EXPOSURE RATE SURVEY REPORT FOR THE GROUNDS AROUND PICKARD HALL AT THE UNIVERSITY OF MISSOURI IN COLUMBIA, MISSOURI

April 2010

Prepared for:
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1 INTRODUCTION

Chase Environmental Group, Inc. retained Auxier & Associates, Inc. (A&A) to conduct a radiological survey on the grounds around Pickard Hall at the University of Missouri in Columbia, Missouri (referred to as the "Site" in the remainder of this document). The radionuclides of interest at the Site were radium-226, thorium-232, and their respective daughter products. Identification of locations where concentrations of these radionuclides might be elevated above their naturally occurring levels was the primary focus of a surface gamma survey at the Site. A&A conducted this survey March 30 - 31, 2010. This report presents the results of that survey.

1.1 OBJECTIVES

The objective of the survey was to assess radiological conditions at the Site and identify areas of elevated direct radiation, if any, attributed to radium-226 or thorium-232. Specific tasks included:

- Measurement of external radiation levels.
- Identification of external radiation levels that could be greater than levels expected due to natural variations in local background radiation levels.

1.2 SITE DESCRIPTION

Pickard Hall is a two story brick building located on the east side of Francis Quadrangle on the University of Missouri's campus in Columbia, Missouri. A&A performed a GPS walkover survey of approximately 2.5 acres of grounds surrounding and immediately adjacent to Pickard Hall.

1.3 ROLES AND RESPONSIBILITIES

Chase Environmental Group, Inc. selected A&A as the radiological survey contractor for this Site. In this role, A&A performed the gamma surface scans of the Site and prepared this report. Mr. Michael K. Bollenbacher performed the duties of the Site Survey Manager and the Principle Surveyor.

2 SURVEY PROCEDURES

This section will describe the measurement, sampling, analysis techniques, and equipment used in the survey. Calibration certificates and daily instrument QC check sheets for all radiation detection instrumentation that were used by A&A personnel to collect quantitative information at the Site are provided in Appendix A. Qualifications of field personnel are provided in Appendix B.

2.1 SURFACE EXPOSURE RATES

The purpose of this survey was to characterize the distribution of surface exposure rates located throughout the Site. Because the radium-226 and thorium-232 decay chains both contain radionuclides that emit gamma radiation when they decay, gamma radiation detectors can be used to locate soil containing elevated levels of radium-226 and thorium-232.

Gamma surface scans were performed with a hand-held survey meter coupled to a gamma scintillation detector[1]. During these surface scans, the survey meter was operated in the ratemeter mode, allowing it to accumulate the number of gamma counts recorded during one-second intervals. This radiation survey instrument package was linked to a portable Trimble global positioning system (GPS) unit to allow simultaneous recording of the survey meter count rate and the measurement location (latitude and longitude) each second.

The detector was held as close to the surface as practical while the surveyor advanced in as straight a line as was possible at a speed of approximately one-meter per second. The surveyor walked back and forth across the property in the same manner as one might mow a lawn. These transect lines (walking paths) were separated by a distance of one to two meters. Results were recorded electronically as counts per minute (cpm) along with the telemetry information (measurement location) for each radiation measurement.

Following collection of measurement/location readings, the survey data were downloaded into a computer and processed using a combination of industry standard commercial computer applications. Results were reported as counts per minute (cpm) for each measurement location.

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[1] A ratemeter (Ludlum Model 2221) connected to a 2" x 2" NaI(Tl) gamma scintillator (Ludlum Model 44-10 detector).

3 RESULTS

This section of the report presents a summary of the results of the radiological characterization survey of the Site.

3.1 INSTRUMENT RESPONSE DURING DAILY CHECKS

Gamma surface measurements were recorded each day between the sidewalk and the front of the journalism school located to the north of Pickard Hall as part of the instrument response checks. This area was selected because it was some distance away from Pickard Hall. Instrument responses at this location were 10,776 and 10,420 cpm.

