RADIATION CONTROL CONTINGENCY PLAN
FOR THE
ASBESTOS ABATEMENT OF BUILDING 401
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

PREPARED FOR:

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, BUFFALO DISTRICT
BUFFALO, NEW YORK
CONTRACT DACW49-00-D-0007

Prepared by:

Jacobs Engineering Group, Inc. - Federal Operations
13723 Riverport Drive
Maryland Heights, MO 63043

October 2001
Revision 1 – January 2002

ROUTING OF SHOP DRAWINGS, EQUIPMENT DATA, MATERIAL SAMPLES, OR MANUFACTURER'S CERTIFICATES OF COMPLIANCE FOR APPROVAL

(Used to route ENG Form 4025 with items attached. Not to become a part of the Contractor's Record.)

	TO:	FROM:	DATE
1	Stephen Yaksich	Todd Kufel	17-Jan-02

The attached items listed on ENG Form 4025 are forwarded for approval action.

CONTRACT NUMBER	CONTRACTOR
DACW49-00-D-0007	Jacobs Engineering
TRANSMITTAL NUMBERS	**PROJECT TITLE AND LOCATION**
Radiation Control Contingency Plan (Rev. 1)	NFSS Building 401 Asbestos Abatement

COMMENTS (Attach additional sheet, if necessary.)

Revised work plan. All PDT comments have been resolved.

NO. OF INCL.	TYPED NAME AND TITLE	SIGNATURE
6	Todd Kufel, Project Engineer	Todd C Kufel

	TO:	FROM:	DATE
2			

COMMENTS (Attach additional sheet, if necessary.)

NO. OF INCL.	TYPED NAME AND TITLE	SIGNATURE

	TO:	FROM:	DATE
3			

COMMENTS (Attach additional sheet, if necessary.)

NO. OF INCL.	TYPED NAME AND TITLE	SIGNATURE

	TO:	FROM:	DATE
4	Judith Leithner	Stephen Yaksich	1/18/02

The following action codes are given to items listed on ENG Form 4025:

ACTION CODES

A - APPROVED AS SUBMITTED.
B - APPROVED, EXCEPT AS NOTED ON DRAWINGS. RESUBMISSION NOT REQUIRED.
C - APPROVED, EXCEPT AS NOTED ON DRAWINGS. REFER TO ATTACHED SHEET, RESUBMISSION REQUIRED.
D - WILL BE RETURNED BY SEPARATE CORRESPONDENCE.
E - DISAPPROVED (SEE ATTACHED)
F - RECEIPT ACKNOWLEDGE
G - OTHER (specify).

ACTION CODES TO BE INSERTED IN COLUMN G, SECTION I, ENG FORM 4025 (Attach sheets, when required.)

ITEM NO. *(Taken from ENG Form 4025)*	1.9a							
CODE GIVEN	B							

REMARKS

Item No. 1.9a - Approved, except as noted on attached comment sheet. Resubmission not required.

NO. OF INCL.	TYPED NAME AND TITLE	SIGNATURE
1	Stephen Yaksich, Chief, Engineering Division	Yaksich

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☐ APPROVAL RECOMMENDED Date ____ Initials ____

☒ APPROVAL RECOMMENDED SUBJECT TO COMMENTS INDICATED Date 1/18/02 Initials ____

☐ DISAPPROVAL RECOMMENDED Date ____ Initials ____

APPROVED/DISAPPROVED Date ____ Signature ____

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Jacobs Engineering Group, Inc. has completed the Radiation Control Contingency Plan for the asbestos abatement of Building 401, Niagara Falls Storage Site, Lewiston, New York. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy.

David J Pfly — 10-10-01

(Signature) (Date)

Study/Design Team Leader and Team Members

Steven Green, CHP
Steven Green — 10-5-2001

(Signature) (Date)

Independent Technical Review Team Leader and Team Members

Brian Kraus — 10-09-01

(Signature) (Date)

Independent Technical Review Team Leader and Team Members

Virgil W Jansen — 10/5/01

(Signature) (Date)

Independent Technical Review Team Leader and Team Members

CERTIFICATION OF INDEPENDENT TECHNICAL REVIEW

Significant concerns and the explanation of the resolution are as follows (Describe the major technical concerns, possible impact, and resolution):

Section 2 – Address the four requirements found in Section 4.8 of the Scope of Work

Section 7.3.2 – List titles of procedures provided as appendices

Section 7.11.3 – Clarify personnel external dosimetry monitoring requirements

Section 7.12.1 & .2 – Clarify internal dosimetry bioassay monitoring requirements

Consider comments as to section titles, paragraph locations, etc.

All concerns resulting from independent technical review of the project have been considered.

Virgil W Jansen
(Signature)

10/5/01
(Date)

(Engineer of Record)

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Appendices

ABBREVIATIONS AND ACRONYMS

AAAP	Asbestos Assessment and Abatement Plan
AAP	Asbestos Abatement Plan
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos Containing Material
AHERA	Asbestos Hazard Emergency Response Act
ALARA	As-Low-As-Reasonably-Achievable
ALI	Annual Limit On Intake
APR	air-purifying respirator
ASHARA	Asbestos School Hazard Abatement Reauthorization Act
ASTM	American Society for Testing and Materials
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
C&D	construction and demolition
CAA	Clean Air Act
CAPE	Cape Environmental Management Inc
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response Compensation and Liability
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHSP	Corporate Health and Safety Procedure
CIH	Certified Industrial Hygienist
CMS	Corrective Measures Study
COC	Chain of Custody
COPC	Chemical of Potential Concern
COR	Contracting Officer Representative
CRs	Carcinogenic Risk
CRZ	Contamination Reduction Zone
CWA	Clean Water Act
DA	Department of the Army
DAC	Inhalation Derived Air Concentrations
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOP	dioctylphthalate
DOT	U.S. Department of Transportation
dpm	Disintegrations Per Minute
EDC	Economic Development Conveyance Area
EMSL	EMSL Analytical, Inc.
EPA	U.S. Environmental Protection Agency
EZ	Exclusion Zone
F	Fahrenheit
f/cc	Fibers per cubic centimeter of air
FMEA	Failure Mode and Effects Analysis
FSP	Field Sampling Plan
GAC	Granulated Activated Carbon
GERT	General Employee Radiological Training
GFCI	Ground Fault Circuit Interrupter
HAZOP	Hazard and Operability Study
HazWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HHE	Human Health Evaluation

HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HVAC	heating, ventilation, and air conditioning
IDLH	Immediately Dangerous to Life or Health
IHT	Industrial Hygiene Technician
IS	Interim Standards
JE	Jacobs Engineering
JEG	Jacobs Engineering Group
LEL	Lower Explosive Limit
LOOW	Lake Ontario Ordnance Works
LPM	liters per minute
MAP	Model Accreditation Plan
MCE	mixed-cellulose ester
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
MDA	Minimum Detectable Activity
MED	Manhattan Engineering District
MSDS's	Material Safety Data Sheets
MSL	Mean Sea Level
NAM	Negative Air Machine
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NFSS	Niagra Falls Storage Site
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NOB	Non-friable Organically Bound
NPDES	National Pollution Discharge Elimination System
NRC	Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation Program
NYCRR	New York Code of Rules and Regulations
NYSDOL	New York State Department of Labor
ORISE	Oak Ridge Institute for Science and Education
OSHA	Occupational Safety and Health Administration
PACM	Presumed Asbestos Containing Materials
PAPR	Powered Air Purifying Respirator
PBC	Public Benefit Conveyance Area
PCM	Phase Contrast Microscopy
PDU	Personal Decontamination Unit
PEL	Permissible Exposure Limit
PHA	Process Hazard Analysis
PLHCP	Physician or other Licensed Health Care Professional
PLM	Polarized Light Microscopy
PPE	personal protective equipment
PRGs	Preliminary Remediation Goals
PVC	polyvinyl chloride
QAPP	Quality Assurance Plan
QC	quality control
QCR	Quality Control Reports
QLFT	Qualitative Fit Test Requirements
QNFI	Quantitative Fit Test Requirements

RA	Restricted Area
RAD	Radiation
RCA	Radiologically Controlled Areas
RCCP	Radiation Control Contingency Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFP	Request For Proposal
RGOs	Remedial Goal Objectives
RME	Reasonable Maximum Exposure
RW II	Radiological Worker II
RWP	Radiological Work Permit
SAR	Supplied-Air Respirator
SCBA	Self-Contained Breathing Apparatus
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SEV	Screening Ecological Value
SHM	Safety and Health Manager
SHP	Safety and Health Plan
SMCLs	Secondary Maximum Contaminant Levels
SOP	Standard Operating Procedures
SOR	Safety Observation Report
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SSL	Soil Screening Level
STL	Severn Trent Services Laboratories
SVOCs	Semi-volatile Organic Compounds
SWMU	Solid Waste Management Unit
SZ	Support Zone
TAL	Total Analyte List
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TEM	Transmission Electron Microscopy
TLV	Threshold Limit Value
TSI	Thermal System Insulation
TSS	Total Suspended Solids
TWA	Time-Weighted Average
UCL	Upper Confidence Level
UCS	Unconfined Compressive Strength
UEL	Upper Explosive Limit
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Center (formerly USATHAMA)
USATHAMA	United States Army Toxic and Hazardous Materials Agency (now USAEC)
USDA	United States Department of Agriculture
VOCs	Volatile Organic Compounds
WA	Work Area (Asbestos Regulated Area)
WBGT	Wet Bulb Globe Temperature Index
WCS	Waste Containment Structure

1.0 POLICY

This policy requires all employees to fully comply with occupational, public, and environmental radiation protection regulations and requirements established by and within the jurisdiction of Federal, state, and local authorities. This includes, but is not limited to, applicable standards established by the U.S. Nuclear Regulatory Commission (NRC), U.S. Occupational Safety and Health Administration (OSHA), U.S. Environmental Protection Agency (EPA), and individual states and local authorities.

Each Manager, Supervisor, and other Employee involved in activities covered by this program shares in the responsibility for maintaining radiation exposures to individuals and releases of radioactive materials to unrestricted or uncontrolled areas below regulatory limits in accordance with the as-low-as-reasonably-achievable (ALARA) philosophy. For ionizing radiation exposure, the fundamental principle to be applied is that no occupational radiation exposure is to be incurred without the expectation of a commensurate benefit from the activity causing the exposure.

The implementation of this policy shall be ensured by incorporating the applicable elements of the controlling Radiation Control Contingency Plan (RCCP) into site-specific health and safety plans, work plans or radiological control documents, as appropriate.

2.0 PURPOSE AND SCOPE

This comprehensive radiation protection plan addresses elements of radiation control protection planning and conducting work at Niagara Falls Storage Site (NFSS). It contains the health physics procedures to be used in support of project activities. It includes responsibilities for implementation of the RCCP, descriptions of each of the program elements, and measures for monitoring and documenting the implementation of the RCCP.

Radiological decontamination techniques to be employed during Building 401 asbestos abatement work activities include the standard methods provided in Exhibit 3 of Appendix II (Personnel, Equipment, and Vehicle Decontamination). It is expected that decontamination methods will be limited to dust removal (e.g., vacuuming, masslin cloth), water, and detergents. Since no specialty decontamination methods are anticipated, no proof of training is provided for personnel operating such equipment. However should specialty decontamination methods be required (e.g., steam, complexing agents, solvents, acids, caustics), workers will be trained in use of equipment, and hazards and preventative measures for chemical and equipment use.

Environmental air monitoring will be conducted in accordance with the guidance provided in NRC Regulatory Guide 8.25. Environmental air sampling will be employed immediately outside of Building 401 at one downwind location (minimum) and one upwind location during asbestos assessment and abatement to confirm that the airborne radioactive material, if generated, has not migrated outside of Building 401.

Environmental air sampling for airborne radioactivity will be conducted with high-volume air samplers. High-volume air samplers are those with sufficient flow rate to achieve a minimum detectable activity (MDA) of 2 percent of the applicable DAC over a 24-hour period. Air samples shall be collected and analyzed in accordance with Appendix VI, Air Particulate Sampling and Analysis. As with the protocol for personal sampling, high-volume sample results shall be compared with the most conservative DAC (i.e. Class W Th-232), which is found in Appendix B to 10 CFR 20.

3.0 RESPONSIBILITY

3.1 SAFETY AND HEATLH MANAGER

The Safety and Health Manager (SHM) is responsible for overall administration of the environmental health and safety program, including the RCCP. The SHM shall approve all exceptions to the RCCP and ensure that periodic audits are conducted of implementation of the program. Brian Knaus is the SHM.

3.2 SITE SAFETY AND HEALTH OFFICER

The Site Safety and Health Officer (SSHO) is responsible for: the development and implementation of the RCCP; the evaluation of site/employee radiation exposure; and the maintenance of all primary radiation protection records for applicable activities. Dave Fleming is the SSHO.

3.3 PROJECT MANAGER

The Project Manager, SSHO, and supervisors are responsible for ensuring that all employees under their control are knowledgeable of applicable radiological safety requirements for their work area and compliance with these requirements. Project management has a responsibility to emphasize the need for high standards for radiological control through direct communication, support of radiation control goals, and a presence in the workplace. Employees are responsible for being knowledgeable of radiological protection requirements for their work areas and complying with these requirements.

4.0 PROCEDURE

4.1 INTRODUCTION

All activities with the potential for exposure to ionizing radiation or radioactive contamination in excess of normal background levels shall be conducted in accordance with this RCCP.

Activities conducted under the jurisdiction of the NRC, primarily U.S. Department of Defense (DOD) and private sector projects, shall also be conducted in accordance with the NRC license commitments.

Implementation of the above requires that the RCCP be developed prior to the start of field activities, and contains operational limitations and requirements that are commensurate with the scope and extent of the activities to be performed. Program elements are addressed in the following sections of the RCCP.

4.2 ORGANIZATION AND STAFFING

The Project SSHO shall be qualified to administer the RCCP. The Project SSHO shall have a properly trained radiological control support staff.

The SSHO shall have direct access to the Project Manager for radiological protection matters. This individual and members of the radiological control staff shall have stop-work authority to mitigate unwarranted safety hazards to employees and the public, or threats to the environment.

The organization, responsibilities and authorities for administrating radiological protection shall be described in the Safety and Health Plan and in this RCCP.

4.3 OPERATIONAL PROCEDURES

Written radiological operational procedures shall be developed for activities where there is a significant threat to the environment or risk to employees from radiological hazards. These procedures shall be commensurate with the level of hazard and address all the RCCP elements necessary for identifying, evaluating, and controlling radiological hazards, and ensuring compliance with environmental permits and radiological regulations. These procedures are included as appendices to this RCCP.

The procedures shall provide for the collection and maintenance of information providing a legal record of protection of employees, the public, and the environment. Procedures provided as appendices to this RCCP include:

Appendix II: Personnel, Equipment, and Vehicle Decontamination
Appendix III: Contamination Survey
Appendix IV: Calibration and Use of Portable Radiological Survey Instruments

Appendix V: Air Particulate Sampling and Analysis
Appendix VI: Radon and Thoron Daughter Concentration Determination
Appendix VII: Radiological Work Permit (RWP)

Procedures for general area and personal breathing zone air sampling for long-lived gross alpha activity are found in the Sampling and Analysis Plan.

4.4 ADMINISTRATIVE GOALS

Administrative goals for radiological protection performance shall be established that are more conservative than regulatory limits, commensurate with the work plan and level of hazard, and in accordance with the ALARA principle. These goals shall be consistent with the goals specified below and the overall goal of providing maximum protection to Employees, members of the public, and the environment while providing high quality, cost-effective services to the Corps of Engineers.

