Response to SCA-TR-2017-SEC008, “Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963”

Response Paper

National Institute for Occupational Safety and Health

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ABBREVIATIONS AND ACRONYMS

α	alpha
ABRWH	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission, a predecessor of the United States Department of Energy
β	beta
CAMS	continuous air monitors
cpm	counts per minute; may also be denoted as c/m
CPP	Chemical Processing Plant
DCAS	NIOSH Division of Compensation Analysis and Support
DOE	Department of Energy
dpm	disintegrations per minute; may also be denoted as d/m
ER	evaluation report
FAP	fission and activation products
HEU	highly enriched uranium
HP	health physics
HSL	Health Services Laboratory, a predecessor name for the Radiological and Sciences Laboratory (RESL)
INL	Idaho National Laboratory
MPC	maximum permissible concentration
NIOSH	National Institute for Occupational Safety and Health
ORAUT	Oak Ridge Associated Universities Team
Pu	plutonium
RCG	radiological control guidelines
SC&A	Sanford Cohen and Associates
SEC	Special Exposure Cohort
SRDB	Site Research Database
SWP	safe work permit
TIMS	Thermal Ionization Mass Spectrometry
U	uranium
UO3	uranium oxide
Y-12	DOE facility in Oak Ridge, Tennessee

SUMMARY RESPONSE TO FINDINGS

On July 10, 2017, SC&A released report SCA-TR-2017-SEC008, Revision 0, entitled *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963.* The report provides the findings and observations from an Advisory Board on Radiation Worker and Health (ABRWH) request to evaluate the feasibility of dose reconstruction for workers at the Idaho National Laboratory's (INL) Chemical Processing Plant (CPP) prior to 1963. The recommended start date for the proposed class to be added to the Special Exposure Cohort (SEC) for CPP from the evaluation of SEC Petition 00219 is 1963. (NIOSH 2017) The SC&A report focused solely on the internal exposure potential to alpha-emitting radionuclides, which was the basis for the recommended addition to the SEC.

There were five findings and five observations presented in the Executive Summary section of *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963*. Each finding is provided below in italic text with a summary response from DCAS provided after each finding. Supporting detail is provided in subsequent sections of this report to present the technical bases for the DCAS responses to the findings. The five observations and DCAS responses are presented in a separate section.

Finding 1: *SC&A found multiple examples in sampled Health Physics (HP) logbooks that indicate alpha contamination was detected without corresponding indications that beta/gamma contamination was also present. This is indicative that there were certain situations and locations at CPP in which alpha contamination may have existed that was not comingled with FAP material.*

Finding 1 Response Summary: DCAS has concluded that alpha contamination without fission products was limited to certain locations within CPP pre-1963 and was related to process stream sampling and analyses, as well as final product storage. These locations were known to CPP staff. Documented communications with former CPP staff have indicated that contamination, with alpha contamination in particular, in CPP, was not tolerated, and was cleaned up quickly during its early years. The alpha contamination levels were typically very small and a special bioassay program was implemented if an internal exposure to an alpha-emitting radionuclide was deemed possible. It should also be recognized that workers involved in end-product activities where mixed fission products were not present were placed on a joint "gross beta" bioassay plus uranium bioassay program.

Finding 2: *SC&A found examples of alpha monitoring taking place in the Product Bottle Room, including smear surveys of product bottles and bird cages, as well as air monitoring for alpha. This is evidence that alpha contamination, including airborne contamination, was of concern to the HP staff for this area. Given the nature of routine work activities encountered in the Product Bottle Room, it is unlikely that workers in this area would also encounter FAP that are comingled with the enriched uranium.*

Finding 2 Response Summary: The Product Bottle Room was a storage room where filled stainless steel product bottles containing highly concentrated uranium solutions (the "product") were kept prior to shipment to Oak Ridge, where it was refined and manufactured into reactor fuel. The product bottles were stored in containers that looked like "bird cages." The purpose of the "bird cages" was to ensure a safe geometry of the highly enriched uranium (HEU) material during storage and movement. Radiological surveillance in the Product Bottle Room was performed because HEU was the potential source term for internal exposure, and, as such, required monitoring for alpha contamination. Smear surveys of the storage bottles and bird cages demonstrate that the CPP Health Physics group was attentive in monitoring those surfaces which would most likely become contaminated, in case one of the product bottles leaked, or had, in some way, been contaminated externally. DCAS has concluded there is no compelling data to indicate that internal exposure potential was even remotely likely.

Finding 3: *SC&A identified several area contamination survey maps from 1954, 1955, 1957, 1960, and 1961 that indicate that alpha contamination may have been the primary radiological concern for certain locations at the time of the survey. In many cases, the survey is a general contamination survey that did not detect beta/gamma activity, but directed that the identified locations with alpha contamination be cleaned up.*

Finding 3 Response Summary: As with the conclusion to Finding #1, DCAS has concluded that alpha contamination without fission products was relegated to certain locations within CPP pre-1963, and was related to process stream sampling and analyses, as well as final product storage. While certain contamination surveys did not report beta/gamma activity, there were often separate beta/gamma and alpha contamination surveys performed in the analytical laboratories. In the response to Finding 3, it is also pointed out that there was a focus on only alpha contamination surveys at CPP during the later data capture trips, in support of the SEC Petition 00219 evaluation report. This was due to a focus on alpha contamination surveys in determination of a start date for the recommended SEC class. Within the complete survey records, there were many more beta-gamma surveys than alpha only surveys.

Finding 4: *Based on a limited set of air samples in Room 216 from November of 1954, it is apparent that there was airborne alpha activity present. Evidence suggests the airborne alpha activity was uranium-233 (U-233) in the form of uranium oxide (U3O8). In two of the three examples, the airborne long-lived alpha activity bounded the airborne beta activity.*

Finding 4 Response Summary: DCAS has concluded that U-233 internal exposure potential is limited to a very small number of workers, with bioassay monitoring performed as deemed necessary. U-233 was an analytical tracer used for Thermal Ionization Mass Spectrometry (TIMS) measurements for uranium concentration. The tracer typically contained more activity than the sample to be analyzed, and was a known concern for contamination potential by the CPP Health Physics staff and analytical laboratory personnel. Bioassay records indicate there was special bioassay monitoring performed for U-233.

Finding 5: *SC&A identified a single example in which internal monitoring for uranium (specifically U-233) occurred out of the 32 reviewed claims who held job titles with the potential for laboratory work at CPP. Two samples were provided in the claimant's monitoring record; however, a log of all medical treatment indicates that two additional follow-up samples occurred, which are missing from the dosimetry records supplied by the U.S. Department of Energy. One of the two follow-up samples was located via the NIOSH process known as "optical recognition imaging." The disposition and availability of the other sample is unknown.*

Finding 5 Response Summary: DCAS has also concluded that the U-233 bioassay records for Claim [redacted] appear to be incomplete, based on a Health Record card in the Department of Energy (DOE) Response File. The records for Claim [redacted] have been re-requested to ascertain if the records may now be available as medical records are now included in DOE Response Files from INL.

In summary, based on further evaluation of the findings and observations from *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963*, DCAS still believes it can reconstruct doses with sufficient accuracy for workers at CPP before 1963. This conclusion was largely reached due to the comprehensive Health Physics at CPP, which included tight contamination controls, airborne radioactivity monitoring, attention to changes in source term based on process knowledge with appropriate monitoring, and a large *in-vitro* bioassay program. There was a small subset of the CPP workforce that was on a routine uranium bioassay program due to internal exposure potential to uranium without fission products present. Internal monitoring for most of the CPP workforce for alpha-emitting material was limited, as such monitoring was typically incident-based, as the actual exposure potential was likely restricted to certain operations and analytical laboratory personnel. Special bioassay monitoring was identified in interviews with former CPP workers, as well as in bioassay records and incident reports.

RESPONSES TO SEPARATE FINDINGS

Finding 1: *SC&A found multiple examples in sampled Health Physics (HP) logbooks that indicate alpha contamination was detected without corresponding indications that beta/gamma contamination was also present. This is indicative that there were certain situations and locations at CPP in which alpha contamination may have existed that was not comingled with FAP material.*

Finding 1 Response: CPP was a multipurpose plant designed specifically to recover uranium from a wide variety of highly-enriched uranium spent nuclear reactor fuels (20 to 93% U-235). Fuel reprocessing operations, isotope recovery, and waste calcination were the three major processes at CPP. The common health physics practice for controlling internal exposures to personnel in most of the facility during its early years was to control the quantity of beta/gamma contamination, as it was present in much higher quantities than alpha contamination. This has been documented in personnel communications in which CPP health physicists indicate that contamination in the early years was typically well tagged with fission products. (DCAS 2014a)

However, there were certain known locations within CPP where this relationship did not hold true. (DCAS 2016) In the process of recovering highly enriched uranium, most fission products were removed from the process stream in the first-cycle extraction raffinate. Sampling of the process stream after first cycle, with subsequent analyses in the CPP analytical laboratories, and end-product activities such as final recovery of uranium, were known to be alpha contamination concerns and were monitored as such. Contamination incidents and contamination measurements of note were recorded in HP Logs, with particular attention paid to alpha contamination. Significant events would also have a related INL incident report. For context, even lost film badges had an incident report. (DCAS 2014b)

Figure 1 in SCA-TR-2017-SEC008 was provided as an example of alpha contamination at CPP. The figure is a screenshot of a Health Physics Daily Logsheet indicating alpha contamination on the floor and wall of Room 207 from January, 10 1955 (not 1995). There are ten locations which are listed as having been surveyed. The locations listed are Access Corridor (twice), 206, 201, Men's Locker Room, Cell X, 207 (four times) and Front Gate. All alpha contamination indications (no contamination levels provided) were from Lab 207, an analytical laboratory. Additionally, Figure 2 provides an example from a 1954 CPP Health Physics Log where U-233 contamination was discovered in Lab 32. No contamination levels were provided except "*smeared on tops of various equipment pieces; max of 27 c/m on top of south locker*." In both cases, the alpha contamination was found in an analytical laboratory, which was the most common location for alpha contamination at CPP. [NOTE: U-233 contamination is specifically addressed in the response to Finding #4.]

Table 1 in SCA-TR-2017-SEC008 provides a listing of alpha contamination that was identified from a review of CPP Health Physics Logbooks from 1953, 1954, and 1955. The listing provides the generic remarks and explanations from the logbooks, with most of the specified areas listed as laboratory areas. There are no specific contamination levels provided in Table 1. Table 2 provides more detailed entries from the Health Physics Logbooks from January and February 1954. In the seven examples provided, there are four entries which provide contamination levels. All are related to laboratory or final product areas. They are:

- LB-12: up to 100 c/m alpha
- PM Area: up to 35 c/m alpha
- LB Area: up to 250 c/m alpha
- LB-28A: 2 c/m alpha max found

Figures 1, 2 and 3 of this report provide examples of CPP radiological surveys from 1957, 1960, and 1962. These surveys include alpha contamination survey data with detected contamination reported in cpm. Figures 1 and 2 are from CPP analytical laboratories, while Figure 3 was a former analytical laboratory which was modified into a research laboratory. The emphasis on alpha contamination due to the nature of the material handled in the laboratory is clear from the surveys. Additional examples are provided in the response to Finding #3. The highest potential for internal alpha exposure was 3rd cycle extraction and subsequent analytical measurements. (DCAS 2014c) It is worth mentioning that the neptunium and plutonium recovery projects, which involved resubmission of first-cycle raffinate through the first-cycle extraction process again to extract these elements, did not take place until 1965, and thus, post-date the time period of this review.