3.2 SURFACE GAMMA SCAN RESULTS

Surface gamma radiation measurements were recorded at 13,033 locations on the Site. These measurements were recorded over a variety of surfaces such as concrete, soil, and mulch. Readings with the detector at (or near) the ground surface ranged up to 14,997 cpm. The average (mean) of the recorded readings was 8,400 cpm and the median value was 8,484 cpm. Table 3-1 presents summary statistics for the 13,033 measurements plotted in Figure 3-1.

Table 3-1 Surface Gamma Survey Statistics

Statistic	Value
Number of Readings	13,033
Median Reading	8,484 cpm
Arithmetic Average (Mean) Reading	8,400 cpm
Standard Deviation	1,225 cpm
Maximum Reading	14,997 cpm

The median and arithmetic mean values are very similar, and the relatively small standard deviation implies the variability of the measurements in the data set is small. This suggests the gamma measurements collected around Pickard Hall during this survey are relatively uniform throughout most of the area scanned.

Figure 3-1 is a histogram that was constructed from the walkover scan data. This histogram illustrates that the values in the population of measurements are skewed slightly to the left of the central tendency. This was expected and is attributable to readings collected over concrete sidewalks and parking lots. The knee, or shelf, located on the left side of the peak in Figure 3-1 is consistent with readings noted over concrete surfaces in the vicinity of Pickard Hall.

This walkover scan included a large area of lawn that was more than 20 meters away from Pickard Hall. Recorded measurements in this area are comparable with the median value listed in Table 3-1. The cumulative distribution plotted in Figure 3-2 illustrates that there is little variability around the median value. Because of this stability, the median was selected as the starting point for the bin definitions used during construction of the aerial plot of the data

presented in Figure 3-3. The data plotted on the aerial photo of the property (Figure 3-3) can be used to illustrate the minor variations noted in the surface radiation levels recorded at the Site.

Based on the information gathered during our March 30 - 31 survey of the grounds immediately around Pickard Hall, surface radiation levels are generally within the range of surface readings recorded over soil at a distance from the structure. A few clusters of elevated measurements were noted over soil between Pickard Hall and the sidewalk to the NW of the building. None of these anomalies emitted enough radiation to double the background terrestrial exposure rate.