Achievement of radiological performance goals shall be monitored and periodically reported by the Project SSHO to the Project Manager.

Activities which may result in an annual collective total effective dose equivalent exceeding one person-rem shall establish appropriate performance indicators which shall be tracked as part of a continuous dose reduction process. Such collective doses are not anticipated on this project.

The annual Jacobs radiological goals include (not to exceed):

- Maximum individual total effective dose equivalent - 100 mrem.
- Maximum individual non-penetrating dose equivalent - 500 mrem.
- Maximum embryo/fetus total organ dose equivalent for a declared pregnancy - 100 mrem.
- Maximum total effective dose equivalent to a member of the public, visitor, or minor (excluding radon/thoron) - 10 mrem.
- Number of individuals with measurable external contamination - none.
- Number of individuals with measurable uptakes - none.
- Release of measurable contamination above background to an uncontrolled area - none.

4.5 OCCUPATIONAL EXPOSURE LIMITS

The occupational exposure to employees performing the duties of radiation workers shall be controlled such that the limits in Table 4-1, below, are not exceeded in one year. Minors and members of the public shall be limited so that the limits in Sections 4.8 and 4.9 are not exceeded in a year.

Furthermore, measures shall be taken to maintain doses as far below these limits as reasonable achievable through use of administrative goals, engineering controls and application of the ALARA process. All of the occupational exposure received during the year, including exposures

while employed elsewhere, shall be included in the determination of occupational exposure. Doses due to non-uniform exposures of skin require determination of the area exposed for comparison to the appropriate regulatory authority limit. Radiation exposures from normal background, therapeutic and diagnostic medical radiation, and voluntary participation in medical research programs shall not be included in the determination of occupational exposure.

Table 4-1 Occupational Radiation Exposure Limits

Part of the Body	Annual Dose Equivalent Limit
Stochastic Effects	
Whole body, head, trunk, arm and leg including elbow and knee.	5 rems (0.05 sievert) total effective dose equivalent - sum of deep dose equivalent at 1 cm and the committed effective dose equivalent
Non-Stochastic (Deterministic) Effects	
Arms and legs (includes hands and feet) below knee	50 rems (0.5 sievert) total dose equivalent from shallow and/or deep dose equivalent
Skin of whole body(1)	50 rems (0.5 sievert) shallow dose equivalent at 0.007 cm
Individual organ or tissue	50 rems (0.5 sievert) sum of deep dose equivalent and the committed dose equivalent
Lens of eye	15 rems (0.15 sievert) dose equivalent at 0.3 cm
Embryo/fetus during entire gestation period - declared pregnancy	0.5 rem (0.005 sievert) dose equivalent - sum of deep dose equivalent and dose equivalent from internal radionuclides

(1) Refer to the appropriate regulations for the area over which the exposure is averaged. NRC regulations provide for an occupationally exposed individual to receive higher planned special exposures in addition to and accounted for separately than those in Table 4-1 under special conditions. Such exposures are not anticipated for employees and provisions for these exposures shall not be authorized for inclusion in site-specific health and safety plans or radiation control protection plans without the approval of the Corporate Health and Safety Manager and concurrence by the Jacobs Radiation Safety Officer.

4.6 SUMMATION OF INTERNAL AND EXTERNAL EXPOSURES

Internal committed effective dose equivalents and external effective dose equivalents during the year shall be combined to determine the annual total effective dose equivalent in accordance with the recommendations of the ICRP and NCRP and the requirements of Federal and state regulations. Generally, summation is required when intakes exceed 10 percent of the annual limit on intake (ALI) or may result in a total effective dose equivalent of 50 mrem (0.5 mSv) for minors or visitors and a dose equivalent 50 mrem (0.5 mSv) to the embryo/fetus for declared pregnant women.

The deep dose equivalent to the whole body may be used as the effective dose equivalent for external exposures. Weighting factors for the relative risk to specific tissues from uniform, whole body irradiation which are applied to obtain the effective dose equivalent shall be as specified in Table 4-2.

The quality factors (Q) prescribed by the applicable regulatory jurisdiction shall be used to calculate the dose equivalent in rem from the absorbed dose. In general, the dose equivalent values should be determined using the quality factors listed in Table 4-3.

Table 4-2 Weighting Factors for Tissues

Organ or tissue	Weighting factor
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder(1)	0.30
Whole body	1.00

(1) Weighting factor of 0.06 each for highest dose to five other organs (liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine).

Table 4-3 Quality Factors

Type of radiation	Quality factor
X- & gamma rays, or beta particles	1
High energy protons	10
Alpha particles and unknown or multiple charged particles of undetermined energy	20

Type of radiation	Quality factor
Neutrons	See note (1)

(1) The applicable regulatory requirement should be consulted.

4.7 EMBRYO/FETUS EXPOSURE LIMITS

The occupational dose equivalent limits applicable to the embryo/fetus are the same as the occupational radiation worker limits in Table 4-1, unless the woman elects to declare the pregnancy and limit the dose received by the embryo/fetus as provided in regulatory requirements. In this case, the dose equivalent limit for the embryo/fetus, from the period of conception to birth from occupational exposure, shall be limited to 0.5 rem (0.005 sievert) with a goal of limiting exposures to no more than 0.1 rem (0.001 sievert). Any individual declaring pregnancy will not be penalized in terms of promotion or pay raises.

Efforts shall be made to maintain exposures ALARA and to avoid significant variations above a uniform monthly exposure during the pregnancy. If the dose equivalent has already exceeded 0.5 rem (0.005 sievert) by the time the pregnancy is declared, steps shall be taken to ensure that additional occupational exposure is unlikely.

4.8 MINOR EXPOSURE LIMITS

The annual exposure limits for individuals under the age of 18 shall be limited to 100 mrem (1.0 mSv) total effective dose equivalent as an occupational worker or 10 percent of the occupational limits when occupationally exposed in activities under the jurisdiction of the NRC, an agreement state, or OSHA. No exposure to this population is anticipated.

4.9 MEMBERS OF THE PUBLIC EXPOSURE LIMITS

The annual exposure limit for any member of the public shall be limited to 100 mrem (1.0 mSv) total effective dose equivalent regardless of whether the individual is inside or outside of a controlled area.

Activities conducted under NRC or agreement state jurisdiction shall be controlled such that the dose equivalent in any unrestricted area from external sources does not exceed 2 mrem (0.02 mSv) in any one hour or 50 mrem (0.5 mSv) per year, regardless of occupancy by a member of the public.

4.10 SURVEYS AND MONITORING

Surveys shall include measurements of concentrations or quantities of radioactive material, and other measurements and evaluations necessary to characterize the potential radiological hazards that could be present. Following is a summary of sections 4.10 through 4.14 radiological monitoring requirements:

Monitoring Requirement	Monitoring Frequency	Applicable To/During
External Dosimetry (TLDs)	During access to radioactive material areas	Workers routinely entering radioactive material areas
Personal Air Sampling	• Initial minimum one-in-three workers • Samples analyzed for long-lived gross alpha activity	Workers performing routine field activities in radioactive material areas
Environmental Air Sampling	Minimum one downwind sampler immediately outside Building 401	During asbestos assessment and abatement
Material & Equipment Contamination Monitoring	Monitoring for total and removable alpha and beta contamination using appropriate detectors (e.g., gas proportional, dual phosphor scintillation)	All material & equipment being brought out of radioactive material areas
Personnel Contamination Monitoring	Monitoring skin, personal clothing & items for gross beta activity using appropriate detectors (e.g., Geiger-Mueller, gas proportional)	All personnel exiting radioactive material areas

4.11 EXTERNAL DOSE MONITORING

Personnel who routinely work in radioactive material areas shall be monitored with appropriate individual dosimetry.

External dosimetry monitoring devices required above shall be processed and evaluated by a processor holding a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST).

Personnel will wear appropriate dosimetry while in the field to assess beta, gamma, and X-ray exposure. Prior to initiating work on a project, the work-related radiation exposure history shall be acquired from past employers where radiation monitoring was required.

4.12 INTERNAL DOSE MONITORING

Based on the radiological characterization of Building 401 at the Niagara Falls Storage Site (NFSS), it is not likely for any worker to exceed an internal dose of 100 mrem CEDE. In fact, worker doses should be at or near 0 mrem CEDE. Therefore, it will not be necessary for anyone to participate in a bioassay program.

Internal dose monitoring for the NFSS Building 401 asbestos abatement project will be achieved via personal and/or general work area air monitoring. During initial asbestos abatement activities, a minimum of one-in-three workers who perform routine field activities in the radioactive material areas of the building will be required to wear a personal breathing zone air sampler for airborne radioactivity monitoring. Personal air monitoring will be used initially versus general work area monitoring because of the likelihood of work groups being widely dispersed within the building. In such cases it can be difficult for general work area air monitoring to be representative of the air inhaled by the various work groups. However work area air monitoring may be performed when work groups are confined to a local area within the building. Also, personal air monitoring will be reduced or eliminated should initial air monitoring results during abatement confirm that airborne radioactivity levels are low (i.e. less than 5% DAC).

Air samples will be analyzed daily to determine dose to workers. The resulting data will be compared with the derived air concentration for Class W Th-232 (i.e. the DAC that is the most conservative for the contaminant(s) expected to be present) to gauge employee exposure potential. DACs for radioactive contaminants in Appendix B to 10 CFR 20 shall be used to assess exposure potentials, as appropriate. The SSHO will review all sampling results, and will recommend improvements in work engineering controls as necessary. Workers' personal air samples may also be composited and sent to an off-site laboratory for isotopic analysis, should lower detection limits be needed.

4.13 AMBIENT AIR MONITORING FOR RADIONUCLIDES

Although the likelihood of an environmental release of radioactive material is considered very remote, general area environmental air sampling will be conducted in accordance with the guidance in NRC Regulatory Guide 8.25. Environmental air sampling will be employed immediately outside of Building 401 at one downwind location during asbestos assessment and abatement to confirm that the airborne radioactive material, if generated, has not migrated outside of Building 401.

Environmental air sampling for airborne radioactivity shall be conducted with high-volume air samplers. High-volume air samplers are those with sufficient flow rate to achieve a minimum detectable activity (MDA) of 2 percent of the applicable DAC over a 24-hour period. Air samples shall be analyzed in accordance with the written procedures provided in the Sampling and Analysis Plan and as Appendix V to this RCCP. As with the protocol for personal sampling, high-volume sample results shall be compared with the most conservative DAC (i.e. Class W Th-232), which is found in Appendix B to 10 CFR 20.

4.14 RADIATION DETECTION INSTRUMENTATION

Radiation detection instrumentation shall be provided as appropriate for performing necessary surveys and monitoring. The instrumentation shall be selected based upon the type of radiation detected, minimum detectable activity (MDA) measurement capability and range in accordance with the radiological hazards present or anticipated for the project.

Calibration of radiological instruments and equipment shall be performed by the vendor or a calibration service (may be approved project service) in accordance with ANSI N323 using standards traceable to the NIST primary standards. The calibration certificate shall be maintained as a radiological protection program record. Each instrument or piece of equipment shall have a calibration sticker with an expiration date affixed. Company personnel shall submit instruments for recalibration before the expiration date or take the instrument out of service after the expiration date until a recalibration has been performed.

Performance tests of radiological instruments shall be conducted before use. Satisfactory performance test results shall be no more than +/- 20 percent of the expected response. Instruments that do not meet performance test criteria, are found to be out of calibration, or are defective shall be removed from service until repaired and/or calibrated. The results of these checks will be recorded in a daily source check log by the performer and be maintained as a radiological protection program record. All performance tests will be conducted in accordance with ANSI N323 guidance using the manufacturer's recommendations and approved written procedures.

4.15 ACCESS CONTROL

Appropriate procedures and measures shall be established to control personnel access to radiologically controlled areas (RCA). (RCAs include all posted radioactive material areas.) The procedures shall provide that only appropriately trained, authorized and qualified personnel are permitted access to the controlled areas. The controls shall be established such that rapid egress from the controlled area in an emergency is not prevented. Within Building 401, all radioactive material areas will be posted as such and demarcated. Workers who enter these areas will have current Radiation Worker training, and will be trained in PPE doffing and personnel contamination monitoring requirements. All workers shall monitor themselves for contamination upon exiting radioactive material areas. Health Physics technicians will monitor material and equipment being brought out of radioactive material areas. Further detail on posting and monitoring requirements are found in Section 9.0 of the Safety and Health Plan, and the procedures in Appendices II & III to this RCCP.

Control measures and procedures established shall incorporate a radiological work permit (RWP) system to ensure appropriate planning, control, hazard communication and documentation of work activities in RCAs. Task-specific RWPs shall be used for short-term work in these RCAs with the potential for changing radiological conditions and general RWPs may be used for longer-term activities in these RCAs with known, stable radiological conditions.

4.16 RELEASE OF MATERIALS AND EQUIPMENT

Radiological contamination survey and documentation requirements shall be established and followed for all equipment/property/material released from a RCA. This includes completion of a record of property release that shall be maintained as a radiological record.

All equipment, materials, and property used in an RCA established for contamination control shall be considered as potentially contaminated and shall not be released to an uncontrolled or unrestricted area until it has been surveyed and meets the unconditional release limits listed in Table 4-4. Equipment, materials, and property which exceeds the Table 4-4 unconditional release limits may be decontaminated using the standard methods provided in Exhibit 3 of Appendix II (Personnel, Equipment, and Vehicle Decontamination). It is expected that decontamination methods will be limited to dust removal (e.g., vacuuming, masslin cloth), water, and detergents. Should specialty decontamination methods be required (e.g., steam, complexing agents, solvents, acids, caustics), workers will be trained in use of equipment, and hazards and preventative measures for chemical and equipment use.

Surveys for total (i.e. fixed-plus-removable) and removable alpha and beta/gamma contamination will be conducted with appropriate radiological instrumentation capable of detection of the type and quantity of radioactive contamination listed in Table 4-4.

If the equipment/property/material to be released either cannot be monitored using standard survey techniques or is a volume or bulk material, such as liquids, soils, etc., it will be considered potentially contaminated and a special property/waste release evaluation conducted prior to release. The release limits for these materials shall be established in accordance with specific guidance from the cognizant regulatory authority. All surveys and evaluations for release of potentially contaminated property/material to uncontrolled or unrestricted areas shall be documented and the documentation retained as radiological records.

In addition, appropriate personnel contamination monitoring procedures shall be established to detect and prevent the spread of contamination by individuals exiting radiologically controlled areas.

Table 4-4 Surface Radioactivity Release Limits

Radionuclide	Removable[1]	Total (Fixed + Removable)[1,2]
U-nat, U-235, U-238, and associated decay products	1,000	5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	100
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (i.e., those with other than alpha or spontaneous fission) except Sr-90 or above radionuclides	1,000	5,000
Tritium organic compounds, surfaces contaminated by HT, HTO and metal tritideaerosols	10,000	10,000

(1) Values in dpm/100 cm^2.
(2) May be averaged over 1 m^2 provided the maximum activity in any 100 cm^2 is < 3 times the values in column 2.

4.17 PERSONAL PROTECTIVE EQUIPMENT SELECTION PRACTICES

Refer to the Site Safety and Health Plan for all personal protective equipment (PPE) selection guidelines.

