January 27, 2005

SUBJECT: Information abstracted from NRC Inspection Reports for the Dresden Generation Station, Units 2 and 3, involving the unanticipated release of tritium and/or radioactive contaminants from the Dresden, Braidwood, and LaSalle Stations since 1990.

List of Materials.

1. Routine Radiological Controls Inspection at Dresden, dated 1993.

2. Notice of Violation (NRC Inspection Report Nos. 10/94008; 237/94008; 249/94008), dated June 20, 1994.

3. Notice of Violation (NRC Inspection Report Nos. 50-010/94014; 50-237/94014; 50-249/94014), dated August 24, 1994.

4. Notice of Violation (NRC Inspection Report Nos. 50-010/94015; 50-237/94015; 50-249/94015), dated October 27, 1994.

5. NRC Radiation Protection Inspection Reports 50-237/98004(DRS); 50-249/98004(DRS), dated February 5, 1998.

6. Circ Water Blowdown Line Vacuum Breaker failure due to low stress, high cycle fatigue, resulting in flooding of Owner Controlled property and discharge outside of NPDES approved path, dated December 5, 2000. (Braidwood Nuclear Power Station)

7. Braidwood Nuclear Station Discharge Pipe Vacuum Beaker Leak Dose Assessment, Rev.1, dated February 19, 2001.

8. Questions from Senator Durbin's Staff Regarding the Dresden Station Tritium Leak. (An email correspondence between the NRC and Senator Durbin's staff regarding a 2004 tritium leak at Dresden)

Attachment 6

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016

Inspection 93-016

Docket No. 50-237
Docket No. 50-249

Commonwealth Edison Company
ATTN: Mr. L. O. DelGeorge, Vice President
Nuclear Oversight and
Regulatory Services
Executive Towers West III
1400 Opus Place, Suite 300
Downers Grove, IL 60515

Dear Mr. DelGeorge:

SUBJECT: ROUTINE RADIOLOGICAL CONTROLS INSPECTION AT DRESDEN

This refers to the routine safety inspection conducted by Messrs. N. Shah and S. K. Orth of this office on May 3 - 7, 1993. The inspection included a review of authorized activities for your Dresden Nuclear Station, Units 2 and 3. At the conclusion of the inspection, the findings were discussed with those members of your staff identified in the enclosed report.

Areas examined during the inspection are identified in the report. Within these areas, the inspection consisted of a selective examination of procedures and representative records, observations, and interviews with personnel.

No violations or deviations were identified during this inspection.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosed inspection report will be placed in the NRC Public Document Room.

We will gladly discuss any questions you have concerning this inspection.

Sincerely,

M. C. Schumacher, Chief
Radiological Controls Section 1

Enclosure: Inspection Reports
No. 50-237/93016(DRSS);
No. 50-249/93016(DRSS)

See Attached Distribution

10. Corrosion in Radwaste Storage Tanks (IP 84750)

In two separate events in September 1992, the licensee observed water leaking from the "B" WST and the Unit 2/3 "B" Condensate Storage Tank (CST) which are both in the protected area. The "B" WST leaked in a pipe tunnel that drained to the plant liquid radwaste system. The CST leaked into soil at the perimeter of the tank. Upon discovery, the licensee began to collect and route the leak to the plant radwaste system. Company metallurgists concluded that the leaks were caused by galvanic corrosion of the aluminum tank bottoms. The licensee replaced the bottoms and is planning to drain and inspect the rest of the onsite storage tanks by the end of 1993.

The event was described in the July-December 1992 Semi-Annual Effluent Report where it was estimated that approximately one microcurie total activity, excepting tritium, was released from the tank in 270 gallons of water. Tritium release was estimated at about one millicurie based on the average concentration in radwaste discharges. The licensee's offsite dose calculation indicated no impact from this release on down river water users. Tritium activity in the nearest well was basically unchanged from previous years and were at or slightly above the licensee's lower limit of detection (200 pCi/liter).

Although samples of the affected soil were surveyed with a pancake GM detector in a low background area and no activity above background was detected, no isotopic analysis was performed. The samples were returned to the ground. The need to analyze soil samples in such events was discussed at the exit interview and in a telephone discussion on May 21, 1993. The inspectors also pointed out that information regarding such events must be kept in an identified location for ready retrieval at the time of site decommissioning. Licensee representatives stated that soil samples would be isotopically analyzed and that their decommissioning file would be reviewed to ensure its adequacy. Licensee progress on these matters will be reviewed in future inspections (IFIs 50-237/93010-02; 50-249/93016-02).

No violations or deviations were identified.

11. Exit Meeting

The inspectors met with licensee representatives (section 1) at the conclusion of the inspection on May 7, 1993, to discuss the scope and findings of the inspection. No documents were identified as proprietary by the licensee, and no violations were identified during this inspection. The following matters were specifically discussed by the inspectors:

- Misaligned filter paper in Unit 1 Chimney SPING (section 2)
- Procedural deficiencies (sections 4 and 9)

Dresden
9/2

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NUCLEAR REGULATORY COMMISSION
REGION III
801 WARRENVILLE ROAD
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JUN 20 1994

Docket Nos. 50-10; 50-237; 50-249
License Nos. DPR-2; DPR-19; DPR-25

Commonwealth Edison Company
ATTN: Mr. M. Lyster
Site Vice President
Dresden Station
6500 North Dresden Road
Morris, IL 60450

Dear Mr. Lyster:

SUBJECT: NOTICE OF VIOLATION (NRC INSPECTION REPORT NOS. 10/94008; 237/94008; 249/94008)

This refers to the inspection conducted by M. Leach, C. Phillips, D. Chyu, M. Kunowski, E. Plettner, J. Smith, and T. Taylor of this office, and by C. Settles of the Illinois Department of Nuclear Safety, on April 12 through May 25, 1994. The inspection included a review of activities authorized for your Dresden Nuclear Station, Units 1, 2, and 3, facility. At the conclusion of the inspection, the findings were discussed with Mr. S. Perry and those members of your staff identified in the enclosed report.

