APPENDIX C

Survey Plan
For Determining
The Final Radiological Status
Of
The Reference Uranium Fuel
Fabrication Plant

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Preface

An example of a final status survey plan for a reference uranium fuel fabrication plant is provided in this Appendix.

The major features used in the site description, such as plant design, radionuclides used, operations conducted, waste-disposal practices, levels of radionuclides remaining, etc., were taken from reports prepared for the NRC for the purpose of evaluating the technology, safety, and costs of decommissioning. The specific source documents were: *NUREG/CR-1266, Technology, Safety, and Costs of Decommissioning a Reference Uranium Fuel Fabrication Plant, and NUREG/CR-2241, Technology and Cost of Termination Surveys Associated with Decommissioning of Nuclear Facilities.*

Some alterations of and/or additions to information from these documents have been made, however, to demonstrate principles and procedures given in this manual. Care has been taken to ensure that these additions represent typical conditions that could be expected at the reference facility. To enhance readability, the term "reference" has been used as though it were the name of the facility; e.g., Reference Uranium Fuel Fabrication (RFF) Plant. Also, a fictitious company, e.g., General Nuclear Corporation, has been named as the owner and operator of the plant, and fictitious personal names have been included to present a more realistic example of a termination survey plan. Fictitious names and titles are shown in italics.

1.0 Background Information

The *Reference Uranium Fuel Fabrication Plant (RFF)* in Yorktown, Pennsylvania was built between 1960 and 1964 and was operated from 1964 until mid 1985 by the *General Nuclear Corporation.* Operating under NRC License XXX-100, Docket No. 00-000, the plant converted natural and enriched uranium hexafluoride (UF_6) to uranium oxide (UO_2), formed the UO_2 into pellets, and incorporated pellets into fuel rods and bundles. Auxiliary facilities were used to recover uranium from scrap and waste materials. The primary method involved the hydrolysis of UF_6 to ammonium diuranate (ADU), which was then reduced and calcined to produce dry UO_2 powder; the secondary process was the conversion of UF_6 to U_3O_8 in a flame conversion reactor, followed by reduction to UO_2 provider in a reduction-calciner. Two processes were used for the UF_6 to UO_2 conversion.

In 1985 the plant was shut down and nuclear materials were removed and shipped to Department of Energy facilities in Idaho Falls, Idaho. The plant remained in the shut-down state until 1986, when decommissioning efforts were initiated. Process equipment, fixtures, piping, etc., were removed and disposed of as radioactive waste. Buildings and adjacent grounds were characterized and those areas exceeding NRC guidelines for license termination were decontaminated; these efforts were completed in late 1990. This document describes the plan for conducting the final status survey of the site. Supporting information is presented in the Site Decommissioning Plan, prepared and submitted to the NRC in May 1986, and in the Characterization Survey Report, submitted in February 1988.

2.0 Site Information

2.1 Site Description

The *Reference Uranium Fuel Fabrication Plant* is located on a total land area of approximately 470 hectares (1160 acres); there is a moderate size stream (Wandering River) running through one corner of the site (Figure 1). Actual plant processing facilities are on a much smaller, restricted, fenced-in area of approximately 30,000 m^2 (3 hectares). The plant area occupies a low bluff that forms a bank of the river, and several flat alluvial terraces comprise the main topographical features of the property. These terraces lie at average elevations of 280 to 284 m above sea level and slope away from the river at grades of 2 to 3 percent. The river is used for disposal of acceptable liquid effluents from the on-site liquid waste systems.