4.18 RESPIRATORY PROTECTION

Refer to the Site Safety and Health Plan for all respiratory protection control measures.

4.19 POSTING AND LABELING

Hazard communication through posting and labeling shall be in accordance with the cognizant regulatory authority requirements. The standard radiation symbol (ANSI N2.1/12.1, Appendix F to EM-385-1-80) in magenta or black on a yellow background (or alternate as provided by regulations) shall be used to warn individuals of the presence of radiation and/or radioactive material. Each access point to a controlled or restricted area shall be posted with the appropriate identification and instructions.

For controlled or restricted areas, each access point to an NRC defined area shall be posted as follows, together with additional radiation control information as appropriate: Any area in which radioactive material is used, handled or stored shall be posted with the radiation symbol and the

words "Caution, Radioactive Material(s)". Each container of radioactive material shall be labeled with the radiation symbol, sufficient information that alerts individuals to take appropriate control measures, and the words "Caution, Radioactive Material". Application of and exceptions to the above posting and labeling requirements shall only be as permitted in the appropriate regulatory authority and site-specific requirements. Any area shall be posted with the radiation symbol and the words "Caution, Airborne Radioactivity Area" if the airborne radioactivity levels exceed one DAC or an individual without respiratory protection could have an intake of 0.6 percent of an ALI or be exposed to 12 DAC-hours in a week.

4.20 RECEIPT AND TRANSPORTATION OF RADIOACTIVE MATERIALS

There will be no receipt or transportation of radioactive material (specific activity >2000 pCi/g).

4.21 RADIOACTIVE MATERIAL STORAGE AND CONTROL

All radioactively contaminated material removed from the building shall be stored in a USACE approved area on-site.

No sources exceeding the exempt concentrations stated in 10 CFR 30 will be brought on site.

4.22 WASTE DISPOSAL

No radioactive waste will be disposed of off-site. All radioactively contaminated material removed from the building shall be stored in a USACE approved area on-site. All waste removed from Building 401 for off-site disposal will meet U.S. NRC Regulatory Guide 1.86 Table I acceptable surface contamination levels for Ra-226 and Th-232, which are: (dpm is disintegrations per minute):

Nuclide	Average[1] (dpm/100 cm^2)	Maximum[2] (dpm/100 cm^2)	Removable (dpm/100 cm^2)
Ra-226	100	300	20
Th-232	1,000	3,000	200

Notes 1: For total contamination. Will not be averaged over more than 1 square meter.
2: For total contamination. Maximum applies to areas not more than 100 cm^2.

4.23 RADIOACTIVITY IN AIR AND LIQUID EFFLUENTS

The release of radioactivity in air or liquid effluents to unrestricted areas shall be monitored and controlled in accordance with the requirements of 10 CFR 20.1302 and 20.2003 as well as state and local regulatory requirements.

For projects at low hazard sites, workplace monitoring and/or conservative modeling can be used to determine compliance with effluent limitations.

Records of radioactive effluent monitoring and/or modeling shall be generated and maintained to demonstrate compliance with effluent limitation requirements.

4.24 REPORTS TO INDIVIDUALS

Information and reports regarding any individuals radiation exposure shall be made available to that individual annually and upon request, in accordance with the provisions of state privacy laws and the Federal Privacy Act (5 USC 552a). Section 4.28 describes the types of radiation exposure records that are required to be maintained and the period of storage.

The types of information reported or available to the individual includes an annual radiation dose report, a report of year-to-date exposure on termination, reports of total exposure during the period worked by an employee, and any report of exposure of an employee to radiation or radioactive material that is required to be submitted to a regulatory authority. The format and content of each of the above reports shall be in accordance with the specific requirements of the cognizant regulatory authority. Request for release of radiation exposure reports to other employers after termination shall be only at written request signed by the former employee.

4.25 TRAINING AND QUALIFICATION

A training program shall be established to provide mandatory training to general employees, radiation workers, and radiological control staff at a project site under this radiological program. Periodic retraining shall be conducted whenever a significant change to the radiation protection program or implementing procedures occurs or at a frequency consistent with applicable regulatory or client requirements. In the absence of a specific retraining frequency requirement, a frequency of two years shall be implemented. All formal training under the program shall verify individual knowledge by an appropriate examination. Documentation of training shall be generated containing the individuals name, date of training, topic(s) covered, pass or fail, and the name of the certifying official. No employee shall be permitted to independently perform tasks inside of a radiologically controlled area until the appropriate training and qualification requirements are met. Specific training and qualification standards shall be as specified in the cognizant regulatory authority requirements or guidance documents and, as a minimum, shall be consistent with the training and qualification criteria in this Section.

The objective and goal of the training program shall be to provide a consistent baseline level of knowledge and practical skills for general employees and radiological workers working in or adjacent to restricted or radiologically controlled areas. Three levels of training are established based on the level of access to controlled or restricted areas and job tasks performed.

The levels and standard core training guidelines are as follows:

- General Employee Radiological Training (GERT) - required for all employees who enter or work adjacent to controlled or restricted areas, but are not authorized for unescorted entry into Radioactive Material or Airborne Radioactivity Areas. Core topics include:

  Definitions
  Sources of Radiation
  Radiological Fundamentals
  Biological Effects
  Radiological Controls
  Monitoring/Dosimetry
  Emergency Procedures
  Responsibilities

- Radiological Worker II (RW II) training - required for all Company Employees designated as radiological workers who are authorized for unescorted access into and hands-on work in Radioactive Material Areas and Airborne Radioactivity Areas. Core topics include:

  Radiological Fundamentals
  Biological Effects
  Radiation Standards
  Personnel Monitoring
  Radiological Posting and Controls
  Contamination Control
  PPE Donning & Doffing (including respirators)
  Emergency Procedures
  Company Radiation Protection Program
  Practical Factors

4.26 EMERGENCY PROCEDURES

Site-specific radiological emergency procedures commensurate with the level of hazard shall be developed or site procedures adopted prior to the initiation of work. The procedures shall address, as appropriate, severe weather actions, transportation accidents or spills, medical emergencies, personnel contamination, and on-site HAZMAT response and notification requirements involving radioactive materials As a minimum, the procedures shall take into account site emergency response procedures and the responsibilities of off-site state, tribal and local emergency response agencies. All site personnel shall be instructed in their emergency responsibilities and the emergency procedures. For this project, the existing site-specific procedures will be adopted.

Nearby hospitals and fire department(s) will be contacted and briefed on what hazards might be expected from radioactive material or toxic substances during an emergency.

Appropriate portions of the emergency response procedures should be routinely drilled/exercised to determine adequacy and timeliness of response. Critiques should be conducted for each drill/exercise. The frequency of these tests will be determined by the SSHO.

4.27 AUDITS

An internal audit of the content and field implementation of this RCCP shall be conducted no less than once during the abatement phase by the SSHO.

Audit findings shall be reported in writing to the appropriate project managers, program managers and the Health and Safety Manager.

Nonconformances and corrective actions shall be tracked by the Health and Safety Manager.

Internal audits and reviews conducted in compliance with NRC regulatory requirements may be accepted as satisfying the requirement of this Section in part or as a whole.

4.28 RECORDS MAINTENANCE

Sufficient radiological protection program records shall be maintained to document compliance with regulatory requirements and the exercise of due diligence in the control of radiological hazards for the protection of Employees, members of the public, and the environment. These records will normally be generated, validated, and maintained in accordance with an approved RCCP pursuant to NRC requirements.

The maintenance of records includes those above as well as copies of all applicable radiological records required to be transferred to the NRC, project files, or Corps of Engineers during and at the conclusion of a project. Periodically, and at the completion of the project, copies of exposure monitoring records shall be sent to the Jacobs Corporate Health and Safety Manager for retention. These records shall be maintained by the Health and Safety Manager, in a manner consistent with applicable Privacy Act requirements, such that the records will be available for retrieval over a period not less than 75 years after the date of creation of the record. All quantities used in the records shall be in special units of curie, rad, or rem, including multiples and subdivisions of these units. Records identified with an individual's name or identifying number shall be available upon request from that individual.

Records to be maintained include the following (as available):

- A dose received by individuals, for whom monitoring was required, during previous employment.
- A dose received by individuals for whom monitoring was required.
- Dose assessments and organ burdens for individuals for whom bioassay was performed.

- Doses to the embryo/fetus of a declared pregnant employee.
- Written declarations of pregnancy.
- Results of surveys for radiation and radioactive material in the workplace and outside of controlled or unrestricted areas as required by regulatory requirements or the RCCP.
- Results of surveys for the release of material or equipment to uncontrolled or unrestricted areas.
- Records of effluents and radioactive waste disposal under Company control.
- Results of calibrations performed on radiological instruments and quality control checks for radiological instrumentation and personal monitoring devices.
- Records of ALARA evaluations and control actions.
- Records of radiological training completed, including general employee radiological training.
- Records of internal reviews and audits with corrective actions closeout.
- Records of regulatory agency inspections and audits with corrective actions closeout.

4.29 EXEMPTIONS AND EXCEPTIONS

The execution of a Delivery Order under the purview of this RCCP is at a construction and environmental investigation/restoration project involving materials containing low levels of radiation and radioactivity. For these activities, many of the elements of the radiological protection program will not be fully applicable or will be applied in alternate equivalent ways in the site-specific SHP. In addition, work will require implementation of nonradiological regulatory standards that must be incorporated with the radiological control elements.

Any exemptions or exceptions from regulatory requirements based on the scope or types of hazards present shall not be unilaterally implemented; and must be processed in accordance with applicable regulatory processes. Failure to do so may subject the project to a stop-work order and/or result in criminal or civil penalties being imposed on the client, Company, or individuals. In addition, all exemptions or exceptions to the RCCP shall be approved by the Health and Safety Manager and concurred in by the Radiation Safety Officer prior to implementation.

5.0 REFERENCES

ANSI Z88.2-1980-1992, Practices for Respiratory Protection.

ICRP Publication 26 (1977), Recommendation of the International Commission on Radiological Protection.

ICRP Publication 30 (1978-79), Limits for Intake of Radionuclides by Workers.

ICRP Publication 60 (1991), 1990 Recommendations of the International Commission on Radiological Protection.

DOT 49 CFR 171-177, Transportation - Hazardous Materials Regulations.

EPA 520/1-88-020 (1988), Federal Guidance Report No.11: Limiting Values of Radionuclide Intake and Air Concentrations, and Dose Conversion Factors for Inhalation, Submersion, and Ingestion.

NCRP Report No. 91 (1987), Recommendations on Limits for Exposure to Ionizing Radiation.

NRC 10 CFR 20 (1991), Standards for Protection Against Radiation.

NRC 10 CFR 30 (1991), Rules of General Applicability to Domestic Licensing of Byproduct Material.

NRC 10 CFR 34 (1991), Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations.

NRC 10 CFR 40 (1991), Domestic Licensing of Source Material.

NRC 10 CFR 70 (1991), Domestic Licensing of Special Nuclear Material.

OSHA 29 CFR 1910.96 (1974), Ionizing Radiation.

OSHA 29 CFR 1926.53 (1974), Ionizing Radiation.

OSHA 29 CFR 1910.134, General Industry Standards - Respiratory Protection.

Appendix I:
Glossary of Radiation Protection Terms

Activity: The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

Airborne Radioactivity: Radioactive material in any chemical or physical form that is present in ambient air, above natural background. Also referred to as airborne radioactive material.

Airborne Radioactivity Area: Area where the measured concentration of airborne radioactivity, above natural background, exceeds one DAC, or an individual without respiratory protection could have an intake of 0.6 percent of an ALI or be exposed to 12 DAC-hours in a week.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in one year. An ALI is the smaller quantity of a given radionuclide which, if inhaled or ingested in 1 year by the reference man (ICRP Publication 23), would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue.

Anti-Cs: Clothing provided to personnel to minimize the potential for skin, personal and company issued clothing contamination. A component of personal protective equipment (PPE). Also referred to as "anticontamination clothing," "protective clothing" and "PCs."

As Low As Reasonably Achievable (ALARA): An approach to radiological control or process to manage and control exposures (individual and collective) to the work force and to the general public at levels as low as is reasonable, taking into account social, technical, economic, practical and public policy considerations.

Background Radiation: Radiation from cosmic sources; naturally occurring radioactive materials which have not been technologically enhanced, including radon (except as a decay product of source or special nuclear material; consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation; and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct or special nuclear materials regulated by the NRC.

Becquerel (Bq): The International System (SI) unit for activity of radioactive material. One becquerel is that quantity of radioactive material in which one atom is transformed per second or undergoes one disintegration per second.

Bioassay: Measurement of radioactive material deposited within or excreted from the body. This process includes whole body and organ counting as well as urine, fecal and other specimen analysis.

Calibration: To adjust or determine either the response of an instrument relative to a standard or the strength of a radiation source relative to a standard.

Containment Device: Barrier such as a glovebag, glovebox or tent for inhibiting the release of radioactive material from a specific location.

Contamination Reduction Zone: A defined area at a hazardous waste site that provides a transition between contaminated and clean zones.

Contamination Survey: Use of wipes, swipes or direct instrument surveys to identify and quantify radioactive material on personnel, on equipment or in areas.

Continuous Air Monitor (CAM): Instrument that continuously samples and measures the levels of airborne radioactive materials on a "real-time" basis and has alarm capabilities at preset levels.

Controlled Area: Generally, any area to which access is controlled in order to protect personnel from exposure to radiation and radioactive materials. More specifically, an area in which the existing or potential radiation and radioactivity levels are above normal background but are less than that designating a Radiological Area or a Restricted Area.

Correction Factor: 100 cm^2/ [active detector probe area (cm^2) x posted detector efficiency (fractional efficiency). Normalizes the instrument reading in cpm to dpm/100 cm^2 taking into account efficiency and active detector area.

Curie: A unit of radioactivity exactly equal to 3.7×10^{10} disintegrations per second.

Declared Pregnant Worker: A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Decontamination: Process of removing radioactive contamination and materials from personnel, equipment or areas.

Deep Dose: The dose equivalent from external radiation determined at a tissue depth of 1 cm.

Derived Air Concentration (DAC): The concentration of a radionuclide in air that, if breathed over the period of a work year, would result in the ALI for that radionuclide being reached. The DAC is obtained by dividing the ALI by the volume of air breathed by an average worker during a working year (2400 m^3)

DAC-Hour: Is the product of the concentration of radioactive material in air (expressed as a fraction of the derived air concentration for each radionuclide) and the time of exposure to that concentration, in hours. The intake of one ALI is equivalent to exposure to 2,000 DAC-hours.

Disintegration Per Minute (dpm): The rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

Dose: A generic term for energy deposited in body tissue due to radiation exposure. Various technical terms, such as dose equivalent, effective dose equivalent, total effective dose equivalent and collective dose are used to evaluate the amount of radiation an exposed worker receives. Some types of radiation, such as neutron and alpha, deposit their energy more densely in affected tissue than gamma radiation and thereby causing more damage to tissue. The term dose equivalent is used to take into account this difference in tissue damage. Therefore one rem from gamma radiation causes damage equivalent to one rem from alpha radiation. However, it takes one-twentieth as much energy from alpha radiation, as compared with gamma radiation, to produce this one rem dose equivalent.

The term collective dose, measured in person-rem, is calculated by summing the dose to each person in the group of interest. For example, if 12 workers each have one rem, then the collective dose is 12 person-rem.

