Summary of the Limited Reconnaissance Effort Regarding the Naturally Occurring Suspect Material at the Grand Canyon National Park

Revision 1

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Prepared for:

National Park Service
Grand Canyon National Park

EXECUTIVE SUMMARY

Arcadia Consulting, Inc., (Arcadia) personnel proceeded to the Grand Canyon National Park in Grand Canyon, Arizona with the assumption and understanding that the National Park Service (NPS) had an unspecified quantity of soil corings that potentially contained 3% of U-nat (naturally occurring Uranium). These materials were supposedly stored at the visitor's center, located on the South Rim of the Grand Canyon, for as long as 40 years. It was also understood there was a mining facility located within approximately 5 miles of the visitor's center, containing additional uranium ores and tailings.

What was actually discovered were various igneous, metamorphic and sedimentary rock samples, located at multiple locations (the museum, the visitor center, the interpretation garage, and the "old warehouse"). These samples included unprocessed ore, semi-processed ore with some yellowish residue, coring samples, and samples of materials in simple geological forms. Due to time limitations, the mine was not visited; therefore, no available data was gathered to make any conclusions regarding mill tailings.

The project duration was approximately four days. During that period, Arcadia personnel performed radiological measurements, obtained all applicable documentation (with the assistance of the NPS), and contacted NPS personnel in order to characterize the radiological potentials. In summation, the primary purpose of the trip to the Grand Canyon was investigation and limited characterization.

The reconnaissance yielded much data, which are incorporated in this report. State of Arizona, NRC, and EPA guidelines are described within, and the general regulatory provisions cited. Items requiring immediate attention and the corresponding regulatory drivers are emphasized

Briefly, this report incorporates the general steps and methodology undertaken in the course of this reconnaissance to differentiate the nature of the hazards. Non-binding recommendations to assist in the administrative control of the naturally occurring [suspect] material (NORM) are detailed in this report. It is recommended that for further guidance, the NPS should consult with the State of Arizona Radiation Regulatory Agency, and a professional firm specializing in this area.

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A. Contamination Survey Reports
B. Radiation Survey Reports
C. Various Assay Data

1.0 INTRODUCTION

1.1 Background and History

Years ago, uranium ore was mined in Arizona at various mining locations, including the Grand Canyon National Park. These activities are believed to be the source of the radioactive materials in question, with special emphasis placed on the Orphan Lode Mine. The Orphan Lode lies on the South Rim just west of the Grand Canyon Village.

The mine was discovered and named by Daniel "John" L. Hogan and his partner Henry Ward. The ore body of the Orphan Lode Mine is located in a breccia pipe that extends vertically to a depth of about two thousand feet. When the mine closed in 1969, it had produced 495,107 tons of ore, including 4,257,071 pounds of uranium oxide averaging 0.43 percent. (Source: Grand Canyon Association, et. al. 1997)

The first ore shipment, on April 25, 1956, contained 20.89 tons averaging 0.53 percent uranium oxide, consigned to the Atomic Energy Commission (AEC) [*now known as the Department of Energy, or DOE]* ore-buying station at Tuba City, AZ, ninety-two miles away. (C.M. Brundy, 1977, has noted that the Orphan Lode at one time yielded the highest-grade single shipments of uranium oxide ore ever in the United States; an average of 4.09 percent, four times richer than other U.S. sources.) (Source: Grand Canyon Association, et. al. 1997)

1.2 Description and Breakdown of Uranium

Listed below is a brief synopsis on the properties of uranium.

Uranium, (V), element number 92, occurs only in radioactive form. Natural uranium (U-nat) is a mixture of U-238 (~99.3%), U-235 (~0.7%), and U-234 (~0.006%). U-238 is the head of the uranium/radium series and U-235 starts the uranium/actinium series. The isotopes of U-nat have extremely long half-lives: 4.5E+9 years for U-238, 7.1E+8 for U-235, and 2.5E+5 years for U-234.

The progeny elements include two noble gases: radon-222 and radon-219; a third, radon–218, occurs in very low frequency and has no biological significance. These gaseous radionuclides are released in uranium mines and then decay to alpha- and beta–emitting isotopes of polonium, bismuth, thallium, astatine, and lead. The radon and the radon progenys adhere to atmospheric dust particles and constitute a serious inhalation hazard.

Most exposures to uranium and its progenys have occurred during the mining, processing, and fabrication of uranium into fuel elements for nuclear reactors or weapons. During this process, the uranium exists in several different physical states and chemical compounds.

Raw ores contain from 0.1% to 1.0 % uranium, chiefly U_3O_8. During the milling operation, the ore is concentrated, leached, and processed to ammonium diuranate and U_3O_8, a mixture called 'yellowcake'.

Uranium is considered either a chemical or a radiological hazard depending on its isotopic composition and its radiation history. With U-nat, the total quantity of metal absorbed is the determinant regardless of the compounds involved.

In view of extensive industrial experience, it appears that natural uranium is less toxic to man than was expected based on animal experiments. There has been no evidence of chronic chemical toxicity after years of exposure to low levels (Scott et al., 1970). (Source: NCRP Report No. 65)

1.3 Purpose

This reconnaissance effort was performed to identify potential radiological hazards posed to NPS employees, the public, and the environment from the materials that resulted from prior mining activities. It is intended that the information contained in this report be used as a tool to determine potential pathways of exposure and allow NPS personnel to implement good radiological practices.

2.0 METHODOLOGY AND DISCLAIMERS

Upon arrival at the Grand Canyon National Park, the initial step was to attempt to gather all relevant paperwork on the suspect material. Minimal documentation and information could be found; therefore, field measurements were used to gather real-time information (data).

Radiological instrumentation sensitive to alpha, beta, and gamma radiations were used for total direct (instrumentation) and indirect (removable swipe) measurements of radioactivity from suspect materials.

Considering the uranium decay chain, alpha, beta, and gamma emitting radionuclides were the only isotopes of concern. No air sampling was performed, as the likelihood of particulates being generated was considered remote at the time.

A Ludlum Model 2224 was used for alpha direct measurements, (direct beta measurements were not available due to a light leak in the instrument); a Ludlum Model 2929 was employed for alpha and beta indirect measurements. Photon emitting radionuclides were measured using a Ludlum Model 19. All instruments were performance/source checked and certified to be in calibration before being used.

3.0 TECHNICAL DATA GATHERING

3.1 Evaluation

Key park personnel were contacted and related documentation referenced as resources before beginning the field analysis.

4.0 AREAS OF INTEREST

It was initially understood that the material was being stored at one location; the visitor's center. In actuality, the suspect material was in five separate locations. These were the **Museum Collection, Natural History Room**; the **"Old Warehouse"**; the **Interpretation Garage**; the **NPS Administration Visitor Center (Basement)**; and the **NPS Administration Visitor Center (Uranium Mining Display)**.

4.1 Locations

4.1.1 Museum Collection, Natural History Room - (Swipe Series 000) various rock specimens contained in storage shelves, and samples of ore from the Orphan Lode Mine were found. The samples had a known assay of 42% U-nat (see appendices).

4.1.2 Old Warehouse - (Swipe Series 100) various rock specimens. Swipes and direct measurements were performed on rock specimens suspected of containing radioactive material. No obvious radiological concerns were found. (See appendices).

4.1.3 Building #183 (Interpretation Garage) – (Swipe Series 200) drill core samples. Door #4 of the Interpretation Garage has a sample cabinet containing drill core samples from the Orphan Lode Mine. No obvious radiological concerns were found (see appendices).