Areas examined during the inspection are identified in the report. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observation of activities in progress. The purpose of the inspection was to determine whether activities authorized by the license were conducted safely and in accordance with NRC requirements.

Based on the results of this inspection, certain of your activities appeared to be in violation of NRC requirements, as specified in the enclosed Notice of Violation (Notice). The violations are of concern because there were multiple examples of inadequate procedures and failure to follow procedures which were identified by the NRC. Good procedural guidance and adherence to procedures are essential to safe operation.

We are also concerned about the inordinately high number of personnel contamination events, a problem that also occurred in 1993 during the Unit 2 refueling outage. To date in 1994, the station has recorded almost 3000 such events. Our review during the current inspection identified a lack of strong upper management focus on this problem. We do not believe that the problem can be solved through the efforts of only your radiation protection and station laborer groups. In addition to your response to the Notice of Violation, please provide us with a description of your plans to address this problem and a schedule of expected completion dates.

The persistence of the contamination control problem represented a weakness. The licensee's actions to resolve this problem will be reviewed as an Inspector Follow-up Item during subsequent inspections (50-010/237/249-94008-05(DRSS)).

e. Unit 1

On May 8, 1994, the licensee discovered water issuing from the ground near an outdoor wall of the Unit 1 decant building. The source of the water was determined to be the Unit 1 contaminated demineralized water storage tank. The jockey pump for the storage tank piping had been put back into service about 28 hours earlier on May 7. The pump was secured and the section of underground pipe (which had a 3/8 inches hole in the pipewall from corrosion) through which the water had leaked was replaced. An estimated 50,000 gallons of slightly contaminated water had leaked to the ground and into the storm sewer system before the pump was secured. Although the concentration of radioactive material in the water was below the 10 CFR 20 release limits, the leak apparently should have been identified and stopped earlier. Radwaste shiftly rounds identified a decrease in the tank level on May 7; however, no actions were taken by radwaste supervision. The licensee assembled a team to investigate the cause of the failure, evaluate staff performance related to the event, and assess the confidence level in the use of other similar underground pipes. The results of that investigation will be reviewed during a future inspection as Inspector Follow-up Item (50-010/237/249-94008-06(DRSS)).

On May 10, the licensee drilled four 50-foot deep wells on the south and east sides of the Unit 1 fuel storage building. These wells were drilled in response to an NRC concern about the potential leakage from the unlined spent fuel pool (Inspection Report 50-010/94009(DRSS)). Gamma isotopic analyses of water from the wells identified only naturally occurring radioactive materials, and no Co-60 or Cs-137, both of which were present in the pool. Analyses of the samples identified elevated levels of tritium. The tritium levels ranged from 2,172 picoCuries/liter (p/Ci) (80 Becquerels/l (Bq/l)) to 51,368 pCi/l (1,900 Bq/l), with the higher values found in the two wells on the east side of the building (in the direction of groundwater flow). Independent analyses of well water samples by the NRC Region III laboratory yielded similar results. The presence of tritium strongly suggested that the pool was leaking. The absence of Co-60 and Cs-137, and the need for makeup to the pool consistent with evaporative losses suggested that the leak was small. The levels found in the wells were a small fraction of the tritium concentration in the pool, about 2.8 million pCi/l (103,600 Bq/l). The offsite dose consequence of the leak of tritium was negligible. On May 26, two hydrology specialists from the NRC visited the site to review the monitoring wells. The results of that review will be documented in a separate report.

No violations or deviation were identified. Two inspector follow-up items were identified regarding contamination control and licensee investigation of Unit 1 spill.

7. Licensee Actions on Previous Inspection Findings (92701, and 92702)

(Closed) Violation (50-237/93032-02 (DRSS); 50-249/93032-02 (DRSS)): Three instances of workers not wearing required dosimeters. Counseling and disciplining of the involved workers and training of other workers were completed. The inspectors had not identified a recurrence of the problem. This item is closed.

/237/

(Closed) Unresolved Item (50-249/94005-04 (DRP)): Poor work request documentation. This item is discussed in detail in paragraph 4.c. The inspectors' findings resulted in a non-cited violation. This item is closed.

(Closed) Inspector Follow-up Item (50-237/93022-01 (DRSS) 50-249/93022-01 (DRSS)): Contamination control problem. As discussed in paragraph 6.d, the licensee's efforts were not successful. This item is closed.

(Closed) Inspector Follow-up Item (50-249/94005-01 (DRP)): Moving fuel in three directions simultaneously. The licensee's evaluation was thorough and the decision to maintain the practice of moving fuel in three directions simultaneously was given considerable thought. The inspectors had no further concerns. This item is closed.

No deviations or violations were identified.

8. Licensee Event Reports (LERs) Follow-up (92700)

Through direct observations, discussions with licensee personnel, and review of records, the following event reports were reviewed to determine that reportability requirements were fulfilled, immediate corrective action was accomplished, and corrective action to prevent recurrence had been accomplished in accordance with technical specifications.