Technical definitions for dose terms necessary for various exposure calculations and recordkeeping purposes include the following:

absorbed dose (D): Energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The units of absorbed dose are the rad and the gray (Gy).

dose equivalent (HT): The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

effective dose equivalent (HE): The sum of the products of the dose equivalent to the organ or tissue (HT) and the weighting factors (WT) applicable to each of the body organs or tissues that are irradiated: $HE = \Sigma (HT * WT)$

committed dose equivalent (HT,50): The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by a person during the 50-year period following the intake.

committed effective dose equivalent (HE,50): The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues: $HE,50 = \Sigma (HT * WT,50)$

total effective dose equivalent (TEDE): The sum of the deep dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

total organ dose equivalent (TODE): The sum of the deep dose equivalent (for external exposures) and the committed dose equivalent to an individual organ or tissue (for internal exposures).

Dose Assessment: Process of determining radiological dose and uncertainty included in the dose estimate through the use of exposure scenarios, bioassay results, monitoring data, source term information and pathway analysis.

Embryo/Fetus: Developing human organism from conception until birth. Same as unborn child.

Engineering Controls: Use of components and systems to reduce airborne radioactivity and the spread of contamination by using piping, containments, ventilation, filtration or shielding.

Exposure: Being exposed to ionizing radiation or to radioactive material.

External Dose: That portion of the dose equivalent received from radiation sources outside of the body. The dose resulting from external exposure.

Extremities: Includes hands and feet, arms below the elbow and legs below the knee.

Eye Dose Equivalent: Applies to the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

Field Measurement Background Count Rate: The background count rate determined in the area where the survey is being performed.

Fixed Contamination: Radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing or washing.

Frisk or Frisking: Process of monitoring personnel for contamination. Frisking can be performed with hand-held survey instruments, automated monitoring devices or by a radiological technician.

Gestation Period: The time from conception to birth, approximately 9 months.

Gray (Gy): SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

High Efficiency Particulate Air (HEPA) Filter: Throwaway extended pleated medium dry-type filter with 1) a rigid casing enclosing the full depth of the pleats, 2) a minimum particle removal efficiency of 99.97 percent for thermally generated monodisperse DOP smoke particles with a diameter of 0.3 micrometer, and 3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

High Radiation Area: An area, accessible to personnel, in which radiation levels could result in a person receiving a dose equivalent in excess of 100 mrem (1.0 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Hot Particle: Fuel fragment, activated corrosion product, or other particles of small size that have a high specific activity as a result of nuclear fission or neutron activation.

Hot Spot: Localized source of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots generally exceed the general area radiation level by more than a factor of five and are greater than 100 mrem (1.0 mSv) per hour on contact.

Internal Dose: That portion of the dose equivalent received from radioactive material taken into the body. The dose from internal exposure.

Lifetime Dose: Total occupational exposure over a worker's lifetime, including external and committed internal dose.

Low-Level Waste: Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, spent nuclear fuel or byproduct material as defined in Section 11e(2) of the Atomic Energy Act, as amended. Test specimens of fissionable material irradiated only for research and development and not for production of power or plutonium may be classified as low-level waste provided the concentration of transuranic activity is less than 100 nCi/g.

Member of the Public: An individual who is not occupationally exposed to radiation or radioactive material.

Minimum Detectable Activity: The least amount of radioactivity that must be present to enable the surveyor to state that the material surface contains above background radioactivity levels to the 95% confidence level.

Minor: An individual less than 18 years of age.

Monitor: Actions intended to detect and quantify radiological conditions.

Mixed Waste: Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act and the Resources Conservation and Recovery Act, respectively.

Nonstochastic Effect: An effect due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists. Also referred to as a deterministic effect.

Nuclear Criticality: A self-sustaining chain reaction, i.e., the state in which the effective neutron multiplication constant of system of fissionable material equals or exceeds unity.

NVLAP: The National Voluntary Laboratory Accreditation Program of the National Institute of Standards and Technology for non-DOE personnel dosimeter processors.

Occupational Dose: The dose received by a person during employment in which the person's assigned duties involves exposure to radiation and to radioactive material. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public. The dose received results from occupational exposure to ionizing radiation (external and internal).

Personnel Dosimetry: Devices designed to be worn by a single person for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), and pocket ionization chambers.

Personnel Monitoring: Systematic and periodic estimate of radiation dose received by personnel during working hours. Also, the monitoring of personnel, their excretions, skin or any part of their clothing to determine the amount of radioactivity present.

Personal Protective Equipment (PPE): Protective clothing and equipment such as anti-Cs, respirators, face shields and safety glasses used to protect workers from excessive exposure to radioactive or hazardous materials.

Planned Special Exposure: Preplanned, infrequent exposure to radiation, separate from and in addition to the annual dose limits.

Posted Detector Background Count Rate: The background count rate listed on the instrument calibration sticker.

Protective Clothing: Clothing provided to personnel to minimize the potential for skin, personal and company issued clothing contamination. Also referred to as "anticontamination clothing," "anti-Cs" and "PCs."

Prenatal Radiation Exposure: The exposure of an embryo/fetus to radiation at any time during the pregnancy.

Primary Dosimeter: A dosimeter worn on the body used to obtain the formal record of whole body radiation dose.

Quality Assurance Record: A completed document that furnishes evidence of the quality of items and/or activities affecting quality.

Quality Factor: The principal modifying factor used to calculate the dose equivalent from the absorbed dose. The absorbed dose is multiplied by the quality factor to obtain the dose equivalent.

RAD: Unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or O.01 joules per kilogram (0.01 gray).

Radiation: Ionizing radiation includes alpha particles, beta particles, X-rays, gamma rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation as used in this Section does not include non-ionizing radiation.

Radiation Area: An area, accessible to personnel, in which radiation levels could result in a person receiving a dose equivalent in excess of 5 mrem (0.05 mSv) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

Radiation Protection Program: A documented methodology for compliance with regulatory requirements for radiation protection.

Radioactive Material: Radioactive material includes any material, equipment or system component determined to be contaminated or suspected of being contaminated with nuclides undergoing radioactive decay. Radioactive material also includes activated material, sealed and unsealed sources, and material that emits radiation. For compliance with Department of Transportation regulations, material with a specific activity greater than 0.002 microcuries per gram.

Radioactive Material Area: A defined controlled area or structure where radioactive material is used, handled or stored.

Radioactive Waste: Solid, liquid or gaseous material that contains radionuclides regulated under the Atomic Energy Act, as amended, and is of negligible economic value considering the cost of recovery.

Radioactivity: A natural and spontaneous process by which the unstable atoms of an element emit or radiate excess energy from their nuclei and, thus, change (or decay) to atoms of a different element or to a lower energy state of the same element.

Radiography: Examination of the structure of materials by nondestructive methods, using a radioactive source or a radiation generating device.

Radiological Posting: Sign or label that indicates the presence or potential presence of radiation or radioactive materials.

Radiological Work: Any work that requires the handling of radioactive material or which requires access to Radiation Areas, High Radiation Areas, Contamination Areas, High Contamination Areas or Airborne Radioactivity Areas. Also termed "radiation work."

Radiological Work Permit (RWP): Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The Radiological Work Permit serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

Radiological Worker: Worker whose job assignment requires work on, with, or in the proximity of radiation producing machines or radioactive materials. A radiological worker has the potential of being exposed to more than 100 mrem (1.0 mSv) per year, which is the sum of the dose equivalent from external irradiation and the committed effective dose equivalent from internal irradiation. A "radiological worker" may also be referred to as a "radiation worker" or a "radworker."

Release to Uncontrolled Areas: Release of material from administrative control after confirming that the residual radioactive material meets the requirements and guidelines of NRC regulations for unrestricted areas.

REM: Unit of dose equivalent. Dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, distribution factor and any other necessary modifying factor (1 rem = 0.01 sievert).

Removable Contamination: Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing or washing.

Respiratory Protective Equipment: Equipment tested and certified by NIOSH/MSHA used to protect personnel from inhalation of radioactive or hazardous materials. A component of personal protective equipment (PPE).

Restricted Area: A NRC defined controlled area, access to which is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive material. Also generally referred to as a radiologically controlled area.

Shallow Dose Equivalent: The external exposure of the skin or an extremity. It is taken as the dose equivalent at a tissue depth of 0.007 centimeter. The area to be averaged is specified in DOE and NRC regulations.

Sievert (Sv): SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in the SI unit of grays multiplied by the quality factor (1 Sv = 100 rems)

Source, Sealed: Radioactive material that is contained in a sealed capsule, sealed between layers of nonradioactive material or firmly fixed to a nonradioactive surface by electroplating or other means. The confining barrier prevents dispersion of the radioactive material under normal and most accidental conditions related to use of the source.

Step-Off Pad: Transition area between contaminated and non-contaminated areas that is used to allow exit of personnel and removal of equipment.

Standard Radiation Symbol: The three-bladed (tri-foil) symbols designed and proportioned as illustrated in accordance with ANSI N2.l for radiation symbols and ANSI N12.1 for fissile material.

Standardized Correction Factor: 100 cm^2/ [active detector probe area (cm^2) x standardized detector efficiency (fractional efficiency).] This normalizes the instrument reading in cpm for a specific model of detector (e.g., 44-9, 44-40, A-50, 43-10, 43-90, 43-10) to dpm/100 cm^2 taking into account efficiency and active detector area.

Standardized Detector Efficiency: The standard efficiency used to calculate the standardized correction factor for a specific model of detector (e.g., 44-9, 43-68, 43-89).

Stochastic Effect: Malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

Survey: An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other source of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities or radioactive material present.

Transuranic Waste: Without regard to source or form, waste that is contaminated with alpha-emitting transuranic (Z larger than 92) radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

Thermoluminescent Dosimeter (TLD): Radiation detection and measuring device used to record the radiological exposure of personnel or areas to certain types of radiation.

Total Effective Dose Equivalent (TEDE): The sum of effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. The deep dose equivalent for external exposures may be used as the effective dose equivalent for external exposures.

Total Radioactive Contamination: The sum of the fixed and removable radioactive material present on a surface.

Unrestricted Area: An area designated by the NRC as being an area to which access is neither limited nor controlled by a NRC licensee.

Visitor: Person permitted access to Controlled Areas, who has not been trained to the level required to permit unescorted access.

Weighting Factor: Factor that represents the proportion of the total stochastic (cancer plus genetic) risk resulting from irradiation to tissue to the total risk when the whole body is irradiated uniformly.

Whole Body: For external exposure, the head, trunk (including male gonads), arms above and including the elbows, or legs above and including the knees.

Whole Body Dose: The sum of the annual deep dose equivalent for external exposures and the committed effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. Also more properly referred to as total effective dose equivalent.

Appendix II:
Personnel, Equipment, and Vehicle Decontamination Procedure

1. PURPOSE

To provide requirements for the decontamination of personnel or equipment and provide a quality record form for documenting personnel contamination incidents, and charts of additional personnel and equipment decontamination methods.

2. SCOPE

This applies to all staff who respond to the detection of personnel contamination events, and who detect contamination on equipment within controlled or uncontrolled areas. This procedure shall be followed whenever a personnel contamination incident is required to be documented.

3. EQUIPMENT AND MATERIALS

- Portable personnel monitoring instrumentation (e.g., alpha detector and/or GM detector)
- Wet wipes, and/or soap and water
- Paper or cloth towels (e.g, masslin)
- Plastic gloves
- Duct tape
- Anti-static agent
- Personnel Contamination Event Report Form
- Suspect Personnel Contamination Event Log
- Contamination Survey Report
- Soft brush, hair dryer, and vacuum cleaner
- Plastic gloves and bags
- Alternative clothing for persons with clothing contamination
- Detergents and/or solvents approved in the Waste Management Plan.
- High-pressure washer or other pressurized water supply

4. PROCEDURE

Personnel

1. Individuals shall monitor for alpha and/or beta-gamma contamination. Contamination is suspected if the individual detects more than twice the background count rate on skin or personal clothing.

2. When contamination is discovered or suspected, the affected worker should perform the following:

    - Note the suspected area of contamination.
    - Whenever possible, remain in the immediate area.
    - Notify a health physics technician.

3. When responding to a suspected contamination event, an health physics technician shall document the event on the "Suspect Personnel Contamination Event Log."

4. The suspect contaminated area(s) shall be surveyed with appropriate hand-held instrumentation in order to confirm and quantify the contamination levels.

    NOTE: *For suspected* β/γ *contamination, a GM probe shall be used for confirmation/quantification measurements. For suspected* α *contamination, an alpha-sensitive probe shall be used for confirmation/quantification measurements.*

5. For all suspect personnel contamination events, the guidance provided on Exhibit 1, "Personnel Contamination Event Flowchart" shall be followed.

6. All items (except radiological protective clothing) found to be contaminated in excess of Exhibit 1, Table 1 values should be confiscated by the health physics technician until radon plate-out is confirmed or long-lived contamination is properly documented and decontaminated. Hard hats may be wiped clean and the wipe kept for radon plate-out confirmation.

7. Radon plate-out may be confirmed if the initial observed activity (i.e., cpm) decreases to less than Exhibit 1, Table 1 values following an appropriate decay period. Radon plate-out should decay at an effective half-life of ½ hour. Thoron plate-out should decay at an effective half-life of 10 hours.

8. If long-lived contamination greater than Exhibit 1, Table 1 values is confirmed or suspected, then the Supervisor shall be notified and the "Personnel Contamination Event Report Form" shall be completed as follows:

    - Indicate whether levels represent α or β/γ contamination.

    - Estimate and document the area of contamination in cm^2.

    - Find the maximum contamination level in cpm and record results in the

appropriate columns for the type of contamination being monitored (i.e., α or β/γ).

- For probes with less than 100 cm^2 , measure and record contamination levels (cpm) in a contiguous cm^2 area, which includes the maximum contamination level.

- Calculate the average dpm/100 cm^2 as follows:

  1) Add each of the "net cpm" measurements;
  2) Divide value by total number of measurements added;
  3) Multiply average cpm by the instrument's standardized correction factor.

- Record the calculated dpm/100 cm^2 result on and the "Personnel Contamination Event Report Form".

9. If decontamination is required, the appropriate mildest methods should be attempted first, progressing to more harsh methods when necessary. Each method may be repeated once before moving to the next method. Methods in general order of increasing harshness are as follows:

SURFACE	METHOD
Skin	Soap and water, or wet wipes
Skin	Lava soap (soft brush optional)
Hair	Shampoo wash, cutting
Eyes, ears, nose, mouth, wounds	Flushing (requires site nurse notification)
Clothing	Duct tape, anti-static agents
Clothing	Vacuuming
Clothing	Washing

Additional personnel decontamination methods are provided in Exhibits 2 of this procedure.

10. Decontamination should continue until the handheld instrument monitoring results are below the values given in Table 4-4 of the RCCP. The Supervisor (or designee) shall be immediately notified when decontamination efforts are not proving successful; in such

cases the final monitoring results shall be recorded on the "Personnel Contamination Event Report Form", and the Supervisor (or designee) will allow the individual to exit the site.

Equipment

1. For equipment to be released for unrestricted use, decontamination is required if removable alpha contamination exceeds 20 dpm/100 cm^2, or if total contamination exceeds the surface radioactivity values published in NRC Reg. Guide 1.86. If contamination is due to radon plateout, the equipment may be held in the controlled area rather than performing decontamination to allow for radioactive decay to within release limits.

