Final Status Survey for the Largest Decommissioning Project on Earth

R.W. Dubiel, CHP
Millennium Services, Inc.
222 Creekstone Ridge, Woodstock, GA 30188
USA

J. Miller
BNG America
804 S. Illinois Avenue, Oak Ridge, TN 37830
USA

D. Quayle
Shonka Research Associates, Inc.
704 S. Illinois Avenue, Oak Ridge, TN 37830
USA

ABSTRACT

To assist the United States Department of Energy's (US DOE's) reindustrialization efforts at its gaseous diffusion site in Oak Ridge, Tennessee, known as the East Tennessee Technology Park (ETTP), the US DOE awarded a 6-year Decontamination and Decommissioning (D&D) contract to BNG America (formerly BNFL Inc.) in 1997. The ETTP 3-Building D&D Project included the removal and disposition of the materials and equipment from the K-33, K-31, and K-29 Gaseous Diffusion Plant buildings. The three buildings comprise more than 4.8 million square feet (446,000 square meters) of floor surface area and more than 350 million pounds (148 million kilograms) of hazardous and radioactively contaminated material, making it the largest nuclear D&D project in progress anywhere in the world. The logistical hurdles involved in a project of this scope and magnitude required an extensive amount of Engineering and Health Physics professionals. In order to accomplish the Final Status Survey (FSS) for a project of this scope, the speed and efficiency of automated survey equipment was essential. Surveys of floors, structural steel and ceilings up to 60 feet (18 meters) were required. The FSS had to be expanded to include additional remediation and surveys due to characterization surveys and assumptions regarding the nature and extent of contamination provided by the US DOE. Survey design and technical bases had to consider highly variable constituents; including uranium from depleted to low enrichment, variable levels of Technicium-99 and transuranic nuclides, which were introduced into the cascade during the 1960's when recycled uranium (RU) from Savanna River was re-enriched at the facility. The RU was transported to unexpected locations from leaks in the cascade by complex building ventilation patterns.

The primary survey tool used for the post remediation and FSS was the Surface Contamination Monitor (SCM) and the associated Survey Information Management System (SIMS), developed by Shonka Research Associates, Inc. (SRA). Final Status Radiological surveys have been performed over the last year on a 24-hour per day and seven day per week basis. As many as eight SCMs have been in use at any one time. Each SCM can perform over 250,000 measurements per hour, simultaneously collecting both scan and static measurement requirements to meet FSS regulatory requirements. Thus, efficient management and quality control of gigabytes of data was needed. In addition, some surveys were accomplished with traditional instrumentation and with some using other automated systems such as smear counters. The FSS Reports required integration of all of the data in a format that permitted undemanding verification by DOE using the ORISE/ESSAP IVT contractor. A project of this scope and magnitude could not have been accomplished without the use of the SCM and SIMS.

This paper reports on the survey and logistical issues that required ingenuity of the entire 1,700-person workforce to resolve. In particular, this paper summarizes the issues addressed and resolved by the integrated team of survey technicians, subject matter experts (SMEs), radiological engineers, data processing staff and BNG America management.

INTRODUCTION

Between 1951 and 1985, the Oak Ridge Gaseous Diffusion Plants (ORGDP) (K-25, K-27, K29, K-31, and K-33) in Oak Ridge, Tennessee, were operated by the U.S. Atomic Energy Commission (AEC) and its successor agency, the U.S. Department of Energy (DOE), for the enrichment of uranium hexafluoride (UF_6) in the U-235 isotope. Operations conducted in these buildings, resulted in large portions of the equipment and structure becoming radiologically and chemically contaminated. Structural components, equipment, systems, and materials in these building also contained other hazardous and/or toxic materials, including asbestos, polychlorinated biphenyls (PCBs), and Resource Conservation and Recovery Act (RCRA) hazardous wastes stored in permitted waste piles. As part of the reindustrialization efforts at the former ORGDP, currently known as the East Tennessee Technology Park (ETTP), the DOE contracted with BNG America (formerly BNFL, Inc.) to decontaminate, decommission, and recycle Buildings K-29, K-31, and K-33 to conditions that will allow reuse as an industrial site.

This paper presents a summary of the historical site assessment (HSA), characterization, decontamination, and final status surveys (FSS) activities performed. It also describes the methodologies used to determine the established project End-Point Criteria (EPC).

SITE HISTORY AND HAS

Construction was initiated in late 1940s, and the facilities were placed into operation in the early 1950s. Under the regulatory authority of the AEC, the facility performed isotopic enrichment of uranium via the gaseous diffusion process until the mid 1980s. Due to overproduction and reduced demand for enriched uranium by the electrical nuclear power industry, the DOE terminated production and placed the buildings into a standby status. At that time, the volatile process gas inventory was evacuated, and the process piping and equipment were purged. Between shutdown (1987) and 1996, some facility support systems, such as HVAC, fire protection, radiation criticality alarm, etc., were maintained operational. Specific process equipment was removed for use in other DOE gaseous diffusion facilities.

The purpose of the Recycle Project was to dismantle and remove process and non-process equipment and materials, process ventilation systems, and scrap or recycle damaged government equipment. Platforms, cell housings, and concrete foundations/pedestals were to be removed flush with the concrete floor. Metals were to be recycled to the extent economically practical. Uranium deposits were to be removed from equipment and systems and properly dispositioned. Radiological and hazardous materials were to be cleaned up to specified EPC, consistent with potential reuse as an industrial site. Portions of the fire protection systems, steam systems, and lighting systems, necessary for accomplishing the other project objectives, were left and remain in place. Also, selected systems and facilities were to remain, including overhead cranes, surveillance and security systems, sanitary water, interior and exterior walls of select offices, portions of the electrical drops and lighting (with necessary cables and transformers), potable water lines, rain water and waste line piping for the roof, and floor drainage. Structural steel and framework were to remain, and, if damaged, repaired or replaced. Removal and remediation were applicable only to accessible building interior equipment, materials, and surfaces. The established radiological EPC for the project was DOE Order 5400.5 and Regulatory Guide 1.86.