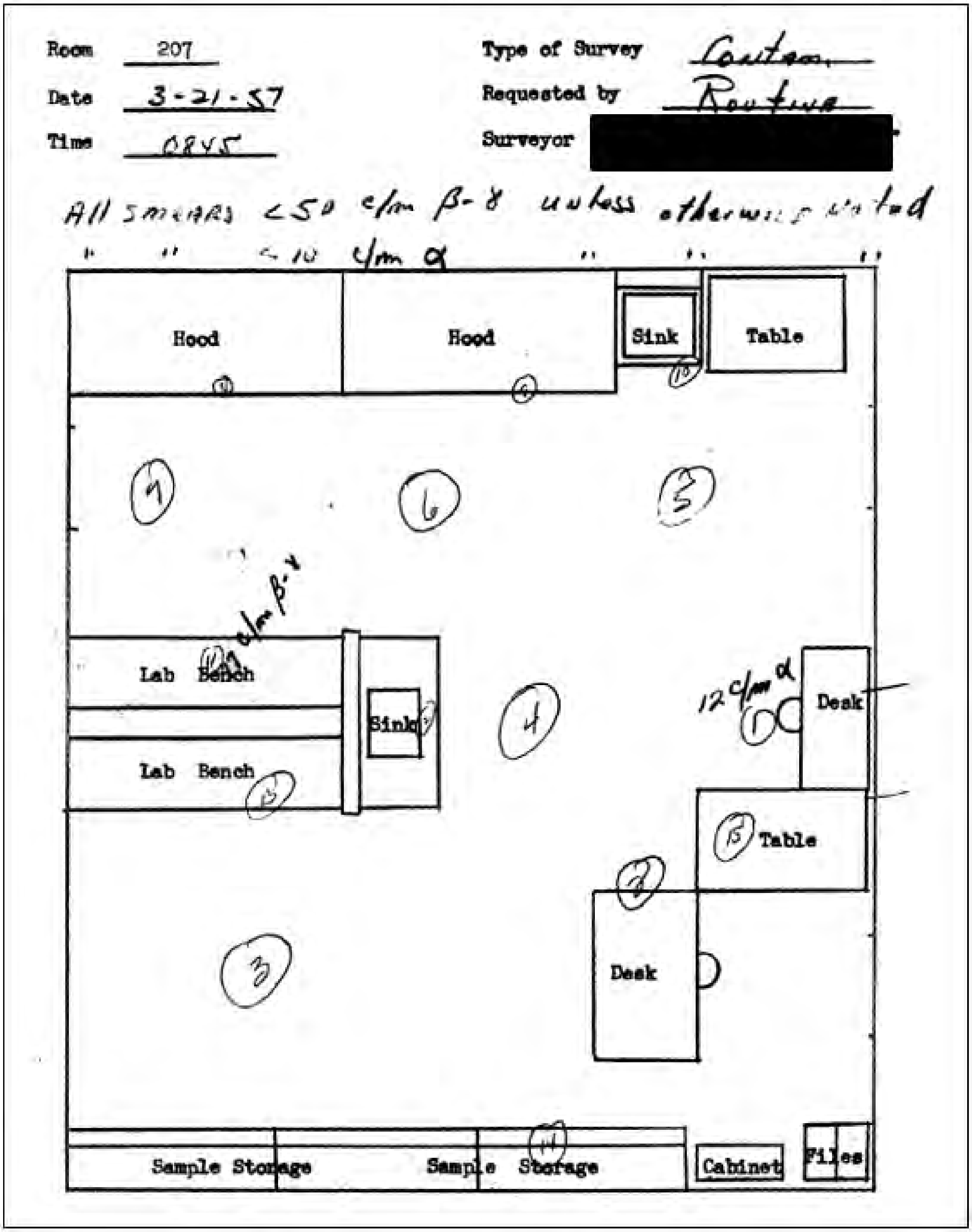


Figure 1: Contamination Survey of CPP Lab 207 in March 1957. (CPP 1957, page 6)

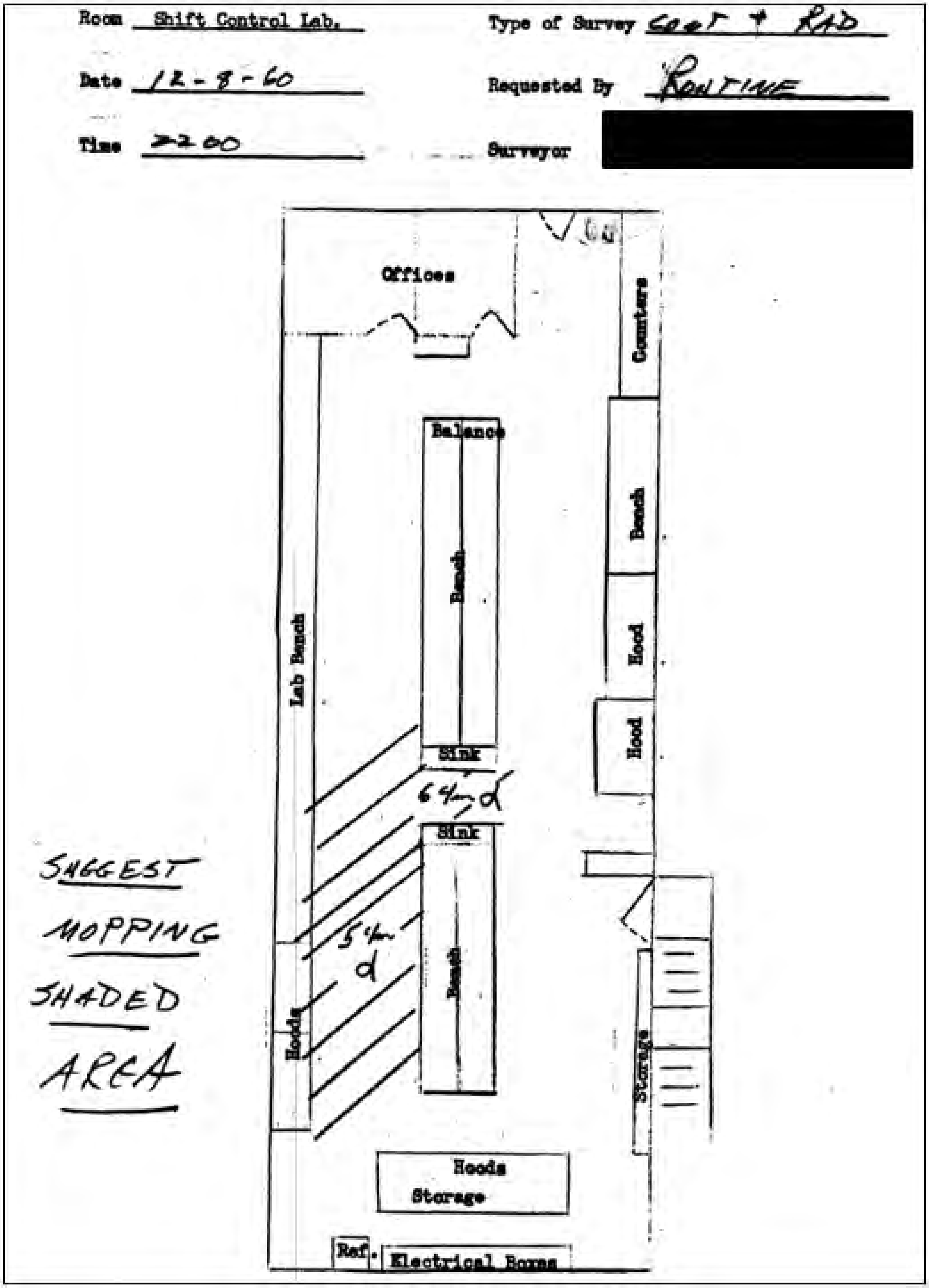


Figure 2: Contamination Survey of CPP Shift Control Lab in December 1960. (CPP 1960a, page 4)

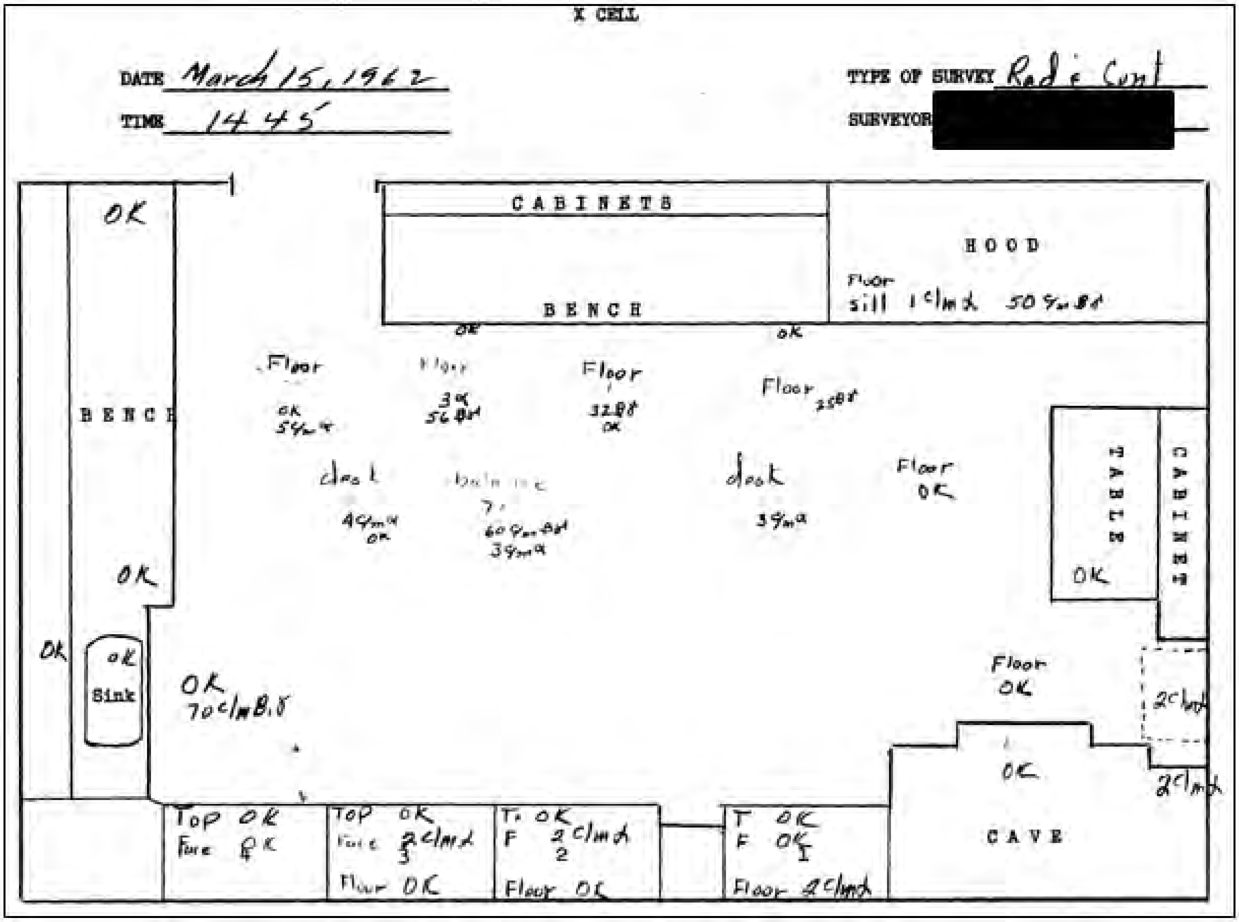


Figure 3: Contamination Survey of CPP X Cell in March 1962. (CPP 1962a, page 16)

In the alpha contamination examples provided in SCA-TR-2017-SEC008, and in Figures 1 through 3 above, a number of observations can be made. First, alpha contamination without mixed fission products was limited to the areas and activities associated with final product sampling, final product analysis, and final product storage. It was not a facility-wide concern. Second, the alpha contamination levels reported are very small. Despite these small quantities, the CPP Health Physics staff was diligent in performing alpha contamination surveys and providing instructions to clean up any contamination that was detected. These cleanup nstructions are often noted on the contamination surveys themselves. Third, alpha contamination was not tolerated and was tightly controlled. In the SEC Petition 00219 evaluation report, it was determined that it was the increase in alpha contamination levels, along with a general acceptance of these contamination levels without additional personnel monitoring, that provided the principal reason for recommending CPP for inclusion in the SEC, beginning in 1963.