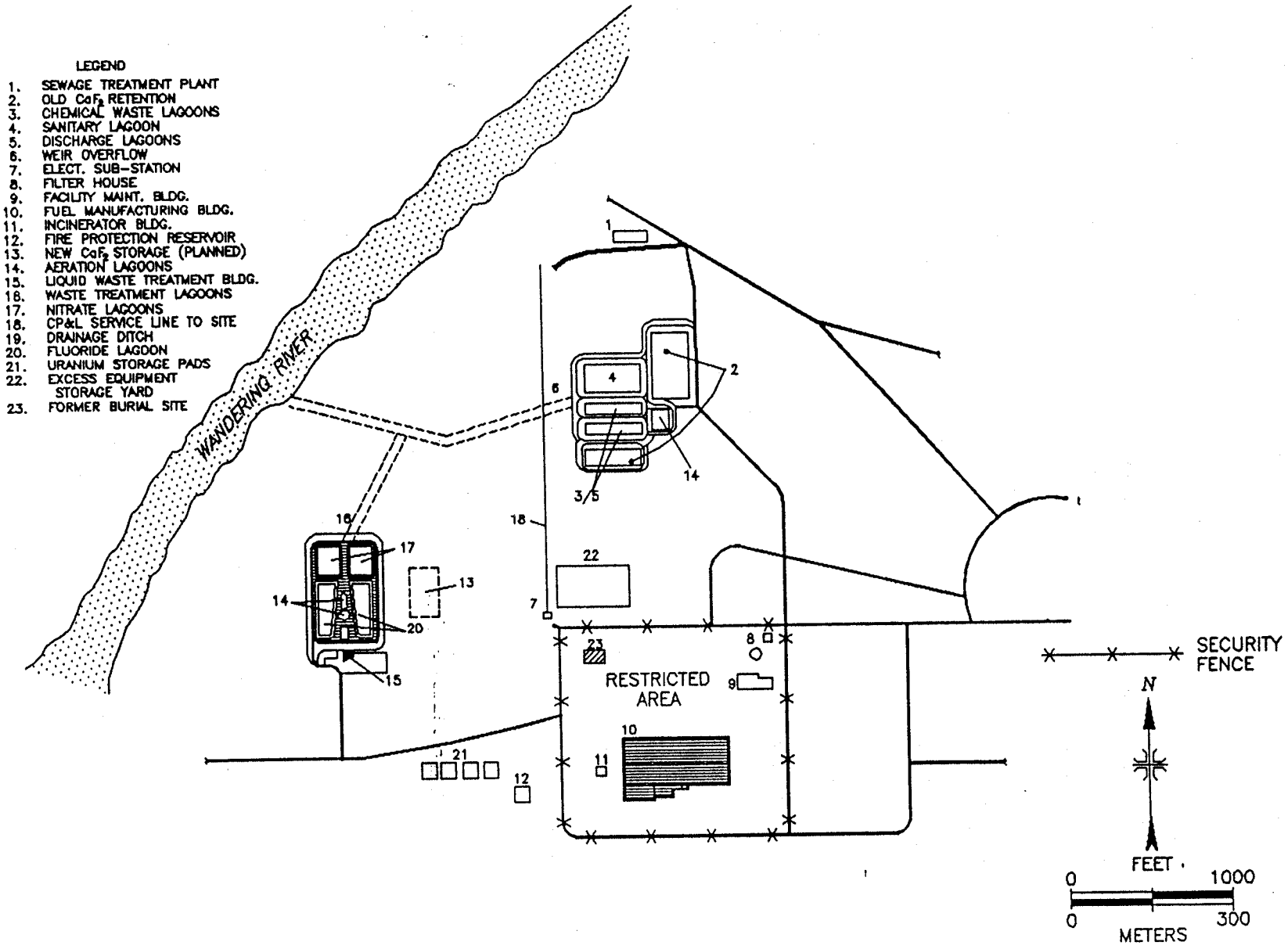

FIGURE 1: Map of the Reference Uranium Fuel Fabrication Plant Site

The major structures in the restricted processing area include the main building (with inter-connected chemical/metal laboratory and uranium scrap recovery and powder warehouse rooms), an incinerator building, a maintenance building, and a filter house (Figures 2A & 2B).

Auxiliary facilities are located outside the fenced area. These include a boiler house, a fluoride and nitrate waste treatment plant and associated lagoons, liquid chemical waste treatment lagoons, a sewage treatment plant and sanitary lagoon, and concrete uranium storage pads. The auxiliary facilities were used to recover uranium from scrap and waste materials and to recover valuable chemicals from gaseous and liquid wastes.

During the plant's 21 years of operation, an estimated total of 0.2 Ci of radioactivity was released into the atmosphere and subsequently deposited on the site. The property also contained one small, shallow land burial area for low-level radioactive waste. This area was operated in accordance with 10 CFR 20.304 between 1966 and 1970, receiving an estimated total activity of 0.3 Ci of uranium. This waste was excavated and disposed of at an authorized burial site as part of the decommissioning process. Although the site has been shut down for five years, total uranium radioactivity would change very little from shutdown due to the dominance of long-lived radionuclides.

2.2 Site Conditions at Time of Final Survey

In the opinion of the licensee the Plant site has been decontaminated to a level which satisfies the current NRC guidelines and is ready for a termination survey. As part of the decommissioning activities, process equipment and supporting fixtures were removed from radioactive materials areas and cleaned and released or disposed of as radioactive waste. Potentially contaminated structural surfaces have been stripped of coatings by grit blasting or use of chemical agents. Contaminated surfaces identified by the characterization survey have been cleaned or removed.

The on-site shallow land burial was excavated. Facilities used for processing of potentially contaminated effluents such as the lagoons and sewage treatment plant have been characterized, and, where necessary, decontamination has been performed. Soil contamination in the vicinity of process building was identified and removed to depths ranging from 5 cm to 1.5 m.