Each of the 3-Buildings (K-29, K-31, and K-33) is two stories and can be seen in Fig. 1. Building K-33 is the large structure to the North, with a checkerboard pattern roof, a result of the ventilation system. The building with a large white area adjoining K-33 is K-31. Building K-29 is immediately below K-31 and to the left (West) of the "U-Shaped" K-25 Building. Building K-33 is 1450 ft long by 970 ft wide (1,406,500 ft^2 = 32.3 acres) by 82 ft high. K-33 is comprised of 2 floors. The upper floor (Cell Floor) contained the process equipment, with the lower floor (Operations Floor) containing the support equipment. The building is of steel column and beam construction with cement-asbestos composite siding (transite) and a built-up roof. K-33 Building is divided into eight (8) process Units on each floor. K-31 is of similar construction, measuring 1200 ft long by 622 ft wide (746,400 ft^2 = 17.1 acres) by 67 ft high. K-31 Building is divided into six (6) process Units on each floor. K-29, originally scheduled for decontamination and final survey was the smallest of the three buildings. In 2003, following characterization efforts, the K-29 building decontamination and survey were removed from the scope of work due to the contamination levels determined in the building.

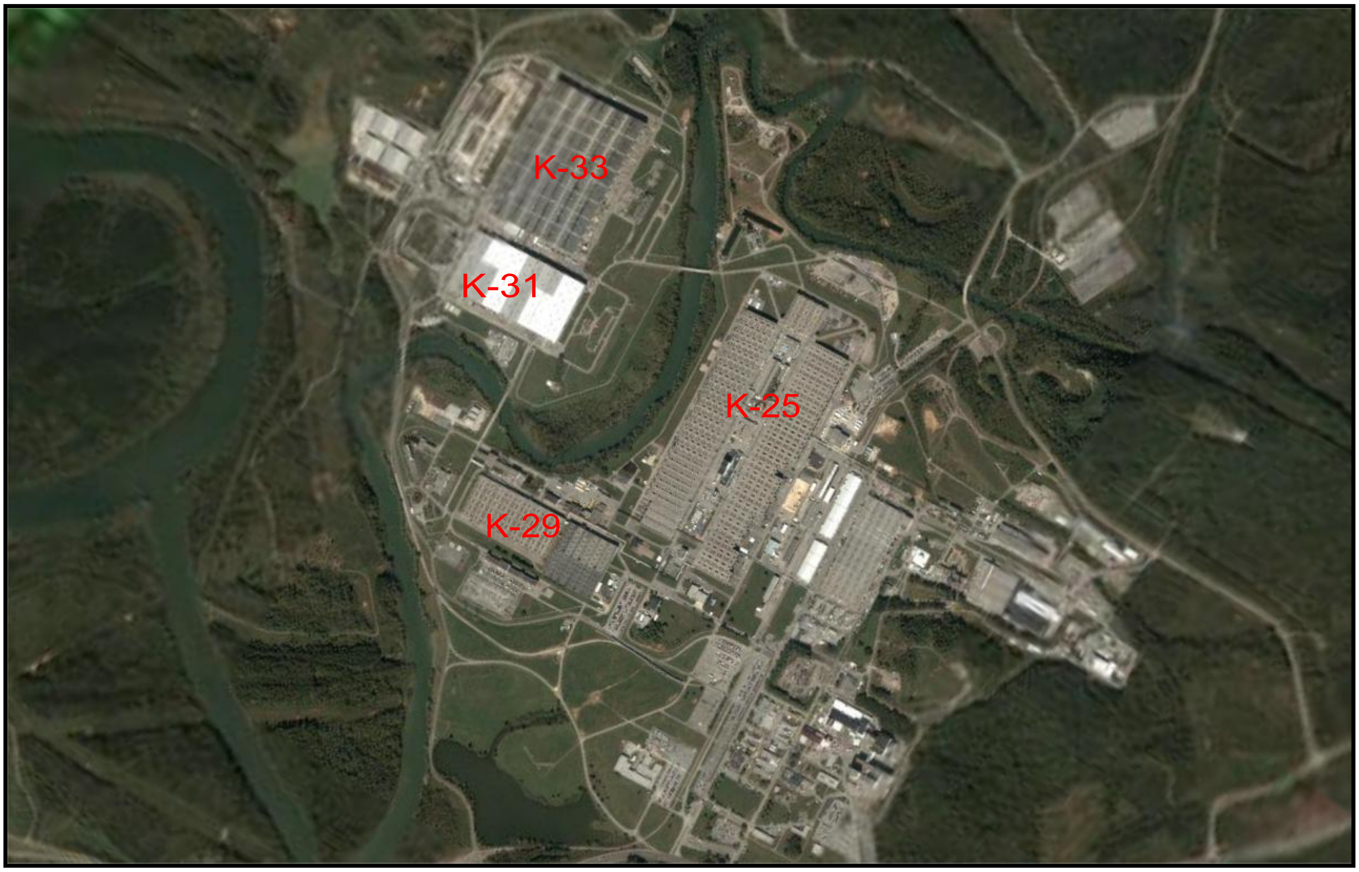

Fig. 1. East Tennessee Technology Park

K-33 and K-31 presented a large area of surfaces to decontaminate and survey. Table I provides the major surfaces and the approximate area of each.