(Closed) LER 237/93009, Revision 0: High pressure coolant injection (HPCI) steam piping found outside the Dresden Final Safety Analysis Report design limits due to absence of grout in the HPCI steam line floor penetration. The inspectors reviewed nuclear work request (NWR) D16705 to verify addition of the grout around the floor drain. The inspectors had no further concerns. This LER is closed.

(Closed) LER 237/93016, Revision 0: HPCI declared inoperable due to turning gear failure. The inspectors reviewed Dresden Electrical Surveillance (DES) 2300-02, "HPCI Turning Gear Preventive Maintenance" to verify inclusion of the appropriate steps to prevent recurrence. In addition, NWR D10290 for Unit 2 and NWR D19335 for Unit 3 were reviewed

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AUG 24 1994

Docket Nos. 50-10; 50-237; 50-249
License Nos. DPR-2; DPR-19; DPR-25

Commonwealth Edison Company
ATTN: Mr. J. Stephen Perry
Vice President BWR Operations
Dresden Station
6500 North Dresden Road
Morris, IL 60450

SUBJECT: NOTICE OF VIOLATION (NRC INSPECTION REPORT NOS. 50-010/94014; 50-237/94014; 50-249/94014)

Dear Mr. Perry:

Enclosed are the results of our inspection conducted by M. Leach and others of this office, and by C. Settles of the Illinois Department of Nuclear Safety, on July 5 through August 15, 1994. The inspectors reviewed activities authorized for your Dresden Nuclear Station, Units 1, 2, and 3. At the conclusion of the inspection, the inspectors discussed their findings with members of your staff.

The areas examined during the inspection are identified in the report. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observation of activities in progress. The purpose of the inspection was to determine whether activities authorized by your licenses were conducted safely and in accordance with NRC requirements.

Overall, we found that the conduct of activities during this period were adequate. However, your performance remains weak in several areas including: conduct of operations, the performance of your high pressure coolant injection (HPCI) system, and radiological work practices. In addition, several violations of NRC requirements were identified regarding the following:

- failure to implement proper test controls,
- two examples of failure to follow procedures (unauthorized temporary alterations and radiation protection),
- failure to submit a licensee event report for a failed local leak rate test, and
- failure to perform a 10 CFR 50, Appendix J, Type B test on a check valve hinge pin flange.

limits were approached; however, the intakes were unplanned and apparently could have been prevented. Review of the licensee's investigation is an Inspector Follow-up Item (50-237/249-94014-11(DRSS)).

4.1.3 Radiation Worker Practices and Updated Survey Maps

On August 8 inspectors observed two laborers exit the RPA of the Unit 2 high radiation sampling system building several times without a proper survey. The survey was required by the workers' radiation work permit (RWP) and the workers were required by Dresden Administrative Procedure DAP 12-25, "Radiation Work Permit Program," to follow the RWP. 10 CFR 50, Appendix B, Criterion V, required that activities affecting quality shall be accomplished in accordance with procedures. Failure to follow the RWP is another example of Violation (50-237/249-94014-07b(DRSS)). In addition, the inspectors noted a discrepancy between the postings of the condensate storage tanks and high radiation sampling system work areas. The licensee corrected the discrepancy.

In addition, the inspectors observed several other poor practices. These included workers inappropriately leaning into RPAs, workers depositing used protective clothing and trash on the floor of the Unit 1 turbine building machine shop area, and the use of a bag intended for storage of radioactive material as a makeshift deflector for the exhaust of a small air conditioning unit. These items were discussed with radiation protection department management who indicated actions to rectify the problems would be taken. The inspectors also observed that several survey maps posted on the board for workers to review prior to entering various RPAs had not been updated to reflect current conditions. For example, the posted survey of the Unit 2 517-foot elevation did not show that the drywell hatch was opened and a contaminated area zone had been established at the entrance, and the posted survey for the Unit 3 high pressure coolant injection room did not show that a contaminated area zone had been established at the entrance to that room. The licensee was to evaluate the survey posting practices to ensure that current information was available to the workers. This is an Inspector Follow-up Item (50-237/249-94014-12(DRSS)) pending review of the licensee's corrective actions.

4.1.4 Tritium in Storm Sewers

On July 12 the licensee reported to the NRC that recent water samples of storm sewers near the Units 2/3 condensate storage tanks (CST) contained elevated levels of tritium. The highest level was approximately 465,000 picocuries/liter (17.2 x 10^6 Becquerels). The sampling was conducted as part of an ongoing project to characterize groundwater flow at the site and estimate the amount of leakage from the Unit 1 spent fuel pool (Inspection Report No. 50-237/249-94008). The licensee subsequently identified the "A" CST as a possible source of the tritium and began work to replace the tank bottom. The inspectors noted several other tanks and pipes containing radioactive material leaked or were found to have corrosion (Inspection Report No. 50-237/249-93016(DRSS)) including:

the "B" CST and the "B" waste sample tank which were repaired late in 1992-early 1993, and an outdoor, underground pipe of the Unit 1 contaminated demineralized water system (Inspection Report No. 50-010/237/249-94008), which was repaired in mid-1994 and subsequently abandoned in place. The licensee anticipated the completion of an ongoing cathodic protection modification would reduce such corrosion. Review of the licensee's evaluation of the groundwater and sewer water tritium is an ongoing Inspector Follow-up Item (50-010/237/249-94011-08(DRSS)). To date, no regulatory limits for discharge of tritium to the unrestricted area have been exceeded.