4.1.4 Visitor Center (Basement) – (Swipe Series 300) the Chemical Storage Locker in the basement contained many specimens of rock samples. Some are suspected of containing naturally occurring radioactive material (NORM). The dose rate survey revealed increased levels of gamma radiation upon entry. (See appendices).

4.1.5 Visitor Center (Uranium Mining Display)– (Swipe Series 500) three pieces of uraninite were on display behind a glass enclave. The potential exists for the buildup of radon-222 and radon-219 gases, because of limited ventilation.

4.2 Table 1 - Summary of Survey Results

On the following page, Table 1 outlines the results of the investigation:

The most active radiation measurements and material with accompanying documentation are noted in the surveys: (Background levels are indicated on the attached survey reports.) The readings are believed to be from isotopes of U-nat and its progeny, which emit alpha, beta, and gamma radiations.

5.0 CONCLUSIONS

5.1 Regulatory Review

5.1.1 State of Arizona

The State of Arizona defers regulation of uranium and uranium by products in their state codes by supplying an exemption for unrefined and unprocessed ore containing source material. This exemption remains in effect provided that the person does not refine, or process the ore, except as authorized in a specific license (Article 3, R12-1302.(B)). The State of Arizona does provide guidance limiting dose to the public; therefore, Arcadia believes the following provisions apply.

5.1.3 Environmental Protection Agency

40 CFR Part 192.12 (b)(1) (UMTRA) states that in any occupied or habitable building…(the) radon decay product concentration [including background] is not to exceed 0.02 Working Levels (WL). In any case, the radon decay product concentration [including background] shall not exceed 0.03 WL; and (2), the level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

40 CFR Part 192 has provisions concerning dose to the public from AEC (now DOE) activities being limited to 25 millirem whole body to any member of the public as a result of exposures to the planned discharge of radioactive materials, radon-220 and its daughters excepted, to the general environment.

5.1.2 Nuclear Regulatory Commission

10 CFR Part 20, Subpart A – "General Provisions", 20.1002 (Scope) applies to "persons licensed by the commission to receive, possess, use, transfer, or dispose of by-products, source, or special nuclear material, or to operate a production or utilization facility under Parts 30 through 36, 39, 40, 60, 61, 70, or 72 of this chapter…" The material controlled by the NPS would have to be evaluated to determine if the licensing quantities described in Appendix C apply. The licensing amount for U-nat is 100 μCi. If the quantities apply, then 10 CFR Part 20, Appendix C to § 20.1001 – 20.2401 "Quantities of Licensed Material Requiring Licensing," Subpart A; and 10 CFR Part 20, where applicable, would need to be followed.

5.1.4 Department of Transportation

49 CFR Part 173.435, (DOT) Table A_1 and A_2 values for radioactive nuclides define the shipping quantity for U (natural) as unlimited.

6.0 RECOMMENDATIONS

6.1 Items Requiring Immediate Attention

Arcadia makes the following statement(s) regarding this subject:

- The dose rates from the identified specimens that exceed the 20 microroentgens per hour background must be alleviated.
- It is recommended that the NPS contact the State of Arizona, Radiation Regulatory Agency, for further guidance addressing this area.

6.2 Observations

Arcadia makes the following observations and statement(s) regarding this subject:

- The State of Arizona codes are for the most part silent; however, since Arizona is an agreement state, the EPA, and NRC regulations can apply.
- If the material will be continually stored in enclosed areas with limited ventilation and accessible to people, radon monitoring must be considered before handling of the specimens.
- If the material is considered beneficial to the NPS, it is recommended that all rock specimens be placed either in impermeable material during storage, or in ventilated specimen containers. They should be removed only when PPE measurements are met (i.e. gloves, perhaps lab coats).
- The NPS should also consider developing a program that prohibits the accidental accumulation of potentially radioactive material, and put a system into place that determines if items are radioactive (a baseline risk assessment).
- It is suggested that all potentially exposed employees receive some form of radiological awareness training.
- Administrative controls should be developed to limit the access of this material to personnel who do not have training on the inherent radiological constituents.
- The material identified in this report could be relocated to a secure area and/or facilities (possibly the museum), secured with industry recognized radiological signs/labeling, tamper indicating seals, and placed inside a lockable enclosure. All radioactive material and RRM transportation requirements must be adhered to during this process.

This report incorporates the general steps and methodology undertaken during this project. Additional sample analysis and data evaluation will be required to provide a full characterization and assessment of the naturally occurring material at the Grand Canyon National Park. In the event sampling is desired, or required, it is recommended that a firm knowledgeable of the radiological aspects of the material be utilized.

7.0 SOURCES OF INFORMATION

The following personnel and resources were contacted or employed for the completion of this project:

- Jay Boisseau, Regional Park Service
- Jeff Cross, NPS Science Center Director
- Sarah White, NPS Chief Environmental Compliance Officer
- John Beshears, NPS Park Engineer
- Don Singer, NPS Park Safety Officer
- Kim Besom, NPS Museum Technician
- Eric D. McKamey, Certified Health Physicist, Arcadia
- David Strand, Environmental Scientist, Arcadia
- Charles J. Bianconi, Certified Health Physicist, Arcadia
- Michalene Rodriguez, Health Physicist, Arcadia
- Technical Measurements Company for instrumentation
- Assorted maps and drawings of the Grand Canyon National Park
- Title 10 CFR Part 20, 30, 40, 50, 51, 70 and 72 (NRC)
- Title 10 CFR , Part 835, Appendix A (DOE)
- Title 40 CFR, Part 192 (EPA – UMTRA Title I)
- USC 42 CFR, Part 88 (U.S. Congress – UMTRCA)
- Title 49 CFR, Parts 173 – 177 (DOT)
- Title 12. Natural Resources, Chapter 1. Radiation Regulatory Agency (Arizona Administrative Code)

8.0 ACRONYM LIST

AEC	U.S. Atomic Energy Commission
AZ	Arizona
CFR	U.S. Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPM	Disintegrations per Minute
EPA	U.S. Environmental Protection Agency
ITR	Independent Technical Review
MAP	Management Action Process
mR	milliroentgen
NCRP	National Council on Radiation Protection and Measurements
NORM	Naturally Occurring Radioactive Material
NPS	U.S. Department of the Interior, National Park Service
NRC	U.S. Nuclear Regulatory Commission
RAP	Remedial Action Plan
RRA	Arizona Radiation Regulatory Agency
RRM	Residual Radioactive Material
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
U-nat	Naturally occurring uranium
U.S.C.	United States Code
WL	Working levels

9.0 LIST OF APPENDICES AND ATTACHMENTS

Appendix A	Contamination Survey Forms
Appendix B	Radiation Survey Forms
Appendix C	Assay Data

10.0 LIST OF REFERENCES

1. 40 CFR Part 192, Subpart D – "Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended."

2. National Council on Radiation Protection and Measurements, "Management of Persons Accidentally Contaminated with Radionuclides," *NCRP Report No. 65.* Washington, D.C.: 1980

3. National Research Council, Health Effects of Exposure to Low Levels of Ionizing Radiation, Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V), National Academy Press, Washington, D.C. 1990.