2. When decontamination is required, the following steps shall be taken:

STEP	ACTION
1	The equipment shall remain within the controlled area, and the Supervisor (or designee) shall be promptly notified.
2	Record the initial monitoring results on the Radiological Survey Report Form.
3	Use appropriate decontamination methods (e.g. masslin, water, detergent)
4	Record final monitoring results on on the Radiological Survey Report Form. Equipment may be released for unrestricted use if monitoring results are below the surface radioactivity values in Table 4-4 of the RCCP. Remove any radiological labels prior to release.
5	If the final monitoring results exceed the surface radioactivity values published in Table 4-4 of the RCCP, confiscate the item or those portions of the item that cannot be cleaned below those levels.

When removing contaminated equipment from restricted areas, appropriate methods shall be implemented as necessary to prevent the spread of contamination (e.g., bag or wrap) to unrestricted areas. The equipment shall then be decontaminated prior to use in an uncontrolled area or released for unrestricted use.

The following steps shall be taken whenever contamination has been spread from radiological to uncontrolled areas such that a personnel contamination incident could result:

- Notify the Supervisor (or designee).

- Notify, as necessary, the site Occurrence Reporting Coordinator, project managers, and deputy directors.

- Record the monitoring results on Radiological Survey Report Form.

- Decontaminate the area until monitoring results demonstrate it is below the surface radioactivity values given Table 4-4 of the RCCP. The Supervisor (or designee) may designate the area as a contamination area if this can not be achieved.

Decontamination methods are provided in Exhibits 2 and 3 of this procedure.

1. RECORDS

1.1. Quality Assurance Records

Permanent quality assurance records generated by this procedure are:

- Contamination Incident Report Form.

2. EXHIBITS

Exhibit 1 Contamination Incident Report Form
Exhibit 2 Personnel Decontamination Methods
Exhibit 3 Equipment, Area, and Material Decontamination Methods

EXHIBIT 1
CONTAMINATION INCIDENT REPORT FORM

Form attached.

CONTAMINATION INCIDENT REPORT FORM

General Information:

Name:_____ WP# _____ Date:_____
Area(s) Above MDA:_____ Time:_____

Areas Entered (reverse order):_____

Entry into any posted restricted areas: Yes / No

Hands-On Work: Yes / No

Precipitation in the last hour: Yes / No

Has Radon plateout been confirmed on other personnel today: Yes / No

CONTAMINATION INCIDENT REPORT FORM

Instrument ID_____Background_____Standard Correction Factor_____

Subsequent readings were:

_____cpm (net) at time_____hrs on_____date
_____cpm (net) at time_____hrs on_____date
_____cpm (net) at time_____hrs on_____date

Explain Potential Cause of Contamination:

Improper Doffing of PPE Defective Equipment/PPE Improper Equipment
Insufficient PPE Insufficient Boot Decon Suspect Radon Plateout
Area Improperly Posted (conduct follow-up) Other:_____

Survey Results:

The following table shall be completed when contamination, other than suspect radon plateout, is confirmed.

Survey Results					
Area Surveyed	Approx. Size of Area (cm^2)	Contaminant: β/ ϒ α			
		Individual Area Readings (6), β/ϒ in CPM		Individual Area Readings (2), α in CPM	Average of α or β/ϒ readings (DPM)/100 cm^2)

Comments: _____

_____

Completed By:_____Date:_____

Validated By:_____Date:_____

EXHIBIT 2
PERSONNEL DECONTAMINATION METHODS

Chart attached.

PERSONNEL DECONTAMINATION						
Step	Method	Surface	Action	Technique	Advantages	Disadvantages
1 & 2	1. Wet Wipes or 2. Soap and water	Skin and Hands	Emulsifies and dissolves contaminant	Wash and monitor. Do not wash more than 3-4 times	Readily available and effective for most radioactive contamination.	Continued washing will defat the skin. Indiscriminate washing of other than affected parts may spread contamination. Never allow contamination to flow into eyes, ears, nose, or mouth
3	Lava soap, soft brush & water	Skin and Hands	Emulsifies, dissolves, and erodes	Use light pressure with heavy lather. Wash for 2 min., 3 times. Rinse and monitor. Use care not to scratch or erode the skin. Apply lanolin or hand cream to prevent chapping.	Same as above	Continued washing will abrade the skin.
4	Tide or detergent (plain)	Skin and Hands	Same as above	Make into a paste. Use with additional water with a mild scrubbing action. Use care not to erode the skin.	Slightly more effective than washing with soap.	Will defat and abrade skin and must be used with care.
1	Soap and Water	Hair	Emulsifies and dissolves contaminant.	Shampoo hair in sink (not shower) and dry prior to alpha survey. If contamination is not lowered to acceptable level cut off contaminated hair.	Readily available and effective.	

PERSONNEL DECONTAMINATION						
Step	Method	Surface	Action	Technique	Advantages	Disadvantages
1	Flushing	Eyes, ears, nose, and mouth	Physical removal by flushing.	Roll back the eyelid as far as possible, flush with large amounts of water. If isotonic irrigants are available apply to eye continually and then flush with large amounts of water. (Isotonic irrigant [0.9% NaCl solution]: 9 grams NaCl in beaker, fill to 1000 cc with water.) Can be purchased from drug suppliers, etc. Further decontamination must be done under medical supervision.		
1	Flushing	Wounds	Physical removal by flushing	Wash wound with large amounts of water and spread edges gently to stimulate bleeding, if not profuse. Further decontamination must be done under medical supervision.	Quick and efficient if wound is not severe.	May spread contamination to other areas of the body if it is not done carefully.

EXHIBIT 3
EQUIPMENT, AREA, AND MATERIAL DECONTAMINATION METHODS

Chart attached.

EQUIPMENT, AREA AND MATERIAL DECONTAMINATION METHODS

Begin with the first method listed, then proceed step by step to the more severe methods as necessary.

Method	Surface	Action	Technique	Advantages	Disadvantages
METHOD 1 Vacuum cleaning, Masslin, Duct Tape	Dry surfaces	Removes contaminated dust by suction, wiping, adhering	Use conventional vacuum technique with efficient filter.	Good on dry, porous surfaces. Avoids water reactions.	All dust must be filtered out of exhaust. Machine is contaminated.
METHOD 2 Water	All nonporous surfaces (metal, painted, plastic, etc.)	Dissolves and erodes.	For large surfaces: Hose with high-pressure water at an optimum distance of 15 to 20 feet. Spray vertical surfaces at an angle of incidence of 30^{o} to 40^{o}; work from top to bottom to avoid recontamination. Work upwind to avoid spray. Determine cleaning rate experimentally if possible; otherwise, use a rate of 4 square feet per minute.	All water equipment may be utilized. Allows operation to be carried out from a distance. Contamination may be reduced by 50%. Water equipment may be used for solutions of other decontaminating agents.	Drainage must be controlled. Not suitable for porous materials. Oiled surfaces cannot be decontaminated. Not applicable on dry contaminated surfaces (use vacuum); not applicable on porous surfaces such as wood, concrete, canvas, etc. Spray will be contaminated.
	All surfaces	Dissolves & erodes.	For small surfaces: Blot up liquid & hand wipe with water & appropriate commercial detergent.	Extremely effective if done immediately after spill & on nonporous surfaces.	Of little value in the decontamination of large areas, long-standing contaminants & porous

Method	Surface	Action	Technique	Advantages	Disadvantages
					surfaces.
METHOD 3 Steam	Nonporous surfaces (especially painted or oiled surfaces).	Dissolves & erodes.	Work from top to bottom & from upwind. Clean surface at a rate of 4 square feet per minute. The cleaning efficiency of steam will be greatly increased by using detergents.	Contamination may be reduced approximately 90% on painted surfaces.	Steam subject to same limitations as water. Spray hazard makes the wearing of waterproof outfits necessary.
METHOD 4 Detergents	Nonporous surfaces (metal, painted, glass, plastic, etc.).	Emulsifies contaminant & increases wetting power of water & cleaning efficiency of steam.	Rub surface 1 minute with a rag moistened with detergent solution then wipe with dry rag; use clean surface of the rag for each application. Use a power rotary brush with pressure feed for more efficient cleaning. Apply solution from a distance with a pressure proportioner. Do not allow solution to drip onto other surfaces. Mist application is all that is necessary.	Dissolves industrial film & other materials which hold contamination. Contamination may be reduced by 90%.	May require personal contact with surface. May not be efficient on long-standing contamination.

Appendix III:
Contamination Survey Procedure

1. PURPOSE & SCOPE:

This instruction establishes the methods for performing radiological contamination surveys. Radiological contamination surveys are required for ensuring compliance with NRC Reg. Guide 1.86. This instruction applies to material and equipment surveys for total and removable radioactive contamination performed for the NFSS.

2. EQUIPMENT AND MATERIALS:

- Handheld alpha scintillation detector.
- Handheld GM detector.
- Handheld gas proportional detector.
- Handheld dual phosphor alpha/beta scintillation detector.
- Ratemeter, Scaler, or Scaler/Ratemeter.
- Alpha/beta scintillation detector for measuring removable contamination.
- Swipes (i.e., removable contamination monitoring paper or cloth).

3. PROCEDURE:

Definition

Critical Detection Level (CDL): Level of instrument response at which there is a 5% probability of incorrectly identifying an instrument background value as a "greater than background" result. In this procedure the units for the CDL have been converted from number of instrument counts to disintegrations per minute (dpm). The CDL equations are derived from Equation (3-2) of NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation survey Instruments for Various Contaminants and Field Conditions*.

Surveying Techniques

Any or all of the following measurement techniques can be used to survey for surface contamination. The technique used depends on the radioactive contaminant, the type of surface being measured for contamination, and the release criteria.

1. **Alpha Scan**

NOTE: *Alpha scans and fixed point measurements should be conducted on surfaces free of moisture and oily residue.*

This measurement is used to scan a surface for the purpose of locating alpha contamination. Refer to Attachment 4, *Calibration and Use of Portable*

Radiological Survey Instruments for operation of an alpha detector and guidance on scanning.

2. **Alpha Fixed Point Measurements**

   Fixed point measurements are made with the detector held stationary for a predetermined time interval to allow total alpha activity to be detected. Refer to Attachment 4, *Calibration and Use of Portable Radiological Survey Instruments* for operation of an alpha detector. This technique enables a lower critical detection level (CDL) to be accomplished when compared to scanning.

3. **Beta/Gamma Scan**

   This measurement is used to scan a surface for the purpose of locating total beta/gamma contamination. Refer to Attachment 4, *Calibration and Use of Portable Radiological Survey Instruments* for operation of a Geiger-Mueller (GM) detector and guidance on scanning.

4. **Beta/Gamma Fixed Point Measurements**

   Fixed point measurements are made with the GM detector held stationary for a predetermined time interval to allow beta/gamma activity to be detected. Refer to Attachment 4, *Calibration and Use of Portable Radiological Survey Instruments* for operation of a GM detector. This technique enables a lower CDL to be accomplished when compared to scanning.

Removable Contamination Survey

Removable contamination surveys are made to determine the amount of removable alpha and beta contamination on a surface.

1. When necessary, sample locations may be identified on the protective flap of the swipe or on the swipe sample paper.

2. Removable contamination surveys shall be taken as follows:

STEP	ACTION
1	Apply moderate uniform pressure with a dry smear sample paper and wipe an area of at least 100 sq. cm (approximately 4 in. X 4 in.) at an appropriate sample location. Appropriate sampling locations are those which have the greatest potential for contamination. For cases where the surface area of the item to be surveyed is less than 100 cm^2, all of the accessible area shall be included in the survey and the size of the area surveyed shall be noted under the Comments section of the Contamination Survey Form. NOTE: *Large area swipes of surface areas greater than 100 cm^2 may be performed. However, if the resultant count rate from the large area swipe is above 20 dpm alpha or 200 dpm beta, the survey must be redone using individual 100 cm^2 area swipes.*
2	Fold protective flap over sample and proceed to the next sample location.
3	Ensure that the alpha and beta counting systems have met the requirements given in Attachment 4, C*alibration and Use of Portable Radiological Survey Instruments*.
4	Dry each smear, if necessary, in a manner that will not remove any matter from the sample.
5	Minimum sample count time is dependent on the alpha and beta counting system critical detection levels. Detection levels shall be less than 20 dpm alpha and 200 dpm beta.
6	After counting, dispose of any smear samples exceeding 20 dpm alpha or 200 dpm beta as radioactive trash.

Survey Documentation

1. The Contamination Survey Form shall be used to document radioactive material area release surveys, unrestricted material/equipment release surveys, and MARSSIM final status surveys.

2. A map or sketch may be included on the Contamination Survey Form (Optional Supplement). The map should contain the measurement locations.

3. Complete the description and date & time surveyed on the Contamination Survey Form. Provide an accurate description that includes the recipient of the released item, if necessary. Record description of the area surveyed in the "Description/Location" column and number accordingly.

4. The swipe survey CDL is calculated:

$$CDL(dpm) = 1.645 \frac{\sqrt{\frac{bcr}{bct} + \frac{bcr}{sct}}}{de}$$

where bcr = background count rate
bct = background count time
sct = sample count time
de = detector efficiency

NOTE: *The CDL may be reduced by increasing the sample count time.*

5. Record applicable survey instrument data on the Contamination Survey Form.

6. Record the removable activity net cpm alpha and beta measurement results on the Contamination Survey Form.

7. To calculate removable alpha activity in dpm/100 cm^2, divide the net alpha cpm by the alpha detector efficiency. Perform the same calculation for removable beta activity. Record both alpha and beta removable activity results on the Contamination Survey Form.

8. If the calculated removable alpha or beta activity is less than the corresponding CDL, then record "<" and the numerical CDL result in the Removable α or Removable β columns (as appropriate) of the Contamination Survey Form. If the removable alpha or beta results are greater than the corresponding CDL, then record the calculated removable results to the nearest whole number in the Removable α or Removable β columns (as appropriate) of the Contamination Survey Form.

NOTE: Items with measured removable activity greater than or equal to 20 dpm α/100 cm^2 or 200 dpm β /100 cm^2 shall not be released for unrestricted use.

Direct Survey Measurements

1. Perform a scan and/or direct survey of the material and/or equipment as directed by the JE Health Physicist.

2. Record applicable survey instrument data on the Contamination Survey Form

3. To determine the highest gross count rate, perform a 1-minute fixed point count on the surface at the highest detectable location (or at any location should there be no readily discernible difference in count rates during the survey).

   NOTE: *Certain circumstances may require a fixed sample count time other than 1 minute to achieve a desired CDL. In such cases, the results must be corrected to counts per minute. Consult the JE Health Physicist for the proper correction factor.*

4. Subtract detector background count rate from the gross count rate and record as Net CPM in the Total β/γ or Total α columns (as appropriate) on the Contamination Survey Form.

5. The direct survey β/γ background count rate may be: the posted detector background count rate; the field measurement background count rate when surveying in an area with elevated background; or no background when performing MARSSIM final status surveys being compared to reference area survey results. The JE Health Physicist will determine the appropriate background value for the situation.

If a MARSSIM final status survey is being performed (no background), note this in the Comments section of the Contamination Survey Form.

The field measurement background count rate may be determined by taking three 1-minute counts with the detector facing upward at a location in the general area of the survey. The sum of these counts is divided by 3 and rounded to the nearest whole number. If a field background count rate is used, record its result in the Comments section of the Contamination Survey Form.

6. To calculate total activity in dpm/100 cm^2, divide the Net CPM by the detector efficiency and multiply by the factor (100 / physical detector area in cm^2).