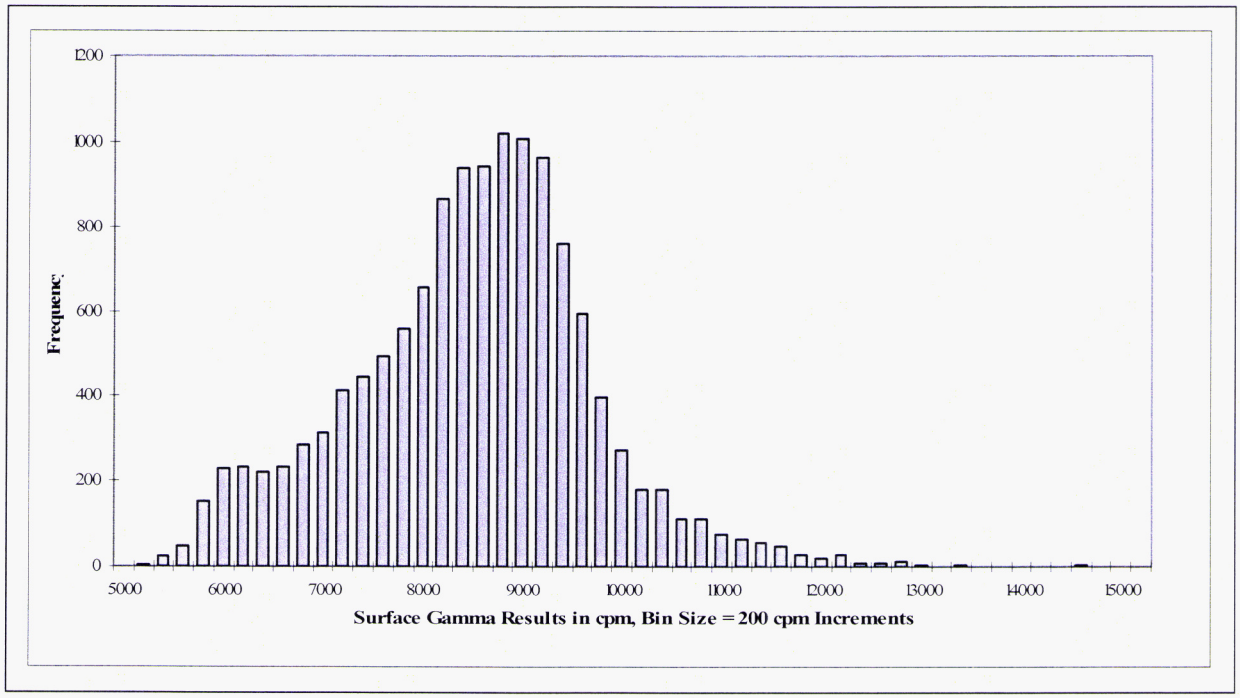

Figure 3-1 Histogram of Surface Gamma Measurements

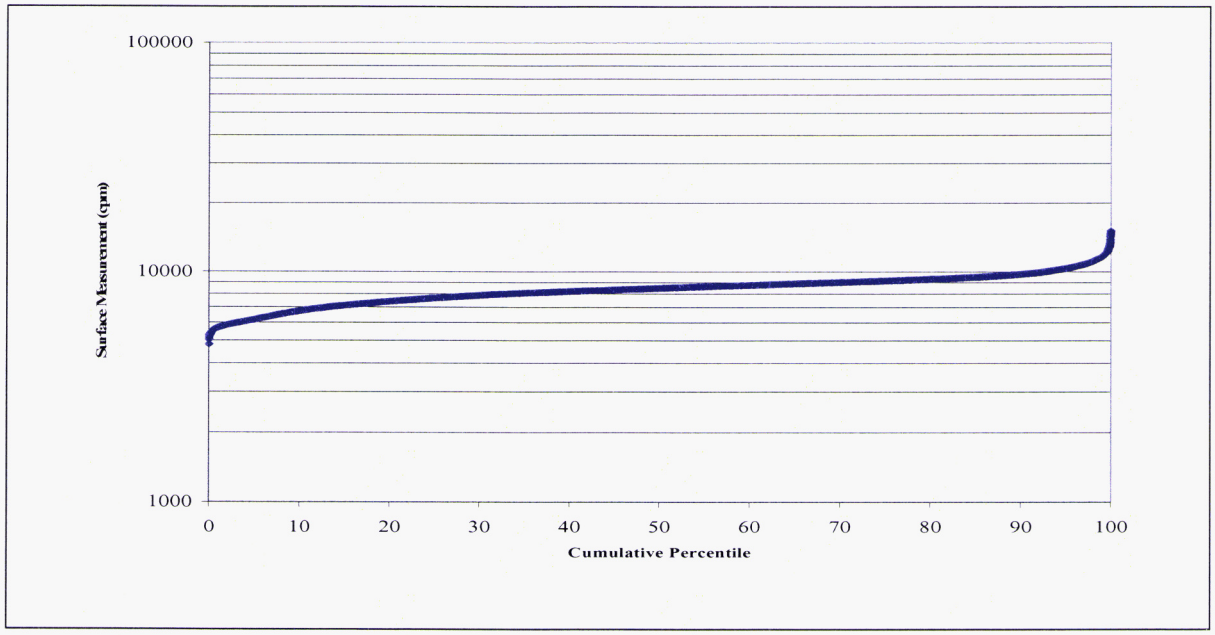

Figure 3-2 Cumulative Distribution Plot of Gamma Measurements

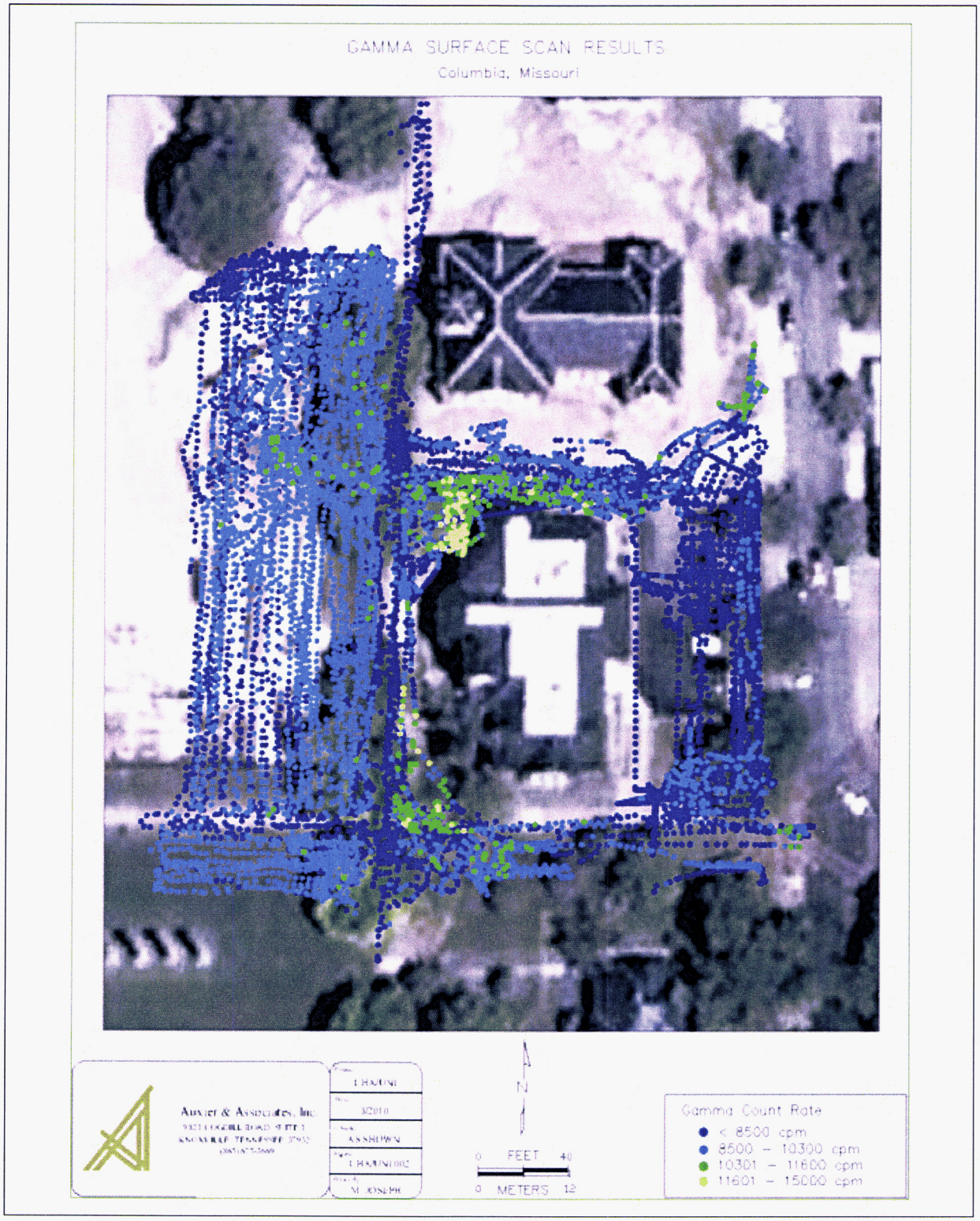

Figure 3-3 Aerial View of Gamma Surface Scan Results

APPENDIX A
INSTRUMENT RECORDS AND FIELD FORMS

INSTRUMENT QUALITY CONTROL CHECK FORM

METER: (READOUT)	MODEL	2221
	S/N	117333
DETECTOR:	MODEL	44-10
	S/N	233859
	UNITS	cpm
	MODE	scaler
	HEADPHONE CHECK	n/a

METER CALIBRATION DUE DATE	12/23/2010
DETECTOR CALIBRATION DUE DATE	5/15/2010
DATE COMBINATION BASELINE RESPONSE ESTABLISHED	3/26/2010