4. Reg. Guide 8.29; Instruction Concerning Risks from Occupational Exposure."

5. Billingsley, Spamer, Menkes, "Quest for the Pillar of Gold-The Mines & Miners of the Grand Canyon," U.S. Geological Survey and Grand Canyon Association. Grand Canyon, AZ: 1997

APPENDIX

APPENDIX A

CONTAMINATION SURVEY REPORTS

APPENDIX B

RADIATION SURVEY REPORTS

APPENDIX C

ASSAY DATA

Arcadia Consulting, Inc.
Health Physics, Environmental and Training

CONTAMINATION SURVEY FORM

Job: NPS RMC
Job #: 001
Date: 6/21/00
Time: 0900
Survey Type α βγ
Page 1 of 3
Technician: Stewart / Matthews
name

INSTRUMENTS

	(1)	(2)	(3)	(4)
Manufacturer	Ludlum (α)	βγ	Ludlum α	Ludlum βγ
Model	2929		2224	
Serial #	137626/PR 149000		140 3631	
Probe	43-10-1		43-89	
Serial #	PR 141372		PR 148500	
Efficiency	Th-230 35%	Tc-99 21%	Th-230 15.6%	βγ [illegible]
Cal Date	6 16 00		6 15 00	[illegible]
Cal Due Date	12-16-00		12 15 00	[illegible]
Bkgd (cpm)	Ø	80	11	[illegible]

Swipe #	Description	Direct Survey Gross Count Rate (cpm) α	Gross Count Rate (cpm) βγ	Net Count Rate (cpm) α	Net Count Rate (cpm) βγ	Total Activity (dpm/100cm²) α	Total Activity (dpm/100cm²) βγ	Swipe Survey Gross Count Rate (cpm) α	Gross Count Rate (cpm) βγ	Net Count Rate (cpm) α	Net Count Rate (cpm) βγ	Total Activity (dpm/100cm²) α	Total Activity (dpm/100cm²) βγ	< Limits
001	Rack 20081	5091		5080		34,564		88	349	88	269	251	1281	
002	Rack 5017	64		58				108	353	108	273	309	1300	
003	Rack 5016	small size & configuration				371.3		73	265	73	185	223	915	
004	Rack 7527	[illegible]						111	335	111	308	317	1467	
005	NEH 04							3	250	3	170	36	509	
006	NEH 05							0	143	0	63	–	300	
007	NEH 03							6	192	6	112	17	533	
008	NEH 02							3	163	3	83	36	395	
009	NEH 07							0	151	0	71	–	338	
010	NEH 06							2	167	2	87	57	414	
011	NEH 08							1	124	1	44	35	210	
012	NEH 09							2	53	2	–	57	–	

CONTAMINATION SURVEY SKETCH/DRAWING

Job: NPS- RMC Job #: 001 Date: 6/21/00 Time: 0900 Technician: Stewart / Mattheiss Page 1 of 3

Comments/Notes Museum

Swipe 001 - suspect material rads 5mR/hr @ contact Item was discovered by performing a AR Survey of the area.

Swipes 002- 004 taken on Samples of ore from the Aspen mine with a known assay of 42% U-nat. Documentation of the assay is attached to this survey packet.

See photos #1 ⇒ #5 for swipes 001 - 004

#6	NE	11	Cabinet
#7	NE	3	Cabinet
#8	NE	2	open shelves

CONTAMINATION SURVEY CONTINUATION FORM

Job: NPS - RMC Job #: 061 Date: 6/21/01 Time: 1000 Technician: Stewart/Matthews Page 2 of 3

		Direct Survey						Swipe Survey						
Swipe #	Description	Gross Rate	Comm (cpm)	Net Rate	Comm (cpm)	Total (cpm)	Activity (dpm)	Gross Rate	Comm (cpm)	Net Rate	Comm (cpm)	Total (cpm)	Activity (dpm)	Comments
		cpm	By	cpm	By	cpm	By	cpm	By	cpm	By	cpm	By	
013	NE11.05							0	58	–	–	–		
014	NE11.04							1	81	1	1	2.8	4.8	
015	NE11.04							1	84	1	4	2.8	19	
016	NE11.03							2	93	2	13	5.7	62	
017	NE11.03							2	89	2	9	5.7	43	
018	NE11.02							1	85	1	5	2.8	24	
019	NE11.02							3	106	3	26	8.6	124	
020	NE11.01							0	93	–	13	–	62	
021	NE11.01							2	84	2	4	5.7	19	
022	outside of NE3							3	101	3	11	8.6	52	
023	NE3.09							0	86	–	6	–	29	
024	NE3.09							0	96	–	16	–	76	
025	NE3.08							1	71	1	–	2.8	–	
026	NE3.08							2	58	2	–	5.7	–	
027	NE3.17							0	76	–	–	–	–	
028	NE3.07							0	73	–	–	–	–	
029	NE3.06							0	82	–	2	–	9.5	
030	NE3.06							1	83	1	3	2.8	14.3	

CONTAMINATION SURVEY CONTINUATION FORM

Job: NPM-RMC Job #: 001 Date: 6/21/00 Time: 1030 Technician: Stuart/Matthews Page 3 of 3

		Direct Survey						Smear Survey						
Survey #	Description	Gross Rate	Counts (cpm)	Net Rate	Count (cpm)	Total (dpm)	Activity (dpm)	Gross Rate	Count (cpm)	Net Rate	Count (cpm)	Total (dpm)	Activity (dpm)	Limits
		cpm	dpm	cpm	dpm	dpm	dpm	cpm	dpm	cpm	dpm	dpm	dpm	
031	NE3.05							2	76	2	-	5.7	-	
032	NE3.05							0	83	-	3	-	14.3	
033	NE3.04							1	99	1	19	2.8	90	
034	NE3.04							0	97	-	17	-	81	
035	NE3.03							0	63	-	-	-	-	
036	NE3.03							0	76	-	-	-	-	
037	NE3.02							0	70	-	-	-	-	
038	NE3.02							1	85	1	5	2.8	24	
039	NE3.01							0	87	-	7	-	33	
040	NE3.01							2	97	2	17	5.7	81	
041	NE2							4	77	4	-	11.4	-	
042	NE2							2	83	2	3	5.7	14.3	
043	NE2							3	83	3	3	8.6	14.3	
044	NE2							1	88	1	8	2.8	38	
045	NE2							2	74	2	-	5.7	-	
046	NE2							1	69	1	-	2.8	-	

Arcadia Consulting, Inc.
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CONTAMINATION SURVEY FORM

INSTRUMENTS

Job: NPS - RML
Job #: 001
Date: 6/21/00
Time: 3:41
Survey Type α βγ
Page 1 of 2
Technician: Stewart/Matthews
name

	(1)	(2)	(3)	(4)
Manufacturer	Ludlum α	(βγ)		
Model	2929			
Serial #	137626 / 93 43556			
Probe	43-10-1			
Serial #	141342			
Efficiency	Th 230 35%	Tc 99 21%		
Cal Date	6-16-00			
Cal Due Date	12-16-00			
Bkgd (cpm)	0	80		