While alpha contamination without fission products was likely in certain areas of CPP, it is important to remember that a large routine bioassay program was in place at CPP for workers with a reasonable potential for internal exposures. CPP did not routinely collect bioassay samples for uranium, except in cases where workers were determined to have an elevated potential for uranium exposure. This can be seen in the CPP Body Fluid Sampling Schedule for 1956. (Hayden 1956) A complete list of CPP workers participating in the routine bioassay program at CPP was provided to the Health Services Laboratory (HSL) which included name, department, film badge number, analysis type, and analysis frequency. Even those not required to participate in a routine bioassay program, mostly Atomic Energy Commission (AEC) and Security personnel, were included in the listing. The most common bioassay method employed at CPP was a gross beta urine bioassay, which was adequate for most workers because of the presence of mixed fission products in the source term for most of CPP. However, there were some workers on a gross beta plus uranium bioassay program. This combination was utilized for workers whose work activities placed them in areas where the mixed fission products had been removed during the chemical separation process in preparation of the final HEU product. It should be noted that any measured activity using a "gross" method resulted in further analysis by HSL to determine the radionuclide(s) detected. A breakdown of the number of workers for each analysis type and frequency in 1956 is provided in Table 1.

Table 1: Number of workers on each type of urine bioassay program at CPP in 1956. (Hayden 1956)

β (annual)	β (semi-annual)	β (quarter)	β + U (semi-annual or quarter)	None
64	50	171	8	19

The bioassay frequency demonstrates that monitoring was focused on workers with the highest potential for intake of radioactive material. For example, an annual frequency was typical of workers in the Engineering and Operations Evaluation departments, while a quarterly frequency was utilized for workers in the Health Physics, Operations, Chemical, and Instrumentation department personnel. It is telling that there was a small subset of workers that were placed on a gross beta plus uranium routine bioassay program. All of the workers placed on these programs were in either the Operations or Chemical departments, and were likely those most involved in final product sample collection, analysis, and storage.

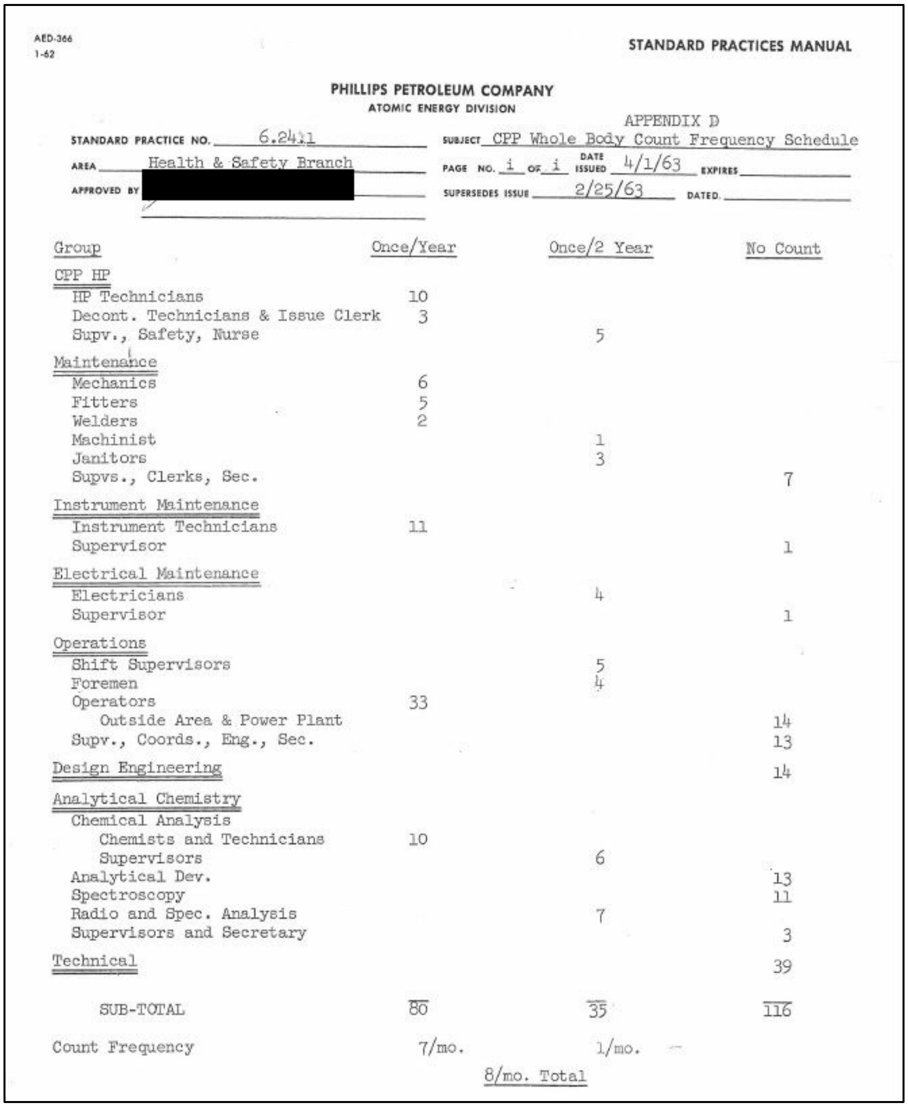
The routine bioassay program at CPP was not a static program. At the discretion of the health physicist, the sampling frequency could be changed, based on a perceived risk of uptake potential. This was demonstrated in the early 1960s, when monthly 24-hour urine samples were collected from personnel who frequented the X-Cell in CPP (an X-Cell contamination survey is provided in Figure 3). The X-cell was originally the high level radio-analytical control laboratory for CPP, where high activity radioactive samples from the process were analyzed for plant control data until 1956. It was repurposed and converted into a research laboratory after the Remote Analytical Facilities (CPP-627) was built. The hazards associated with the X-Cell correlated with the material and work done in the cell. Gram quantities of alpha emitting radionuclides and pure fission product isotopes were handled in the hood, cave, and/or glove boxes of the X-Cell, depending on the amounts, concentrations and chemical composition of the materials. Constant health physics coverage was provided 1) during any particularly hazardous work or 2) any time lab personnel requested it.

The required urine samples were routinely processed for gamma, plutonium, and other radionuclides, as needed. Any radioactivity detected by gross analysis was identified, and additional samples were requested when it was thought to be necessary. (Stroschein 1967) The group of personnel sampled was relatively small, as highly-skilled chemists were needed to perform the research in the X-Cell. A review of the *in-vitro* bioassay data currently being assembled for INL coworker models reflected the described increased bioassay monitoring for the X-Cell chemists, as is presented in Table 2. This data clearly demonstrates that the increased internal exposure potential due to the work in the X-Cell was recognized by the CPP Health Physics staff. The stringent bioassay program established reflects the elevated hazard concern.

Table 2: Example of Enhanced Routine Bioassay Program for X-Cell workers. Data is for 1962-1965. (INL Coworker In-Vitro Working Dataset)

Job Title	Gamma Analyses	Plutonium Analyses	Strontium Analyses
Chemist	28	32	2
Chemist	37	41	2
Chemist	24	24	2
Analytical Supervisor	11	2	3
Chemist	27	14	2

The same philosophy used to determine analyses and frequency for *in-vitro* bioassay was utilized when the *in-vivo* bioassay program was implemented in 1961. Workers with the highest internal exposure potential were counted more frequently. While not a uranium bioassay method, it again demonstrates focusing bioassay measurements based on internal exposure potential. An excerpt from the 1963 Whole Body Count Frequency Schedule for INL is shown in Figure 4. (McCaslin 1963)



AED-366
1-62

STANDARD PRACTICES MANUAL

PHILLIPS PETROLEUM COMPANY
ATOMIC ENERGY DIVISION

APPENDIX D

STANDARD PRACTICE NO. 6.2411 SUBJECT CPP Whole Body Count Frequency Schedule
AREA Health & Safety Branch PAGE NO. i OF i DATE ISSUED 4/1/63 EXPIRES
APPROVED BY [redacted] SUPERSEDES ISSUE 2/25/63 DATED

Group	Once/Year	Once/2 Year	No Count
CPP HP			
HP Technicians	10		
Decont. Technicians & Issue Clerk	3		
Supv., Safety, Nurse		5	
Maintenance			
Mechanics	6		
Fitters	5		
Welders	2		
Machinist		1	
Janitors		3	
Supvs., Clerks, Sec.			7
Instrument Maintenance			
Instrument Technicians	11		
Supervisor			1
Electrical Maintenance			
Electricians		4	
Supervisor			1
Operations			
Shift Supervisors		5	
Foremen		4	
Operators	33		
Outside Area & Power Plant			14
Supv., Coords., Eng., Sec.			13
Design Engineering			14
Analytical Chemistry			
Chemical Analysis			
Chemists and Technicians	10		
Supervisors		6	
Analytical Dev.			13
Spectroscopy			11
Radio and Spec. Analysis		7	
Supervisors and Secretary			3
Technical			39
SUB-TOTAL	80	35	116
Count Frequency	7/mo.	1/mo.	

8/mo. Total

Figure 4: CPP Whole Body Counting Frequency Schedule for 1963 (McCaslin 1963)

Special bioassay was also utilized at CPP. Internal exposure to uranium was carefully controlled by the use of Safe Work Permits (SWPs) and monitored via radiation/contamination surveys, as well as the use of CAMs (continuous air monitoring) for alpha and beta-emitting radionuclides in the ambient air. At CPP pre-1963, special bioassays were conducted for suspected intakes, based on radiological indicators and the professional judgement of the CPP Health Physics staff (there was at least one HP [Masters-level] and 2-3 technicians [Bachelors-level] on every shift). Workers were sent to HSL for bioassay if they had "any facial contamination or if they worked in an area where airborne contamination was detected. When alpha contamination was discovered in the lab (1950s), the entire crew was sent for urine bioassay – looking for U and Pu. Alpha bioassay was done when conditions indicated; alpha contamination was not seen often." (DCAS 2014c)

DCAS has concluded that alpha contamination without fission products was only in certain locations within CPP pre-1963 and was related to process stream sampling and analyses. These locations were known to the CPP staff. Documented communications with former CPP staff have indicated that contamination, with alpha contamination in particular, in CPP was not tolerated and was cleaned up quickly. The alpha contamination levels were typically very small, and a special bioassay program was implemented if an internal exposure to an alpha-emitting radionuclide was deemed possible. It should also be recognized that there was a comprehensive bioassay program that included uranium analyses for workers with elevated internal exposure potential to the HEU final product.

Finding 2: *SC&A found examples of alpha monitoring taking place in the Product Bottle Room, including smear surveys of product bottles and bird cages, as well as air monitoring for alpha. This is evidence that alpha contamination, including airborne contamination, was of concern to the HP staff for this area. Given the nature of routine work activities encountered in the Product Bottle Room, it is unlikely that workers in this area would also encounter FAP that are comingled with the enriched uranium.*

Finding 2 Response: The Product Bottle Room in CPP was where highly concentrated liquid uranyl nitrate solution product bottles were stored and then shipped to Oak Ridge to be further refined and manufactured into reactor fuel. This process was used until 1969, when the uranium was converted to a solid oxide. To maintain a safe geometry, the stainless steel product bottles were kept in containers that looked like “bird cages.”

Due to the composition of the product material, tight radiological controls with an emphasis on alpha contamination detection were utilized. This is illustrated in Figures 5, 6, and 7, which list alpha contamination smear results from product “bird cages” in 1955 and 1956. Contamination levels on a smear above the minimum detectable amount of 10 cpm gross alpha for a one minute count time were acted on. Figure 7 provides an example of two “bird cages” requiring “decontamination.” In both cases, the recorded gross alpha contamination levels are extremely low even before the adjustment for background (5 cpm). It should also be noted that the detected beta activity was also elevated on some of the smears. These measurements were made with no consideration of radon-thoron daughter interferences which were present in CPP.