4.1.5 Radiation Protection Department Staffing

During the outage, the inspectors noted that the radiation protection department had a vacant senior manager position and several vacant health physicist positions. These vacancies exacerbated the impact on the radiation protection department of a heavy outage work load and of issues related to the operating Unit 2 and the shutdown Unit 3.

4.2 Security

During the inspection period, the inspectors monitored the licensee's security program to ensure that observed actions were being implemented according to the approved security plan.

4.2.1 Incore Detectors Found in Unit 1 Equipment Storage Room

On July 14 the licensee found several bags containing twenty incore detectors stored in an equipment room in the Unit 1 containment. The detectors were purchased before 1979 and were never used. The licensee was unaware of the detectors; therefore, the licensee did not account for these detectors in the special nuclear material inventory program. The licensee immediately initiated corrective action which included searching for more material and properly processing the found material. Review of the licensee's root cause investigation and corrective actions is an Inspector Follow-up Item (50-010/94014-13(DRSS)).

4.3 Emergency Preparedness and Fire Protection

The inspectors verified the operational readiness of the control room, technical support center, and operation support center. Non-routine events were reviewed to insure proper classification and appropriate emergency management involvement. These events are discussed in paragraph 1.2.

4.3.1 Operations Support Center Readiness During Pre-exercise Drill

The inspectors observed the licensee's pre-exercise drill on July 13 to evaluate the readiness of the Operations Support Center (OSC). The condition of the OSC was acceptable. Communication at the beginning of the drill was difficult and at times impossible due to severe static in the phone lines. Poor communications later resulted in an operator

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UNITED STATES
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801 WARRENVILLE ROAD
LISLE, ILLINOIS 60532-4351

October 27, 1994

Commonwealth Edison Company
ATTN: Mr. J. Stephen Perry
Vice President BWR Operations
Dresden Station
6500 North Dresden Road
Morris, IL 60450

SUBJECT: NOTICE OF VIOLATION (NRC INSPECTION REPORT NOS. 50-010/94015; 50-237/94015; 50-249/94015)

Dear Mr. Perry:

Enclosed are the results of our inspection conducted by M. Leach and others of this office, and by C. Settles of the Illinois Department of Nuclear Safety, on August 16 through October 5, 1994. The inspectors reviewed activities authorized for your Dresden Nuclear Station, Units 1, 2, and 3. At the conclusion of the inspection, the inspectors discussed their findings with members of your staff.

The areas examined during the inspection are identified in the report. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observation of activities in progress. The purpose of the inspection was to determine whether activities authorized by your licenses were conducted safely and in accordance with NRC requirements.

Overall, we found the conduct of activities during this period were adequate. We are encouraged by the increased management involvement in daily plant activities and will evaluate the effectiveness in future inspections. However, during this period, several of your activities were violations of NRC requirements or deviations from previous commitments. In general, these discrepancies involved identification and resolution of past engineering decisions; weak communication and coordination; and inadequate system configuration control. The details of the violations, deviations, and non-cited violations are discussed in the enclosed Notices and inspection report.

With regard to the identification and resolution of past engineering decisions, numerous issues emerged including failure to control design changes for motor control centers, inoperable check valve due to a known failure mechanism, and pipe stresses exceeding the American Society of Mechanical Engineers code allowable stress values. Although your staff implemented actions to resolve each specific issue, we are concerned by the potential for other similar conditions and their cumulative effect on plant safety. We request you evaluate these and other examples and determine if any appropriate actions are warranted. Please respond within 60 days to this request with your observations and strategies to this concern.

given little time to plan and implement the unitization of the department once the decision to do so was announced. The functioning of the re-organized RP department will continue to be reviewed during future inspections.

4.1.5 Tritium in Storm Sewers and Site Cathodic Protection

As discussed in Inspection Report 50-010/237/249-94014, the licensee identified leaks in outdoor storage tanks and underground pipes, some containing radioactive liquid. The most recent problem, with the "A" condensate storage tank (CST), was resolved by replacing the tank bottom. In the fall of 1993, as part of the review of the leak problem in general, the licensee determined that the existing (distributed or shallow anode) cathodic protection system was degraded. A new system was recently installed, consisting of anodes in 9 deep wells. In addition, a system engineer was assigned, a position previously not filled by onsite personnel. The new cathodic protection system was expected to reduce the corrosion of components in contact with the ground.

Following the "A" CST repair, tritium continued to be identified in water samples from storm sewers in the vicinity of the tank, indicating another source of the tritium. Two pits were subsequently excavated near the tank to allow examination of associated underground pipes. Samples of water that seeped into the pits showed the tritium concentrations in the west pit as high as 800,000 picocuries/liters (29.6 x 10^6 Becquerels (Bqs)/l) and in the east pit as high as 19,000 picocuries/liters (0.7 x 10^6 Bqs/l). The licensee suspected that the tritium source in the west pit was possibly the 18" HPCI test return line. On October 3 the licensee began pumping water from the east pit to a storm sewer that discharged to the Unit 2/3 discharge canal, upstream of the normal liquid radwaste discharge point. Pumping was necessary because water seepage into the pit prevented examination of the pipes for leaks. Periodic grab samples were taken and analyzed by the licensee for tritium and gamma-emitting isotopes because the storm sewer was not monitored. The licensee's calculations showed the offsite dose from the tritium in this water would be well below regulatory limits. This is considered an Inspection Followup Item 50-237/249-94015-07(DRSS)) pending further review of the licensee's 10 CFR 50.59 evaluation of the release of the water through the storm sewer.