Each building contained other surfaces that required decontamination and final survey. Those surfaces consisted of stairwell, interior buildings of concrete block construction, systems such as fire service piping and lighting, electrical conduit, floor penetrations and ventilation louvers.

Table I. Surface Area Summary

Surface	K-33 Cell Floor (ft^2)	K-33 Ops Floor (ft^2)	K-31 Cell Floor (ft^2)	K-31 Ops Floor (ft^2)	Total (ft^2)
Floor	1,406,500	1,406,500	746,400	746,400	4,305,800
Ceiling	1,406,500	1,406,500	746,400	746,400	4,305,800
Walls	590,760	306,320	163,980	80,168	1,141,288
Interior column and steel	4,608,432	3,225,900	2,445,600	1,712,300	11,992,300

Interior K-33 structural surfaces and materials, and equipment were known to be potentially contaminated with uranium. Because K-33 was designed and operated for low enrichment (peak assay up to 2.5% U-235), the isotopic nature of the uranium contamination was expected to vary from depleted to low enrichment. Feed material was predominantly non-irradiated uranium; however, during the lifetime of the facility, the process also received limited quantities of recycled uranium from reactor fuel returns. A consequence of reactor fuel returns in feed material was the introduction of small quantities of fission products; e.g., Tc-99, and activation products; e.g., Am-241, Pu-238/239/240, and Np-237, (trans-uranics) into the systems. Due to their physical behavior in the gaseous diffusion process, there was selective enhancement of the relative fractions of some of these radionuclides at certain locations within the equipment and facility. Historic radiological characterization data, developed prior to this project, were based on a combination of process knowledge of components and systems, feed material assay, operating history, and radiological field survey and sample analysis data. Total contamination levels were highly variable, depending on the equipment or structure surfaces surveyed. The contamination was primarily uranium, but Tc-99 and Np-237 constituted enough of a significant fraction to alter the activity correlations outside the process systems at some locations.

In February 1998, BNG America established a contract to perform limited characterization of K-33 Building. Results indicated 19% of surveyed surfaces on the Cell floor and 11% of surveyed surfaces on the Operations floor were radioactively contaminated in excess of 5000 dpm/100 cm^2. The majority of contamination was beta-gamma and fixed. As anticipated, the highest levels of contamination were associated with interior surfaces of process equipment and systems. Exposure rates at several locations were significantly elevated, ranging up to 450 μR/h; however, typical levels were indistinguishable from background. Analyses for radionuclide mixes were performed on samples of materials or deposits from process equipment and surfaces at or near the floor surfaces. The primary objective of the sampling and analysis program was to support the waste characterization effort for material shipments off site. Access to overhead areas was generally restricted due to safety concerns (energized 440 Volt bus bars powering the building cranes).

Characterization and FSS Plan

Access to building surfaces for characterization was greatly restricted due to dismantlement activities. The need to continually operate overhead cranes restricted access to overhead areas due to the exposed 440 Volt bus bars that energized the cranes. The addition of a large super-compactor to the south face of K-33 greatly reduced the project waste volumes and cost, but created added impacts to the characterization effort by creating equipment flow paths and lay-down areas within the building. After complete removal of all large process equipment from any area, concrete pedestal removal operations occurred. This removal process consisted of diamond wire cutting of the pedestals, relocation of the concrete blocks, and clean-up of the concrete sludge generated by the process. Until an area was completed cleared, characterization was severely limited.

In 2002, several areas in the Northeast corner of K-33 became available for characterization. Surveys of more than 90% of the Building Unit 4 floor areas, using the large area detectors of the SCM confirmed that large portions of the floor were in excess of the established radiological EPC. However, limited surveys using hand-held instrumentation in overhead areas identified compliance with the radiological EPC. When contamination in excess of the EPC was identified in the overhead areas, the contamination was widely distributed, representative of an event in the area that released contamination in a gaseous form. Floor contamination, as depicted by the SCM using SIMS software shown in Fig. 2 below, showed patterns that are the result of non-gaseous material from systems and the possible impact of equipment operating on the floor area. The white areas represent elevated areas of radioactivity.

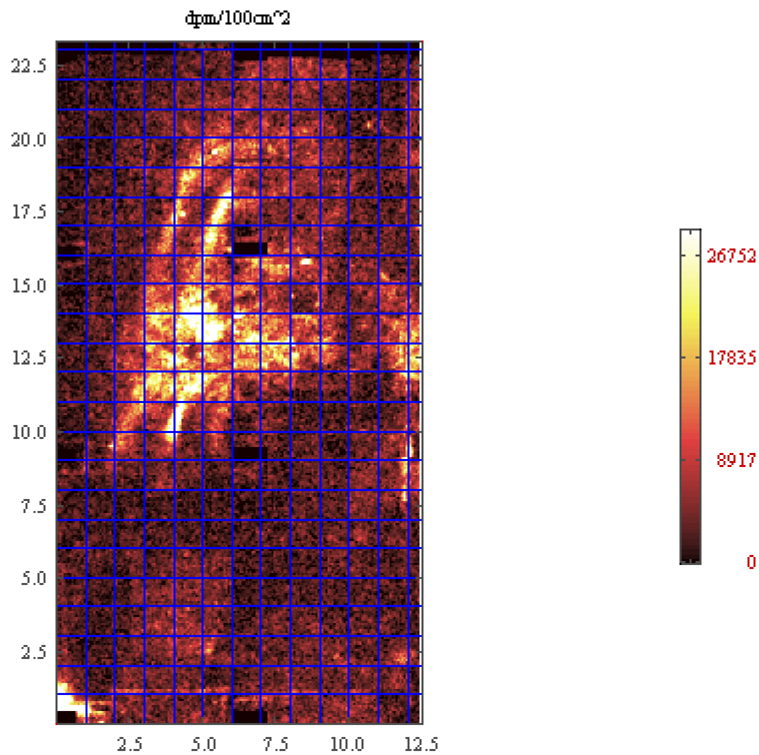

Fig. 2. Radioactivity Distribution in Building K-33

There were no areas of the limited accessible portions of K-33 that had sample results indicating TRU levels that would impact the survey process. However, since there were small areas within K-33 that contained activity within the process equipment with TRU levels, this did impact the radiological EPC, and an agreement was reached to develop a separate plan to address the TRU areas.