CPP SAMPLE RECORD

Type of Sample Smear
Collected by Huff
Date Submitted 3 May 1955

Analyzed by [redacted]
Method of Determination Vert Pig
Date Reported 3 May 55

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Time	Quantity	Analyse For	Quantity	Total Count	Count Time	Bkgd C/M	Counts Per Min.	Results
1	5/3	1300	Bird Cage # 113				α		2	1	2	0	OK
2			do 170						12	1		10	OK
3			do 163						2	1		0	OK
4			do 150						8	1		6	OK
5			do 127						5	1		3	OK
6			do 134						2	1		0	OK
7			do 116						6	1		4	OK
8			do 117						4	1		2	OK
9			do 135						4			2	OK
10			do 166						2			0	OK
11			do 187						7			5	OK
12			do 171						4			2	OK
13			do 153						9			7	OK
14			do 182						5			3	OK
15			do 149						6			4	OK
16			do 188						6			4	OK

Figure 5: Page 1 of 2 of Alpha Contamination Surveys for Product Bird Cages (Bird Cages 1955, page 2)

CPP SAMPLE RECORD

Type of Sample Smear
Collected by Huff
Date Submitted 3 May 55

Analyzed by [redacted]
Method of Determination
Vert Cig.
Date Reported 5/8/55

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Sampling Data Time	Sampling Data Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts Per Min.	Results
17	5/8	1300	Bird Cage 127				α		4	1 m	2	2	OK
18			128						7			5	OK
19			131						9			7	OK
20			139						2			0	OK
21			125						4			2	OK
22			145						4			2	OK
23			115						5			3	OK
24			144						1			0	OK
25			181						2			0	OK
26			141						10			8	OK
27			167						7			5	OK
28			189						3			1	OK
29			109						6			4	OK
30			156						6			4	OK
31			MT						2			0	OK

AEC Dupl #EL 500 8/17/53

Figure 6: Page 2 of 2 of Alpha Contamination Surveys for Product Bird Cages (Bird Cages 1955, page 3)

Rev. #1

Chemical Processing Plant - National Reactor Testing Station
Health and Safety Branch

HEALTH PHYSICS SAMPLE RECORD SHEET

Date 2/9/56
Time 1100
Type of Survey Rad. Econt.
Area Surveyed Product Bottle Cages
Surveyor [redacted]

Beta Counter No. 64 Scaler
Background 45 c/m
Standard c/m
Observed c/m
Geometry 9.9%

Alpha Counter No. 106-B
Background 5 c/m
Standard c/m
Observed c/m
Geometry 50%

Sample Nos.		Gross Beta	Net Beta	Gross Alpha	Net Alpha	Identity, Location, Remarks, Results, uc/cc, etc.	Gross Beta	Net Beta	Gross Alpha	Net Alpha	Identity, Location, Remarks, Results, uc/cc, etc.
1	26	46	1	6	1	ICPP 273 (empty) α	56	11	4	—	ICPP 207 α
2	27	60	15	2	—	" 206			4	—	" 253 Decond.
3	28	64	19	10	5	" 264			5	—	" 271 Decond.
4	29			16	11	" 262					
5	30	68	23	4	—	" 261					
6	31			4	—	" 260					
7	32	48	3	18	13	" 253					
8	33			4	—	" 249 α					
9	34	56	11	10	5	" 248					
10	35			5	—	" 247					
11	36	52	7	8	3	" 245					
12	37			6	1	" 209					
13	38	45	—	8	3	" 239					
14	39			14	9	" 238					
15	40	52	7	8	3	" 236					
16	41			5	—	" 235					
17	42	64	19	10	5	" 234					
18	43			5	[illegible]	" 265					
19	44	45	—	8	3	" 267					
20	45	45	-	35	30	" 271					
21	46	52	7	10	5	" 272 α					
22	47	53	8	5	—	" 252					
23	48	54	9	5	—	" 254					
24	49	9		5	—	" 256					
25	50	48	3	5	—	" 258					

Figure 7: Alpha Contamination Surveys for Product Bird Cages in February 1956 (Product Bottles 1956, page 2)

On page twenty one of *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963*, an example is provided of potential alpha air activity in the Final Product Room in September 1954. The same example is provided in Figure 8 of this report. An initial alpha result appears to be 5E-11 µCi. The result unit is likely to have been µCi/cc, as astutely pointed out in the note associated with Figure 5 in the SC&A report. It should be pointed out that there was a recount performed 40 minutes later to allow for radon-thoron daughter interferences to decay away. The count result is provided. There is not a calculated value provided but the count result is roughly 40% lower, and based on the count result, seemed to require no further action. The 1952 CPP Health Physics Manual reports a general permissible concentration of 3E-11 µCi/cc for alpha emitters, as seen in Figure 9. (CPP 1952) The recount value would correspond to an air concentration less than 3E-11 µCi/cc.

Cudson

CPP SAMPLE RECORD

Type of Sample Air

Collected by [redacted]

Date Submitted Sept 3, 54

Analyzed by [redacted]

Method of Determination α prop. counter

Date Reported Sept 3, 1954

Sample No.	Date	Hour	Sample Description	Sampling Data Rate	Time	Quantity	Analyze For	Quantity	Total Count	Count Time	Bkgd C/M	Counts PerMin.	Results
1	9-3-54	1020	Final Prod. room	30 l/m	10 m	300 l	α		60	5	.6	11.4	5×10^{-12} uc
		1100	Same		Same		α		73	10 m	.6	6.7	

Figure 8: Air Sample Record for CPP Final Product Room September 3, 1954 (Air Sampling 1955, page 15)

General permissible concentration of gross fission products in air and water, for use when the particular isotopes are unknown, will be:

Air Concentration	alpha	3×10^{-11} uc/cc
	beta-gamma	10^{-8} uc/cc
Water Concentration	all	10^{-7} uc/cc

* Air concentrations are calculated on the basis of 168 hours per week exposure with a breathing rate of 1.25×10^6 cc per hour of working time and 0.63×10^6 cc per hour of off-time.

** These concentrations are calculated on the basis of 40 hours per week working time at a breathing rate of 1.25×10^6 cc per hour and negligible exposure during the non-working time.

*** Water concentrations are based on assumption of 1.5 liters per day of intake as liquid and 1.0 liters per day of intake as food.

Figure 9: CPP Health Physics Manual, April 1952 (CPP 1952, page 49)

It is agreed that contamination survey and air sampling related to the activities associated with final product at CPP demonstrate that area health physicists were cognizant of the potential for alpha contamination. A long-time CPP health physicist, in a documented communication, recalled not remembering “air activity in the product packaging area of ICPP, which was to be expected because they were very careful not to lose any of the product during those operations.” (DCAS 2014b). DCAS has concluded there is no compelling data to indicate that internal exposure potential was even remotely likely.

Finding 3: *SC&A identified several area contamination survey maps from 1954, 1955, 1957, 1960, and 1961 that indicate that alpha contamination may have been the primary radiological concern for certain locations at the time of the survey. In many cases, the survey is a general contamination survey that did not detect beta/gamma activity, but directed that the identified locations with alpha contamination be cleaned up.*

Finding 3 Response: As a fuel reprocessing facility which employed three cycles of solvent extraction, the radionuclide composition of the process stream changed from fuel dissolution through final product bottling and storage. For most of CPP, beta/gamma contamination monitoring for controlling internal exposure potential was utilized because the source term was well tagged with fission products. Examples are provided in Figures 10 and 11, which are surveys of the Operating/Sample Corridors and South Access Corridor respectively. The contamination levels reported were assumed to be beta/gamma unless noted otherwise.

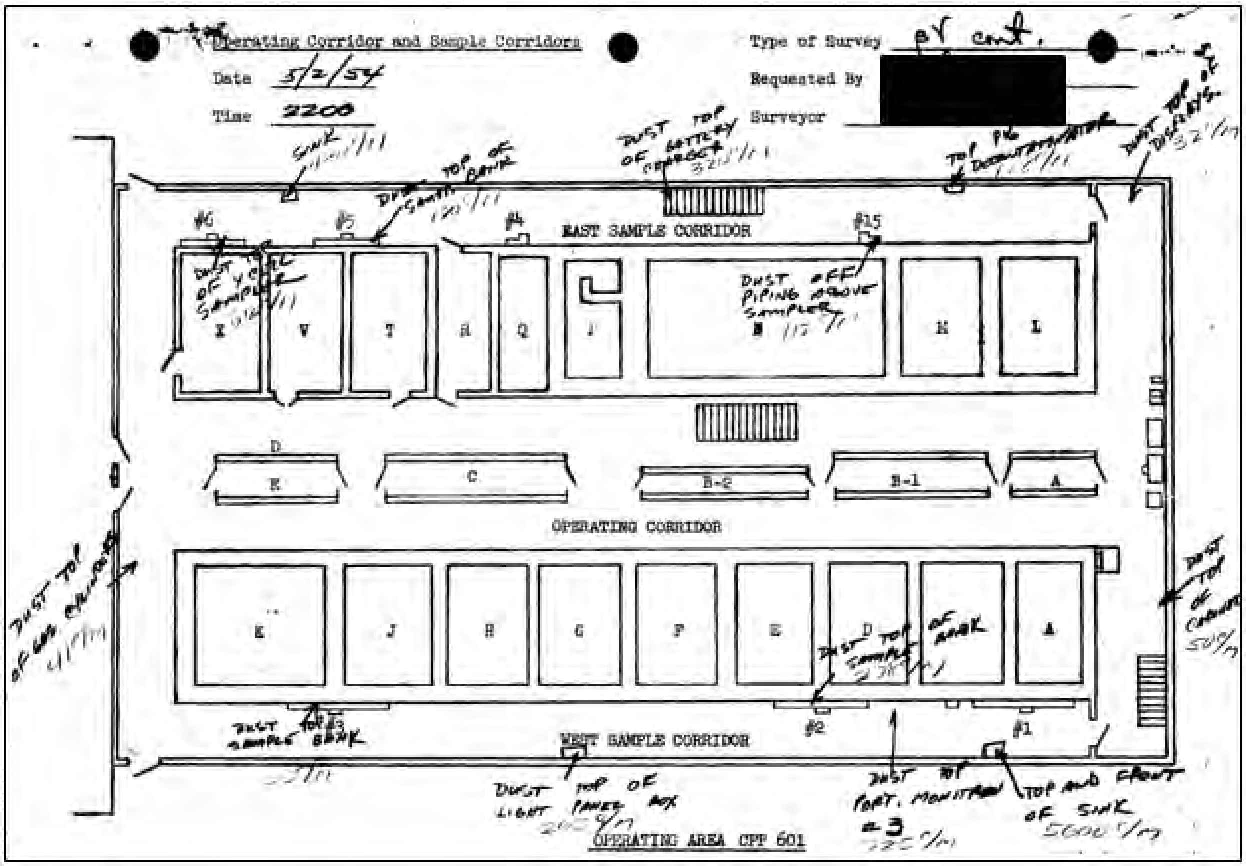


Figure 10: Beta-Gamma Contamination Survey of Overhead Survey in the CPP-601 Sample Corridor in May 1954 (Overhead Contamination 1954, page 3)