4.1.6 Unit 1 Activities

On August 31 an operator identified a level decrease of about 1.5" in the Unit 1 spent fuel and transfer pools. An investigation was initiated to determine the cause of the decrease, including a walkdown of the accessible areas of the Unit 1 sphere to look for leaks. The licensee concluded that the decrease resulted from a resin transfer from the pools' temporary demineralizer system to a radwaste liner (the resin was being changed because of a microbiological growth problem in the pool). About 1000 gallons of pool water was used in this transfer. The workers transferring the resin failed to communicate to the operations staff the effect the transfer would have on pool level. The licensee took actions to ensure future evolutions involving the pool would be communicated to ondfs

February 5, 1998

Mr. Oliver D. Kingsley
President, Nuclear Generation Group
Commonwealth Edison Company
ATTN: Regulatory Services
Executive Towers West III
1400 Opus Place, Suite 500
Downers Grove, IL 60515

SUBJECT: NRC RADIATION PROTECTION INSPECTION REPORTS 50-237/98004(DRS); 50-249/98004(DRS)

Dear Mr. Kingsley

On January 21, 1998, the NRC completed an inspection at your Dresden Generating Station, Units 2 and 3. The results of the inspection were discussed with Mr. Larry Aldrich and other members of your staff on January 21, 1998. The enclosed report presents the results of this inspection.

The purpose of the inspection was to review the unconditional material release program, and the effectiveness of the actions taken on previous open items and violations.

Overall, the unconditional material release program was comprehensive, technically sound and well implemented. Actions taken to prevent recurrence of previously identified violations, inspection follow-up items, and licensee event report items appeared effective.

No violations of NRC requirements were identified during the course of this inspection.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be placed in the NRC Public Document Room.

R8.3 (Closed) LER No. 94-025-00: Inadvertent placement of the Units 2/3 main chimney monitor (SPING) into the flush mode by a chemistry technician during a routine sample change. The problem could not be immediately corrected so operations switched to the backup (GE) monitoring system. However, when operations switched over they discovered difficulties in placing the GE system into service because of deficiencies and ambiguities in the operation procedure DOP 1700-11, and chemistry procedure DCP 2213-01. To correct this problem the licensee revised procedure DCP 2213-01 to include in the checklist an initialed step and verification that the SPING was found operable before changing the samples. In addition, operation procedure DOP 1700-11 was enhanced to provide clear instructions on the method for switching systems following flow oscillations. The inspector reviewed these revisions and noted they had been accomplished.

R8.4 (Closed) Violation 50-237/96009-10; 50-249/96009-10: Failure to perform an adequate survey to assure compliance with 10 CFR 20.1201(a)(1)(I) which limits radiation exposure to the Total Effective Dose Equivalent of 5 rems per year. The licensee failed to properly evaluate the potential radiological hazards, and use process or other engineering controls to control airborne radioactivity concentrations during the removal and transfer of contaminated bags of radioactive material. The corrective actions to prevent recurrence included revision of procedure DAP 12-09 to require a radiation protection shift supervisor at prejob briefings for work identified as high risk, reiteration of expectations to radiation protection technicians regarding the necessity of the duty supervisor to be informed of all work activities and job scope changes, presented a training course to radiation protection technicians entitled "Conservative Decision Making", and discussed this event, radiation work permits, and expectations concerning survey requirements.

R8.5 (Closed) IFI 50-237/94-015-07; 50-249-94015-07: Evaluation of water with tritium concentrations released through the station storm sewer system. On October 3, 1993, the licensee pumped contaminated water (tritium) to a storm sewer that discharged into the Unit 2/3 discharge canal. Periodic grab samples were taken and analyzed by the licensee for tritium and gamma-emitting isotopes because the storm sewer was not monitored, nor was it the normal handling system for discharge. Sample analysis indicated that offsite dose to the public was well below regulatory limits. In accordance with technical specification requirements, the licensee issued an LER for this event because the liquid radioactive waste was not processed through the normal waste handling system. The discharge was incorporated into the Station Semi-Annual Effluent Report for the period of July-December, 1994. In the thirty day report issued to the NRC, dated December 9, 1994, the licensee listed actions taken to prevent recurrence of this type release. The inspector reviewed the actions and concluded they were implemented.

V. Management Meetings

X1 Exit Meeting Summary

On January 21, 1998, the inspector presented the preliminary inspection results to licensee management. The licensee acknowledged the findings presented at the exit meeting.

The licensee did not identify any information discussed as proprietary.

TITLE: Circ Water Blowdown Line Vacuum Breaker failure due to low stress, high cycle fatigue, resulting in flooding of Owner Controlled property and discharge outside of NPDES approved path.

UNIT: Braidwood Station Unit Common

EVENT DATE: 11/06/2000
EVENT TIME: 14:30

REPORT NUMBER: AT # 38237 / CR # A2000-04281
REPORT DATE: 12/05/00
REVISION: 2

INVESTIGATORS: Mike Riegel (Team Lead), Paul Uremovic (Qualified Root Cause Investigator), Luis Rhoden, Kimberly Aleshire, Joe Tidmore, and Harry King

ABSTRACT:

On 11/06/00, Circ Water Blowdown Vacuum Breaker, 0CW136, was discovered leaking following a report from a local resident of water in a ditch adjacent to his property. The vacuum breaker had been leaking for several days. It is estimated that as much as 3 million gallons of water may have leaked from the failed valve. Since multiple radwaste releases may have been made while the valve was leaking some slightly radioactively contaminated water was discharged to site property and to a ditch immediately adjacent to site property. No Offsite Dose Calculation Manual (ODCM) or National Pollutant Discharge Elimination System (NPDES) limits were exceeded; therefore the event is not reportable.