CHECK SOURCES

RADIONUCLIDE	Ra-226
ID	A&A - 101
RADIONUCLIDE	
ID	

Year: 2010 MM/DD & TIME OF CHECK	BATTERY RESPONSE (volts or OK)	HIGH VOLTAGE (volts)	INPUT SENSITIVITY (THRESHOLD)	INSTRUMENT READINGS					SURVEY INITIALS	LOCATION/ COMMENTS
				BASELINE RESPONSE	CHECK SOURCE #1		CHECK SOURCE #2			
					GROSS	NET	GROSS	NET		
3/26/2010 7:29	6.1	1104	350	4344	141722	137378			MKB	A&A Office
3/30/2010 7:29	6.1	1109	350	10776	138529	127753			MKB	Front - Journalism School
3/31/2010 7:46	6.0	1105	350	10420	139966	129546			MKB	Front - Journalism School

Check Source #1: + or - 20% Net Source Response Limits are between 109902 and 164854

g:\marsha\forms\field.frm\instrument QC_2.xls 2/7/97

Data Reviewed By: JE

Date Reviewed: 04/12/10

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2221 SERIAL# 117333

Owner: AUXIER

DATE: 12/23/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 02/18/09

Reason For Calibration: ○ Due For Calibration ● Repair (See Remarks)

○ Other (See Remarks) ○ Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114512 CAL. DUE: 09/05/10

MODEL: SERIAL #: CAL DUE:

✔ Fast/Slow Switch working properly ✔ Audio Response ✔ Geotropism CABLE LENGTH 39"

CONDITION: Sat AF MECHANICAL ZERO: 0 AL MECHANICAL ZERO: 0

NEW BATTERIES: ○ Yes ● No BATT. CHECK >4.8V: 6.2 V

HV (+/-10%)	AS FOUND HV	AS LEFT HV
600 V:	606	A.F.
1200 V:	1192	A.F.
1800 V:	1786	A.F.

AF INPUT SENSITIVITY (mV): 35 AL INPUT SENSITIVITY (mV): A.F.

RATE METER / SCALER

SCALE	RATE CPM	AS FOUND	% ERROR	AS LEFT	% ERROR	AS FOUND	% ERROR	AS LEFT	% ERROR
x.1 or x1	100	100	0.0%	A.F.					
	250	250	0.0%	A.F.		250	0.0%	A.F.	
	400	400	0.0%	A.F.					
x1 or x10	1000	1000	0.0%	A.F.					
	2500	2500	0.0%	A.F.					
	4000	4000	0.0%	A.F.					
x10 or x100	10K	10 K	0.0%	A.F.					
	25K	25 K	0.0%	A.F.					
	40K	40 K	0.0%	A.F.					
x100 or x1000	100K	100 K	0.0%	A.F.					
	250K	250 K	0.0%	A.F.					
	400K	400 K	0.0%	A.F.					

Is the As Found Data Within 20% of the Set Point?: ● Yes ○ No

LOG SCALE

SCALE	RATE CPM	AS FOUND	% ERROR	AS LEFT	% ERROR
Log	200	200	0.0%	A.F.	
	2000	2000	0.0%	A.F.	
	20K	20 K	0.0%	A.F.	
	200K	200 K	0.0%	A.F.	

Is the As Found Data Within 20% of the Set Point?: ● Yes ○ No

GRIFFIN INSTRUMENTS

SERIAL # 117333

12/23/09

Audio Divide:	• Sat	Unsat	Push Buttons:	• Sat	Unsat
Lamp:	• Sat	Unsat	Scaler/Digital:	• Sat	Unsat

Remarks: Replaced broken Scaler/Dig Rate switch and broken Lamp switch. Tightened Vol knob. Replaced meter bezel, glass falling in.

Does Instrument Meet Final Acceptance Criteria?:	• Yes	No
Calibration Sticker Attached?:	• Yes	No
Date Instrument is Due For Next Calibration:	12/23/10	

INSTRUMENT MARRIED WITH #

Performed/Reviewed by: Jeanne Glenn Date: 12/23/2009 Entered by: _____ Initials

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 44-10 PROBE # PR233859

Owner: AUXIER

DATE: 05/15/09
TECH: E.M. Glenn

LOCATION: Griffin Inst
DATE LAST CAL EXPIRES: 05/20/09

- Due For Calibration
Repair (See Remarks)
Other (See Remarks)
Due and Repair

Cable Length: 39"
I.S.: 35mV

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2221 SERIAL #: 183999 CAL. DUE: 06/07/09

SOURCE #: 99-1816 ISOTOPE: Cs137 ACTIVITY: 1.23 uCi ASSAY DATE: 08/12/99

GEOMETRY: Jig upside down with source underneath, activity side up.