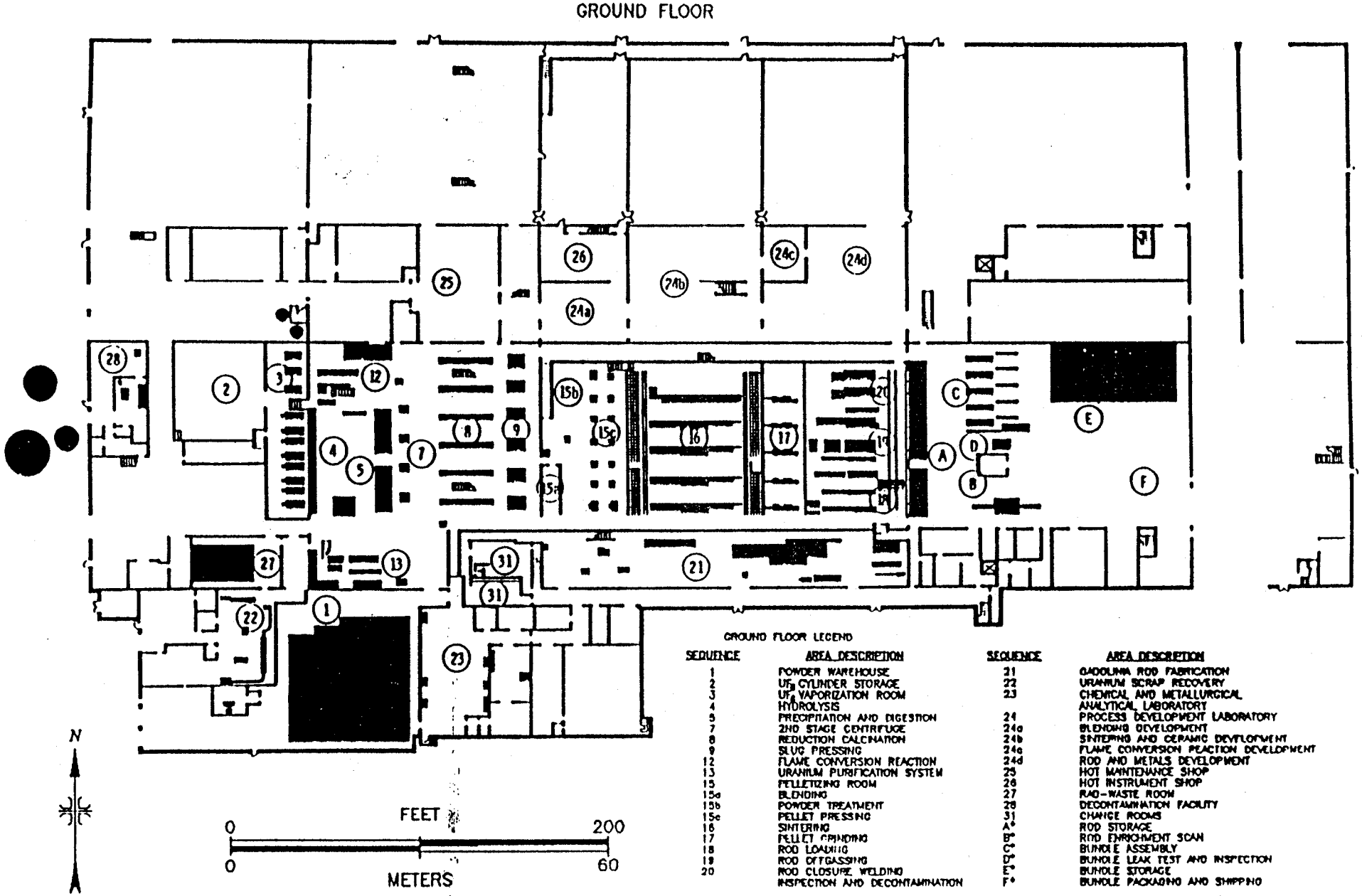

FIGURE 2A: Process Building Layout, Indicating Those Areas Used for Licer d Activities

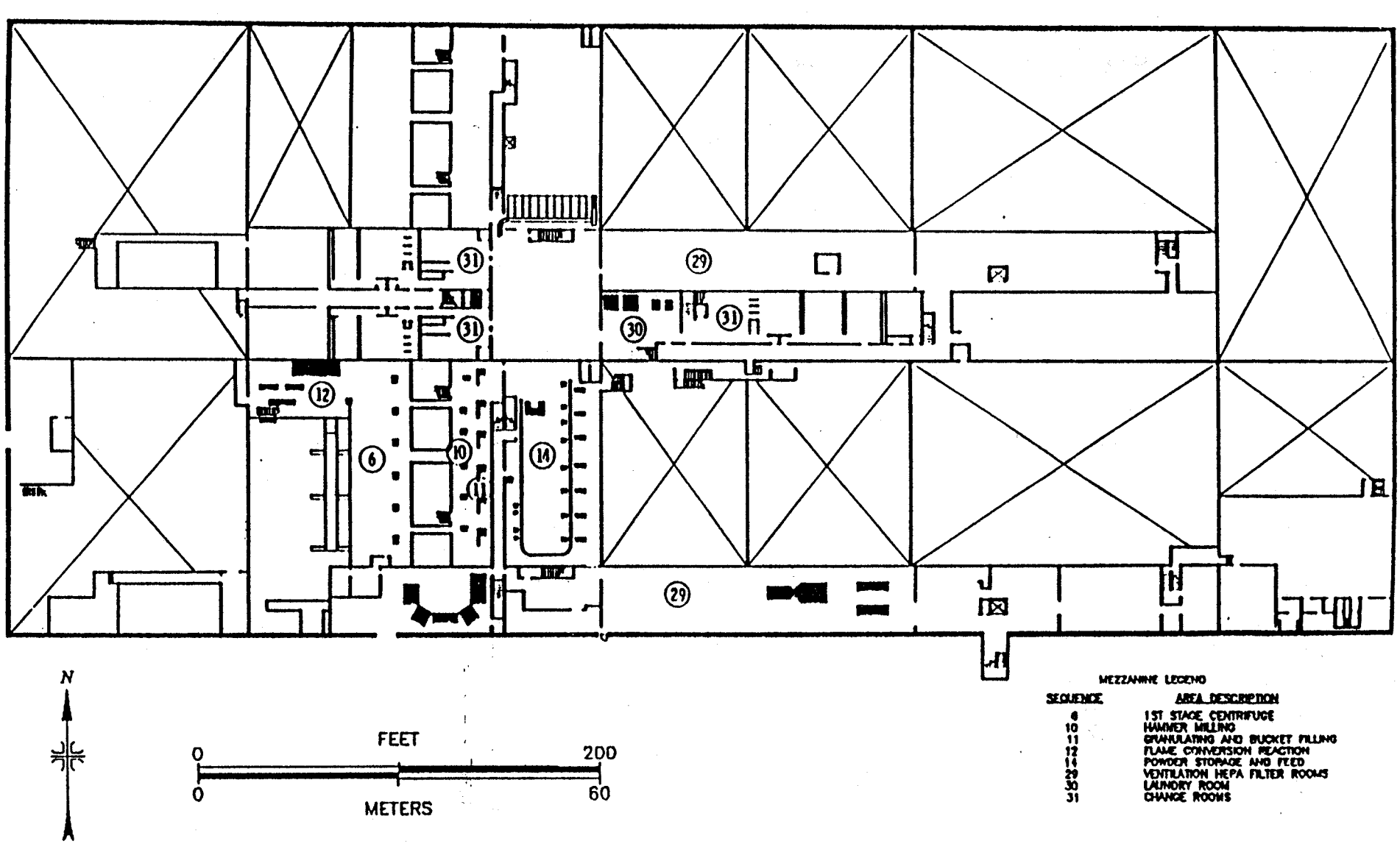

FIGURE 2B: Process Building Layout, Indicating Those Areas Used for Licensed Activities

Details regarding the decontamination actions will be presented in the Final Site Decommissioning Report, currently in preparation.

3.0 Final Status Survey Overview

3.1 Survey Objectives

The purpose of the final status survey is to demonstrate that the radiological conditions at the *Reference Uranium Fuel Fabrication Plant* satisfy the NRC guidelines and that the plant site can, therefore, be released from licensing restrictions for future use without radiological controls. The specific objectives of the survey are to show that:

A. Surface Activity of Buildings and Structures

1. Average surface contamination levels for each survey unit are within the authorized values.

2. Small, areas of residual activity, known as "hot-spots" do not exceed three times the average value. The hot-spot limit applies to areas of up to 100 cm^2. The average activity level within the 1 m^2 area containing a hot-spot must be within the guideline.

3. Reasonable efforts have been made to clean up removable activity and removable activity does not exceed 20% of the average surface activity guidelines.

4. Exposure rates in occupiable locations are less than 5 μR/h above background. Exposure levels are measured at 1 m from floor/lower wall surfaces and are averaged over floor areas, not to exceed the size of a small office, i.e. about 10 m^2.