The leaking valve was replaced and as much of the spilled water as possible was pumped back into the CW Blowdown piping. A root cause investigation was conducted to determine factors that contributed to the failure of the valve and subsequent release of water. Analytical techniques employed in performing the root cause investigation included Failure Modes and Effects Analysis, Barrier Analysis, Event and Causal Factor Charting and interviewing.

The vacuum breaker valve failed due to low stress high cycle fatigue. This valve had been in service since initial construction. Root causes for the valve failure were lack of an adequate preventive maintenance program for the vacuum breaker valves and an inappropriate configuration (lack of internal surge protection) of the currently installed vacuum breaker valves. Additionally, system operating methodology is a significant contributing factor in that the operating procedure allows reinitiating blowdown flow following short duration shutdowns by using the motor operator on the isolation valves. Opening the valves using the motor operator rapidly establishes full flow and causes significant pressure surges since the piping will be depressurized and partially drained.

The failure mechanism and root causes would be applicable to all vacuum breaker valves in the Circ Water Blowdown and Makeup (M/U) systems. Similar systems are installed at Byron and LaSalle stations. However, Byron uses a different type valve.

Corrective Actions include implementing adequate preventive maintenance programs, replacing the valves and revising the operating procedure to prevent power opening of the isolation valves to establish blowdown flow.

CONDITION STATEMENT:

The float assembly for the Circ Water Blowdown Vacuum Breaker, 0CW136, experienced fatigue failure due to impact loading from excessive operating cycles and inadequate preventive maintenance. The failure of the float assembly resulted in the unapproved discharge of some slightly radioactively contaminated water to Site property and to the south side ditch of Smiley Road immediately adjacent to Site property. Levels were up to 8.9E-7 Co-58, 2.3E-7 Co-60, 1.4E-7 Mn-54, and 8.1E-7 Te-123m (all µCi/g). Particulate activity was all contained within 50 meters of the failed vacuum breaker vault on Site property and was well within designated pathway release limits. Detailed radioactivity sample results and Lower Limits of Detection (LLD) are provided in Attachment 6. Activity found off site property was limited to Tritium in the water contained in the ditch along Smiley road. Tritium activity was all within designated pathway release limits, but slightly in excess of unrestricted drinking water limits. To the maximum extent feasible, all water was pumped back into the CW Blowdown line.

EVENT DESCRIPTION:
(Refer to detailed timeline (Attachment 1) for additional information.)

At approximately 14:30 on 11/6/00, the National Pollutant Discharge Elimination System (NPDES) Coordinator received a call from Illinois Environmental Protection Agency (IEPA) regarding standing water in a ditch adjacent to Site property along the south side of Smiley Road. An area resident had reported the water and noted that the water was present in the ditch for approximately 7-10 days prior to IEPA notification. Suspecting that a faulty vacuum breaker on either the Circ Water M/U or Blowdown System was the source of the water, the NPDES Coordinator notified the Shift Manager and OCC Director of the IEPA notification.

The NPDES Coordinator walked down the Circ Water Blowdown system at approximately 15:00 and identified that the water was coming from a valve vault that houses the 0CW135/6 vacuum breaker/isolation valve assembly. The NPDES Coordinator assessed the site and concluded that the water was confined to Site property and the ditch along the south side of Smiley Road immediately adjacent to Site property.
The water in the ditch was confined by the resident's driveway to the west and by higher elevation to the east. The total length of ditch containing water was approximately 600 – 800 feet, and the total volume in the ditch was later estimated to be approximately 80,000 gallons.

The NPDES Coordinator notified the IEPA of his findings regarding the water source and the boundaries of the discharge. Station NPDES monitoring requirements were discussed and the IEPA concluded that no additional sampling was required and that there were no NPDES concerns since the water was contained and not discharging to Waters of the State.

Between 16:00 -17:00, a meeting was held with senior station management, the Shift manager and the OCC staff. The NPDES coordinator briefed the attendees on the results of his field observations of the area surrounding the vacuum breaker valve. Station management was also briefed on the discussions between the NPDES coordinator and the IEPA. Senior management directed the following actions be taken:

1. Operating personnel were to evaluate water inventories and to explore potential alternate release options.
2. Isolate the CW Blowdown System
3. Make preparations to take the CW blowdown system out of service, drain the piping section and replace the failed vacuum breaker valve.

The Circ Water Blowdown system was then isolated in preparation for draining and repairs. There was no discussion at this time of any need to sample for radioactivity in the water that had been discharged.

At approximately 0615 on 11/7/00, the RP Manager was contacted by the Operations Manager that there was a blowdown line leak and that RP was requested to meet with the Chemistry Manager to look at potential alternate release paths for radwaste. The reason for this request was that radwaste releases would not be possible via the blowdown system while blowdown was isolated for repairs to the vacuum breaker valve.

Following this phone conversation, the RP Manager spoke with the RP Technical Superintendent and discussed the need to pull water samples. Included in this discussion was a conclusion that the samples should contain no radioactivity because of the belief that the spilled water was "only lake water".

A decision to conduct water sampling of the water leaking from the manway cover of the vacuum breaker structure was made at 0800. The sample was taken at approximately 0845 and the results of the gamma isotopic analysis indicated no quantifiable peaks found (NQPF), and the tritium result was less than the lower limit of detection (LLD) of 1.87E-06 uCi/ml.