7. The direct survey CDL is calculated:

$$CDL(dpm) = 1.645 \frac{\sqrt{\frac{bcr}{bct} + \frac{bcr}{sct}}}{de} \text{ x } (100 / da)$$

where bcr = background count rate
bct = background count time
sct = sample count time
de = detector efficiency
da = physical detector area in cm^2

NOTE: *The CDL may be reduced by increasing the sample count time.*

8. If the calculated total alpha or beta activity is less than the corresponding CDL, then record "<" and the numerical CDL result in the Total β/γ or Total α columns (as appropriate) of the Contamination Survey Form. If the total alpha or beta results are greater than the corresponding CDL, then record the calculated total results to the nearest whole number in the Total β/γ or Total α columns (as appropriate) of the Contamination Survey Form.

   NOTE: Items with measured total activity greater than or equal to:

   - 1000 dpm/100 cm^2 β/γ averaged over 1 m^2,
   - 3000 dpm/100 cm^2 β/γ in any 100 cm^2 section,
   - 100 dpm/100 cm^2 α averaged over 1 m^2, or
   - 300 dpm/100 cm^2 α in any 100 cm^2 section

   shall not be released for unrestricted use.

Resurvey Measurements

Forms documenting repeat surveys should clearly reference the initial survey in the comments section of the Contamination Survey Form, or be attached to the initial survey to ensure proper documentation.

EXHIBITS

Exhibit 1: Contamination Survey Form
Exhibit 2: Unrestricted Use Release Form

Niagara Falls Storage Site - Lewiston, New York **CONTAMINATION SURVEY FORM** Page _____ of

DESCRIPTION**:** DATE: TIME:

PURPOSE OF SURVEY (For Release Surveys Include Recipient): _____

_____

INSTRUMENT DATA:	**Manufacturer/Model**	**Serial Number**	**Calibration Due Date**	**Background**	**Efficiency**	**Correction Factor**
Detector:						
Meter/Scaler:						
Detector:						
Meter/Scaler:						
Detector:						
Meter/Scaler:						
Detector:						
Meter/Scaler:						
Detector:						
Meter/Scaler:						

SURVEY RESULTS

Sample No.	Description/Location	Total β-γ Net CPM	Total β-γ dpm/100 cm^2	Total α Net CPM	Total α dpm/100cm^2	Removable βγ Net CPM	Removable βγ dpm/100 cm^2	Removable α Net CPM	Removable α dpm/100 cm^2

CORRECTION FACTOR FORMULAS:

Direct: CF = 100/ Efficiency x Physical Detector Area Removable: CF = 1 / Efficiency

COMMENTS: _____

TECHNICIAN(S) SIGNATURE/DATE: _____/_____ _____/_____

REVIEWER SIGNATURE/DATE: _____/_____

Page _____ of

DESCRIPTION**:** DATE: TIME:

SURVEY RESULTS

Sample No.	Description/Location	Total β-γ Net CPM	Total β-γ dpm/100 cm^2	Total α Net CPM	Total α dpm/100 cm^2	Removable βγ Net CPM	Removable βγ dpm/100 cm^2	Removable α Net CPM	Removable α dpm/100 cm^2

COMMENTS: _____

TECHNICIAN(S) SIGNATURE/DATE: _____/_____ _____/_____

REVIEWER SIGNATURE/DATE: _____/_____

DESCRIPTION**:** DATE: TIME:
SURVEY MAP
REMARKS: _____
TECHNICIAN(S) SIGNATURE/DATE: _____/_____ _____/_____
REVIEWER SIGNATURE/DATE: _____/_____

Niagara Falls Storage Site (NFSS)
Lewiston, New York

UNRESTRICTED USE RELEASE FORM

Date:___/___/_____

Check One: ☐ Vehicle ☐ Equipment

Material Description:

_____

_____

_____

_____

A comprehensive radiological survey has been performed on the above (check one) vehicle, equipment, and/or material. The survey results for the item(s) specified above indicate that these materials meet the Nuclear Regulatory Commission (NRC) release guidelines established in NRC Reg. Guide 1.86. The item(s) specified above have been released for unrestricted use.

_____ _____

Surveyor Title

_____ _____

Supervisor Title

Appendix IV:
Calibration and Use of Portable Radiological Survey Instruments

1. PURPOSE & SCOPE

This procedure specifies the steps for instrument calibration, source check, and operation of the following instruments:

- Scaler/Ratemeters
- Geiger-Mueller (GM) detectors
- Hand-held alpha and alpha/beta scintillation detectors
- Gas proportional detectors
- Gross alpha/beta scintillation sample counters

The Site Safety and Health Officer (SSHO) is responsible for the execution of this and all other kradiological procedures.

Scaler/Ratemeters

Counting instruments/meters designed for operation with scintillation, proportional, or GM detectors.

Hand-Held GM Detectors

GM detectors are used to detect beta and gamma radiation. The GM detectors may be used to monitor personnel and equipment for radioactive contamination.

Hand-Held Alpha and Alpha/Beta Detectors

Hand-held alpha and alpha/beta scintillation detectors are used to detect alpha or alpha & beta radiation. These detectors may be used to monitor personnel and equipment for radioactive contamination.

Gas Proportional Detectors

Gas proportional detectors are used to detect total alpha and beta radiation on personnel and equipment, and may also be used to count gross alpha and beta radiation on swipes and filters.

Gross Alpha/Beta Sample Counters Gross alpha/beta scintillation sample counters are used to count gross alpha and beta radiation on swipes and filters.

REFERENCES

Bicron Model A-50 Instruction Manual
Ludlum Model 3 Instruction Manual
Ludlum Model 12 Instruction Manual
Ludlum Model 16 Instruction Manual
Ludlum Model 2000/2200 Instruction Manual
Ludlum Model 2220/2221 Instruction Manual
Ludlum Model 2223 Instruction Manual
Ludlum Model 2224 Instruction Manual
Ludlum Model 2350 Instruction Manual
Ludlum Model 2929 Instruction Manual
Ludlum Model 43-2 Instruction Manual
Ludlum Model 43-5 Instruction Manual
Ludlum Model 43-10 Instruction Manual
Ludlum Model 43-10-1 Instruction Manual
Ludlum Model 43-20 Instruction Manual
Ludlum Model 43-37 Instruction Manual
Ludlum Model 43-68 Instruction Manual
Ludlum Model 43-90 Instruction Manual
Ludlum Model 44-9 Instruction Manual
Ludlum Model 44-40 Instruction Manual

2. DEFINITIONS

Plateau - A region on a voltage versus count rate graph where an insignificant increase in count rate occurs with increasing detector voltage.

Acronyms and Abbreviations

AC	alternating current
CDL	critical detection level
CPM	counts per minute
DC	direct current
DPM	disintegrations per minute
GM	Geiger-Mueller
HV	high voltage
NIST	National Institute for Standards and Technology

3. EQUIPMENT AND MATERIALS

Saler/ratemeters
Geiger-Mueller (GM) detectors

Hand-held alpha and alpha/beta scintillation detectors
Gas proportional detectors
Gross alpha/beta scintillation sample counters
NIST-traceable sources for calibration
Radioactive alpha & beta check sources for operational checks
Source holder
BNC Cable
Up to four "D" cell batteries
P-10 gas

4. PROCEDURE

4.1. Maintenance and Calibration

Scaler/ratemeters and detectors shall be calibrated annually and/or each time a component is dismantled or adjusted such that the assigned efficiency and/or background may be affected. Battery and/or cable change-outs do not require recalibration. However, such change-outs shall be documented on the *Response Check Control Log*.

4.1.1. Instrument Precalibration and Preoperational Checks

STEP	ACTION
1	Inspect the detector, scaler/ratemeter, and cable for damage and dirt and ensure that all connections are properly made.
2	Prior to operation, verify meter and probe both have a valid and current calibration label.
3	Check that the scaler/ratemeter reads zero when the instrument is turned off, if applicable.
4	For hand-held scaler/ratemetrs: [a] Turn scaler to the **ON** position and check the batteries by moving the switch to the **BATTERY** position or by depressing the **BATTERY** switch. [b] Verify the batteries are charged to at least 5 volts or the needle falls inside the acceptable range. [c] If the battery check fails, turn the scaler/ratemeter to the **OFF** position, replace the batteries, and/or clean the contacts, then repeat the battery check.

Steps continued on next page.

WARNING

If the Model 2000/2200 scaler is equipped with nonrechargable batteries, do not set the scaler to the CHG position. The batteries could rupture or explode.

CAUTION
Do not supply voltage to a gas proportional detector without proper P-10 gas supplied. Serious damage to the detector could occur.

STEP	ACTION
5	For gas proportional detectors: [a] Place P-10 gas cylinder in service at 5 psi or less. [b] Purge detector with P10 gas for 1 hour at a flow rate of 100 cc/hr. This is required for initial operation only. [c] After purge is complete, adjust P10 gas flow to 40 (30-50) cc/hr. [d] Perform a battery check on applicable meter boxes. Replace batteries as needed. [e] Verify that inlet and outlet gas flows do not indicate detector gas leak (i.e., within 5 cc/hr of each other).
6.	For the Alpha/Beta Sample Counter: **NOTE**: *If AC power is not available, ensure that the scaler is equipped with four D cell batteries*. [a] If using AC power, turn the scaler on by rotating the appropriate knob to the **LINE** position. [b] If using batteries, toggle the selector switch to the **BAT** position. If the needle fails to indicate the correct operating voltage, replace the batteries and repeat the battery check.
7	For Hand-Held Alpha and Alpha/Beta Scintillation Detectors: [a] With the instrument operable, verify no mylar light leaks by exposing the probe window to a light source and checking for a rapid meter response. [b] If a rapid meter response is observed due to the light source, then remove the probe from service. [c] Replace mylar probe window under low light conditions. [d] Before returning the instrument to service, verify that average detector efficiency has not change by more than 5% as a result of the repair (see Section 7.1.3.2)

4.1.2. Scaler/Ratemeter Electronic Calibration

STEP	ACTION
1	Place the scaler/ratemeter in an upright position. With the instrument turned off, adjust (if applicable) the instrument to read zero by using the “mechanical” zero screw.
2	Using the appropriate instrument manual, locate/access the instrument calibration potentiometers.
3	Connect the scaler/ratemeter to a calibrated pulser using coaxial cable.
4	Turn on the scaler/ratemeter and pulser.

STEP	ACTION
5	Adjust the pulser amplitude to 100 mV.
6	For ratemeters: • Pulse each scale at 20% at 80% values of the full-scale reading. For example: If full-scale equals 500 cpm, then pulse scale at 100 cpm and 400 cpm. • Record "as found" readings on Exhibit 7, "Scaler/Ratemeter Electronic Calibration" or equivalent. • Adjust, as necessary, the appropriate poteniometer(s) in order to match all ratemeter readings to pulser outputs (i.e., within +/- 10%). • Record "as left" readings on Exhibit 7, "Scaler/Ratemeter Electronic Calibration" or equivalent. • Check geotropism on an intermediate scale by pulsing the meter at scale mid-point and orientating the meter in the three mutually perpendicular planes. Except for initial deflection, meter should remain at initial reading (+/- 2% of full-scale reading). If meter has greater than 2% of full-scale geotropism, then remove from service until appropriate repairs are made.
	Steps continued on next page.
7	For scalers: • Pluse at 10, 100, 1k and 10K cpm (1 minute counts). • Record counts on Exhibit 7, "Scaler/Ratemeter Electronic Calibration" or equivalent. • Verify all scaler readings are within +/- 10% of pulser outputs.
8	If unable to properly adjust a scaler/ratemeter within +/- 10% tolerance, then remove from service until appropriate repairs/adjustments are made.

4.1.3. Operating Voltage Assignment

4.1.3.1. Hand-Held GM Detector

This detector will operate with any Ludlum or equivalent scaler/ratemeter that provides 900 operational volts (+/- 50 volts) and a threshold of approximately 35 mV.

4.1.3.2. Hand-Held Scintillation and Gas Proportional Detectors, and Alpha/Beta Sample Counter

STEP	ACTION
1	Remove all radioactive sources from the vicinity of the detector.

2	Position detectors as follows: **Instrument** — **Probe Position** Hand-Held Scintillation or Gas Proportional Detectors — Place probe's detection area such that it is unobstructed. Alpha/Beta Sample Counter — Place a clean, empty planchet in sample holder. Close and lock sample holder.
3	Set window **IN/OUT** switch to the **OUT** position, if applicable.
4	Set the count time to 1 minute.
5	Set the threshold and high voltage (HV) to the manufacturer's recommended values for calibration initialization.

NOTE: *Only a calibrated external voltmeter shall be used for high voltage measurements in support of portable instrument calibrations.*

STEP	ACTION
6	Take a 1 minute background count.
7	Increase the HV in increments of 50 volts, taking a 1 minute background count at each increment.
8	Record the HV versus background count rate on the Plateau Calibration Form (Exhibit 2) or equivalent as background cpm.
9	Continue until the end of the plateau is reached or HV reaches 1,500 volts.
	CAUTION Promptly reduce the scaler HV to the initial setting. Failure to do so could result in flooding or damage to the probe.
10	Set the detector up for a source count as follows: Hand-Held Scintillation or Gas Proportional Detector — Center the detector over the source (Th-230 source for alpha channel, Sr/Y-90 source for beta channel) Alpha/Beta Sample Counter — Insert and secure the source in the sample holder (Th-230 source for alpha channel, Sr/Y-90 source for beta channel)
11	Take a 1-minute source count.
12	Increase the HV in increments of 50 volts, taking a 1-minute source count at each increment.
13	Record the HV versus source count rate as source cpm on the Plateau Calibration Form (Exhibit 2) or equivalent.
14	Continue until the end of the plateau is reached as indicated by the scaler.
	Steps continued on next page.

STEP	ACTION
15	Using the data from the Plateau Calibration Form (Exhibit 2) or equivalent., plot graphs showing HV versus cpm for background cpm and source cpm. (See Exhibit 8 for an example.) **NOTE:** *Use of a computer to prepare this graph is recommended.*
16	For hand-held scintillation and gas proportional detectors, and alpha/beta sample counters, select and set the HV of the scaler at the middle of the source plateau. Alpha background should not exceed 7 cpm, beta background should not exceed 400 cpm. **NOTE:** *If the source count and background count plateaus do not overlap satisfactorily, the scaler threshold may need to be adjusted.*
17	Record the HV and threshold selected on the Plateau Calibration Form (Exhibit 2) or equivalent.