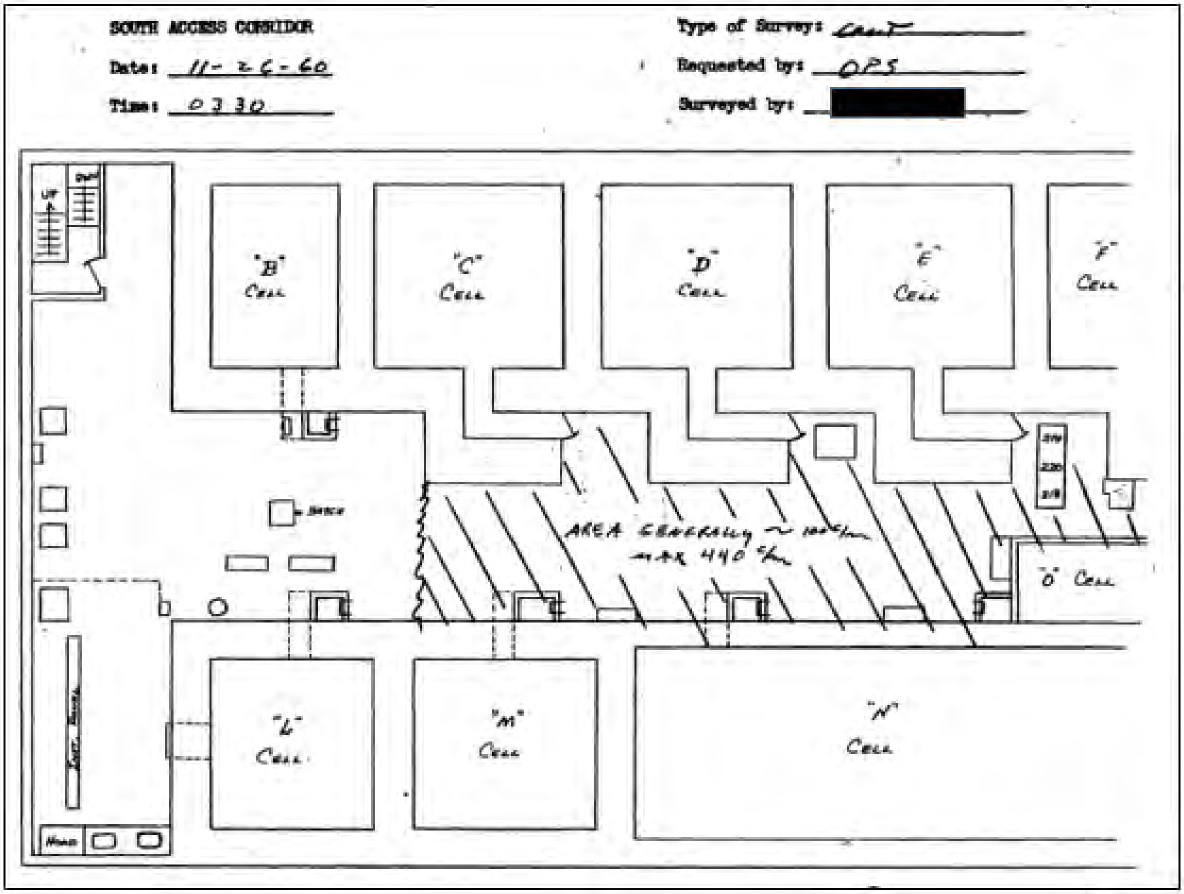


Figure 11: Beta-Gamma Contamination Survey of CPP-601 South Access Corridor (CPP 1960a, page 14)

This is in sharp contrast to the analytical laboratories, where surveys for alpha contamination were much more prevalent. The recognition that alpha-emitting radionuclides could be present without a fission product tag is demonstrated in the examples provided in Figures 12 and 13. Figure 3, which was previously presented, is also of particular interest on this topic, because it demonstrates that even in the X-Cell, a high activity analytical cell used for research, including large quantities of alpha-emitting radionuclides, there was a focus on alpha contamination monitoring. Remarkably, there is very little alpha activity measured. This was due to good radiological hygiene practices that were utilized at the time. In practice, this included good housekeeping, "papering" down work surfaces with frequent replacement, and a general intolerance for contamination by the CPP health physics staff. (DCAS 2015). It was the relaxing of permissible contamination levels that led to the future contamination control problems at CPP.

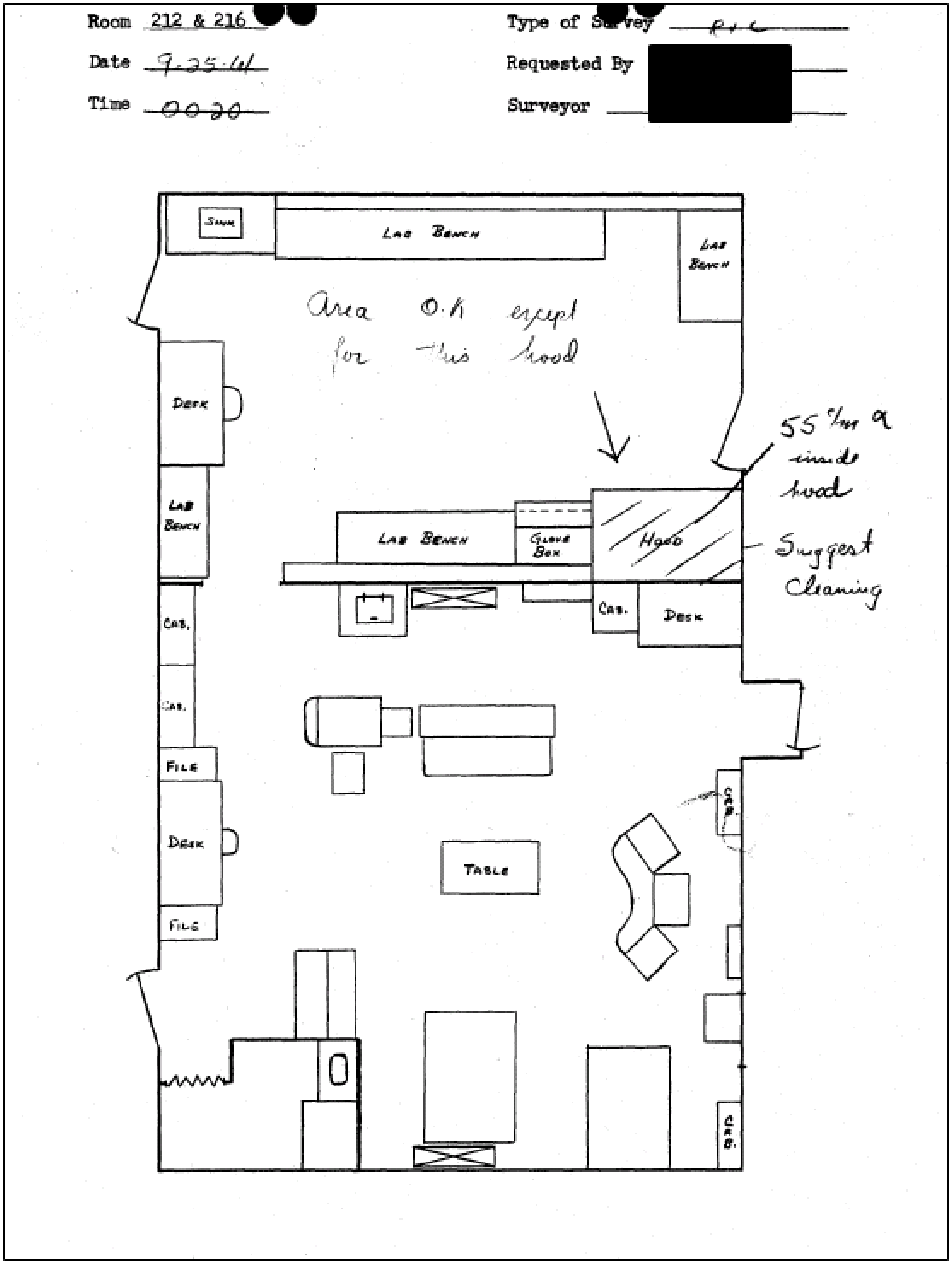


Figure 12: Contamination Survey of CPP Labs 212/216 (CPP 1961a, page 25)

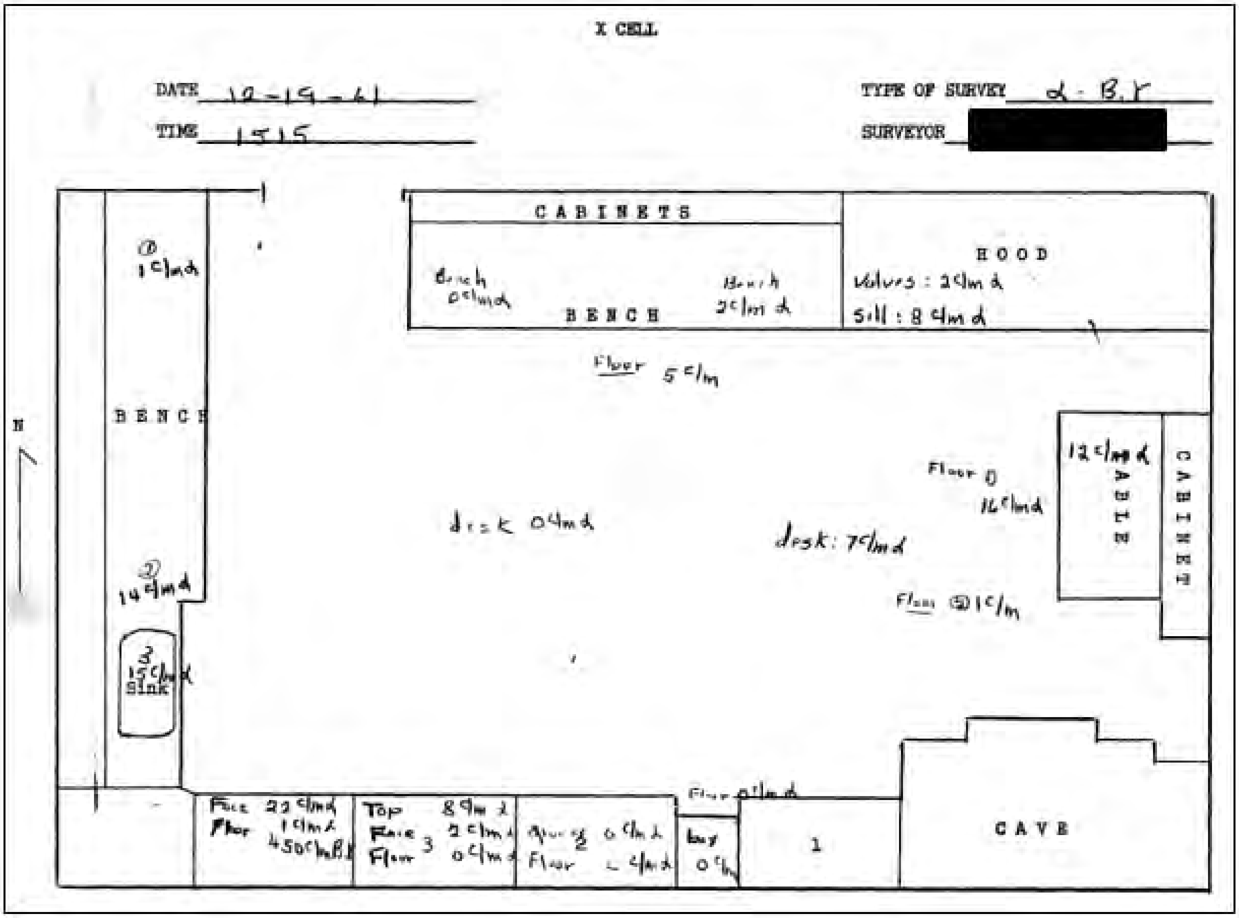


Figure 13: Contamination Survey of X-Cell in December 1961. Note the beta/gamma contamination level recording in the lower left hand corner. (CPP 1961a, page 6)

Figure 14 provides an example of not only a contamination survey of an analytical laboratory, but also the identification of potential sources of contamination. In the survey, there are several items identified – namely "used syringe," "used tissues," and "gloves" (in two locations). There is also a directive to promptly discard of the items. As noted in *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963* in Figure 10, radiological surveys were marked with areas shaded that required cleaning of the areas. Hoods and sinks were typically the locations with the highest contamination levels. These are good health physics practices in keeping contamination levels to a minimum.