At approximately 1130, RP received information that the leak may have occurred for a period of 7-10 days and that the water that leaked was from the circulating water blowdown line which carries the liquid radwaste discharges from the station to the river. At 1230 on 11/7/00, a decision was made to initiate soil sampling in the vicinity of the vacuum breaker structure, and to obtain a water sample from the standing water that was onsite, but near the Smiley Road ditch.

At approximately 0830, Mechanical Maintenance (MMD) personnel with assistance from System Engineering pumped out the 0CW135/136 vault and began draining the blowdown piping to facilitate work on 0CW135/136. At approximately 1200, after the CW Blowdown line had drained sufficiently, the entire 0CW 135/136 isolation valve and vacuum breaker assembly was replaced.

A total of 5 soil samples were obtained within approximately 30 feet of the vacuum breaker structure, and 2 of the 5 samples had detectable levels of radioactivity. The onsite soil sample obtained near the Smiley Road ditch was analyzed and the gamma isotopic indicated NQPF and the water analysis indicated tritium at a level of 3.5E-5 uCi/ml.

The results of these samples were discussed with corporate Generation Support Department (GSD) RP Manager at 1900 on 11-7-00. Corporate GSD agreed to discuss the issue with the corporate Generation Support General Manager. At 1945, the Station Manager and Site Vice President were notified of the sample results.

At 0830 on 11-8-00, the RPM discussed the sample results on the morning call. At 1400, the RP, Chemistry, Regulatory Assurance, Station Manager, and Site VP met to discuss the current status, next steps, and sampling for the event.

On 11-8-00, additional onsite sampling of the standing water in the area leading to the Smiley Road ditch was performed. Four water samples were taken at approximately 1600 and results indicated tritium levels 3.7E-05 to 5.3E-05 uCi/ml.

On 11-9-00 at 1000, a conference call was held with the site and corporate and an Offsite Sampling Plan, Remediation Plan, and Communications Plan was agreed to. At 1200, discussions were held with site NRC and regional NRC. At 1210, notification of the offsite release was made to Will County authorities and to the Reed Township Highway Commissioner. At 1245, RP was dispatched to obtain water samples from the Smiley Road ditch.

At approximately 1400, four water samples were obtained from the Smiley Road ditch. Gamma isotopic analysis indicated NQPF and the tritium analyses ranged from 1.9E-05 to 2.5E-05 uCi/ml. These samples were also analyzed by Teledyne Isotopes Midwest Laboratory with similar results.

The evening of 11-9-00, the NRC Regional Office and IDNS were notified of the Smiley Road ditch sample analyses results.

At approximately 1100 on 11-10-00, pumping of the water back to the blowdown line commenced. Pumping continued using a 600 gpm pump, approximately 18 hours per day, until 2000 on 11-15-00 when all possible water had been pumped back into the blowdown line.

BACKGROUND INFORMATION:

The primary function of the Circ Water Blowdown System is to provide for Lake turnover to prevent undesirable chemical buildup in Lake. The secondary function of the Circ Water Blowdown System is to provide dilution for liquid releases.

The Circ Water Blowdown System (Attachment 7) is designed to return Cooling Lake water back to the Kankakee River. Processed fluids from the Sewage Treatment System and the Radwaste Treatment Systems discharge directly to the Circ Water Blowdown system where dilution occurs prior to release to the Kankakee River. The Wastewater Treatment Plant and the Demineralizer Regenerant Waste systems along with various strainer/filter backwashes are returned to the Cooling Lake and thus are indirectly returned to the Kankakee River through the Blowdown line after dilution by the Cooling Lake.

The Circ Water Blowdown system begins at the Circ Water System supply to the condenser. Two 24" carbon steel pipes tap off the Circ Water supply piping (one from each unit) and combine into a 36" common header. Motor operated isolation valves, 1/2CW018, are provided on each 24" line. The 6" Radwaste Treatment System discharge pipe connects to the 36" Blowdown header. Downstream of the Radwaste connection, the Blowdown pipe is expanded to 48" prior to connection of the 3" Sewage Treatment Plant discharge pipe. The 48" diameter Blowdown pipe is reinforced concrete pipe (RCP) and runs along owner controlled property to the Blowdown River Screen House. Eleven vacuum breaker assemblies are incorporated at the high points along the 48" diameter RCP to prevent pipe implosion. The 48" RCP is eventually split and reduced to two 24" discharge pipes at the Kankakee River. Each 24" discharge pipe was originally equipped with a motor operated spray valve, 0CW018A/B. The entire piping network is approximately 29,000 ft long and is operated at about 12,000 gpm (~2.5 ft/s).

A typical vacuum breaker is shown on attachment 4. On system startup, the vacuum breaker exhausts air from the piping system until the float assembly rises with water level to close and seal for system operation. Upon system shutdown, the vacuum breaker is designed to open as water level decreases. The air release or 'pilot' valve provides two functions. The primary pilot valve function is to release entrained air that accumulates at the high points during normal system operation, air that would increase head loss and reduce process flow if not removed. The pilot valve also facilitates earlier opening of the vacuum breaker on system shutdown. On shutdowns, air pockets that develop at high points may be at positive pressure, tending to hold the vacuum breaker on its seat even though water level is below the float assembly. However, the pilot valve will release the air and allow the vacuum breaker to open as soon as level drops. Each vacuum breaker is provided with a butterfly isolation valve to facilitate vacuum breaker maintenance.