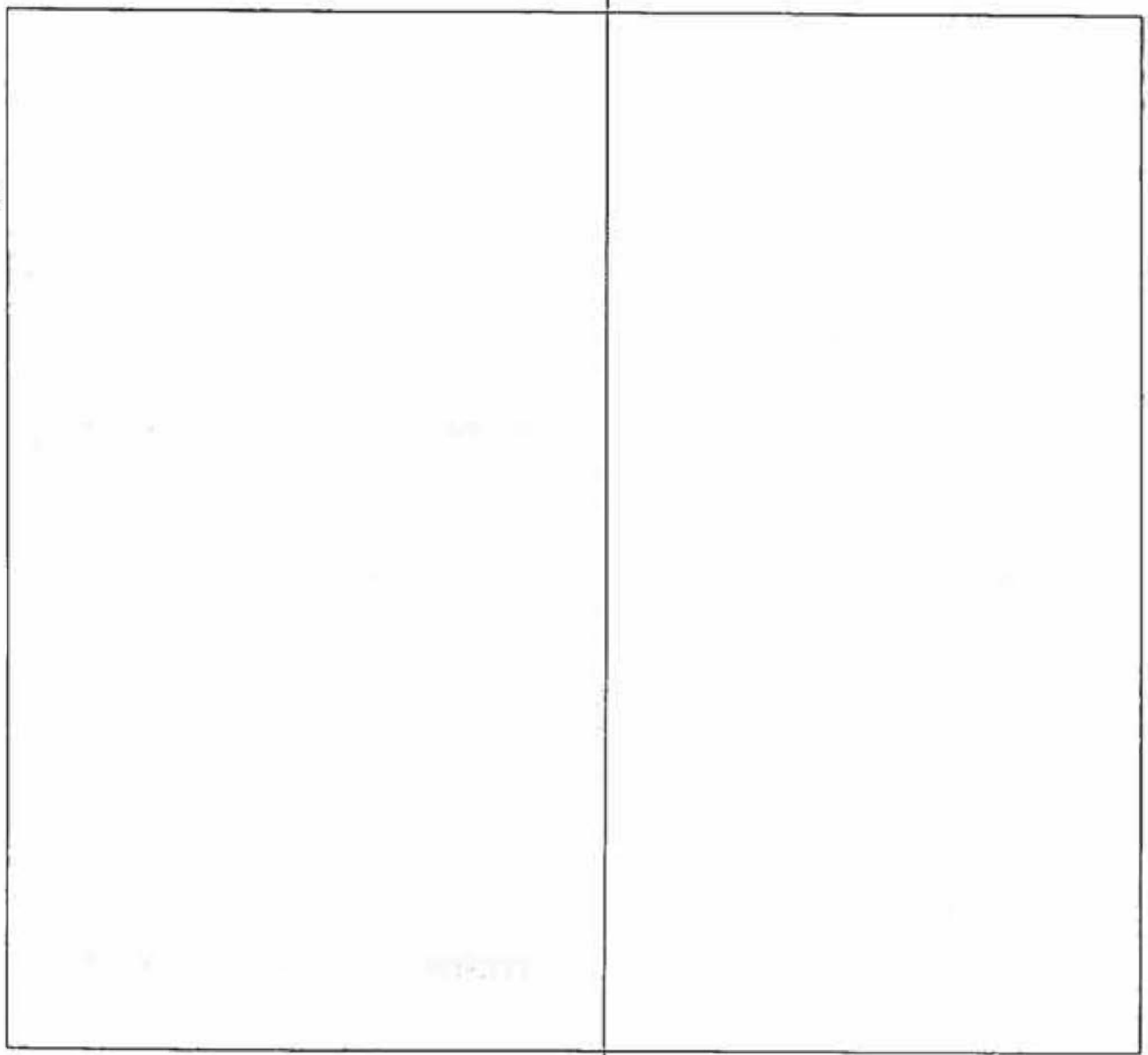
Swipe #	Description	Direct Survey: Gross Count Rate (cpm) α	βγ	Net Count Rate (cpm) α	βγ	Total Activity (dpm/100cm²) α	βγ	Swipe Survey: Gross Count Rate (cpm) α	βγ	Net Count Rate (cpm) α	βγ	Total Activity (dpm/100cm²) α	βγ	< Limits
100	Floor							1	89	1	9	3	43	
101	Wood							0	89	—	9	—	43	
102	Sed. mounting block							1	97	1	17	3	462	
103	Sed. mounting block							0	91	—	11	—	433	
104	Sed. mounting block							2	72	2	—		343	
105	Sed. mounting block							0	81	—	1	—	386	
106	Fossils							0	86	—	6	—	410	
107	cubic rocks							0	71	—	—	—	338	
108	Fossils							0	81	—	1	—	386	
109	Metamorphic rock							1	73	1	—	3	348	
110	# 496							1	76	1	—	3	362	
111	# 496							1	76	1	—	3	362	

CONTAMINATION SURVEY SKETCH/DRAWING

Job: NPS-RMC- Job #: 001 Date: 6/21/20 Time: 3:45 Technician: Strecker/Matthews Page 1 of ____

Comments/Notes Old Warehouse

Swipes taken in old warehouse of rock specimins that were suspected of containing radioactive materials



CONTAMINATION SURVEY CONTINUATION FORM

Job: NPS RMC Job #: 001 Date: 6/21/00 Time: 3:44 Technician: Stewart/Matthews Page 2 of 2

Survey #	Description	Direct Survey Gross Rate (cpm)	Direct Survey Gross Rate (dpm)	Direct Survey Net Rate (cpm)	Direct Survey Net Rate (dpm)	Direct Survey Total (dpm)	Direct Survey Activity (dpm/100cm²)	Swipe Survey Gross Rate (cpm)	Swipe Survey Gross Rate (dpm)	Swipe Survey Net Rate (cpm)	Swipe Survey Net Rate (dpm)	Swipe Survey Total (dpm)	Swipe Survey Activity (dpm/100cm²)	Remarks
		A	B	C	D	E	F	A	B	C	D	E	F	
112	#435							0	81	—	1	—	386	
113	#435							1	85	1	5	3	25	

Arcadia Consulting, Inc.
Health Physics, Environmental and Training

CONTAMINATION SURVEY FORM

INSTRUMENTS

Job: NPS - RML
Job #: 001
Date: 6/21/00
Time: 1230
Survey Type α βγ
Page 1 of 1
Technician:
Stuart/Mathois
name

Manufacturer	(1) Ludlum (α)	(2) Ludlum (βγ)	(3)	(4)	
Model	(1) 2929	(2)	(3)	(4)	
Serial #	(1) 137620/PR141500	(2)	(3)	(4)	
Probe	(1) 43-10-1	(2)	(3)	(4)	
Serial #	(1) PR141392	(2)	(3)	(4)	
Efficiency	(1) α Th-230 35%	(2) βγ Tc-99 21%	(3)	(4)	
Cal Date	(1) 6-16-00	(2)	(3)	(4)	
Cal Due Date	(1) 12-16-00	(2)	(3)	(4)	
Bkgd (cpm)	(1) 0	(2) 80	(3)	(4)	

		Direct Survey						Fixed Survey						
		Gross Count Rate (cpm)		Net Count Rate (cpm)		Fixed Activity (dpm/100cm²)		Gross Count Rate (cpm)		Net Count Rate (cpm)		Fixed Activity (dpm/100cm²)		
Survey #	Description	α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	Comments
200	Core							5	95	5	15	143	71	
201	Core							7	71	7	–	20	~~33~~	
202	Core							3	76	3	–	8.6	–	
203	Core							4	72	4	–	11.4	–	
204	Core							8	91	8	11	22.9	52	
205	Core							6	94	6	14	17.1	67	
206	Outside Cabinet							1	84	1	4	2.8	19	

CONTAMINATION SURVEY SKETCH/DRAWING

Job: NPS- RMC Job #: 001 Date: 6/21/00 Time: 1230 Technician: Stewart/Mattheiss Page 1 of 1

Comments/Notes Interp Garage

Door #4 of the Interp Garage has a Sample cabinet containing Drill core specimins from the Orphan Mine.

