed and areas of standing water drained. (Sampling and analysis of standing water may be necessary to assure that it does not contain radioactive contaminants.) The reference grid is then established, as appropriate, based on the contamination potential of the area (Sections 4.2.1 and 4.2.2). Grids are usually marked by wooden or metal stakes, driven into the surface at grid line intersections. Where surface coverings prevent installation of stakes, the grid intersection can be marked by painting. The last step in site preparation is to prepare scale drawings of the survey areas, indicating facility features and the grid reference systems.

6.5.2 Scanning

Prior to sampling, surfaces are gamma scanned to identify the presence of elevated direct radiation, which might indicate residual gross activity or hot-spots. The most sensitive detection system available is used for these scans. The detector is kept as close as possible to the surface and is moved back and forth, while walking over the surface at a speed of about 0.5 m per second. For optimum detection sensitivity changes in the instrument response are monitored via the audible output, rather than by noting fluctuations in the analog meter reading. Locations of direct radiation, discernable above the ambient level, are marked on facility maps and identified for further measurements and/or sampling.

In addition to the gamma scans, paved areas are scanned for alpha and/or beta radiations. The same techniques are used as described in Section 6.4.2 for scans of building surfaces.

6.5.3 Direct Measurements

Direct measurements of surface activity levels are performed on paved surfaces, following the procedures described in Section 6.4.3 for building surfaces.

Exposure rate measurements are conducted at 1 m above the ground at systematic and random locations (Section 4.2.3) and at locations of elevated radiation, identified by area gamma scans. For high-energy gamma emitters, for which the predominant exposure pathway is direct gamma radiation (for example Co-60 and Cs-137), the exposure rate measurement above may be sufficient to demonstrate the guideline is satisfied. Some limited sampling will, however, be required to identify the radionuclide and to demonstrate that the residual activity is distributed in the surface layer of soil. Measurements of alpha and beta radiations on soil surfaces are generally not meaningful and are therefore not recommended for surveys to determine the final site status.

6.5.4 Removable Activity Measurements

It is unlikely that outside surfaces, exposed to wind and rain, will have significant levels of removable surface activity. If removable activity is suspected smears or swabs may be obtained and evaluated as described in Section 6.4.4.

6.5.5 Soil Sampling

Surface soil samples are collected from the top 15 cm of soil at locations established in Section 4.2.3. A sample size of approximately 1 kg is usually desirable, if gamma spectrometry is to be performed; if only wet chemistry analyses are to be performed, a sample size of 100 grams or less may be adequate, depending upon the specific laboratory procedures and the detection sensitivities required. The possibility of compositing certain groups of samples should also be considered when determining the quantity of sample to be obtained. Sampling may be conducted using a variety of simple hand tools, such as a shovel or trowel. If the sample is to be representative of a known surface area (for example when distribution patterns from airborne activity are of interest), special "cookie-cutter" type tools are used. Sampling tools are cleaned and monitored, as appropriate, after each use.

If there is a potential for soil activity beneath paved surfaces, the surface can be removed by coring and the underlying soil sampled, as described above for surface soils.

Grass, rocks, sticks, and foreign objects are removed from soil samples to the degree practical at the time of sampling. If there is reason to believe these materials contain activity they should be retained as separate samples.

Locations of known or suspected subsurface activity are sampled using the same grid block spacing and systematic pattern as used for surface areas of high contamination-potential. Subsurface soil may be sampled using portable manual equipment or, if the sampling depth is greater than several meters, heavier truck-mounted sampling rigs. For shallow subsurface sampling the hole is advanced to the desired starting depth, using a post-hole digger, shovel, twist auger, motorized auger, or punch-type shelby tube sampler. Loose material is removed from the hole and the sample collected over the next 15 or 30 cm depth. Continuous coring samplers or split-barrel samplers, advanced through hollow-stem augers, are usually used for obtaining deeper subsurface samples. The entire core can be retained and monitored, intact, to determine if layers of activity are present, or sections of the core can be removed for analysis. Unless there is prior information regarding the depth and distribution of subsurface activity, samples should be obtained at approximately 1 m intervals from the surface to below the suspected depth of the residual activity. Samples of subsurface water should also be collected, where available, to assist in evaluation of the migration of activity into the water table; expertise in such sampling should be sought to assure the validity of the resulting data.