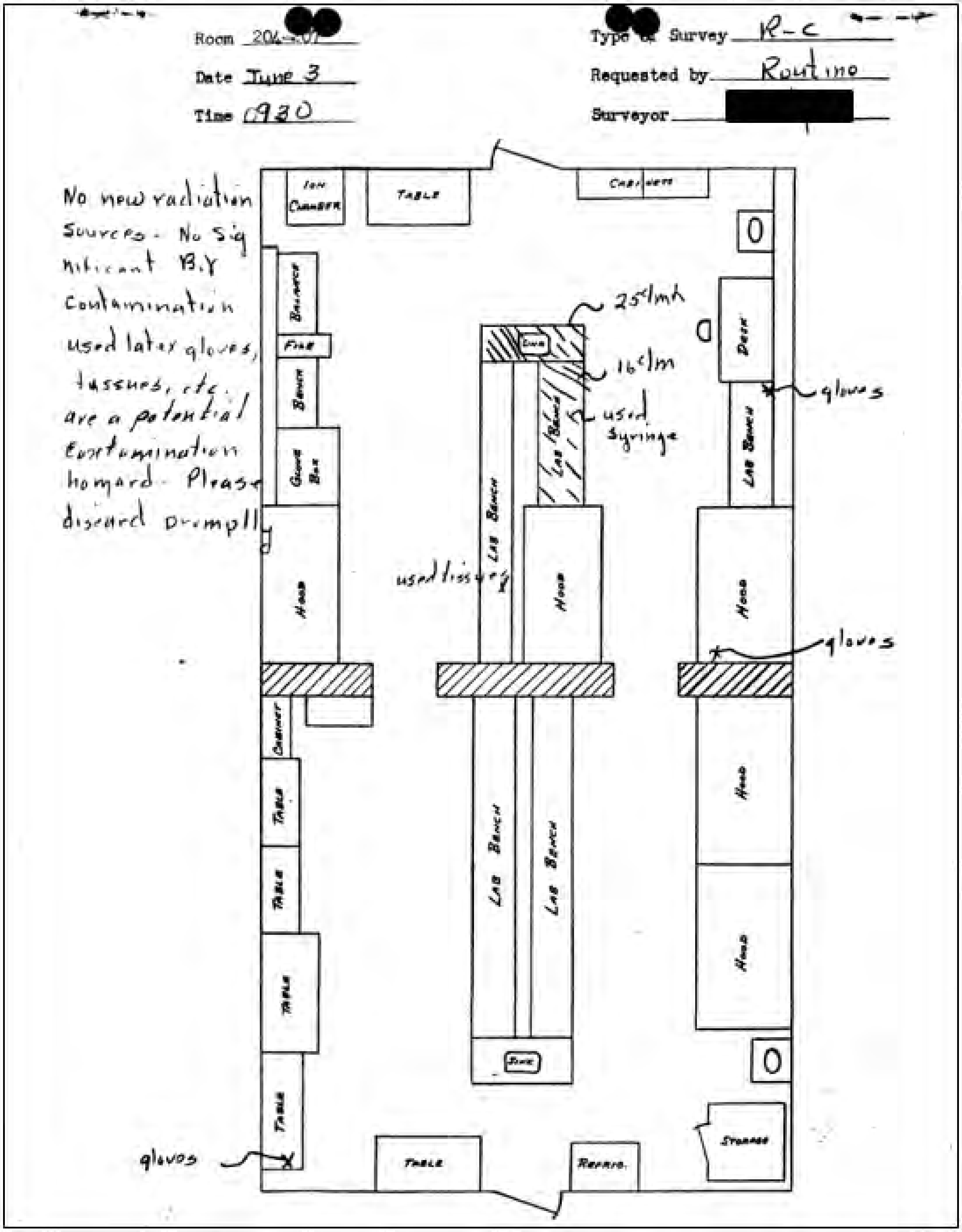


Figure 14: Contamination Survey of CPP Labs 204/207 in June 1961. Note the identification of potential sources of contamination on the survey. (CPP 1961a, page 6)

Figure 12 provided an example of a survey where the contamination survey did not reflect that any measurements were made for beta/gamma contamination. Whether beta/gamma activity was not detected or if the survey was strictly at alpha survey is impossible to ascertain. However, it is clear from other surveys that beta/gamma contamination surveys were performed. Figures 15 and 16 provide examples of alpha and beta/gamma contamination results being reported on the same radiological survey.

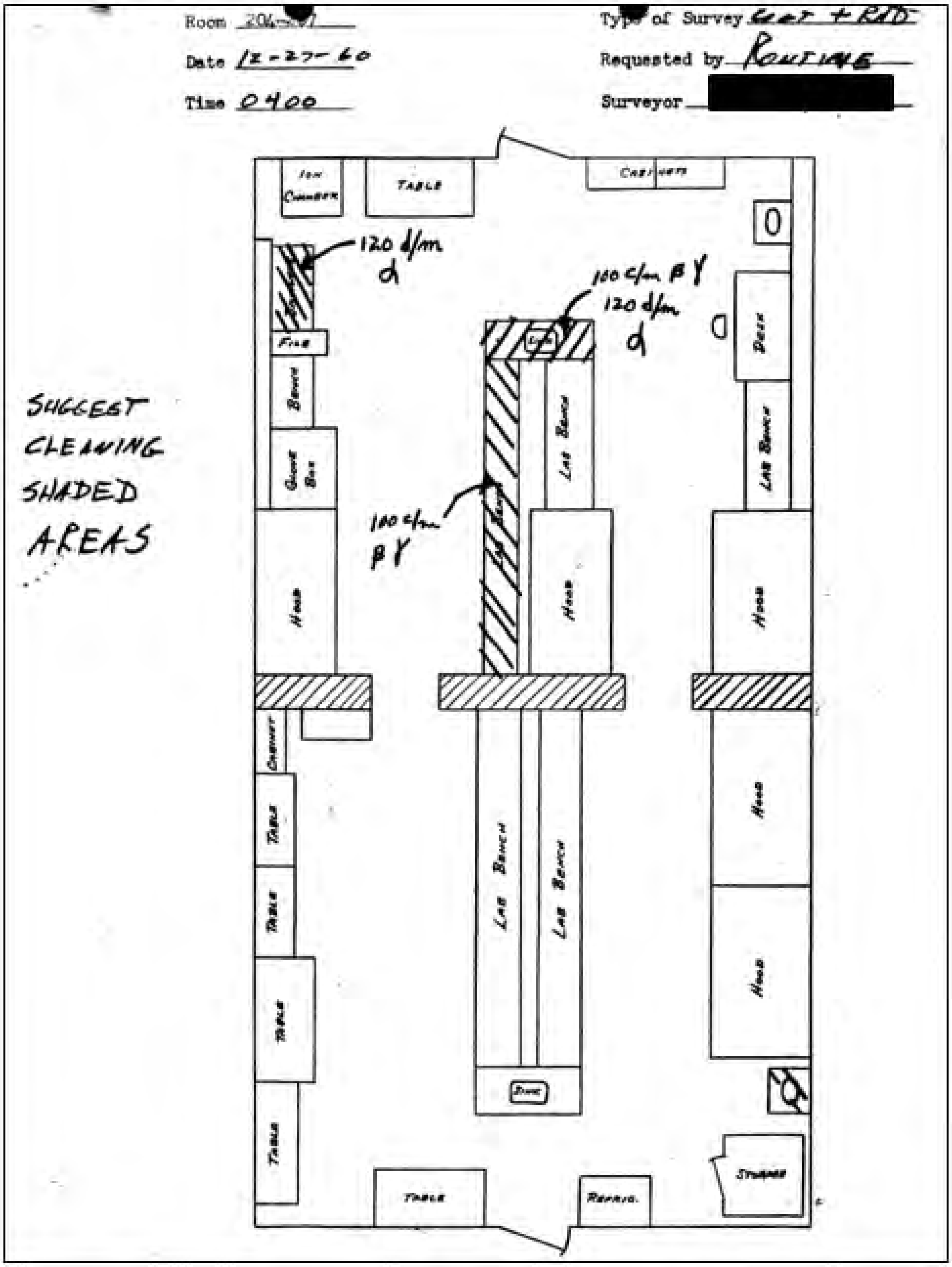


Figure 15: Alpha and Beta-Gamma Contamination Survey of CPP Labs 204/207 in December 1960. (CPP 1960a, page 2)

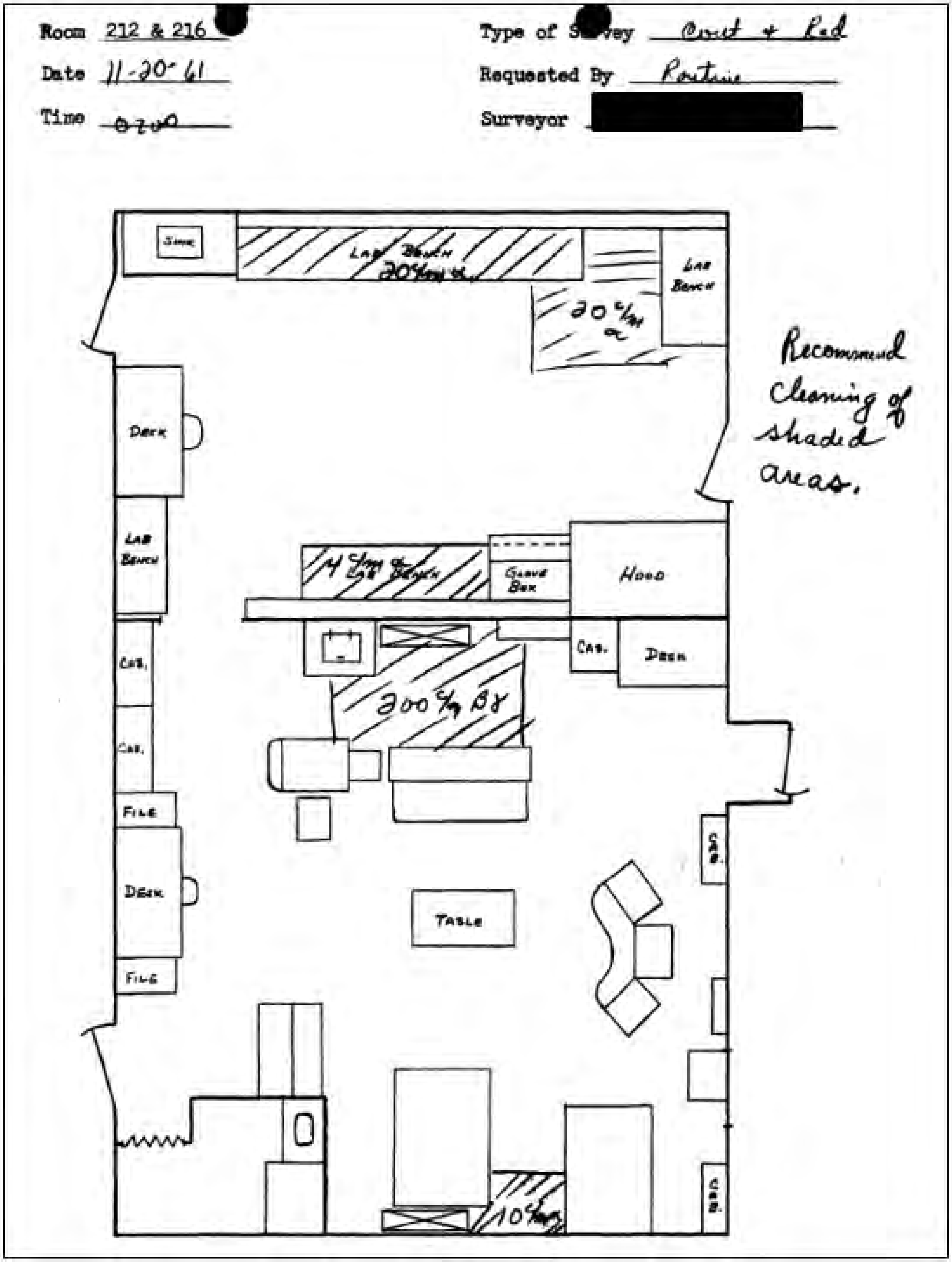


Figure 16: Alpha and Beta-Gamma Contamination Survey of CPP Labs 212/216 in November 1961. (CPP 1961b, page 24)

It should be noted that during some of the later data captures to the INL Records Center for the SEC-00219 petition evaluation, there was a concerted effort to focus on alpha contamination surveys to aid in determining the beginning of the then already-identified alpha contamination control problem at CPP. This is seen in some of the names of the documents captured during the last data capture (January 2015) in support of the 83.13 evaluation. (See Table 3). Most of the health physics surveys, which provided alpha survey results, were captured. There were also many beta/gamma surveys that were not captured. It was noted that the results of beta/gamma surveys and alpha surveys were sometimes recorded separately.