Physical Condition: • Sat Unsat

Efficiency From Last Calibration: 5.1% Previous HV Set Point: 1050 V

Counts (CPM)	Background (CPM)	Net CPM:
123680	9140	114540

AF Efficiency: 5.25%

Is the AF efficiency within 20% of the efficiency from the last calibration? • Yes No

Reproducibility: 123680 122830 123010 Average: 123173.33

Are the individual counts within 10% of the average? • Yes No

High Voltage:	Source Response (CPM):	Background (CPM):	Net CPM:
N/A			

HV RESPONSE BACKGROUND NET CPM

V Efficiency:

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: • Yes No

Calibration Sticker Attached?: • Yes No

Date Instrument is Due For Next Calibration: 05/15/10

INSTRUMENT MARRIED WITH #

Performed/Reviewed by: E.M. Glenn Date: 5/15/2009 Entered by: _____ Initials

1

Calibrations performed to ANSI N323A-1997 standards

APPENDIX B
PERSONNEL QUALIFICATIONS

MICHAEL K. BOLLENBACHER, CHP, REA

Professional Qualifications

Mr. Bollenbacher has over 25 years of experience performing a wide range of environmental work with radiological materials and hazardous chemicals on contaminated sites in over 24 states. He has been the principal investigator or task manager for site characterizations, fate and transport modeling, risk assessments, and feasibility studies. As a project engineer and health physicist he has been involved in site remediations, and has actively participated in decontamination and decommissioning of land, buildings and equipment. He has also designed specialized equipment used by the U.S. Environmental Protection Agency (EPA) to measure the permeability of soil to radon gas.

Education

M.S., Environmental Engineering, Clarkson University, Potsdam, New York; 1982.
B.A., Biology, New York State University College at Oswego, New York; 1976.

Registrations/Certifications

Certification by the American Board of Health Physics 1992 through 2012.
OSHA 40-hour Hazardous Waste Operations Training and 8-hour Hazardous Waste Supervisor Training meeting the requirements of 29 CFR 1910.120.
Over 40-hours fire-fighting training.

Experience and Background

2008 - Present ***Vice President, Auxier & Associates, Inc., Knoxville, TN.***
Directs and manages health physics and environmental projects for a variety of clients.

1993 - 2008 ***Senior Scientist, Auxier & Associates, Inc., Knoxville, TN.***
Provides consultant services in health physics and environmental science, with particular emphasis on site characterization and remediation, dose reconstruction, environmental auditing, due-diligence and both long-term and short-term risk assessment. Project management and technical activities include site characterization and remediation, work plan preparation, dosimetry, radiological risk analysis, environmental transport modeling, derivation of cleanup levels, radiological support during planning and field operation phases of site and equipment remediation, interaction with regulatory agencies and the public, and data evaluation, validation, and analysis.

1990 - 1993 ***Health Physicist, IT Corporation, Knoxville, TN.***
Provided health physics, risk assessment, and environmental modeling services to government and private clients. Served as the principal investigator for the CERCLA risk assessment of the eight radioactive waste disposal areas known collectively as Operable Unit One during the Fernald Environmental Management Project. Provided radiological and risk assessment support for remedial investigations and feasibility studies at DOE and DOD facilities. Developed technical approaches used to model contaminant transport and exposures for a variety of projects. Developed health and safety plans for the excavation of a low-level mixed waste underground storage tank at Oak Ridge National Laboratory. Prepared the radiological sampling and analysis plan for a 300 acre soil survey. Provided technical support for negotiations with regulatory agencies. Designed the radon measurement system used by IT labs to determine radon emission rates from laboratory samples.