No AR readings greater than background were observed

Arcadia Consulting, Inc.
Health Physics, Environmental, and Training

CONTAMINATION SURVEY FORM

INSTRUMENTS

Job: NPS-RMC
Job #: 001
Date: 6/21/00
Time: 1400
Survey Type α βγ
Page 1 of 3
Technician:
Stewart/Matthew
name

Manufacturer	(1)	Ludlum (α)	(2)	(βγ)	(3)	Ludlum (α)	(4)	(βγ)
Model	(1)	2929	(2)		(3)	2224	(4)	
Serial #	(1)	137620/PR148500	(2)		(3)	1403031	(4)	
Probe	(1)	43-10-1	(2)		(3)	43-89	(4)	
Serial #	(1)	PR141392	(2)		(3)	PR 148500	(4)	
Efficiency	(1)	α Tl-230 35%	(2)	βγ Tc-99 21%	(3)	Th-230 15.6%	(4)	βγ - Unsat light
Cal Date	(1)	6-16-00	(2)		(3)	6-15-00	(4)	results of
Cal Due Date	(1)	12-16-00	(2)		(3)	12-15-00	(4)	performance check
Bkgd (cpm)	(1)	0	(2)	80	(3)	11	(4)	N/A

		Direct Survey						Smear Survey						
Sample #	Description	Gross Counts Rate (cpm)		Net Counts Rate (cpm)		Total Activity (dpm) / 100cm²		Gross Counts Rate (cpm)		Net Counts Rate (cpm)		Total Activity (dpm) / 100cm²		Comments
		α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	
300	* 21337	5,000		4,989		31,980		26	140	26	60	74	124	
301	* 21337							99	191	99	111	283	529	
302	Chem locker							10	110	10	30	29	143	
303	* 7358	150		~~150~~ 139		891		0	86	0	6	0	29	
304	* 7358							2	88	2	8	6	38	
305	* 7354	100		89		571		6	84	6	4	17	19	
306	* 7354							3	81	3	1	9	5	
307	* 20.071	12,000		11,989		76,852		43	136	43	56	123	267	
308	* 20.071							141	276	141	196	403	933	
309	* 47363							422	554	422	474	1206	2257	
310	47363							467	576	467	496	1334	2362	
311	* 7434	300		289		1,853		4	83	4	3	11	14	

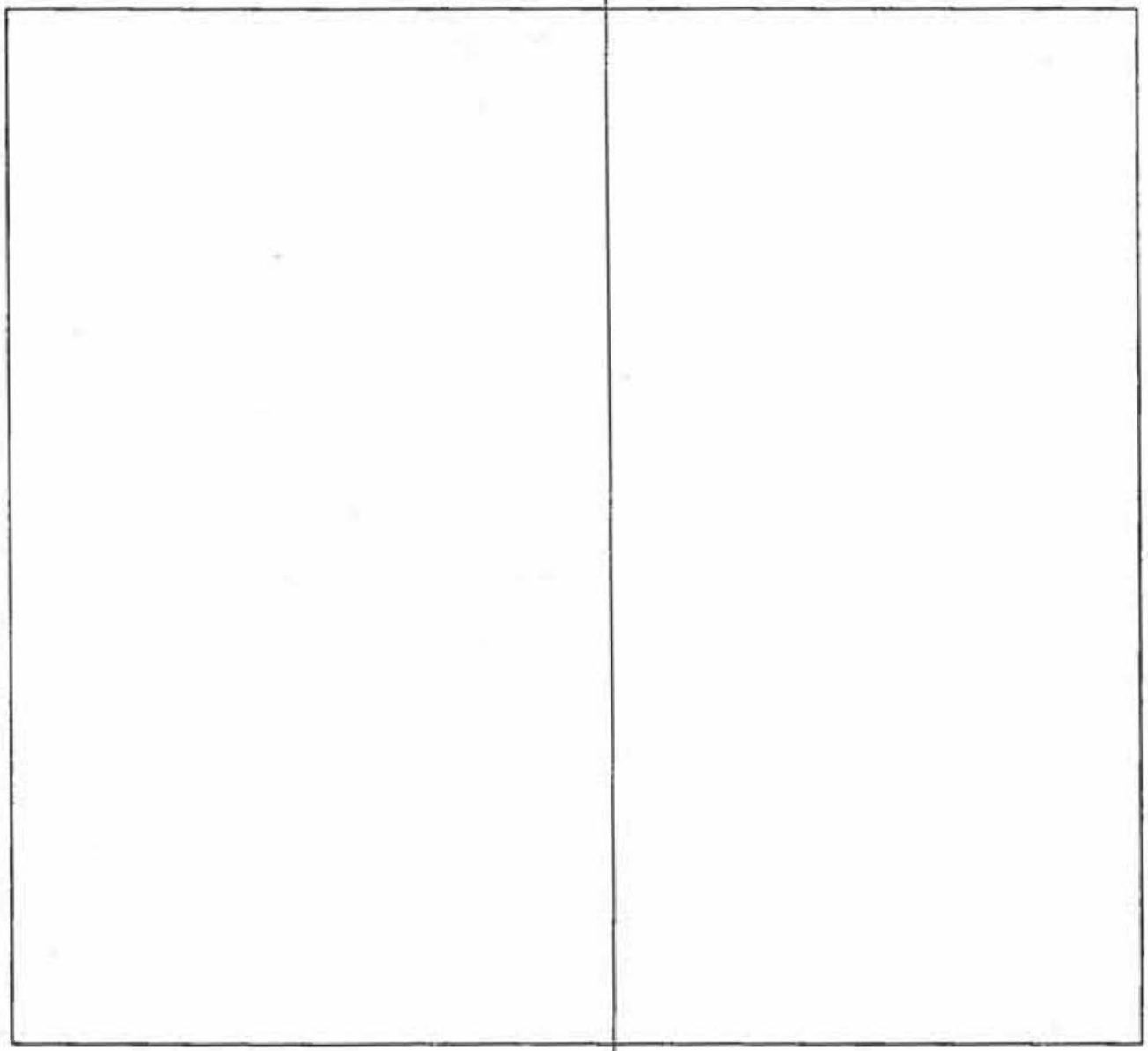
CONTAMINATION SURVEY SKETCH/DRAWING

Job: NPS-RMC Job #: 001 Date: 6/21/00 Time: 1430 Technician: Stewart/Matthews Page 1 of 3

Comments/Notes Visitors Center - Basement

Chemical Storage locker contains many various specimins of Rock Some are suspected of containing naturally occuring radiomtive material.

AR Survey revealed increased levels of γ present. Refer to accompanying Radiation Survey.



CONTAMINATION SURVEY CONTINUATION FORM

Job: NPS- RMC Job #: 001 Date: 6/21/00 Time: 1430 Technician: Stewart/Matthews Page 2 of 3

Swipe #	Description	Direct Survey Gross Rate	Direct Survey Count (cpm)	Direct Survey Net Rate	Swipe Survey Count (cpm)	Swipe Survey Total (dpm)	Swipe Survey Activity (dpm)	Swipe Survey Gross Rate	Swipe Survey Count (cpm)	Swipe Survey Net Rate	Swipe Survey Count (cpm)	Swipe Survey Total (dpm)	Swipe Survey Activity (dpm)	Limits
		A	B	C	D	E	F	G	H	I	J	K	L	
312	7434							10	103	10	23	29	110	
313	7540	8,000		7989		51,212		131	247	131	167	374	795	
314	7538							33	107	33	27	94	129	
315														
316	7539	10,000		9,989		64,032		87	188	87	108	249	514	
317	7539							61	176	61	96	174	457	
318	20235	10,000		9,989		64,032		34	141	34	61	97	290	
319	20235							33	139	33	59	94	281	
320	17508	500,000		499,989		3,205,058		856	1402	856	1322	2448	6295	
321	17508							101	257	101	177	289	843	
322	20.057	1,000		989		6,339		13	113	13	33	37	157	
323	20.057							19	111	19	31	54	148	
324	20.082	15,000		14,989		96,083		13	88	13	8	37	39	
325	20.082							16	102	16	22	46	105	
326	20.083							12	89	12	9	34	43	
327	20.083							11	99	11	19	31	90	
328	Floor near door at locker							12	103	12	23	34	110	
329	Wall of wooden cabinet/locker							5	93	5	13	14	62	