B. Volume Activity of Soil and Building Materials

1. Average radionuclide concentrations are within the authorized value. Averaging is based on a 100 m^2 grid area.

2. Reasonable efforts have been made to identify and remove hot-spots that may exceed the average guideline by greater than a factor of $(100/A)^{½}$, where A is the area (in m^2) of the hot spot.

3. Exposure rates do not exceed 5 μR/h above background at 1 m above the surface. Exposure rates may be averaged over a 100 m^2 grid areas. Maximum exposure rates over any discrete area of < 100 m^2 may not exceed 10 μR/h above background.

The above conditions will be demonstrated at a 95% confidence level for each survey unit as a whole.

Finally, the survey data will be used to calculate the total inventory of residual activity from licensed site operations.

3.2 Identity of Contaminants

Based on the knowledge of site operations and the results of the preliminary assessment and characterization survey the significant radiological contaminants have been determined to be isotopes of uranium. The uranium is enriched in U-234 and U-235 above naturally occurring levels; the average activity ratios of the uranium isotopes is:

U-234	81.4%
U-238	15.5%
U-235	3.1%

On the basis of this combination of contaminants the surface contamination guidelines for the site are:

_____ dpm/100 cm^2, average over 1 m^2
_____ dpm/100 cm^2, maximum over 100 cm^2
_____ dpm/200 cm^2, removable

The soil contamination guidelines are _____ pCi/g, average total uranium.

In addition to the radiological contaminants the site contains soil areas of nitrate and fluoride contamination. These areas will be addressed in accordance with requirements of the Commonwealth of Pennsylvania and the U.S. Environmental Protection Agency.

3.3 Organization and Responsibilities

The survey will be performed by a team composed of qualified personnel currently employed by the *RFF Plant* and *General Nuclear Corporation.* This is the same organizational structure which conducted the characterization survey activities. Figure 3 is an organizational chart for the survey activities.

The team will operate under the supervision of *Dr. Allen Babcock,* Nuclear Engineer for *General Nuclear Corporation. Dr. Babcock* will have the authority to make appropriate changes to the survey plan (subject to the established QA/QC program) as deemed necessary as the survey progresses.

Field measurements of radiological parameters and sample collection will be under the direction of *Mr. Raymond Metter* of the *General Nuclear Corporation's Environmental Measurements Section. Mr. Metter* will also oversee the activities of field subcontracts.

Mr. John Scott of the *RFF Plant Analytical Services Group* will direct laboratory activities for both in-house analyses and the contractor laboratory services of *Analytical Operations,Inc.*

QA/QC responsibilities will be handled by a QA officer whose work responsibilities are otherwise separate from those on the termination survey team. *Mr. John Perkins* from the Plant's Quality Assurance/Quality Control Office will serve as the QA officer and will, in that capacity, coordinate all interface requirements during the survey process and name members of the QA/QC team as needed. QA/QC procedures will be adopted from the ANSI/ASTM NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities* (ANSI 1989) and where applicable, Reg. Guide 4.15, *Quality Assurance for Radiological Monitoring Programs--Effluent Streams and the Environment* (NRC-1979). Any changes or alterations to these procedures will be handled in the same manner as changes to survey procedures, except that approval will be required at a higher level of management. All changes from procedures will be documented and will become a part of the final report submitted to NRC.

Mr. Al Hillman will provide expertise on Health and Safety issues for the survey process. *Mr. Hillman* currently serves as a Health and Safety officer in *General Nuclear's Environmental Safety Division.* Health and safety considerations for workers and for the general public are incorporated into the survey plan. The *General Nuclear Corporation Health and Safety Procedures Manual* will be used as procedural guidelines, since this manual is both based on industry standard and already encompasses specific plant areas and conditions.