The contract between the DOE and BNG America required the co-development of a final status survey plan for the buildings. The plan was to be put into effect prior to the initiation of final status surveys. To be applicable to all surveys that would be conducted in both K-33 and K-31, in a time frame that would span several years, the plan would require flexibility. The plan established the survey methods and surface coverage requirements to show compliance with the radiological EPC. Critical features of the plan included:

- Development of survey units;
- Classification of areas and required survey coverage;
  - Class 1 requiring 100% coverage;
  - Class 2 requiring a minimum of 10%;
- Survey percentage and/or reclassification of class 2 areas based on a graduated scale;
- Classification of areas on a building unit basis using characterization data and “extrapolated” data from previous units;
- Submittal by BNG America to the DOE of building unit classification and basis documents for a building unit prior to starting final surveys in that unit;
- Instrument calibration requirements (ISO-7503-1);
- Instrumentation sensitivity and quality control requirements;
- Background determination requirements;
- Isolation and Control processes;
- Survey methods; and
- Report requirements.

Survey units were established based on surface type, and with size limitations to facilitate data handling. Application of survey requirements and reclassification was developed on a survey unit basis. The typical floor survey unit was a 2 x 3 column area, approximately 50 ft. x 75 ft.

The reclassification process was an important aspect of the plan since the non-floor areas comprised a high percentage of the surface area within the buildings. Initial characterization results indicated that areas in the overheads had received limited impact from operations. Surveying 100% of the non-floor areas would have a significant impact on project cost and schedule, yet would provide limited benefit. The graduated approach requires increasing the amount of surface surveyed if contamination greater than 75% of the radiological EPC was identified. The graduated scale requirements are shown in Table 2. The basis for the Class 2 survey approach included the use of large area detectors in a distributed and biased manner. Since the predominant means of contamination was from a gaseous process, distributed contamination would be expected. Surveys performed with large area detectors would have a high probability of detecting an area of contamination. Distributed and biased surveys (ex. 10% of every beam, rather than 1 out of 10 beams, with more area of the top horizontal surface surveyed than the sides or bottom) increased that probability. Procedures for all activities were also co-developed, gaining DOE buy-in to the process implementation.

Table II. Survey Frequency Requirements for Class 2 Areas

Points > 75% EPC	**Increase Survey %**	**% of Total Area Surveyed**
0-1	0	10
2-4	15	25
5-8	25	50
9-12	25	75
>12	Reclassify as Class 1	

Final Survey Initial Implementation

In early 2003, the FSS began in the Northeast corner of K-33 in cells 10, 9, and 8, which comprised 30% of the building unit. During the initial surveys two issues were identified that impacted the efforts. First, a decision was made to scarify 100% of the concrete floor due to PBC contamination. Second, high levels of contamination were found on support beams that supported the by-pass piping. Most of those beams were not building structural beams, and therefore removal, vice decontamination was the preferred option.

Following scarification and by-pass support beam removal, surveys were restarted in cells 10, 9, and 8. No additional issues were identified in those areas. Starting in cell 7 and continuing throughout cells 5, 3, and 1, a more significant issue was identified. The galvanized sheet metal ceilings were found to have extensive contamination above the radiological EPC. Detailed evaluation determined the contamination to be Tc-99. The contamination levels were extensive, and within an individual piece of sheet metal, were found to be very uniform. Decontamination efforts were extremely difficult and time consuming. As additional surveys occurred and areas in the overhead were found to be contaminated, Tc-99 was determined to be the predominant isotope. Discussions with the DOE indicated that requests for modification of the radiological EPC would be entertained due to the extensive amount (quantity and distribution) of the low dose, low risk isotope Tc-99. Surveys continued risk while efforts were commenced to modify the radiological EPC.

Modified Final Survey Plan

In early 2004, efforts began to develop modified radiological EPC based on dose (supplemental limits). A target of 5 mR/yr was established by the DOE. Following several iterations, the radiological EPC were divided at the 2 meter above floor level. All floors, and walls and structural steel up to 2 meters would continue to have DOE Order 5400.5 and Regulatory Guide 1.86; criteria adjusted using the sum-of-fractions. Surfaces above 2 meters would have radiological EPC that are dose based. The contribution to the dose from the floors and surfaces below 2 meters at the EPC was estimated to be approximately 3 mR/yr. Therefore, the dose basis for surfaces above 2 meters was 2 mR/yr. The RESRAD Build computer code, developed at Argonne Laboratory, was used to establish the activity-dose relationship. Several potential scenarios were evaluated with the building renovation worker determined to be the most highly exposed group. Additional samples taken throughout K-33 and K-31 determined that the distribution of isotopes above 2 meters was 90% Tc-99 and 10% U (at average enrichment of 2% U-235). Below 2 meters, the ratio was 80% U (average enrichment 2% U-235) and 20% Tc-99.