CONTAMINATION SURVEY CONTINUATION FORM

Job: NPS-RML Job #: 001 Date: 6/21/00 Time: 1430 Technician: Stewart/Matthews Page 3 of 3

		Direct Survey						Swipe Survey						
Swipe #	Description	Gross Rate (cpm)	Count (cpm)	Net Rate (cpm)	Count (cpm)	Total (dpm)	Activity (dpm/100cm²)	Gross Rate (cpm)	Count (cpm)	Net Rate (cpm)	Count (cpm)	Total (dpm)	Activity (dpm/100cm²)	Limits
		a	b	c	d	e	f	g	h	i	j	k	l	
330	Wall of Hidden Cabinet/locker							4	78	4	8	11	8	
331	Wall of Wooden cabinet/locker							5	79	5	8	14	8	
332	Floor outside of cabinet							3	61	3	8	9	8	

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CONTAMINATION SURVEY FORM

INSTRUMENTS

Job: NPS-SMC
Job #: 021
Date: 6/22/00
Time: 0725
Survey Type α βγ
Page 1 of 2
Technician:
Stewart/Matthiesen
name

	(1)	(2)	(3)	(4)
Manufacturer	Ludlum (α)	(βγ)	Ludlum (α)	(βγ)
Model	2924		2224	
Serial #	131644/PR 141566		140303	
Probe	43-10-1		43-89	
Serial #	PR 141392		PR 148500	βγ unused due to
Efficiency	Th-230 35%	Tc-99 21%	Th-230 15.6%	high bkgd. -
Cal Date	6-16-00		6-15-00	impact
Cal Due Date	12-16-00		12-15-00	
Bkgd (cpm)	0	85	10	

Swipe #	Description	Direct Survey Gross Count Rate (cpm) α	βγ	Net Count Rate (cpm) α	βγ	Total Activity (dpm/100cm²) α	βγ	Swipe Survey Gross Count Rate (cpm) α	βγ	Net Count Rate (cpm) α	βγ	Total Activity (dpm/100cm²) α	βγ	< Limits
500	sample 17093	1456		1446		9264		19	125	19	40	54	190	
501	17093							18	109	18	24	51	114	
502	17091	3,000		2,990		19,167		15	144	15	59	43	281	
503	17091							3	98	3	13	9	62	
504	17087	1,000		990		6,346		30	127	30	42	86	200	
504-1	17087							21	152	21	47	60	224	
~~504~~ 505	left wall of display case							0	85	—	—	—	—	
~~505~~ 506	Bottom of display case							0	80	—	—	—	—	
~~506~~ 507	back wall of display case							4	83	4	—	11	—	
~~507~~ 508	top of plastic above sample 17087							18	124	18	39	51	136	
~~510~~ 509	plastic light [illegible]							1	76	1	—	2.8	—	
~~509~~ 510	plastic light [illegible]							1	69	1	-	2.8	—	

512

CONTAMINATION SURVEY SKETCH/DRAWING

Job: NPS - RMC Job #: 001 Date: 6/22/10 Time: 0730 Technician: Stewart/Mathias Page 1 of 2

Comments/Notes Visitors Center
Uranium Mining Display
3 pieces of Uranitite/Uranite (?)
on Display behind Glass enclosure.
1R background was 10 1R
on contact w/ case was 10 1R
on contact w/ Samples was
approx 2 x Bkgd.

Direct readings - Swipes were
taken.

Not much ventilation - could
potentially have a Radon
Thoron build-up inside display
case.

CONTAMINATION SURVEY CONTINUATION FORM

Job: NPS-RMC Job #: 001 Date: 6/22/00 Time: 0730 Technician: Stewart/ Matthews Page 2 of 2

		Fixed	Survey					Swipe	Survey			
Swipe #	Description	Gross Rate	Count (cpm)	Net Rate	Count (cpm)	Total (dpm)	Activity (/100cm²)	Gross Rate	Count (cpm)	Net Rate	Count (dpm)	Total Activity (dpm/100cm²)		Comments
		α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	α	βγ	
511	glass seal aluminum frame							1	78	1	–	2.8	–	
512	For RT wall, inside display							0	86	–	1	–	4.8	

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RADIATION SURVEY FORM

Job: NPS-RMC Job #: 001 Date: 6/21/00 Time: 09:13

Survey Type ☑ β ☑ γ ☐ η Page 1 of ____ Name: Stewart / Mattheiss

Purpose/Survey Description: High MR readings on suspect materials

INSTRUMENTS

Manufacturer	(1)	Ludlum	(2)	Ludlum	(3)		
Model	(1)	2224	(2)	19	(3)		
Serial Number	(1)	140303I	(2)	78063	(3)		
Cal Date	(1)	6-15-00	(2)	10-11-99	(3)		
Cal Due Date	(1)	12-15-00	(2)	10-11-00	(3)		
Op Check Sat	(1)	Sat	(2)	Sat	(3)		
Background	(1)	α = 0 cpm	(2)	10 uR/hr.	(3)		

Source check: 500 micro R/hr (Ct.) Cs-137

Source check: 2000 cpm (Ct.) Tc-99 (β)
" " : 3500 cpm (Ct.) Th-230 (α)

SURVEY RESULTS

Location	Type	Dose Rate (η,γ,β)	Units
Rock/Sample # 20,081		5mR contact 0.5mR @ 1m	
Rock/Sample # 8017		1mR contact 0.1mR @ 1m	
Rock/Sample # 8016		2mR contact 0.1mR @ 1m	
Rock/Sample # 7527		4mR contact 0.5mR @ 1m	

SKETCH/DRAWING

See photo's #1 / #5

#2

#3

#4

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RADIATION SURVEY FORM

Job: NPS- RMC Job #: ~~300~~ 001 (6.21.00) Date: 6/21/00 Time: 1625

Survey Type ☐ β ☒ γ ☐ η Page 1 of ____ Name: Matthaiss / Stewart

Purpose/Survey Description: 300 series of surges - Visitors Center Basement Chemical Storage locker.