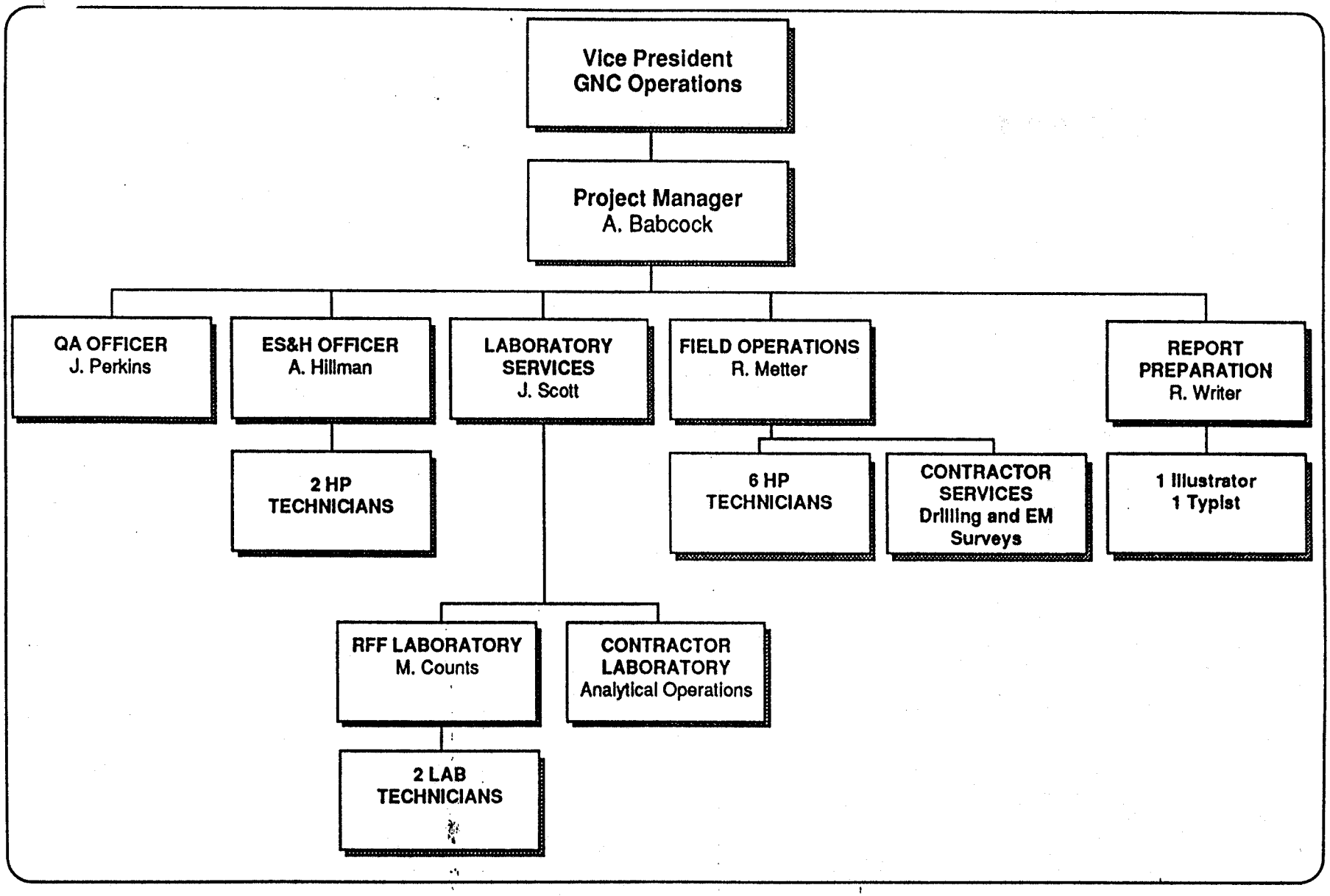

FIGURE 3: Organization Chart for Final Status Survey Activities

Qualifications of each key team member were presented in Attachment 1 of the decommissioning plan and the characterization survey report, previously provided to the NRC.

3.4 Training

The *Reference Uranium Fuel Fabrication Plant* provides continuing training for its health physics personnel and other workers who may be exposed to radioactive materials. Training varies according to potential exposure and the nature of the employee's job duties. In addition to the regular training, special training will be provided on equipment, special techniques, and practices relative to the survey activities for those employees who will be involved in taking radiological measurements and samples. All members of the final status survey team will attend an in-house training session reviewing radiation protection, survey procedures, and quality assurance activities. Documentation of training participation and results of testing to demonstrate knowledge and skills will be retained in the *General Nuclear Corporation* training files.

3.5 Laboratory Services

Analytical services for gross alpha/beta levels on smears, air, and water samples will be performed by the Plant Analytical Services Laboratory in accordance with standard Plant procedures, "Laboratory Analyses of Environmental Samples" procedures GNC/RFF-HP 3.1, 3.2, 3.4, and 3.7 (1988). Samples of soil and other special samples, requiring gamma spectrometry or wet chemistry analyses will be conducted by a contract laboratory, *Analytical Operations*, Inc. QA/QC programs for both in-house and contractor laboratory services will be monitored by the QA coordinator of the termination survey team.

3.6 General Survey Plan

This survey plan consists systematic processes and procedures that have been deemed acceptable by industry standards and the NRC. Activities (organized units of work needed to complete a function) have been defined and tasks (specific work assignments within a specific activity) have been delegated to the appropriate team members. Table 1 provides a breakdown of activities and tasks that are currently a part of the termination survey plan.

TABLE 1

OVERVIEW OF MAJOR ACTIVITIES AND TASKS

ACTIVITIES		TASKS
Evaluate contamination potential	1.	Review operating history with respect to facility use, spills, releases etc.
	2.	Review radiological data from scoping and characterization surveys.
	3.	Identify radionuclides of concern and determine guidelines.
	4.	Classify areas as to "affected" and "unaffected".
Establish grid reference system	1.	Install grids.
	2.	Prepare facility survey maps.
Determine background levels	1.	Measure indoor exposure rates and ambient beta-gamma levels.
	2.	Measure outdoor exposure rates.
	3.	Collect background soil samples.
Perform direct measurements	1.	Conduct surface scans.
	2.	Determine frequency and locations of measurements to meet criteria.
	3.	Conduct surface activity measurements.
	4.	Measure exposure rates.
Collect Samples	1.	Determine frequency and locations of sampling to meet criteria.
	2.	Conduct electromagnetic scans of subsurface sampling areas.
	3.	Collect systematic and special samples.
Analyze samples	1.	Count smears and swabs.
	2.	Analyze soil, paint, residue and other solid samples for uranium activity.
Interpret data	1.	Convert data to standard units.
	2.	Calculate average levels.
	3.	Compare data with criteria.
	4.	Compute total residue activity inventory.
Prepare report	1.	Construct data tables.
	2.	Develop graphics.
	3.	Prepare text.
	4.	Submit report to NRC.

Tasks will be performed in accordance with guidelines stated in the *Manual for Conducting Radiological Survey in Support of License Termination, NUREG/CR-5849.*

- Section 4.0 - Planning and Designing the Final Status Survey
- Section 5.0 - Radiological Instrumentation
- Section 6.0 - Survey Techniques
- Section 7.0 - Samples Analysis
- Section 8.0 - Interpretation of Survey Results

3.7 Tentative Schedule

The termination survey is scheduled to begin in February 1991 and completed by the end of September 1991. A milestone chart showing tentative dates for performing the major termination survey activities is shown in Figure 4.

3.8 Survey Report

A report, describing the survey procedures and findings, will be prepared and submitted to the NRC. Report format and content will follow the recommendations contained in *Manual for Conducting Radiological Surveys in Support of License Termination*, NUREG/CR-5849.

4.0 Survey Plan and Procedures

4.1 General

Due to the nature of the operations and the estimated extent of airborne contamination, both main plant and auxiliary facilities must be surveyed as well as any potentially contaminated surrounding land areas. The number of sample taken per area in the total facility will be stratified based on the potential for residual radioactivity. Contamination potential has been based on a review of site history and the results of the preliminary assessment and characterization survey. Additional information on classifications is provided in Section 4.3.1 of this plan. To the extent that locations of measurements or sampling in support of characterization, remedial action control, or other previous surveys have not been disturbed since those earlier surveys and the radiological status would therefore unchanged, that data will be utilized in support of the termination survey.