A sampling and analysis plan to determine existence of TRU had been completed at the time of the efforts to establish modified EPC. The results indicated that isolated areas within K-31 had TRU levels in quantities that impacted the 5400.5 limits. Other areas indicated less than 0.5% of the total activity was TRU. Therefore, the sum-of-fractions was used to account for mixed radionuclides with differing EPC.

A revision to the Final Survey Plan was approved in January 2005. The revision incorporated the modified EPC and defined acceptance criteria as Surface Activity Guidelines (SAG) and maximum Surface Activity Guidelines (SAG_{EMC}). The SAG value applied to the average activity allowed in a defined area. For surfaces less than 2 meters, the average activity limit is applied to a one square meter area. For surfaces above 2 meters, the limit is applied to a survey unit. The maximum activity limit (SAG_{EMC}) in either case is applied to a 100 cm^2 area and was capped with an Area Factor (AF) of 3. Compliance with the SAG for surfaces greater than 2 meters was to be demonstrated at the 95% upper confidence level. Tables 3 & 4 list the SAG and SAG_{EMC} values for the project.

Table III. SAGs for Building Major Floor Surfaces

Location – Description	SAG (dpm/100 cm^2)		SAG_{EMC} (dpm/100 cm^2)	
	K-31	K-33	K-31	K-33
Cell Floor – Floor & Surfaces below 2 meters default value	4,500	4,800	13,500	14,400
K-31 Cell Floor Exception – TRU impacted area in Unit 1	3,500	N/A	10,500	N/A
K-31 Cell Floor Exception – TRU impacted area in Unit 2	850	N/A	2,500	N/A
K-31 Cell Floor Exception – TRU impacted area in Unit 3	3,100	N/A	9,300	N/A
K-31 Cell Floor Exception – Unit 3 Default	4,000	N/A	12,000	N/A
Operations Floor – Floor & Surfaces below 2 meters default value	4,500	4,800	13,500	14,400

Table IV. Default SAG Values for Overhead Surfaces > 2 Meters

Floor	SAG (dpm/100 cm^2)		SAG_{EMC} (dpm/100 cm^2)	
	K-31	K-33	K-31	K-33
Cell Floor (50% U: 50% Tc-99)	58,100	58,100	174,300	174,300
Operations (80% U: 20% Tc-99)	36,300	36,300	108,900	108,900

Final Survey Plan Implementation

During the development of the modified EPC, surveys continued under the survey requirements of the initial plan. Surveys were performed to the survey requirements of the classification documents and in compliance with all quality control requirements—issues that were not expected to change with the revised plan. More importantly, the majority of the surveys were conducted in such a way that the raw data, i.e. the counts obtained in a unit time in a given area, were recorded. At the time of approval of the revised survey plan and modified EPC, the east half of K-33 and portions of K-31 had completed their FSS surveys. The impact caused by the revised plan was minimal, since the survey process was essentially the same and the proposed modified EPC were used as the acceptance criteria. Reprocessing the data that was collected with the SCM was easily adjusted for the revised instrument efficiencies due to the processing power of SIMS, a computer processing effort, and did not impact schedule. The hand-held data, which for the most part, was not collected electronically, slightly impacted the process; however, this data was less than 1% of the total FSS data.

The survey process relied heavily on large, position sensitive proportional detectors with computerized data recording. Specifically, the SCM developed by Shonka Research Associates was the predominant survey instrument used during the final survey. The SCM was used in “dynamic” rolling mode for floor surfaces and in a “static” corner mode for steel beams, ceilings, walls and other large surfaces. In the rolling mode, the 180 cm length detector was operated at 10 cm per second, while recording data in 5 cm x 5 cm (25 cm^2) pixels of data. The SIMS software then applies a summing filter to determine the highest 100 cm^2 area in the data set. While rolling, the SCM would survey 10 square meters in less than a minute. The speed of the SCM was critical in maintaining production, while the spatially correlated position-sensitive data presented in 2-dimensional graphics allowed for rapid location of areas in excess of EPC and subsequent decontamination. The speed was determined based on the required sensitivity and the need to minimize false positives. Lower speeds had greater sensitivity and fewer false positives, but increased survey time, impacting schedule and cost. This driver was extensively considered as the schedule cost per day was significant. Without the use of the SCM, this would have been an enormous impact on cost and schedule.

In corner mode, the SCM was operated with a timer to control data acquisitions, ensuring adequate sensitivity while optimizing productivity. Detailed mapping of acquisition locations as well as chalk marks in the field allowed investigation of areas greater than pre-established investigation levels.