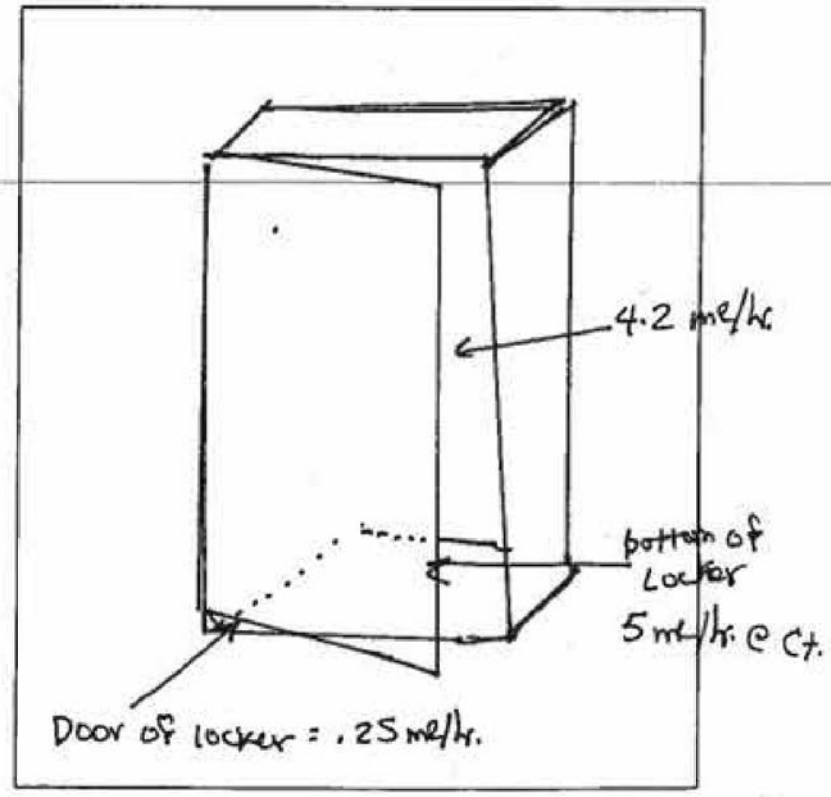
INSTRUMENTS

Manufacturer	(1)	Ludlum	(2)	Ludlum	(3)		
Model	(1)	2224	(2)	19	(3)		
Serial Number	(1)	140303I	(2)	98063	(3)		
Cal Date	(1)	6-15-00	(2)	10-11-99	(3)		
Cal Due Date	(1)	12-15-00	(2)	10-11-00	(3)		
Op Check Sat	(1)	Sat (α)	(2)	Sat	(3)		
Background	(1)	α: 0 cpm	(2)	10 uR/hr.	(3)		

SURVEY RESULTS

Location	Type	Dose Rate (η,γ,β)	Units
Visitors Center (basement)			
# 7540		.49	mR/hr @ ct.
# 7539		N/A	
# 20235		3.2	mR/hr @ ct.
# 17508		4.8	mR/hr @ ct.
# 20057		.2	mR/hr @ ct.
# 20082		4	mR/hr @ ct.
# 7539		.8	mR/hr @ ct.
# 7354		N/A	
# 7434		N/A	
# 7231		N/A	
Petrified wood w/ yellow:			
# 20071		N/A	
# 21088		N/A	
# 7358		.15	mR/hr @ ct.
# 21337		N/A	
# 2083		.75	mR/hr @ ct.

SKETCH/DRAWING



Entry way to basement = 25 - 30 μR/hr.

asbestos

Catalog #: GRCA 32944

Object: ASBESTOS

Location: 98.02

Descrip: 6 PIECES OF ASBESTOS. GREEN IN COLOR AND STRINGY ALONG EXTERIOR. LARGEST PIECE IS L-7.0, W-2.3 CM. COLLECTED FROM HANCE'S ASBESTOS MINE ON 18MAY1977 BY ROBERT & GLORIA EULER.

Catalog #: GRCA 34265

Object: PROBLEMATICAL, ASBESTOS

Location: 99.01

Descrip: TWO PIECES OF WOVEN ASBESTOS. GRAY. LARGER HAS DIMENSIONS OF L 19.0, W 3.0, T 2.0 CM, SMALLER HAS DIMENSIONS OF L 9.0, W 0.8, T 0.6 CM.
CLASSIFICATION CROSS-REFERENCED IN ARCHEOLOGY

RES MGT, CULT; ARCH; VILLAGE, GRCA

Catalog #: GRCA 34362

Object: PROBLEMATICAL

Location: 99.01

Descrip: ASBESTOS MATTING. GRAY. WORN. LARGER HAS DIMENSIONS OF L 18, W 6, T 1 CM, SMALLER HAS DIMENSIONS OF L 6.5, W 2.7, T 1 CM.

CLASSIFICATION CROSS REFERENCE IN ARCHEOLOGY.

Catalog #: GRCA 34407

Object: ASBESTOS

Location: 99.01

Descrip: PIECE OF ASBESTOS. OBLONG. GRAY. WORN AT EDGES, CORNERS.

Catalog #: GRCA 48995

Object: LINOLEUM

Location: HF01.02

Descrip: A SECTION OF THE ORIGINAL LINOLEUM TAKEN FROM RESIDENCE BUILT AND OWNED BY FRED HARVEY, 1929 AT 805 B APACHE ST., GRCA VILLAGE; NOW OWNED BY NPS. SECTION IS GREEN, BEIGE, GREY, BLACK AND BROWN. MOSAIC PATTERN. BADLY CRACKED, CHIPPED. COLLECTED BY RICK SHIREMAN, BUILDINGS FOREMAN, GRCA AZ. NEEDS TO BE ASBESTOS TESTED.

HARVEY; BUILDING, RESIDENCE

Catalog #: GRCA 49899

Total Records: 8

Catalog #: GRCA 5016

Location: 119.26

Sci. Name: METAMORPHOSED MATERIAL

Descrip.: ASBESTOS LOCALITY HORIZON- BASS LIMESTONE PRESENT LOCATION- LAYMAN'S LITHOLOGY EXHIBIT OLD CATALOG # A1-51 GEOLOGY, METAMORPHIC; CANYON, HAKATAI; MCKEE

Catalog #: GRCA 5019

Location: NE07.05

Sci. Name: BASS LIMESTONE __BASS LIMESTONE

Descrip.: MATERIAL FROM ASBESTOS QUARRY

SHOWING SLIKENSIDING HORIZON- BASS LIMESTONE OLD CATALOG # A1-54 GEOLOGY, SED; CANYON, HAKATAI; MCKEE

Catalog #: GRCA 5136

Location: NE11.01

Sci. Name: CHRYSOTILE ASBESTOS

Descrip.: NOTES ON ORIGINAL CATALOG CARD: --OLD CATALOG NUMBER 0-25 --SENT TO N.P.S. LAB., WASHINGTON, D.C. 8/20/56 TAKEN OFF EXHIBIT 1/16/1997 EXHIBIT; MUSEUM, INV; MUSEUM, VC

Catalog #: GRCA 17092

Location: NE11.01

Sci. Name: CHRYSOTILE ASBESTOS

Descrip.: NO OTHER INFORMATION OR PROVENIENCE FROM OLD CATALOG CARD TAKEN OFF EXHIBIT IN VC ON 1/16/1997 EXHIBIT; MUSEUM, INV; MUSEUM, VC

Catalog #: GRCA 17095

Location: NE11.01

Sci. Name: ASBESTOS FIBERS

Descrip.: A NUMBER OF ASBESTOS FIBERS IN A GLASS DISH. NO PROVENIENCE OR OTHER INFORMATION AVAILABLE FROM THE OLD CATALOG CARD. TAKEN OFF EXHIBIT IN VC ON 1/16/1997 EXHIBIT; MUSEUM, INV; MUSEUM, VC

SPECIMEN HAS SOME SEED CASINGS MIXED IN WITH FIBERS

Catalog #: GRCA 8119

Location: NE11.08

Sci. Name: CALCITE __CALCITE

Descrip.: CALCITE CRYSTAL WITH BORNITE, CHALCOPYRITE, MALACHITE, ASBESTOS, HEMATITE, AND SERPENTINE

HORIZON: REDWALL LIMESTONE

Catalog #: GRCA 6749

Location: NE9.01

Sci. Name: SLICKENSIDE __SLICKENSIDE

Descrip.: SLICKENSIDED SURFACE ON MATERIAL FROM ASBESTOS QUARRY
HORIZON: BASS LIMESTONE

ORIGINALLY CATALOGED UNDER STRUCTURE/ FAULTING

Total Records: 7

URANIUM 238 (U238) RADIOACTIVE DECAY

type of radiation	nuclide	half-life
	uranium—238	4.5×10^{9} years
α	thorium—234	24.5 days
β	protactinium—234	1.14 minutes
β	uranium—234	2.33×10^{5} years
α	thorium—230	8.3×10^{4} years
α	radium—226	1590 years
α	radon—222	3.825 days
α	polonium—218	3.05 minutes
α	lead—214	26.8 minutes
β	bismuth—214	19.7 minutes
β	polonium—214	1.5×10^{-4} seconds
α	lead—210	22 years
β	bismuth—210	5 days
β	polonium—210	140 days
α	lead—206	stable