ACTIVITY / MONTH 1991	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Evaluate Contamination Potential	<------->					
Establish Grid		<---------->				
Determine Background	<---->					
Perform Direct Measurements		<-------	----------	----------	---------->	
Collect Samples				<----------	---------->	
Analyze Samples				<----------	---------->	
Interpret Data				<----	----------	-------->
Prepare Report					<---------	---------->

FIGURE 4. MILESTONE CHART FOR TERMINATION SURVEY ACTIVITIES

4.2 Instrumentation

Table 2 lists the instrumentation to be used for the survey activities, along with typical parameters and detection sensitivities for the instrumentation and survey technique. The combination of instrumentation and technique were chosen to provide a detection sensitivity of 25% or less of the guideline levels.

The basic equation for determining field instrument detection limits is:

$$MDA = \frac{2.71 + 4.65\sqrt{Background}}{counting\ time \bullet efficiency \bullet \frac{probe\ area}{100}}$$

Sensitivities for scanning techniques are based on movement of the detector over the surface at 1 detector width per second and use of audible indicators to sense changes in instrument count rate. Experience documented in comparing training files demonstrates that qualified surveyors can detect the levels listed in Table 2 with a 90% confidence level. All instruments will be calibrated a minimum of once every 3 months, using NIST-traceable standards. Calibration will be for the specific uranium radiation energies expected to be present at the site. Operational and background checks will be performed at least once each 4 hours of instrument use.

4.3 Survey Plan

4.3.1 Area Classification

For purposes of establishing the sampling and measurement frequency and pattern, the site has been divided into affected and unaffected areas. The bases for these classifications are:

- **affected areas:** Areas that have potential radioactive contamination (based on plant operating history) or known radioactive contamination (based on past of preliminary radiological surveillance). This includes areas where radioactive materials were used and stored, where records indicate spills or other unusual occurrences that could have resulted in spread of contamination, and where radioactive materials were buried. Areas immediately surrounding or adjacent to locations where radioactive

materials were used or stored, spilled, or buried were included in this classification because of the potential for inadvertent spread of contamination.

- **unaffected areas:** All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on a knowledge of site history and previous survey information.

Table 3 lists the various site areas in each classification category.

4.3.2 Reference Grids

Grids will be established for the purpose of referencing locations of samples and measurements, relative to building and other site features. The gridding intervals are based on the potential for residual contamination in the various plant areas. (See Table 3). All affected building area floor and lower wall (up to 2 m) surfaces will be gridded at 1 m intervals; upper walls and ceilings of affected areas will also be gridded at 1 m intervals, if residual activity above 25% of the guideline is known or suspected. Building surfaces in unaffected areas or those upper surfaces in affected areas that have not been contaminated as a result of prior activities will not be gridded; measurements will be referenced to other grid systems or to prominent building features. Affected outside areas will be gridded at 10 m intervals; unaffected areas will not be gridded. This grid system is identical to the one used during the characterization survey and the remedial action activities; where necessary the earlier grid will be reestablished, expanded, or subdivided.

The facility will be divided into "survey units" having common history, contamination potential, or that are naturally distinguishable from other sites areas. These survey units will be sized to assure a minimum of 30 measurement locations each for floors and lower walls, other vertical surfaces, and other horizontal surfaces.

Areas identified by scans or direct measurements or as exceeding guidelines will be reclassified as affected areas and will be gridded and resurveyed accordingly.

TABLE 2

INSTRUMENTATION FOR RADIOLOGICAL SURVEYS

Type of Measurement	Instrumentation		Bkgd.[1]	4 π[1] Eff. (%)	Detection Sensitivity
	Detector	Meter			
Surface scans - alpha	large area gas prop., AB Co., Model 100	Countrate meter[2], AB Co., Model 1000	20 cpm	25	70 dpm/100 cm^2
Surface scans - alpha	scintillation, XYZ Inc. Model 10	Countrate meter[2], AB Co., Model 1000	2 cpm	18	100 dpm/100 cm^2
Surface scans - beta	large area gas prop., AB Co.,Model 100	Countrate meter[2], AB Co., Model 1000	1500 cpm	30	1500 dpm/100 cm^2
Surface scans - beta-gamma	pancake GM, XYZ Inc., Model 20	Countrate meter[2], XYZ Inc., Model 120	40 cpm	20	3500 dpm/100 cm^2
Surface scans - gamma	NaI scintillation, N Products, Model X	Countrate meter[2], XYZ Inc., Model 120	3500 cpm	N/A	2 μR/h
Surface activity - alpha	gas prop., AB Co.,Model 200	Digital scaler[3], N Prod., Model Y-1	5 cpm	25	60 dpm/100 cm^2
Surface activity - alpha	scintillation, XYZ Inc., Model 10	Digital scaler[3], N. Prod., Model Y-1	2 cpm	18	100 dpm/100 cm^2
Surface activity - beta	gas prop., AB Co.,Model 200	Digital scaler[3], N. Prod., Model Y-1	350 cpm	30	300 dpm/100 cm^2
Surface activity - beta-gamma	pancake GM, XYZ Inc., Model 20	Digital scaler[3], N. Prod., Model Y-1	40 cpm	20	1100 dpm/100 cm^2
Exposure rates	pressurized ionization, R. Co., Model 1111	(same as detector)			$<$1 μR/h
Gross α/β on smears	gas prop., T&C Co., Model 5000	(same as detector)	0.2 cpm α 1.5 cpm β	35 40	10 dpm 20 dpm

[1]Nominal Values.
[2]Monitoring audible signal.
[3]1 minute integrated count.