1985- 1990 ***Environmental Engineer, Rogers, and Associates Engineering Corp., Salt Lake City, UT.*** Provided site characterization, decontamination and decommissioning, fate and transport modeling, dose and risk assessment, and laboratory services to a variety of private, industrial and government clients. Planned and conducted field sampling programs to characterize sites contaminated with hazardous or radioactive materials in nine states and the Gulf of Mexico. Actively participated in remediation of sites and decontamination/decommissioning of structures contaminated with radioactive materials. Established survey protocols, conducted equipment surveys, coordinated survey activities, and supervised dirt-moving operations. Participated in verification of cleanup for a 64,000 sq. ft. manufacturing facility. Characterized radon distribution and migration potential in soils and structures. Performed NESHAPS compliance surveys of radon fluence at a variety of federal and commercial facilities. Designed and built specialty sampling equipment, including radon/soil gas sampling and measurement equipment used by EPA to measure the movement of radon in soil. Established and maintained monitoring programs to track and document internal and external occupational exposures to 23 full time employees during a uranium mill tailings cover project. Performed radiological entrance and exit surveys to verify status of personnel and equipment. Wrote protocols on the shipping and handling of naturally occurring radioactive material (NORM) for a major oil company's domestic operations. Conducted dose and risk assessments for several disposal facilities at humid and arid sites handling mixed waste, low-level radioactive waste, and NORM. Ancillary work included modeling the fate and transport of environmental contaminants at these sites. Established and managed large project databases using FORTRAN, Excel, and dBase III.

1983 - 1985 ***Environmental Engineer, Aerojet Heavy Metals Company, Jonesborough, TN.***
Coordinated environmental monitoring programs and supported the remediation of portions of a manufacturing and milling facility contaminated with uranium and thorium. Upgraded and maintained the site's compliance monitoring network, and expanded the existing environmental program. Set up and managed an on-site radiological soils laboratory. Improved runoff control for a 1.2 acre pond

contaminated with radioactive and chemical wastes. Operated 20,000 gpd industrial wastewater treatment plant during evening shifts. Prepared documentation for shipments of radioactive sludge and soil to a LLW disposal facility. Tracked costs for the final two stages of a three stage, two million dollar remediation project. Developed unique computer applications for analysis of waste, contaminated soils and building materials. Developed "Rapid Air Quality Analysis" computer code to subtract radon interference from air samples used to monitor occupational and environmental airborne levels of uranium. This application cut remedial response time from three days to one day, and reduced program manpower requirements by approximately 25%. Performed equipment decontamination and radiological surveys to verify status of equipment prior to release from the facility.

1980 - 1982 ***Research Assistant, Clarkson University, Potsdam, NY.***
Used ion exchange resins to estimate bio-available phosphorous in river systems. Established and maintained project databases. Developed conceptual models describing the fate of pollutants in river, lake, and estuarine systems. Wrote computer codes to apply these models. Course work emphasized water/waste water processes and aquatic chemistry.

Prior to 1980 ***Various technician level positions.***
Collected fish and small mammals for an Environmental Impact Statement (EIS) on the pesticide DIMILIN prepared by the SURCO Corporation, Oswego, New York. Collected data on near-shore fish populations for two EISs on proposed nuclear power plant complexes for Hazelton Environmental Services, Syracuse, New York. Tested and developed chemical coatings as an R&D technician at Strathmore Products, Syracuse, NY. Served as an open water volunteer instructor for Peace Corps sponsored courses in tropical marine biology at the University of Honduras at Tegucigalpa.

1976 ***Co-Recipient, National Science Foundation, Oswego, NY.***
Performed a baseline population survey of amphibians and reptiles along a 35-mile coastal zone shoreline. Co-authored the first comprehensive wildlife and habitat-based land-use plan ever developed for Oswego County's shoreline. This report was cited during the State's acquisition of 250 acres of highly sensitive wetlands. Co-authored the first student-originated research proposal from a NY State University College Center to be accepted for funding by the National Science Foundation (NSF).

Awards/Activities

IT Technical Associate, 1990 – 1993
Aerojet General's, R. B. Young Technical Innovation Award, 1985
Dean's List, State University College at Oswego, Spring, 73 through Spring, 76, Graduated Cum Laude
Reviewer for Health Physics Journal

Professional Affiliations

American Academy of Health Physics (Director, 2009)
Health Physics Society
East Tennessee Chapter Health Physics Society (Past Treasurer, 2009)
American Chemical Society

Publications

Mr. Bollenbacher has prepared or contributed to hundreds of reports and publications in the fields of health physics and environmental science.