Surveys were performed over 4 million square feet of floor area (more than 120 acres), more than 400 thousand square feet of ceiling surface, and more than 2.5 million square feet of structural steel surface as well as floor penetrations, expansion joints, systems, stairs and ladders, lighting and other surfaces. Individual survey reports were generated for each survey unit. Approximately 12,000 FSS reports were generated for K-33 and K-31. The final surveys performed by the SCMs alone resulted in over 40 million measurements. Hand held instrumentation added to that number and made up approximately 1-2% of the total survey data. Fig. 3, with the SCM and survey personnel, shows the enormity of these buildings
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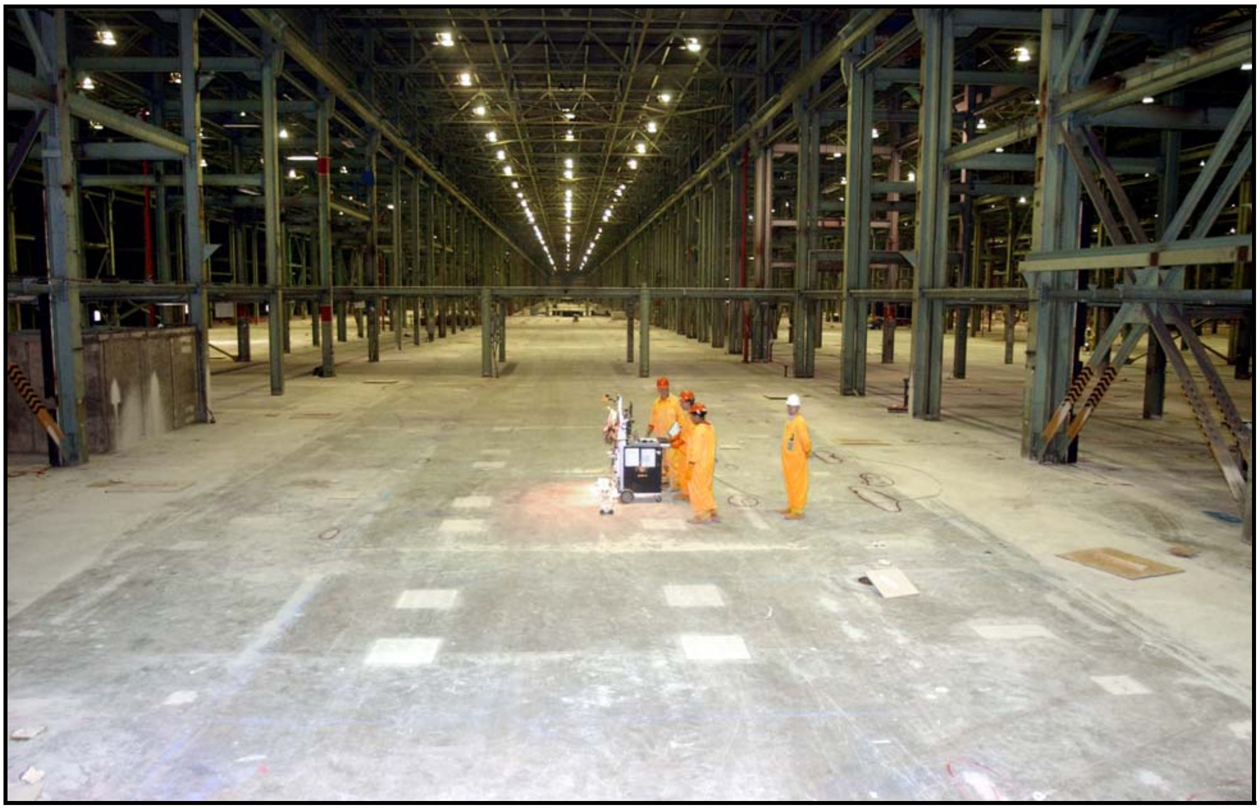

Fig. 3. SCM Survey of Floors in K-33

Management of the survey program required the use of computers for tracking surveys, processing data, analyzing results, and storing records. The SCM is integrated with a Survey Information Management System (SIMS) designed to meet all of the functions required for the project and worked in concert with BNG America's Extreme Database. The reports generated by SIMS were transferred electronically and stored in the Extreme database. The design basis of any electronic database is to eliminate manual entry of data, therefore eliminating transcription errors. Reports produced for each survey unit include demographics for the survey (Technician names, date, system used, survey name, etc.) and specific parameters used for that survey (system efficiency, background value, end point criteria, investigation criteria, etc.). Results are presented in summary form, as 2 dimensional color graphics, as a cumulative frequency distribution (CFD) graph, as a table providing data for each 1 square meter grid, and an exception plot. Fig. 4 and Fig. 5 provide examples of a graphic display, and CFD from K-33, Cell floor

Unit 5 survey area FS6002. The survey was conducted after a 100% single path scarification to a depth of approximately 1/8th inch was complete.

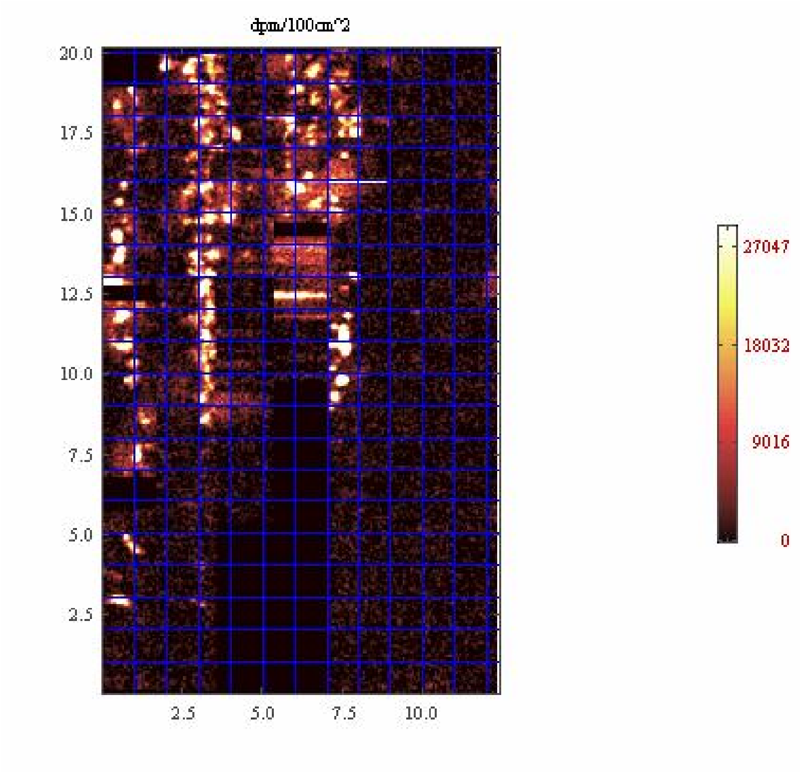

Fig. 4. Survey unit FS6002 graphic activity plot

The color graphic display represents the activity level in dpm/100 cm^2. The scale is on the right side. The data is truncated at a factor of 2 above the end point criteria. The blue lines are a computer applied 1 meter by 1 meter grid for ease of locating areas above criteria.