TABLE 3

CLASSIFICATION OF RFF PLANT SURFACES
AND AREAS ACCORDING TO CONTAMINATION POTENTIAL

Plant Area	Bldg. or Facility	Room or Area	Classification of Contamination Potential	Remarks
Restricted	Process Bldg.	Powder Warehouse	Affected	
		UF_6 Cyl. Storage	Affected	
		UF_6 Vapor. Rm.	Affected	
		Hydrolysis	Affected	
		Precip. & Digestion	Affected	
		2nd Stage Centrifuge	Affected	
		Reduction Calculation	Affected	
		Slug Pressing	Affected	
		Flame Conv. Reaction	Affected	
		Uranium Purif. System	Affected	
		Pelletizing Room	Affected	
		Blending	Affected	
		Powder Treatment	Affected	
		Pellet Pressing	Affected	
		Sintering	Affected	
		Pellet Grinding	Affected	
		Rod Loading	Affected	
		Rod Offgassing	Affected	

TABLE 3 (Cont'd)

CLASSIFICATION OF RFF PLANT SURFACES
AND AREAS ACCORDING TO CONTAMINATION POTENTIAL

Plant Area	Bldg. or Facility	Room or Area	Classification of Contamination Potential	Remarks
Restricted	Process Bldg.	Rod Closure Welding Inspection & Decon.	Affected	
		Gadolinia Rod Fab.	Affected	
		Uran. Scrap Recovery	Affected	
		Chem & Metallurgical Anal. Laboratory	Affected	
		Process Devel. Lab.	Affected	
		Blending Development	Affected	
		Sint. & Cer. Develop.	Affected	
		Flame Con. Reac. Dev.	Affected	
		Rod & Metal Develop.	Affected	
		Hot Maint. Shop	Affected	
		Hot Inst. Shop	Affected	
		Rad-Waste Rm.	Affected	
		Decon. Facility	Affected	
		Change Rooms	Affected	
		1st Stage Centri.	Affected	
		Hammer Milling	Affected	

CLASSIFICATION OF RFF PLANT SURFACES AND AREAS ACCORDING TO CONTAMINATION POTENTIAL

Plant Area	Bldg. or Facility	Room or Area	Classification of Contamination Potential	Remarks
Restricted	Process Bldg.	Gran. & Bucket Fill	Affected	
		Flame Conv. Reaction	Affected	
		Powd. Storage & Feed	Affected	
		Vent. Hepa Filt. Rm.	Affected	
		Laundry Room	Affected	
		Rod Storage	Affected	Upper surfaces not affected.
		Rod Enrichment Scan	Affected	Upper surfaces not affected.
		Bundle Assembly	Affected	Upper surfaces not affected.
		Bundle Leak Test & Inspection	Affected	Upper surfaces not affected.
		Bundle Storage	Affected	Upper surfaces not affected.
		Bundle Packaging & Shipping	Affected	Upper surfaces not affected.
		Office and Admin. Areas	Unaffected	Upper surfaces not affected.

TABLE 3 (Cont'd)

CLASSIFICATION OF RFF PLANT SURFACES
AND AREAS ACCORDING TO CONTAMINATION POTENTIAL

Plant Area	Bldg. or Facility	Room or Area	Classification of Contamination Potential	Remarks
Restricted	Filter House	Entire Interior	Affected	
		Roof	Affected	
	Former Waste Burial Site	-----	Affected	
	Grounds Adj. to Proc. Areas	-----	Affected	
	Liquid Waste Transfer Line	-----	Affected	
		Soil	Affected	Upper surfaces not affected.
		Paved Areas	Affected	Upper surfaces not affected.
Unrestricted	Other Buildings	Entire Interior	Unaffected	Upper surfaces not affected.
	Roofs		Unaffected	Upper surfaces not affected.
	Sewage Trmt. Plant	Entire Interior	Affected	Upper surfaces not affected.
		Roof	Unaffected	Upper surfaces not affected.
	Grounds	Entire Unrestricted Plant Area	Unaffected	Upper surfaces not affected.

4.3.3 Surface Scans

Scanning of surfaces to identify locations of residual surface and near-surface activity will be performed according to the following schedule:

Affected Area Surfaces - 100% of surface

Non-contaminated upper surfaces in affected areas - scans in immediate vicinity of measurement

Unaffected Area Surfaces - 10% of lower surface

Building interior surface scans will be conducted for alpha, beta, and gamma radiations. Scans of exterior building and paved surfaces will be for beta and gamma radiations. Soil surfaces will be scanned for gamma radiations only.

Instrumentation for scanning is listed in Table 2. The instruments having the lowest detection sensitivity will be used for the scans, wherever physical surface conditions and measurement locations permit.

Scanning speeds will be no greater than 1 detector width per second for alpha and beta detection instruments and 0.5 m per second for gamma instruments. Audible indicators (headphones) will be used to identify locations, having elevated (1.5 to 3 times ambient) levels of direct radiation. All scanning results will be noted on standard field record forms; locations of elevated radiation will be identified for later investigation.

4.3.4 Surface Activity Measurements

Direct Measurements

Direct measurements of alpha, beta, and/or beta-gamma surface activity will be performed at selected locations using instrumentation described in Table 2. Unless precluded by surface conditions or physical parameters, the most sensitive of the instruments listed for surface measurements (Table 2) will be used. Measurements will be conducted by integrating counts over a 1 minute period.

Because scanning techniques are capable of detecting residual uranium activity at <25% of the guideline level, direct surface activity measurements will be systematically performed at 2 m intervals on floors and lower walls of affected areas and at the same intervals on upper surfaces that may have residual activities in excess of 25% of the guidelines.

On upper surfaces of affected areas which are not inspected of residual activity, measurements will be performed at a minimum of 30 locations each on vertical and horizontal surfaces. These locations will include surfaces where radioactive material would likely settle, and sufficient additional locations to provide coverage at a minimum average of 1 location per 20 m^2 of surface area.

On surfaces of unaffected areas, a minimum of 30 random measurements or an average measurement of 1 per 50 m^2 of building surface area, whichever is greater, will be performed for each survey unit. These locations will include all building surfaces.

Removable Contamination Measurements

A smear for removable contamination will be performed at each measurement location.

4.3.5 Exposure Rate Measurements

Gamma exposure rates will be measured at 1 m above ground or floor surfaces, using a pressurized ionization chamber or a gamma scintillation instrument, calibrated for low enrichment uranium energies. Measurements will be uniformly spaced according to the following pattern:

Building Interiors

Affected Areas: 1 measurement per 4 m^2.
Unaffected Areas: 1 measurement per 200 m^2.

Grounds

Affected Areas: 5 measurements per 100 m^2 grid block.
Unaffected Areas: 50 measurements at randomly selected locations.