Gamma logging of boreholes is performed to identify the presence of subsurface deposits of gamma-emitting radionuclides. A sensitive gamma detector such as a NaI gamma scintillation probe is lowered into the hole and a count rate determined at about 0.3 to 0.5 m intervals. The sensitivity and specificity cf this technique may be improved by placing the detector inside a shielded collimator assembly.

As was indicated in Section 4.2.5, electromagnetic sensing techniques are useful in locating potential areas of subsurface activity, due to buried piping, tanks, and former waste disposals. These techniques also increase surveyor safety by identifying buried utilities or containers of potentially hazardous material (radiological or chemical) which the surveyor will want to avoid disturbing.

Federal, state, and local agencies may have regulations restricting the drilling of boreholes and requiring special handling of drilling spoils and backfilling of holes. Surveyors should consult these agencies before initiating subsurface investigations.

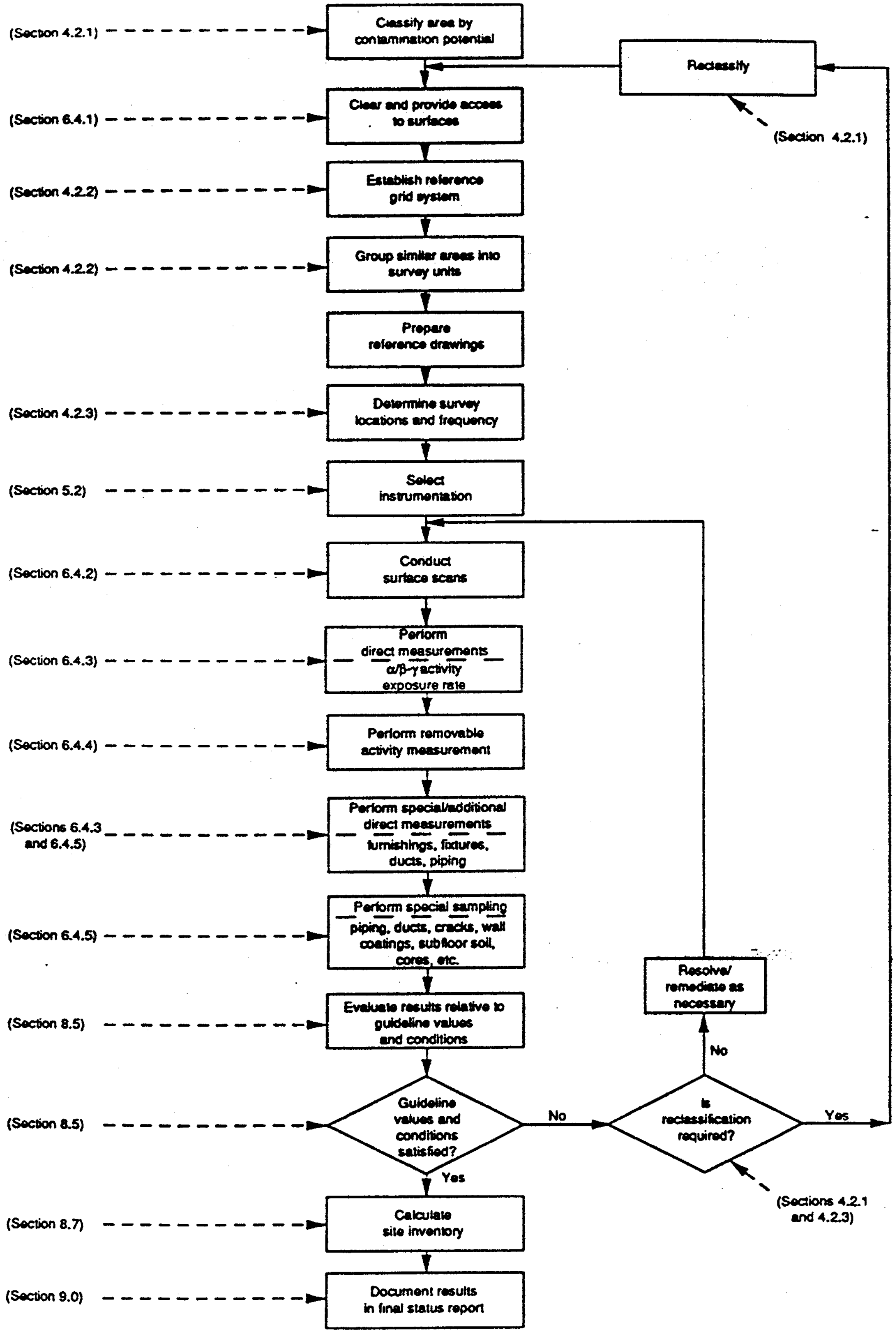

FIGURE 6-1: Flow Diagram for Final Status Survey of Buildings

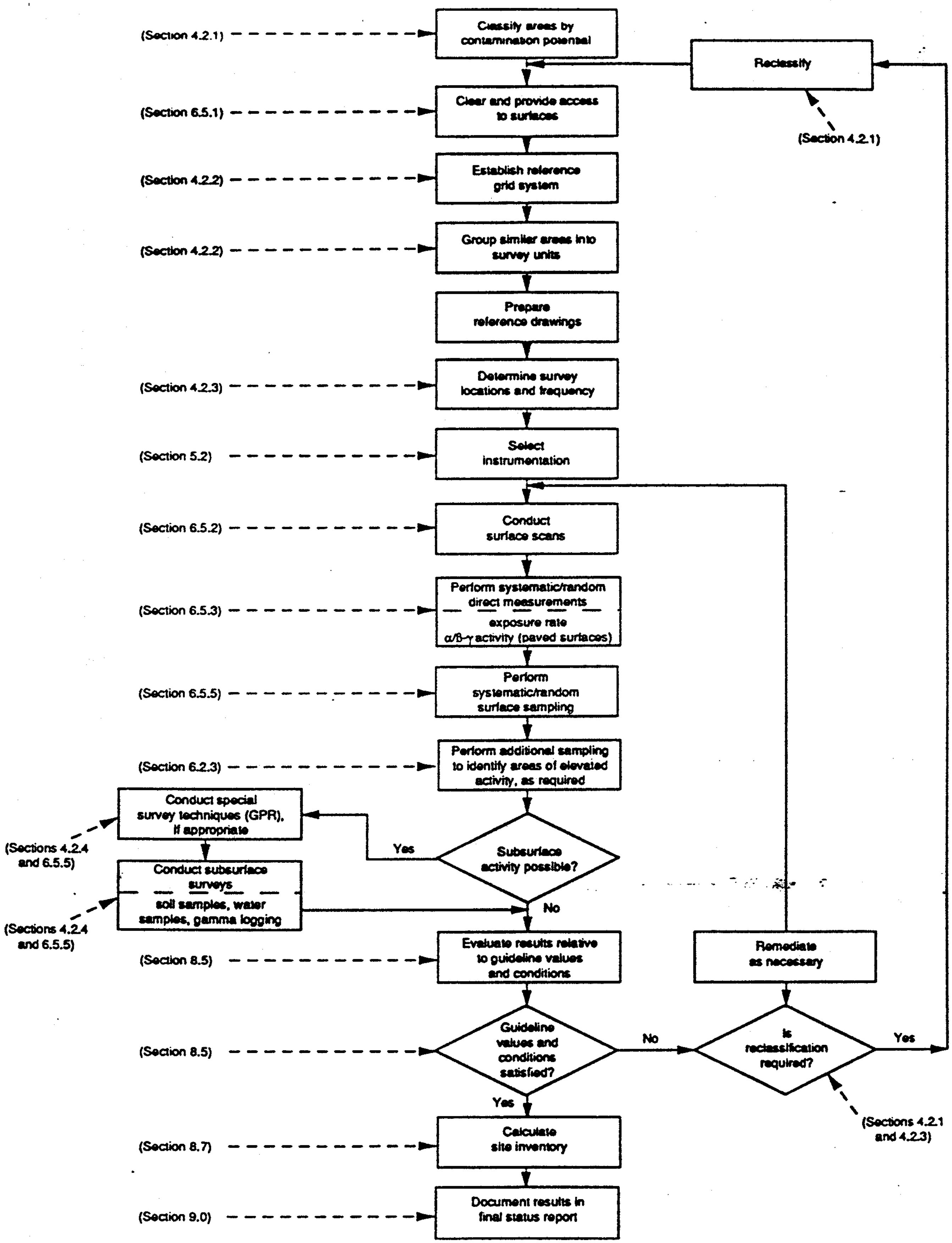

FIGURE 6-2: Flow Diagram for Final Status Survey of Site Grounds