4.1.4. Absolute Efficiency Verification

4.1.4.1. Hand-Held GM Detector, Hand-Held Scintillation or Gas Proportional Detector, and Alpha/Beta Sample Counter

STEP	ACTION
1	Verify that the window is toggled out, if applicable.
2	Remove all radioactive sources from the vicinity of the detector.
3	For the GM Detector, set the scaler HV to 900 V and the scaler Threshold to 35 mV (applicable to models 2220 and 2221).
4	For the Hand-Held Scintillation and Gas Proportional Detector and Alpha/Beta Sample Counter, set the scaler HV and Threshold to the values determined from the calibration plateaus.
5	Position detectors as follows for a background count: **Instrument** — **Probe Position** Hand-Held GM, Scintillation, and Gas Proportional Detector — Place probe's detection area so that it is unobstructed. Alpha/Beta Sample Counter — Place a clean, empty planchet in sample holder. Close and lock sample holder.
6	Take 10 background counts using the following background count times: **Instrument** — **Background Count Time** Hand-Held GM — 1 minute Hand-Held Scintillation and

	Gas Proportional Detector, Alpha/Beta Sample Counter 10 minutes
7	Record the results on the Efficiency Calibration Form (Exhibit 3) or equivalent.
8	Use Equation 1 in Exhibit 1 to calculate the mean of the 10 background counts. Record results on on the Efficiency Calibration Form (Exhibit 3) or equivalent.
9	Set the detector up for a source count as follows: **Instrument** — **Source and Placement** Hand-Held GM Detector — Place the Sr/Y-90 disc source in source holder and center the probe head over the source. Hand-Held Alpha Detector — Center the detector area over the Th-230 disk source. Alpha/Beta Sample Counter — Insert and secure the Th-230 disc source in the sample holder. Hand-Held Scintillation or Gas Proportional Detector — Center the detector over the source (Th-230 source for alpha channel, Sr/Y-90 source for beta channel) Alpha/Beta Sample Counter — Insert and secure the source in the sample holder (Th-230 source for alpha channel, Sr/Y-90 source for beta channel)
10	Take 10 1-minute source counts.
11	Record the results on the Efficiency Calibration Form (Exhibit 3) or equivalent.
12	Use Equation 3 in Exhibit 1 to calculate the mean of the 10 *gross* source counts.
13	Calculate ± 20% of the mean gross source count rate.
14	Use Equation 5 in Exhibit 1 to calculate the mean *net* source count rate.
15	Use Equation 6 in Exhibit 1 to calculate the absolute efficiency of the detector.
16	Record the results of Steps 12,13,14, and 15 on the Efficiency Calibration Form (Exhibit 3) or equivalent.
17	Prepare a new calibration label with the following information and place it on the detector: • Operating Voltage • Operating Threshold • Standardized Correction Factor (CF) • Mean Background Count Rate • Date of Calibration • Calibration Due Date • Initials of Calibrator
18	Complete the heading of the Response Check Control Log Form (Exhibit 4).

4.1.4.2. Hand-Held Scintillation and Gas Proportional Detectors: Efficiency Check Following Replacement of Mylar Probe Window

STEP	ACTION
1	Remove all radioactive sources from the vicinity of the detector.
2	Set the scaler HV and Threshold to the values previously determined from the calibration plateaus.
3	Positioning the probe's detection area so that it is unobstructed, take five 10-minute background counts. Record results on Exhibit 5.
4	Use Equation 2 in Exhibit 1 to calculate the mean of the five background counts. Record results on Exhibit 5. This value should be less than 3 cpm.
5	Set the detector up for a source count by centering the detector area over the Th-230 disk source.
6	Take five 1-minute source counts and record on Exhibit 5.
7	Use Equation 4 in Exhibit 1 to calculate the mean of the five gross source counts. Record this value on Exhibit 5.
8	Use Equation 5 in Exhibit 1 to calculate the mean net source count rate. Record this value on Exhibitt5.
9	Use Equation 6 in Exhibit 1 to calculate the absolute efficiency of the detector.
10	Use Equation 7 in Exhibit 1 to compare the absolute detector efficiency following window replacement with the absolute detector efficiency recorded on the calibration sticker.
11	If the absolute detector efficiency following window replacement does not fall within the required ±5% range of the previous detector efficiency, perform a full recalibration of the detector.

4.2. Operating Procedure

4.2.1. Daily Operational Check

Instruments operated in accordance with this procedure shall be response checked daily (when in operation) and within 24 hours of initial or return to operation.

STEP	ACTION
1	Perform the instrument pre-operational checks in Section 7.1.1 of this procedure.
2	Verify the scaler ratemeter's HV and Threshold levels are set to the levels indicated on the detector's calibration label and record the HV setting in the Response Check Control Log Form (Exhibit 4).
3	Set the detector up for a source count as follows: **Instrument Placement** — **Source and Probe Position** Hand-Held GM Detector — Place the Sr/Y-90 disc source in source holder and center the probe head over the source. Hand-Held Scintillation or Gas Proportional Detector — Center the detector over the source (Th-230 source for alpha channel, Sr/Y-90 source for beta channel) Alpha/Beta Sample Counter — Insert and secure the source in the sample holder (Th-230 source for alpha channel, Sr/Y-90 source for beta channel)
4	Perform a 1-minute source count check for all detectors.
5	Verify that the gross source count rate is within ± 20% of the gross source count range documented in the Response Check Control Log Form for the instrument.
6	Record the results from Steps 2 through 5 on the Response Check Control Log Form for the instrument.
7	If the source count rate is not within ± 20% of its posted value, perform the response check again.
8	If the detector still does not check in, remove it from service and notify the JE Health Physicist. **NOTE:** *Important! Record any repairs or maintenance in the "comments" section of the Response Check Control Log Form before instrument is returned to service.*

4.2.2. Operation

4.2.2.1. Hand-Held GM Detector

NOTE: *The manufacturer recommends operating the instrument in a temperature range of 5° to 122° F. Operating the instrument outside this range could result in inaccurate measurements. If temperatures are outside this range, consult the JE Health Physicist for appropriate actions.*

1. When making quantitative estimates of the level of radioactivity, hold the detector approximately 0.5 in. from the surface to ensure uniformity of detector response.

2. Know the general background level in the area where you are performing surveys. In areas of elevated background, the field measurement background count rate may be determined and used as provided for in Appendix III.

3. Perform scans by moving the detector slowly over the surface at an average rate of 1 in. to 2 in. per second.

4. If beta-gamma radiation is to be measured at a single fixed point location, hold the detector stationary and near contact with the surface.

5. Record the survey results if required in accordance with Appendix III.

4.2.2.2. Hand-Held Scintillation Detector

NOTE: *The manufacturers recommend operating the instrument in a temperature range of 14° to 122° F. Operating the instrument outside this range could result in inaccurate measurements. If temperatures are outside this range, consult the JE Health Physicist for appropriate actions.*

1. Surfaces to be surveyed should be free of soil and moisture.

2. When making quantitative estimates of the level of contamination on a surface, hold the detector 0.25 in., or closer if possible, from the surface being surveyed.

3. Scan survey areas by moving the detector over the surface at a rate of no more than 0.5 in. per second.

4. If the alpha channel audio output signals two or more closely spaced counts, stop to allow the instrument time to respond. If the signal falls to zero, the cause is a random

background event. If the signal remains elevated, the cause is an area of low level alpha contamination.

5. When measuring alpha radiation at a fixed point, hold the detector stationary and as close to the surface as possible and no further from the surface than 0.25 in.

6. Record the survey results in accordance with Appendix III.

4.2.2.3. Alpha/Beta Sample Counter

NOTE: *The manufacturer recommends operating the detector in a temperature range of 5° F to 122° F. Operating the instrument outside this range could result in inaccurate measurements. If temperatures are outside this range, consult the JE Health Physicist for appropriate actions.*

1. The swipe or filter paper should be dry and free of oil. Failure to dry the smear or the presence of oil will lead to significant alpha attenuation.

2. The swipe or filter paper to be counted must be placed flat on the planchet with no part of the sample protruding from the sample holder. The slide must be pushed in and the slide lever rotated to lock the slide in place.

4.2.2.4. Gas Proportional Detector

1. Adjust the detector face to 1/4 inch from the surface to be monitored or otherwise as low as possible to prevent damage to the detector.

2. Connect the detector BNC cable to an appropriate calibrated meter box. Be aware of meter box calibration status (i.e., alpha voltage vs. alpha/beta voltage).

3. Verify sufficient detector gas flow prior to turning on meter box. Adjust scale as necessary to account for background.

4. Scan surfaces as slowly as possible or in accordance with specific survey plan.

5. Investigate any detector response to suspected net activity by maintaining the detector stationary over suspect area for approximately 10 seconds.

6. When measuring alpha radiation at a fixed point, hold the detector stationary and as close to the surface as possible and no further from the surface than 0.25 in. Record the alpha and beta survey results in accordance with Appendix III.

5. RECORDS

5.1. Quality Assurance Records and Exhibits

Permanent quality assurance records generated by this procedure include Exhibits 2 through 6.

Exhibit 1 Equations
Exhibit 2 Plateau Calibration Form
Exhibit 3 Efficiency Calibration Form
Exhibit 4 Response Check Control Log
Exhibit 5 Efficiency Check Following Replacement of Hand-Held Scintillation Detector Mylar Window
Exhibit 6 Scaler/Ratemeter Electronic Calibration

EXHIBIT 1
EQUATIONS

Equation 1: Use this equation to calculate the mean background count rate for 10 background counts.

$$R_B = \frac{\sum_{i=1}^{10} N_i}{10} / CT$$

where:

R_B = mean background count rate (cpm).
N_i = number of background counts for the i^{th} count.
CT = count time.

Equation 2: Use this equation when replacing alpha probe mylar window to calculate the mean count rate for 5 background counts.

$$R_B = \frac{\sum_{i=1}^{5} N_i}{5} / CT$$

where:

R_B = mean background count rate (cpm).
N_i = number of background counts for the i^{th} count.
CT = count time.

Equation 3: Use this equation to calculate the mean gross count rate for 10 source counts.

$$\overline{X}_{Ci} = \frac{\sum_{i=1}^{10} C_i}{10} / CT$$

where:

$\overline{X}_{Ci}$ = mean gross source count rate (cpm).
C_i = number of gross source counts for the i^{th} count.
CT = count time, generally 1 min.

Equation 4: Use this equation when replacing alpha probe mylar window to calculate the mean gross count rate for 5 source counts.

$$\overline{X}_{Ci} = \frac{\sum_{i=1}^{5} C_i}{5} / CT$$

where:

X_{Ci} = mean gross source count rate.
C_i= number of gross source counts for the ith count.
CT= count time, generally 1 minute.

Equation 5: Use this equation to calculate the mean *net* source count rate.

$$R_S = \overline{X}_{Ci} - R_B$$

where:

R_S = mean net source count rate.
$\overline{X}_{Ci}$ = mean gross source count rate.
R_B = mean background count rate.

Equation 6: Use this equation to compute absolute efficiency.

$$E = \frac{R_s}{A_S}$$

where:

R_S = mean net source count rate (cpm).
A_S = posted activity of the source in disintegrations per minute (dpm).
E = fractional detector absolute efficiency.

Equation 7: Use this equation to determine whether detector efficiency following window replacement is within 5% of the previously determined efficiency.

$$\Delta E(\%) = \frac{\left| E_{previous}\ (\%) - E(\%) \right|}{E_{previous}(\%)}\ x\ 100$$

where:

ΔE = percent change in absolute detector efficiency as a result of replacing the mylar window (must be less than or equal to 5%).
$E_{previous}$ = the absolute detector efficiency (%) prior to the window changeout, recorded on instrument's calibration sticker.
E = The absolute detector efficiency following window changeout, calculated in Equation 6 above, expressed as a percentage.

EXHIBIT 2
PLATEAU CALIBRATION FORM

(Next Page)

Niagara Falls Storage Site
Lewiston, New York

PLATEAU CALIBRATION FORM

Detector: _____ Serial #: _____

Instrument: _____ Serial #: _____ Cal. Date: _____

HV Volts	Background (cpm)	Source (cpm)
300		
350		
400		
450		
500		
550		
600		
650		
700		
750		
800		
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		
1450		
1500		

High Voltage Selected: _____ Volts

Threshold Selected: _____ mV

Calibrated by: _____ Date: _____

EXHIBIT 3
EFFICIENCY CALIBRATION FORM

(Next Page)

EFFICIENCY CALIBRATION FORM

Detector:_____ **Serial #:**_____

Meter: _____ **Serial #:**_____ **Cal. Date:**_____

Source DPM, As: **Serial #:**_____ **Type:**_____

Background Counts (N_i)	Source Counts (C_i)
Background Count Time:_____	Source Count Time:_____
1._____	1._____
2._____	2._____
3._____	3._____
4._____	4._____
5._____	5._____
6._____	6._____
7._____	7._____
8._____	8._____
9._____	9._____
10._____	10._____
	$\overline{X}_{Ci}$ = _____ *cpm*
R_b = _____ cpm	**R_s = _____ cpm**
3 x SDB _____cpm	$\pm 20\% \overline{X}ci$ _____ *to* _____ *cpm*

Absolute Efficiency = Rs/As = _____ (may be reported in percent)

High Voltage Assigned: _____ Volts

Threshold Assigned: _____mV

Calibrated by: _____ Date: _____

Checked by: _____ Date: _____

EXHIBIT 4

RESPONSE CHECK CONTROL LOG

(Next Page)

RESPONSE CHECK CONTROL LOG *Niagara Falls Storage Site* *Lewiston, New York*

Detector & Serial No.:	**Detector ID:**	**Source Description & ID:**
Source Range (cpm) :	**Meter Cal Due:**	**Detector Cal Due:**

Date	**Time Military**	Source cpm	**H.V.**	**BAT.**	**Checked By**	**Meter**	**Month: _____________ Year:** **Comments**

EXHIBIT 5
FORM FOR EFFICIENCY CHECK FOLLOWING REPLACEMENT OF HAND-HELD SCINTILLATION DETECTOR MYLAR WINDOW

(Next Page)

Niagara Falls Storage Site *Lewiston, New York*

EFFICIENCY CHECK FOLLOWING REPLACEMENT OF HAND-HELD SCINTILLATION DETECTOR MYLAR WINDOW

Detector: _____ Serial #: _____

Meter: _____ Serial #: _____ Calibration Date: _____

Source dpm, A_S: _____ Serial #: _____ Type: _____

Background Counts (N_i)	Source Counts (C_i)
Background Count Time: _____	Source Count Time: _____
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

$\bar{X}_{ci}$= _____ cpm

R_B = _____ cpm	R_S = _____ cpm $E_{Previous}$ = _____% (from calibration sticker) E = _____% ΔE = _____% (must be less than 5%)

EXHIBIT 6

SCALER/RATEMETER ELECTRONIC CALIBRATION

(Next Page)

Niagara Falls Storage Site *Lewiston, New York*

SCALER/RATEMETER ELECTRONIC CALIBRATION

Mfg.: _____ Model: _____ Serial No.: _____

Cal. Date: _____ Cal. Due Date: _____

Pulser Mfg/Model: _____ Pulser Cal. Due Date: _____

Ratemeter Calibration

INST. RANGE	PULSER INPUT (cpm)	INST. "AS FOUND" READING (cpm)	INST. "AS LEFT" READING (cpm)

Geotropism Check: Pass Fail

Scaler Calibration (1-min. count)

PULSER INPUT (cpm)	INST. READING (counts)
10	
100	
1,000	
10,000	

Comments: _____

Calibrated By: _____ Date: _____

Checked By: _____ Date: _____

Appendix V:
Air Particulate Sampling and Analysis

Personal Breathing Zone Air Monitoring

Equipment

- 0.8 micrometer pore size, 37-mm diameter mixed cellulose ester filter with a back-up pad and cartridge.
- Low volume personal sampling pumps capable of maintaining a minimum flow of 4 L/min over an eight hour period.
- Precision rotameter (a secondary calibration device) capable of indicating a minimum flow rate of 4 L/min.
- Scintillation detector (Ludlum Model 43-10-1 or equivalent) and compatible scaler (Ludlum Model 2000 or equivalent)

Sample Collection

1. Connect an unused, loaded sample cartridge to the personal sampling pump.

2. Connect the precision rotameter to the cartridge inlet and turn the pump on. Adjust the sampling pump flow screw until the desired steady flow rate is obtained.