4.3.6 Soil/Sediment Sampling

Surface

Samples (about 500 grams each) of surface soil (0-15 cm) will be systematically collected from the center and 4 points midway between the center and the block corners for each 10 m x 10 m grid in affected areas. Fifty samples will be obtained from random locations in unaffected areas, outside the restricted plant site. Samples will be collected at 10 m intervals along the drainage ditches from the former waste processing facilities to the *Wandering River* and from other natural surface drainage pathways to the River. At each surface sampling location, contact gamma levels before and after sampling will be monitored to determine whether subsurface contamination may be present.

Sediment (about 500 grams) samples will be obtained at the outfall of drainage ditches to the *Wandering River* and from 25 to 50 m upstream and downstream of the outfall. Sampling will be from the River center and near both banks.

Subsurface

Subsurface investigations will be performed at the locations of the former burial site, liquid waste lagoons, and previously excavated underground piping between the processing areas and the waste ponds. These locations will be scanned by a commercial contractor using electromagnetic sensors (ground penetrating radar) to verify that no buried objects remain and to guide placement of subsurface sampling locations. Subsurface samples will be obtained by a commercial contractor, using the split-barrel method. Sampling will be at the surface (0-15 cm) and at 1 m intervals to a depth of 7 m at the former burial site and liquid waste lagoon areas; along the path of the previously excavated liquid waste transfer piping, sampling will be at 1 m intervals to a depth of 3 m. Ten, uniformly spaced sampling locations will be selected in the former burial site and twenty uniformly spaced locations will be selected in the area of the lagoons. In addition, two sampling locations will be selected on each side around the perimeter of these facilities, to confirm absence of subsurface migration. Subsurface samples will be obtained at approximately 6 locations along the former waste transfer piping system.

Following sampling, a gamma scintillation probe will be inserted into the borehole and relative count rates determined at approximately 50 cm intervals between the surface and the hole bottom. This data will assist

in evaluating the presence of residual radioactive material in vicinity of the sampling location. If results are positive, additional subsurface sampling will be conducted to define the area of residual contamination.

4.3.7 Special Measurements and Samples

Building Interiors

Samples of paint will be obtained from 100 cm^2 areas on lower walls in former liquid and powder processing rooms. One paint sample per 10 m^2 will be obtained from these surfaces. Paint samples will also be collected from surfaces where direct and removable activity measurements suggest contamination may have been painted over.

Trenches where contaminated drain piping was excavated in the Analytical Laboratory, Rad Waste Decontamination, and Change Room facilities will be sampled at locations of elevated direct radiation and at approximately 3 m intervals along the excavations. (Conversion, powder handling, and other product processing facilities did not have subfloor piping.) Other remaining drains and piping in affected areas will be accessed, direct alpha and beta-gamma scans and measurements performed at all access points, and a large-area swab obtained from the piping, using a plumbers "snake" and piece of cloth.

Remaining ducts, electrical boxes, conduit, or other interior surfaces in affected areas, which may contain residual contamination, will be accessed at random and measurements of direct and removable activity performed. Swabs will be obtained from insides of wall and floor penetrations, anchor bolt holes, and floor cracks or expansion joints.

Floor cores will be removed from 10 locations in the areas where conversion was performed; gamma scans of subfloor soil will be performed and soil samples from the floor/soil interface and 0.5 m below the interface will be collected at each coring location. Additional floor coring and subfloor sampling will be conducted, if surface scans and measurements suggest subfloor contamination.

Building Exteriors

Measurements of direct and removable activity will be performed on exterior and interior surfaces of air exhaust equipment and at representative locations on roof drains. Samples of roofing material will be obtained where direct measurements suggest possible entrained contamination.

Grounds

Cores will be removed at 6 locations on the uranium storage pads and samples of subpad soil collected. Coring and soil sampling will also be performed on other paved outside surfaces, where scans or direct measurements suggest possible contamination beneath the paving. The number and location of these cores will be determined on the basis of findings as the survey progresses.

4.4 Background Level Determinations

Background exposure rates will be determined for the building interior by taking a minimum of 8-10 pressurized ionization chamber measurements at locations of similar construction but without a history of radioactive materials use. Also, 8-10 locations for area background measurement and sampling will be selected within a 0.5 to 10 km radius of the site. Exposure rate measurements will be performed using a pressurized ionization chamber. A background soil sample will be collected from each location of external background measurement. Results of background exposure rate and uranium soil concentrations will be evaluated to assure that the averages determined are representative of the true averages, using procedures described in NUREG/CR-5849. Additional sampling or measurements will be performed if necessary to satisfy criteria.

4.5 Sample Analysis

Smears and swabs for removable contamination will be analyzed for gross alpha, gross beta activity. Soil, sediment, gravel, roofing material, and other large volume samples will be analyzed for U-235 and U-238 by gamma spectrometry; total uranium will be calculated on the basis of previously determined (Section 3.2) isotopic activity ratios for this site. Samples of paint, residue, and other samples of small volume will be analyzed for uranium by wet chemical separation and alpha spectroscopy.

Laboratory chain-of-custody procedures (GNC/RFF-HP 3.6-1988) will be observed for all sample analyses.

5.0 Data Interpretation

Measurement data will be converted to units of dpm/100 cm^2 (surface activity), μR/h (exposure rates) and pCi/g (soil concentrations) for comparison with guidelines. Values will be adjusted for contributions from natural background. Individual measurements and soil levels will be compared with "hot-spot" criteria. Average values for survey units will be determined and compared with guideline levels. Data for each survey unit will be tested against the confidence level objective, using guidance and procedures described in NUREG/CR-5849.

Additional remediation and/or further sampling and measurements will be performed where guidelines are not met or cannot be demonstrated to the specified level c confidence. Computations and comparisons will be repeated, as necessary.

The average levels will be used to estimate the total residual inventory of uranium at the site.

6.0 Report

A report, describing the procedures and findings of the final status survey will be prepared and submitted to the NRC. Data will be summarized in tables. Measurement and sampling locations will be shown on scale drawings.

All field and analytical data will be archived by *General Nuclear Corporation* until such time as the NRC authorizes disposal.