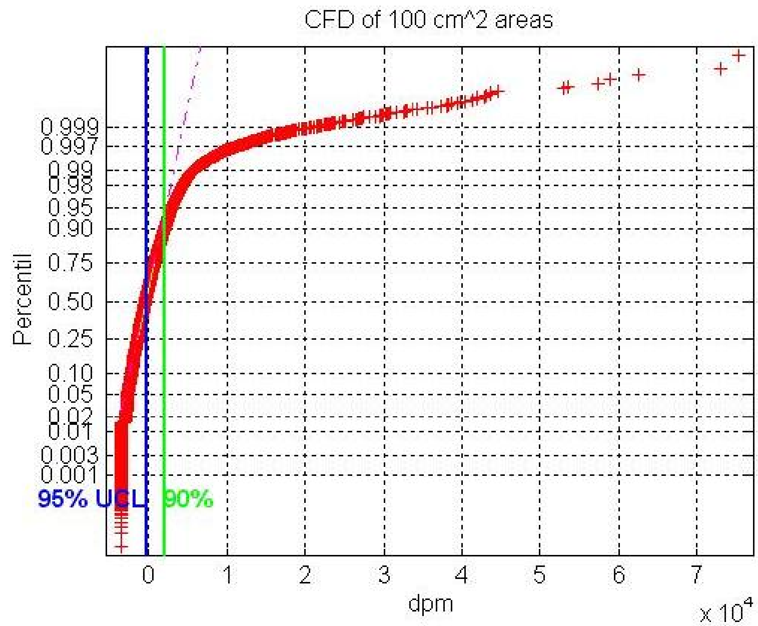

Fig. 5. CFD Plot from Survey Area FS6002

The CFD shows the percentage of measurements (Y-axis) that are equal to or greater than a specific value (x-axis). The values given in dpm are net values, background has been subtracted. The 50% value is close to zero, indicating that a large percentage of the survey unit is near background. The 95% Upper Confidence Level is shown to be near the median value, typical when such a large number of measurements (greater than 80,000) are used in the calculation. The 90% line identifies the value (approximately 2000 dpm) above which 10% of the measurements fall.

The SIMS capabilities allowed the incorporation of survey information to be consolidated over any area of interest. Typically, work planning, surveys, and report generation was performed based on building units. Management decisions and remedial action planning was facilitated through the use of building unit exception reports that provided an overview of radiological conditions in an area. Fig. 6 shows the entire floor area of K-33, Cell floor, Unit 5 after initial scarification. The exception reports were used to mark areas that required additional scarification. Results of surveys performed of areas receiving additional decontamination efforts were overlaid on the original survey documents to show the progress from the remediation process.

Fig. 6 represents approximately 4.5 acres of floor. The areas shaded in red are those above the SAG_{emc}. The blue coloring is added as a one square meter “halo” around areas that contain individual 100 cm^2 areas above SAG_{emc}, since they would not be visible on a 4.5-acre display. The yellow coloring represents square meter areas that exceed the SAG. The red will overwrite the yellow, while red and yellow overwrite blue.

BNFL ETTP 3-Building D&D Project - Building K-33
Cell Floor Unit 5 FSS Survey Areas