3. Record the sample start time (using the time or a zero as applicable), beginning flow rate, collection date, and wearer's name on the Air Sampling Form.

4. Attach the sampling pump to the wearer with the sample cartridge within 12 inches of the wearer's nose and mouth. The inlet opening of the cartridge should face down.

5. Shut the pump off at the end of the sampling period. Connect the rotameter to the cartridge inlet and measure the flow rate prior to removing the cartridge from the pump.

6. Record the sample stop time or minutes ran (as applicable), ending flow rate, pump ID number, and rotameter ID number on the Air Sampling Form. Remove the cartridge from the sampling pump.

7. The sample should be stored for a minimum of 72 hours to allow short-lived radon-222 and radon-220 daughters to decay. More rapid analysis (i.e., “quick count”) is possible and may be performed as determined necessary by the JE Health Physicist on a case-by-case basis.

8. The sample shall be analyzed following the appropriate decay period using the alpha scintillation detector and compatible scaler. Record analysis results, analysis times, posted detector background count rate, posted detector efficiency, and detector & scaler serial number.

9. Sample Calculations. The long-lived gross alpha activity concentration is calculated using the following equation (modified from Equation 14.8 in *Operational Health Physics Training*, ANL-88-26, prepared by Argonne National Laboratory for the U.S. Department of Energy, Assistant Secretary for Environment, Safety, and Health, September 1988):

$$C = \frac{\frac{SC}{SCt} - DR}{DExVx2.22E+06}$$

where:

C = long-lived gross alpha activity concentration (uCi/ml)
SC = number of sample counts
SCt = sample count time (minutes)
DR = detector background count rate (cpm)
DE = detector efficiency (cpm/dpm)
V = air volume (ml)
2.22E+06 = conversion from dpm to uCi

The Critical Level Concentration (CLC) is the level of air filter analysis instrument response at which there is a 5% probability of incorrectly identifying an instrument background value as a "greater than background" result. In this procedure the units for the CLC have been converted from number of instrument counts to airborne radioactivity concentration in uCi/ml. The CLC equation is derived from Equation (3-2) of NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation survey Instruments for Various Contaminants and Field Conditions*. The CLC is calculated using the following equation:

$$CLC = \frac{1.645x\sqrt{\frac{DR}{SCt}+\frac{DR}{BCt}}}{DExVx2.22E\ +\ 06}$$

where:

CLC	= critical level concentration (uCi/ml)
DR	= detector background count rate (cpm)
SCt	= sample count time (minutes)
BCt	= background count time (minutes)
DE	= detector efficiency (cpm/dpm)
V	= volume (ml)

Environmental Air Monitoring

Equipment

- 5 micrometer pore size, minimum 4-inch diameter glass fiber filter with a backing pad and sampling head.
- High volume area sampling pumps capable of maintaining a minimum flow of 200 L/min over a 24-hour period.
- Precision rotameter (a secondary calibration device) capable of indicating flow rate of at least 200 L/min.
- Gas proportional or scintillation detector (Ludlum Model 43-69 or 43-89 or equivalent) and compatible scaler

Sample Collection

1. Without touching the filter, place an unused filter and backing pad on the sampling head. Do not invert the filter face: side facing out in the package must also face out on the sampling head.

2. Connect the sampling head to the precision rotameter, and connect the rotameter to the pump. Turn the pump on and adjust the flow screw until the desired steady flow rate is obtained. When ambient temperatures are below 32^{o} F, check the flow rate again after 10 minutes of pump operation.

3. Record the sample start time, beginning flow rate, and collection date on the Air Sampling Form.

4. At the end of the sampling period, connect the rotameter between the sampling head and the pump to measure the flow rate.

5. Shut off the pump. Without touching the filter, remove the filter and backing pad and place them in a protective envelope.

6. Record the sample stop time, ending flow rate, pump ID number, and rotameter ID number on the Air Sampling Form.

7. The sample should be stored for a minimum of 72 hours to allow short-lived radon-222 and radon-220 daughters to decay. More rapid analysis (i.e., "quick count") is possible and may be performed as determined necessary by the JE Health Physicist on a case-by-case basis.

8. The sample shall be analyzed following the appropriate decay period using the gas proportional or scintillation detector and compatible scaler. Record analysis results, analysis times, posted detector background count rate, posted detector efficiency, and detector & scaler serial number.

9. Sample Calculations. The long-lived gross alpha activity concentration is calculated using the same equation specified in Step 9 of Section 4.3.1.3.2 above.

10. Samples may be sent off-site for isotopic analysis to achieve lower detection limits as needed.

NAME: _____ EMPLOYER: _____
LOCATION: _____
DATE COLLECTED: _____ COLLECTED BY: _____
DATE ANALYZED: _____ ANALYZED BY: _____

Location	Start Time	Stop Time	Total Time (min.)	Flow Rate (LPM)		Avg. Flow Rate (LPM)	Total Volume (mL)	Sample Gross α Count	Count Time (min.)	α Conc. (uCi/mL)	α CDC (uCi/mL)
				Start	Stop						

$$CONCENTRATION = \frac{\frac{SAMPLE\ COUNTS}{SAMPLE\ COUNT\ TIME} - DETECTOR\ BKG\ COUNT\ RATE}{DE\ x\ V\ x\ (2.22E+06)}$$

$$CDC = \frac{1.645\ x\ \sqrt{\frac{DETECTOR\ BKG.COUNT\ RATE}{SAMPLE\ COUNT\ TIME} + \frac{DETECTOR\ BKG.COUNT\ RATE}{BKG.COUNT\ TIME}}}{DE\ x\ V\ x\ (2.22E+06)}$$

Detector Type_____ DE = Detector Efficiency V = Volume (mL)

Scaler Model_____ Detector Model_____ Pump ID#_____

Scaler Serial#_____ Detector Serial#_____ Flow Setting_____

Cal. Due Date_____ Cal. Due Date _____ Flow Meter ID. _____

Detector Eff._____ Detector Bkg._____ Cal. Due Date_____

Reviewed by:_____ Date: _____

Appendix VI:
Radon and Thoron Daughter Concentration Determination

1.0 PURPOSE

This procedure describes the sampling and analytical methods used to determine grab sample concentrations of radon (Rn-222) daughters (RDC) and thoron (Rn-220) daughters (TDC). These radon daughter and thoron daughter measurements are used to evaluate personnel protection requirements for workers assigned to areas suspected or known to have elevated RDC and TDC, and/or to determine when further sampling with continuous radon daughter monitors may be required. The samples are intended to be representative area samples with results calculated in working level (WL).

2.0 SCOPE

This procedure shall be followed to determine (via grab sampling) both radon daughter and thoron daughter determinations when either radon or thoron gas are suspected to be present. Measurements performed using this procedure are intended to be grab (5 minute) samples representative of the general area in which they were collected.

3.0 REFERENCES

Ref. 1: Rock, R.L., "Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters", Mining Enforcement and Safety Administration, U.S. DOI, Informational Report 1015, 1975.

Ref. 2: Kusnetz, H.L., 1956, "Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations", Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87.

U.S. Department of Labor Mine Safety and Health Administration, Radiation Monitoring, 1979.

4.0 EQUIPMENT and MATERIALS

- Low Volume Air Sampler.
- Mixed cellulose ester filter, 0.4-0.8 micron pore size, filter backing, and envelope.
- Alpha Probe
- Scaler
- Timepiece.
- Mass flow meter or calibrated rotameter.

5.0 PROCEDURE

5.1 Sample Collection

5.1.1 Pre-Sampling Preparation

Prior to sampling, the availability of counting equipment should be determined since the filter must be counted for a 5 minute interval between 40 minutes and 90 minutes after sample collection. Additionally, the same filter must be recounted between 5 hours and 17 hours after collection.

5.1.2 Sampler Location and Flow Rates

The location of the sample shall be representative of the general area that will be evaluated. The air sampler shall be placed approximately 1 meter above the ground. Set the sampler flow rate between 10 liters and 30 liters per minute (1pm).

NOTE: *The determination of RDC and TDC using the same filter requires a sample time of 5 minutes for accurate RDC and at least 50 liters collected for accurate TDC. This requires, at a minimum, a sample flow rate of 10 1pm.*

5.1.3 Sampling Set-up

Mount a clean filter on the air sampler and set the flow rate using a mass flow meter or calibrated rotameter. Record all data pertaining to sample location on the Radon and Thoron Daughter Concentration Determination Form (see Exhibit 1) and the envelope. A sample shall be collected for 5 minutes with no more than 5 seconds uncertainty. A timepiece with the capability of measuring to the nearest second shall be used to determine sample collection time.

5.1.4 Post Sampling Processing

After sample collection, place the filter in an envelope for protection, and record the sample interval, ending time, date, flow rate, and any other pertinent information regarding sample identification, as appropriate, on the Radon and Thoron Daughter Concentration Determination Form and the envelope.

5.2 Analysis

Perform a 5 minute sample count at any time between 40 minutes and 90 minutes after sample collection. Reanalyze the sample using the same detector at any time between 5 hours and 17 hours after sample collection by performing a minimum 15 minute sample count. Look up the appropriate RDC and TDC correction factors for the counting delay times from the graphs displayed on the Radon and Thoron Daughter Concentration Determination Form and record these values. Record the counting results, counting times, detector efficiency, and detector background count rate on the Radon and Thoron Daughter Concentration Determination Form. If the filter gets wet, it must be dried before counting.

5.3 Calculations

5.3.1 Thoron Daughter Concentration Calculation

The TDC is calculated using the count taken during the 5 hour to 17 hour delay period and the following equation (from Ref. 1, p. 13):

$$TDC\,(WL) = \frac{\dfrac{Sample\ Counts}{Sample\ Count\ Time^{*}} - Detector\ Bkg.Count\ Rate}{(Detector\ Eff.)(Volume, liters)(Factor\ 1)^{**}}$$

5.3.2 Radon Daughter Concentration Calculation

Use the calculated TDC WL and the calculated volume to adjust the RDC count (count after 40 minutes-90 minutes delay) according to the following equation (from Ref. 1, p. 13):

$$RDC(dpm/liter) = \frac{\dfrac{Sample\ Counts}{Sample\ Count\ Time^{*}} - Detector\ Bkg.Count\ Rate}{(Detector\ Eff.)(Volume, liters)} - (TDC(WL))\ x\ 16.5$$

The RDC is calculated using the following equation (from Ref. 1, p. 13):

$$RDC\,(WL) = \frac{RDC\ \ (dpm/liter)}{Factor\ 2^{**}}$$

*Time in minutes

**Correction Factors 1 and 2 are interpolated from the appropriate graphs derived on the Radon and Thoron Daughter Concentration Determination Form.

5.4 Reviewing Calculations

After the Radon and Thoron Daughter Concentration Determination Form has been completed in full, it shall be checked by someone other than the person performing the original calculation. The computational check shall be signed or initialled and dated by the reviewer.

6.0 RECORDS

6.1 **Quality Assurance Record**s

The Radon and Thoron Daughter Concentration Determination is a permanent quality assurance record generated by this procedure.

RADON AND THORON DAUGHTER CONCENTRATION DETERMINATION

AREA_____ SURVEYOR_____ DATE_____
DETECTOR_____ SCALER_____ PUMP ID. #_____
DETECTOR SERIAL #_____ SCALER SERIAL #_____ FLOW RATE_____
DETECTOR CAL. DUE._____ SCALER CAL. DUE_____ FLOW METER ID._____
DETECTOR EFF._____ FLOW METER CAL. DUE_____
DETECTOR BKG._____

Count Number	Start Time	Stop Time	Total Time (min.)	Flow Rate (SLPM)	Total Vol. (liters)	Gross Counts	Count Time (min)	TAS* (hr/min)	Graph Factor	TDC (WL)1	RDC (WL)2
1										N/A	
2	N/A	N/A	N/A	N/A	N/A						N/A

*TAS=Time After Sampling (hr/min)

$$TDC(WL) = \frac{\frac{\#2\ Gross\ Counts}{\#2\ Count\ Time} - \text{Det. } Bkg.\ Count\ Rate}{(Eff.)(Factor\ 1)(Total\ Volume, l)}$$

$$RDC(dpm/l) = \frac{\frac{\#1\ Gross\ Counts}{\#1\ Count\ Time} - \text{Det. } Bkg.\ Count\ Rate}{(Eff.)(Total\ Volume, l)} - (TDC(WL))\ x\ 16.5$$

$$RDC(WL) = \frac{RDC(dpm/l)}{Factor\ \ 2}$$

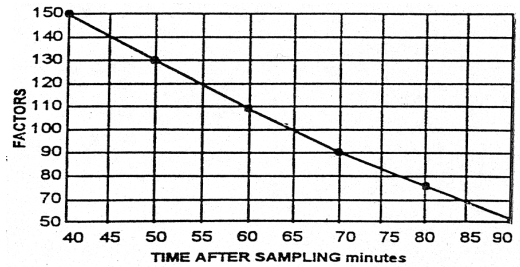

Figure 1 Factor 1 (TDC)

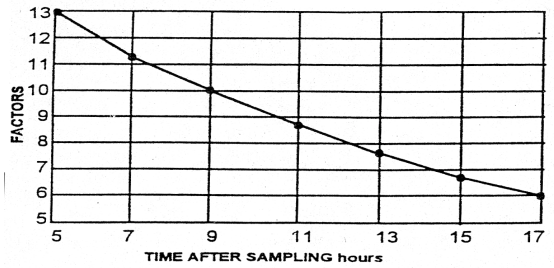

Figure 2 Factor 2 (RDC)

COMMENTS:

CHECKED BY:_____ DATE:_____

Appendix VII:
Radiological Work Permit (RWP)

1. An RWP must be completed the Site Safety and Health Officer (SSHO) whenever a work task requires use of personal protective equipment (PPE) for radiological protective purposes, or personnel and/or equipment contamination survey for exit from radioactive material areas.

2. The SSHO will determine if an RWP is required based on the work task.

3. The SSHO will complete all applicable sections of the RWP.

4. The SSHO will ensure that PPE requirements are consistent with those in the Safety and Health Plan.

5. The SSHO will issue copies of applicable RWPs as needed and will review RWP requirements with the affected workers.

Form Completion:

The RWP form is divided into the following 9 major sections:

1. Contamination Present - this section provides information on potential contamination for the work activity.

2. Air Monitoring - this section provides information on air sampling requirements for the work activity.

3. Dosimetry – this section specifies personnel dosimetry requirements (i.e. personal TLD and bioassay requirements)

4. Contamination Monitoring – this section specifies both worker and material/equipment contamination monitoring requirements.

5. Personal Protective Clothing and Equipment (PPE) - this section provides information on the PPE requirements associated with the work task(s).

6. Doffing Sequence - this section provides information on the required steps and sequence for PPE removal.

7. Training Required for Entry - this section denotes the level of training required to perform the work. Training can include Radiation Worker, OSHA HAZWOPER, and site-specific training.

8. Additional Control Measures - this section provides information on any special instructions, or circumstances requiring work activities to cease.

9. Approvals - this section shall be signed and dated by the SSHO. The SSHO shall also complete the Issue and Expiration Dates.

RADIOLOGICAL WORK PERMIT

Niagara Falls Storage Site Lewiston, New York

Location:	Work Activity:	Issue Date:	Expiration Date:
Contamination Present:	Air Monitoring:	Dosimetry:	Contamination Monitoring:
PPE Required:	Doffing Sequence:	Training:	Additional Controls:
Approval:	Date:		