Table 3: Examples of CPP Health Physics Surveys in Early 1960s Captured in January 2015

SRDB Ref ID	Title
CPP 1960a	CPP Surveys with Alpha Results April - December 1960
CPP 1961a	CPP Routine HP Surveys with Alpha Results January - June 1961
CPP 1961b	CPP Routine HP Surveys with Alpha Results July - December 1961
CPP 1962c	CPP Routine HP Surveys with Alpha Results January - February 1962
CPP 1962b	CPP Routine HP Surveys with Alpha Results February - March 1962
CPP 1962a	CPP Routine HP Surveys with Alpha Results March 1962
CPP 1962d	CPP Routine HP Surveys with Alpha Results April 1962

As with the conclusion to Finding #1, DCAS has concluded that alpha contamination without fission products was only in certain locations at CPP, related to process stream sampling and analyses, which were known to CPP staff. Radiation and contamination surveys demonstrate that even low levels of alpha contamination were not tolerated and were cleaned up quickly.

The internal exposure potential from the alpha contamination levels presented in SCA-TR-2017-SEC008 would be very small. The largest alpha contamination level from the examples presented was 1,500 dpm/100 cm^2 in Figure 8, which was a close-up from Figure 7. The figure shows the alpha contamination detected on opening to a hood in Lab 216 in 1955, which appears to be fixed, as there is an additional note of "31 cpm alpha on smear." Even if the 1,500 dpm is assumed to be transferrable, is uniformly distributed on the entire lip of the hood, and can be resuspended into the air, the quantity of activity available to be inhaled by the worker is less than 1 dpm using the following assumptions:

- Total surface area (hood lip) = 6 ft. by 1 ft. (5575 cm^2)
- Total activity = 1,500 dpm/100 cm^2 x 5575 cm^2
- Resuspension factor = 1E-05

Because of the episodic nature of the alpha contamination, present for short periods of time, due to decontamination efforts and not allowing the conditions to become persistent, a chronic exposure would be unlikely. It is important to remember that the class added to the SEC for CPP was due to increased alpha contamination levels, leading to increased internal exposure potential. There was not an increase in personnel monitoring, specifically bioassay, as the contamination levels increased. An ever-increasing accepting attitude of contamination and contamination problems at CPP eventually led to a facility Health Physics upgrade program.

Dose reconstruction for INL workers accounts for actinides for both monitored and unmonitored workers. Even if a worker at CPP was not on a uranium bioassay program, the gross beta and gross gamma bioassay measurements for monitored workers have ratios of actinides assigned based on ratios to Sr-90 and Cs-137 (the gross beta and gross gamma indicator nuclides). These ratios are provided in Table 5-22 and Table 5-23 in ORAUT-TKBS-0007-5 Rev 3, *Idaho National Laboratory and Argonne National Laboratory-West – Occupational Internal Dose.* This is also true for whole body counts which were performed at INL, beginning in 1961.

For unmonitored workers, a hypothetical missed internal dose approach is based on the assumption that the most likely type of bioassay measurement was performed on the last day of the calendar year and the result was one half the minimum detectable activity (MDA). The contribution from actinides is assumed for an unmonitored worker just like for a monitored worker. Again, this would be true for whole body counting as well. Thus, the current dose reconstruction methods account for potential small contributions from actinides.

Finding 4: *Based on a limited set of air samples in Room 216 from November of 1954, it is apparent that there was airborne alpha activity present. Evidence suggests the airborne alpha activity was uranium-233 (U-233), in the form of uranium oxide (U3O8). In two of the three examples, the airborne long-lived alpha activity bounded the airborne beta activity.*

Finding 4 Response: CPP-602 was a three story building which housed numerous laboratory facilities. Rooms 212 and 216 in CPP-602 were analytical laboratories dedicated to uranium process measurements to quantify uranium isotopes. (CPP 1977) The laboratories were connected, as seen in Figure 17. Sample preparations and mass spectrometry measurements were performed in the laboratories. A mass spectrometry method called Thermal Ionization Mass Spectrometry (TIMS) was utilized in these laboratories. The TIMS method requires a chemically purified sample and tracer to be plated onto a rhenium filament. The filament was then heated in a chamber connected to the mass spectrometer, causing ionization of the atoms, which were then introduced into the mass spectrometer and separated by the electromagnet, based on the mass to charge ratio. TIMS is a highly sensitive isotope mass characterization technique, making it an ideal method of uranium process measurements.

CPP utilized uranium-233 (U-233) as the analytical tracer for TIMS. In a personnel interview with an analytical chemist that worked in the CPP laboratories, it was recalled that "the spike of U-233 was the dominant uranium isotope in the samples submitted for analysis (and in loose contamination in the mass spec lab). Since the spike was added in the shift lab as an analytical tracer, workers in other areas of the plant, outside the labs, were not exposed to U-233." (DCAS 2014d) The chemist went on to state that while the lab was capable of analyzing nanogram samples of uranium, larger samples were often run, including samples of a "few micrograms with 1 microgram of U-233 added to each sample."

Given the large quantity of U-233 used in TIMS measurements and the need to plate the samples on a metal filament, it is not surprising that small contamination events occurred. However, the U-233 contamination tended to be small and was cleaned up quickly. Given the function of the laboratories, contaminants could not be tolerated for long without affecting the accuracy of the mass measurements. Figures 17, 18 and 19 provide a series of contamination surveys of Rooms 212 and 216 from September 2, 1960 through December 9, 1960, which demonstrate this.

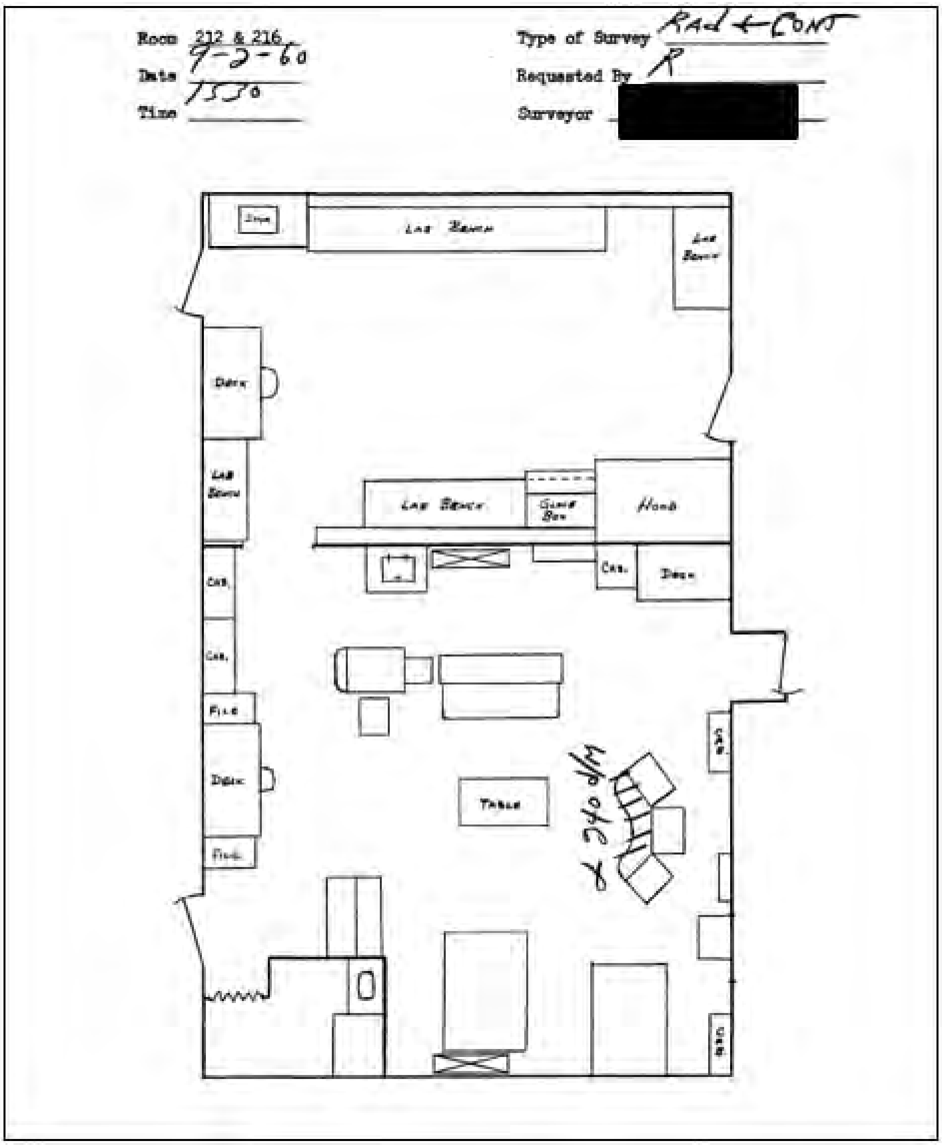


Figure 17: CPP-602 Room 212 and 216 Contamination Survey, September 2, 1960 (CPP 1960, page 9)

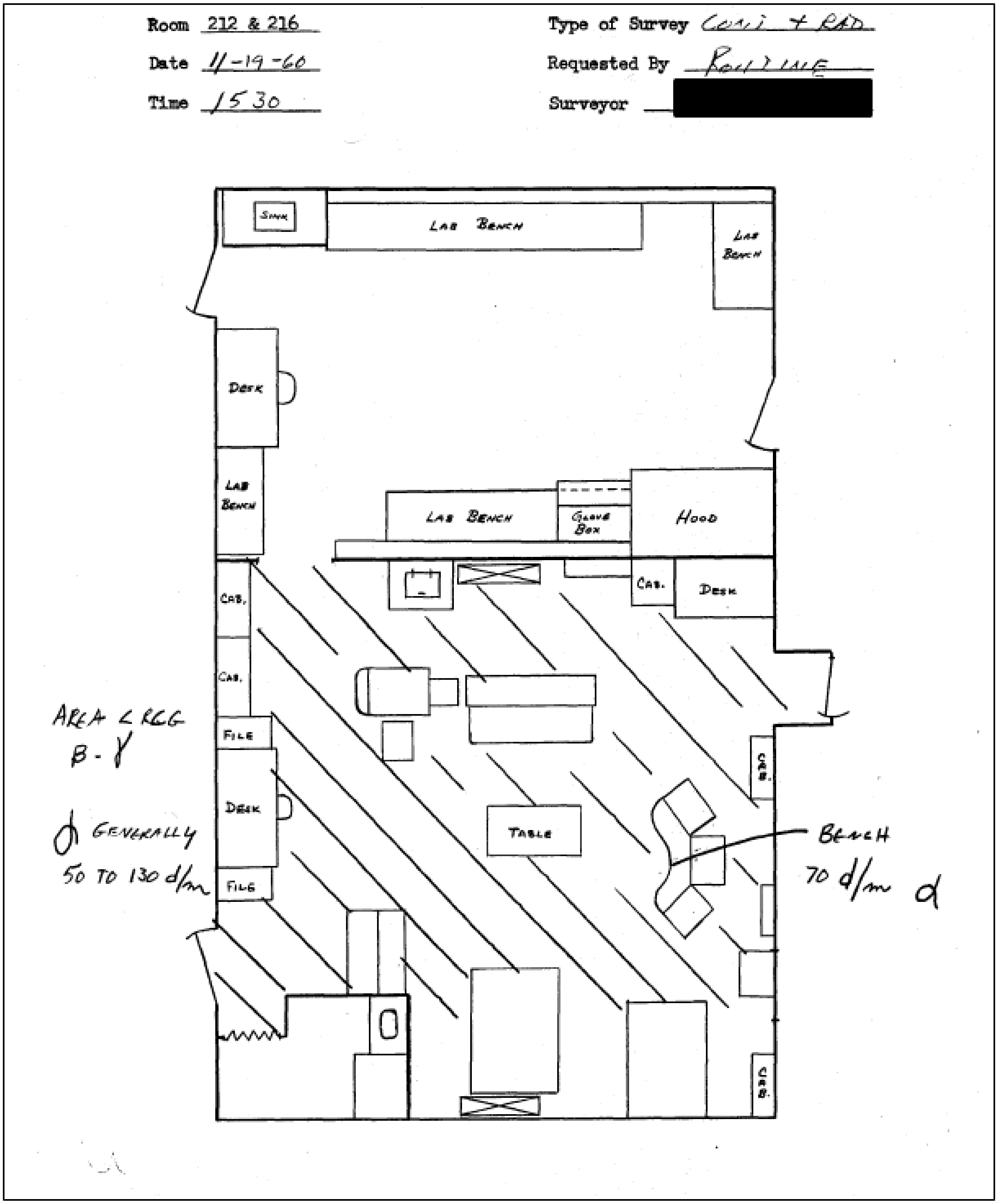


Figure 18: CPP-602 Room 212 and 216 Contamination Survey, November 19, 1960 (CPP 1960, page 6)