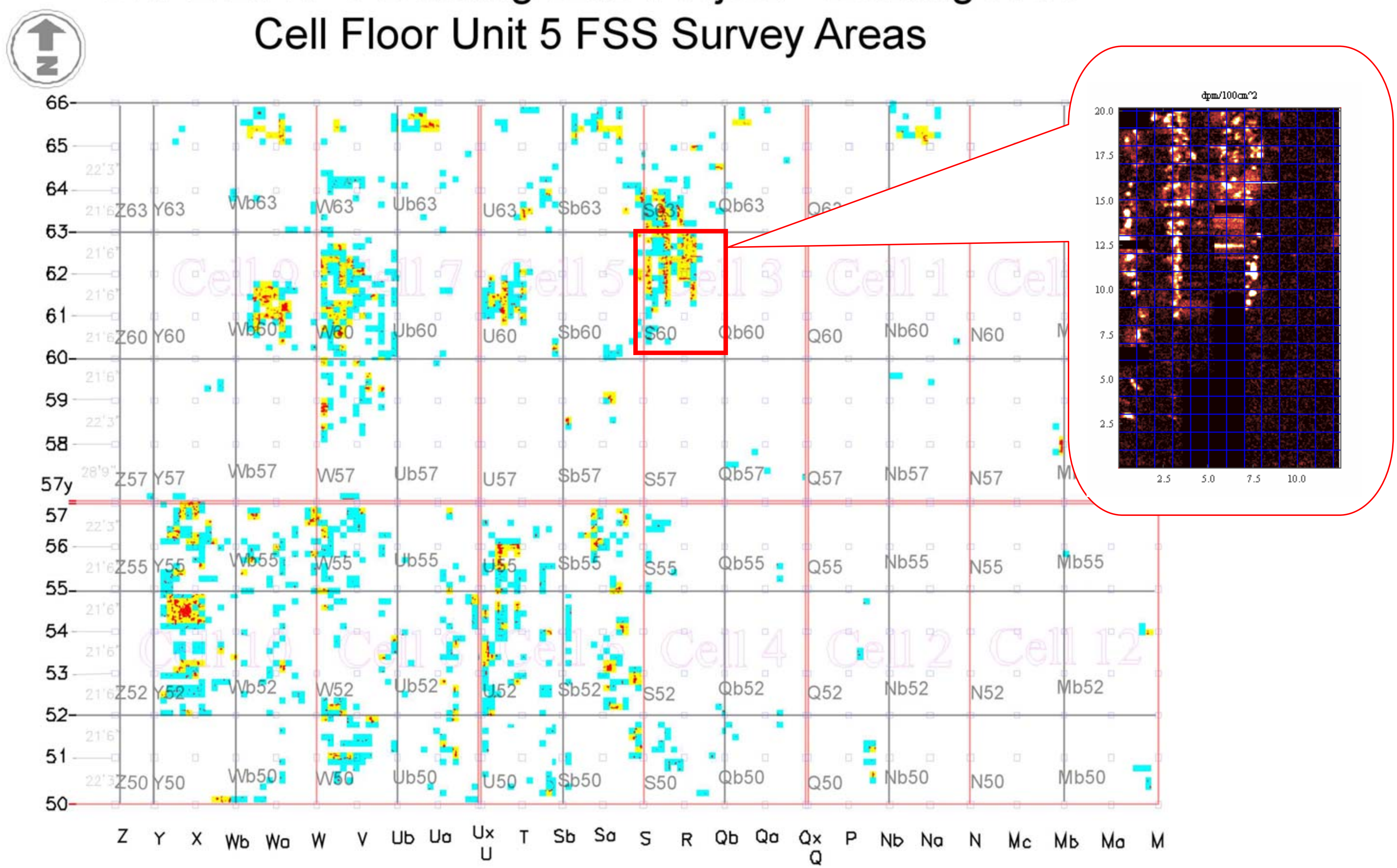

Fig. 6.

Management of surveys performed with hand-held instruments was through an access database that required manual entry of results. The Access database did not provide spatial correlation with results, but relied on mapping performed by the survey technicians in the field. The survey maps were then used to locate areas that required investigation.

Several critical issues were noted during the performance of the surveys in K-33 and K-31. First, registering background values for the concrete floor required detailed review of the areas surveyed. Although a reference area was surveyed with results that reflected favorably with the initial characterization of the building concrete floors, remediation efforts changed the profile considerably. Initially, the floors were finished concrete, with some areas under pedestals exposed following diamond wire cutting. Initial efforts to scabble the surfaces were conducted using shot blast equipment that easily removed the cement, but left the aggregate. The aggregate contained minimal natural radioactivity while the cement provided substantial natural activity. The actual background values for the shot-blasted areas were approximately 1/3rd of the values for un-scabbled concrete. Following the early efforts, the shot blast approach was replaced with scarifying heads. The scarifying approach removed the surface layer of cement, then cut the cement and aggregate evenly. The process left more cement than the shot blast approach. The resultant background values were approximately 2/3rd the value of un-scabbled concrete. To complicate matters, some survey units had both areas that were scabbled and areas that were not. The ability of the SCM to gather large amounts of individual measurements spatially correlated, and SIMS analytic tools allowed for engineering evaluations to assure that background was properly assessed for all surveys.

Secondly, much of the surface area, floors, structural steel and other surfaces contained widespread low-level activity. Instrument sensitivity and scan speed are normally based on EPC values and calculated MDCs that establish activity above background that can be detected in the field. When large surfaces are contaminated with low-level activity, the sensitivity values and scan speeds may no longer be adequate. The low level contamination also is not uniformly distributed, introducing another variable beyond the space and time variability of background. Again, the large amounts of individual spatially correlated measurements spatially produced by the SCM, and SIMS analytic tools allowed for engineering evaluation of individual surveys for adequate sensitivity.

Finally, the survey process was able to readily support the remediation efforts, but the remediation efforts were not always successful. Large amounts of contamination were eliminated from the building surfaces, but not all areas were remediated to EPC. In many areas, after several remediation attempts, agreement was reached with the Department of Energy representatives that further efforts could have a detrimental effect on the building structure. Thus, although the program was highly successful at removing thousands of tons of process equipment and remediating over 99% of the contamination from the building surfaces, some areas of localized contamination, primarily on the floors, remain.

CONCLUSIONS

The survey program at the K-33 and K-31 Gaseous Diffusion Plants may be the largest survey effort to be undertaken in support of Decontamination and Decommissioning activities. Approximately 400 to 500 million measurements spanning almost 4 years, involving hundreds of survey personnel, have been obtained. The radiological conditions of the facilities are likely to be the most thoroughly understood of any large facility in the world. More than 280 binders (3 inch each) of final survey reports have been generated, and are supported by more than 90GB of electronic data. The ultimate disposition of the facilities is with the Department of Energy. Re-industrialization continues to be the goal.

During the course of the survey program, many lessons were learned. A synopsis of some of the more critical lessons learned follows:

- Characterization efforts need to be integrated into the project at the beginning. A staff knowledgeable in the survey process should be on the project early. Integration of characterization activities into the large component removal schedule is vital. For large facilities localized sampling and surveys should not be extrapolated to entire areas or buildings.

- End Point Criteria should be defined prior to start of the final survey process with minimal risk of change. Minimal risk is supported by thorough characterization.
- Critical parameters such as background activity levels and instrument sensitivity may vary during the course of a project. Include mechanisms to evaluate and modify those parameters as necessary. Provide technical bases for any change.
- The development of a common data management system for all activities will have large paybacks. The system should have program management capabilities (surveys required, surveys completed, surveys completed but back to the field for investigation, surveys schedule near term, etc.), data analysis tools, information displays (spatial correlation of data, etc.) and data storage. The system must be developed with recognition of the survey report structure and should facilitate the report development optimizing electronic data transfer.