Table 1- Summary of Survey Results

Location	Description	Swipe #s	Dose Rate on Contact [1]	Dose Rate @ 1 Meter [2]	Total Activity – Direct (α) [3] (dpm/100 cm^2)	Total Activity – Removable (α) [4] (dpm/100 cm^2)	(β) [4] (dpm/100 cm^2)
Museum Collection, Natural History Room	Various rock specimens and limestone core contained in storage shelves	***Swipe Series 000***					
	Discovered with a µR/hr survey	Swipe 001 (Rock # 20081)	5 mR/hr	0.5 mR/hr	32,564	251	1,281
	Ore from the Orphan Lode Mine	Swipes 002-004	Surveys taken on samples of ore from the Orphan Lode Mine. The samples had a known assay of 42% U-nat (see appendices).				
Old Warehouse	Various rock specimens	***Swipe Series 100***	Swipes and direct measurements were performed. No radiological measurements showed total or removable contamination of levels of concern.				
Building #183 (Interpretation Garage)	Drill core samples	***Swipe Series 200***	Door #4 of the Interpretation Garage has a sample cabinet containing drill core samples from the Orphan Lode Mine. No radiological measurements showed total or removable contamination of levels of concern.				
NPS Administration Visitor Center (Basement)	Various rock specimens	***Swipe Series 300***	The chemical storage locker in the basement contained many specimens of rock samples. Some are suspected of containing NORM. The dose rate survey indicated increased gamma radiation up entry into this area.				
		Swipe 300 (Rock #21137)			31,980	74	124
		Swipe 307 & 308 (Rock #20.071)			76,852	403	933
		Swipe 309 (Rock #47363)				1,206	2,257

[1] Micro-R Meter – Ludlum Model 19 [2] Ludlum Model 19 (γ and χ-ray) [3] Ludlum Model 2224 [4] Ludlum Model 2929
[5] Swipe Series 400 was not used

Table 1- Summary of Survey Results

Location	Description	Swipe #s	Dose Rate on Contact [1]	Dose Rate @ 1 Meter [2]	Total Activity – Direct (α) [3] (dpm/100 cm^2)	Total Activity – Removable (α) [4] (dpm/100 cm^2)	Total Activity – Removable (β) [4] (dpm/100 cm^2)
Museum Collection, Natural History Room	Various rock specimens and limestone core contained in storage shelves	*Swipe Series 000*					
	Discovered with a µR/hr survey	Swipe 001 (Rock # 20081)	5 mR/hr	0.5 mR/hr	32,564	251	1281
	Ore from the Orphan Lode Mine	Swipes 002-004	Taken on samples of ore from the Orphan Lode Mine. The samples had a known assay of 42% U-nat (see sppendices).				
Old Warehouse	Various rock specimens	*Swipe Series 100*	Swipes and direct measurements were performed. No radiological measurements showed total or removable contamination of levels of concern.				
Building #183 (Interpretation Garage)	Drill core samples	*Swipe Series 200*	Door #4 of the Interpretation Garage has a sample cabinet containing drill core samples from the Orphan Lode Mine. No radiological measurements showed total or removable containing of levels of concern.				
NPS Administration Visitor Center (Basement)	Various rock specimens	*Swipe Series 300*	The chemical storage locker in the basement contained many specimens of rock samples. Some are suspected of containing NORM. The dose rate survey indicated increased gamma radiation up entry into this area.				
		Swipe 300 (Rock #21137)			31,980	74	124
		Swipe 307 & 308 (Rock #20.071)			76,852	403	933
		Swipe 309 (Rock #47363				1206	2257

Table 1- Summary of Survey Results

Location	Description	Swipe #s	Dose Rate on Contact [1]	Dose Rate @ 1 Meter [2]	Total Activity – Direct (α) [3] (dpm/100 cm^2)	Total Activity – Removable (α) [4] (dpm/100 cm^2)	(β) [4] (dpm/100 cm^2)
Museum Collection, Natural History Room	Various rock specimens and limestone core contained in storage shelves	***Swipe Series 000***					
	Discovered with a µR/hr survey	Swipe 001 (Rock # 20081)	5 mR/hr	0.5 mR/hr	32,564	251	1,281
	Ore from the Orphan Lode Mine	Swipes 002-004	Surveys taken on samples of ore from the Orphan Lode Mine. The samples had a known assay of 42% U-nat (see sppendices).				
Old Warehouse	Various rock specimens	***Swipe Series 100***	Swipes and direct measurements were performed. No radiological measurements showed total or removable contamination of levels of concern.				
Building #183 (Interpretation Garage)	Drill core samples	***Swipe Series 200***	Door #4 of the Interpretation Garage has a sample cabinet containing drill core samples from the Orphan Lode Mine. No radiological measurements showed total or removable contamination of levels of concern.				
NPS Administration Visitor Center (Basement)	Various rock specimens	***Swipe Series 300***	The chemical storage locker in the basement contained many specimens of rock samples. Some are suspected of containing NORM. The dose rate survey indicated increased gamma radiation up entry into this area.				
		Swipe 300 (Rock #21137)			31,980	74	124
		Swipe 307 & 308 (Rock #20.071)			76,852	403	933
		Swipe 309 (Rock #47363)				1,206	2,257

[1] Micro-R Meter – Ludlum Model 19 [2] Ludlum Model 19 (γ and χ-ray) [3] Ludlum Model 2224 [4] Ludlum Model 2929
[5] Swipe Series 400 was not used

Location	Description	Swipe #s	Dose Rate on Contact [1]	Dose Rate @ 1 Meter [2]	Total Activity – Direct (α) [3] (dpm/100 cm^2)	Total Activity – Removable (α) [4] (dpm/100 cm^2)	(β) [4] (dpm/100 cm^2)
NPS Administration Visitor Center (Basement) cont.	Various rock specimens cont.	Swipe 313 (Rock #7540)	0.49 mR/hr		51,212	374	795
		Swipe 316 (Rock #7539)	0.8 mR/hr		64,032	249	514
		Swipe 318 (Rock #20235)	3.2 mR/hr		64,032	97	290
		Swipe 320 (Rock #17508)	4.8 mR/hr		3,205,058	244	6,295
		Swipe 322 (Rock #20.057)	0.2 mR/hr		6,339	37	157
		Swipe 324 (Rock #20.082)	4 mR/hr		96,083	37	38
NPS Administration Visitor Center (Uranium Mining Display)	Three pieces of uraninite on display behind glass enclave	***Swipe Series 500*** [5]	The potential exists for the build-up of Radon-222 and Radon-219 gases due to the limited ventilation of this area.				
		Swipe 500 (Rock #17093)			9,264	54	190
		Swipe 502 (Rock #17091)			19,167	43	281
		Swipe 504 (Rock #17087)			6,346	86	200

[1] Micro-R Meter – Ludlum Model 19 [2] Ludlum Model 19 (γ and χ-ray) [3] Ludlum Model 2224 [4] Ludlum Model 2929
[5] Swipe Series 400 was not used