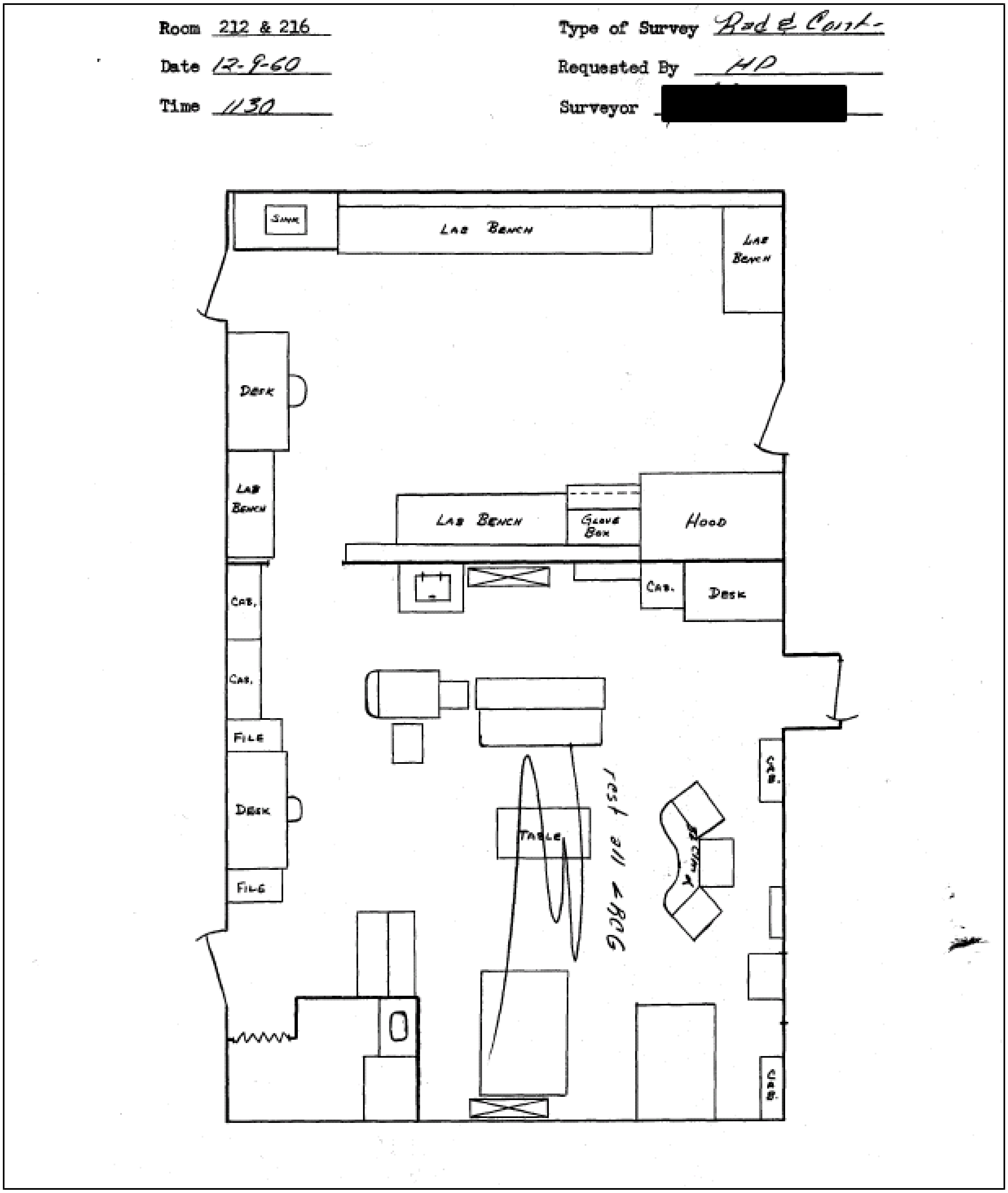


Figure 19: CPP-602 Room 212 and 216 Contamination Survey, December 9, 1960 (CPP 1960, page 4)

Special bioassay for elevated levels of contamination due to U-233 were requested when deemed necessary by CPP Health Physics. A review of *in-vitro* bioassay collected at CPP in November 1954, the time period of concern identified in the SC&A report, indicated there are thirteen special analyses for uranium. A review of the workers sampled indicates many were in the Chemistry department at CPP. (Hayden 1956) Uranium was not detected in any of the special bioassay samples. It should be noted that, in 1958, a U-233 specific urinalysis method was developed at INL. There were a small number of U-233 bioassay analyses in the late 1950s and early 1960s. All of these analyses were designated as "special" sample types, indicating that they were specific responses to U-233 contamination, which was only found in the CPP analytical laboratories.

U-233 contamination in analytical laboratories that were involved in the preparation of process samples for mass spectrometry measurements and the measurements themselves was known, and even expected, given the large quantity of U-233 used as an analytical tracer is some measurements. This is documented in alpha contamination surveys and in documented communications with a former analytical chemist. When contamination from U-233 was found, it was typically small in quantity and was cleaned up quickly. There are also documented cases identified where CPP health physicists requested special bioassay due to U-233. All bioassay results for U-233 were less than detection level. DCAS has concluded that U-233 internal exposure potential is limited to a very small number of workers with bioassay monitoring performed as deemed necessary.

Finding 5: *SC&A identified a single example in which internal monitoring for uranium (specifically U-233) occurred out of the 32 reviewed claims who held job titles with the potential for laboratory work at CPP. Two samples were provided in the claimant's monitoring record; however, a log of all medical treatment indicates that two additional follow-up samples occurred, which are missing from the dosimetry records supplied by the U.S. Department of Energy. One of the two follow-up samples was located via the NIOSH process known as "optical recognition imaging." The disposition and availability of the other sample is unknown.*

Finding 5 Response: Claim1480 was reviewed for bioassay data included in the DOE Response File. The December 23, 1959 and December 31, 1959 urinalysis results for U-233 were found. As indicated on the Health Record in Figure 21 (page 42) of the *Draft Review of Internal Alpha Exposure Potential at CPP Prior to 1963*, there appear to have been two additional follow-up samples. The additional follow-up samples dated January 5, 1960 and January 11, 1960 were not found in this review, either. Of some interest is that that the December 23rd and December 31st samples were collected by "Medical Services," which, while not unusual at that time, may account for the possibility of results being in Medical records. Discussion with the lead dose reconstructor for INL indicated that occasionally indications of bioassay sampling are part of Medical records. He also indicated that the only bioassay data in those records are urine sample dates without the analytical results. This is exactly what SC&A discovered in Finding #5. The occupational medical records are now routinely being provided by INL in the DOE Response files for claimants. However, this has not always been the case. The medical records started being provided around claims numbered 20,000 and higher. The DOE Response File, which includes medical records, has been re-requested for Claim [redacted]. DOE Request ADD_[redacted]_D132 was requested on March 6, 2018.

RESPONSES TO SEPARATE OBSERVATIONS

Observation 1: *Based on five identified interviews with former CPP workers having some knowledge of radiological operations, it is apparent that the HP staff were aware of, and took steps to control, alpha contamination in certain areas of the plant. These areas include the laboratories and other "product" areas. While the interviews indicate that an "incident"-based internal monitoring program was employed for alpha emitters, it is unclear what levels of alpha contamination would actually trigger "special bioassay" samples, versus more common decontamination activities.*

Observation 1 Response: CPP Health Physics staff members were expected to understand the operations processes in order to determine the source term of interest in various locations within CPP. Alpha contamination without fission products present were found at locations where the recovered uranium product was sampled, analyzed, and bottled. The administration of special bioassay was based on the professional judgment of the CPP health physicists. A review of the SRDB documents for CPP pre-1963 did not locate a document with prescriptive action levels for special bioassay. It should be kept in mind that the CPP Health Physics staff during the time period of interest included technicians that were Bachelor-level educated health physicists.

Observation 2: *Thirty-one of 32 claimants who worked at CPP prior to 1963 and had job types most likely to be associated with laboratory work did not have any internal monitoring results for uranium or other transuranic material (either special or routine). It cannot be inferred from available claimant files whether these workers should have been monitored and were not, were monitored and the records are unavailable, or did not experience any exposure potential to uranium warranting routine monitoring.*

Observation 2 Response: CPP analytical laboratory workers were placed on routine bioassay programs pre-1963. The CPP Body Fluid Sampling Schedule for 1956 provides a list of all CPP workers required by the CPP Health Physics manager to participate in routine bioassay to the Health Services Laboratory. The workers are listed by name and the requested analyses and frequencies are provided as well. It is evident from the document that the health physics staff considered the internal exposure potential for each worker before arriving at the requested bioassay program. There clearly were certain workers that were placed on uranium-specific bioassay due to internal exposure potential.

Observation 3: *During its review of claimants who may have worked in the laboratory areas of CPP, SC&A identified several non-claimants who appear to have been part of a regular routine monitoring program for uranium. This is logically indicative that a group of workers existed at CPP who had the potential for chronic (rather than episodic) exposure to uranium that was of radiological concern to the health and safety staff.*

Observation 3 Response: The CPP Body Fluid Sampling Schedule for 1956 provides a listing of all CPP workers required to participate in routine bioassay programs. (Hayden 1956) As seen in Table 1 of this report, there was a small group of CPP workers (chemistry analysts and operations personnel) who were on a gross beta and uranium routine bioassay program. CPP Health Physics likely requested these analyses due to an elevated potential for uranium exposure, due to the nature of their tasks and locations. Some of these workers were on a semi-annual frequency, while others were on a quarterly frequency, again, due to internal exposure potential. Intakes of radioactive material, whether acute or chronic, that are identified via routine bioassay, are indications of failures in the protection of workers. Bioassay represents a final quality control check of workers for intakes of radioactive material.

Observation 4: *A documented 1958 incident involving airborne U-235 alpha activity in the Z-Cell indicates that HP was notified immediately and appropriate actions were taken, including air sampling, area swipe contamination surveys, and worker nasal swipes. Multiple bioassay samples were collected in the days immediately following the incident. Analysis of the available bioassay related to the incident indicates that exposures were likely minimal. This incident was also discussed in NIOSH 2015b.*

Observation 5: *A documented incident in December 1958 describes a product line maintenance activity that resulted in a spill of U-235 in the access corridor of CPP. The activity involved an “HP Permit” and also had an HP presence in at least one of the two maintenance locations. Follow-up reports indicate HP and safety permits required more detail to avoid future incidents. Although not specified in the incident report, SC&A located at least one special uranium sample that was taken for a pipefitter involved in the spill.*

Observation 4 and 5 Response: The response to Observations #4 and #5 is combined, as both observations describe uranium contamination events with follow-up monitoring. Special bioassay, which is bioassay requested due to off-normal radiological conditions, was requested in both cases. Liquid spills, elevated airborne radioactivity, and facial contamination are examples of radiological indicators which would likely require some form of excreta measurement to determine 1) if an intake of radioactive material occurred and 2) if so, to aid in quantifying the intake and resultant radiative dose. The documentation of the December 1958 contamination event is consistent with the documented communication with a former CPP health physicist that significant events would have an INL incident report. (DCAS 2014b)

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