The Circ Water Blowdown system was originally designed to be maintained full and pressurized. This was accomplished through manipulation of the Blowdown Spray Valves, 0CW018A/B. These valves were susceptible to freezing due to design and system operation requirements. Based on this, other maintenance issues, and parts obsolescence, these valves were eventually abandoned in the full open position in the mid 1980s. System control was transferred to the upstream motor operator isolation valves, 1/2CW018. The system would no longer be maintained full and pressurized on shutdown as a result of this change. Minimal technical review was performed on the hydraulic effects on the vacuum breakers from this method of operation (ie: surge check valves were not evaluated for system incorporation).

In 1997, Chemical Feed System was relocated from the Turbine Building to the Lake Screen House under Modification M20-0-95-003. One of the primary reasons for centralization of the Chemical Feed system to the Lake Screen House was to reduce maintenance cost via system size. This design change necessitated isolating the Circ Water Blowdown System on a daily basis to accommodate biocide injections into the Circ Water System, because our permits do not authorize discharge of biocide to the Kankakee River.

The daily requirement to isolate Circ Water Blowdown for biocide injection prompted the Operations Department to challenge the BwOP CW-12 procedural requirement to slowly open the 1/2CW018 valves for system start-up. BwOP CW-12 was revised to allow fast motorized operation of 1/2CW018, in lieu of slower manual throttling, following short periods of system shutdown (i.e.: biocide injections). Minimal technical review was performed on the hydraulic effects on the vacuum breakers from this method of operation.

Work history on the Circ Water Blowdown System vacuum breakers was reviewed. There were no recorded vacuum breaker float assembly failures prior to this event. Several instances of leaking pilot valves were noted from the review. The 0CW060 pilot valve was discovered leaking in 12/98. PIF # A1998-04324 was generated to address the flooding of site property and the Smiley Rd ditch immediately adjacent to site property. The piping to the air release valve on the 0CW058 failed in 12/96. The complete vacuum breaker assembly including pilot valve was replaced with a new assembly in 6/97. It should be noted that the 0CW058 vacuum breaker failed again on about 11/20/2000 while this root cause investigation was in progress. The float assembly broke at the bowl to guide bar weld. No other significant work history was identified.

The failure of the 0CW136 float assembly was discussed with the vendor. Based on the failure description, the vendor indicated that it appeared to be consistent with the effects of a pressure surge (i.e.: water hammer). The vendor indicated that surge protection check valves should be considered for a vacuum breaker when pipe flows exceed 6 ft/s and are required when flow velocities exceed 10 ft/s. The vendor also recommended a 7-10 year PM frequency to address valve elastomer degradation.

ROOT CAUSE ANALYSIS AND CORRECTIVE ACTIONS:

A. Investigation and Root Cause Analysis Techniques

Methods utilized for performing this investigation included interviewing, Barrier Analysis, Event and Causal Factor charting (Attachment 2), and Failure Modes and Effects Analysis (Attachment 3). Task analysis had also been specified in the root cause report charter. However, since task analysis is a tool that is used on investigations where problems during performance of tasks contribute to the event and no such performance issues were identified during this investigation, the task analysis technique was not utilized. The majority of the conclusions in this report are based upon outcome of the Failure Modes and Effects Analysis and Barrier Analysis. Event and Causal Factor charting did lead to the development of some questions, and the identification of potential barriers, but otherwise did not provide much useful assistance in this investigation.

Root Cause Analysis

The investigation determined that inadequate material condition of the 0CW136 Vacuum Breaker Valve resulting from inadequate preventive maintenance, inappropriate configuration of the vacuum breaker valve assembly and system operation methodology led to valve failure and release of water from the blowdown system.

Event and Causal Factor Chart

An Event and Causal Factor Chart (E&CF) is included as Attachment 2. As stated above, the E&CF chart was used principally to identify potential barriers and to develop questions for interviews.

Barrier Analysis

Barrier analysis shows 3 barriers which could have prevented or mitigated the vacuum breaker valve failure. A discussion of each barrier and its failure method/mode is provided below. Interview results contributed significantly to the barrier analysis

A. <u>Preventive Maintenance</u> – **This program ensures that equipment and systems are checked periodically and maintained within acceptable parameters so they will function as designed.** *The preventive maintenance program has no requirement to perform any kind of internal valve inspection or operational check and no requirement to periodically replace the valves.*

The vacuum breaker valves were essentially installed as run to failure components. There are no Technical Specification requirements or NRC commitments to conduct periodic maintenance. Prior to 1999, informal walkdowns of the blowdown system were performed on an annual basis. For the most part, results of the walkdowns were not logged and no records maintained of the observed material condition of the valves, other than action requests for repair of observed deficiencies (e.g. leaking pilot valve). A handwritten record of a 1995 walkdown of both the CW Blowdown and Makeup lines was found. This record noted whether valves were open or shut, any leaks found, and any water in the valve vaults.

In July 1999, a preventive maintenance template from STANDARD NES-G-08, ComEd Performance Centered Maintenance (PCM) Templates, was adopted for application to the vacuum breaker valves. The particular template chosen is specifically applicable to spring actuated safety relief valves, and contains no discussion of applicability to float type valves. The predefine task description is "perform setpoint verification and seat leak check, or replace valve". The periodicity was set at 10 years. Although most of the valves had been in service since initial construction and had no previous maintenance history, due dates for maintenance were set well into the future, and no consideration given to replacing any of the valves based upon age or time in service. This issue is also discussed under **Root Cause #1**

The template chosen was the closest match from all those available in the standard PCM template index. Time pressure to complete the project was given as the reason for choosing this default as opposed to developing an appropriate template applicable to the vacuum breakers. CA 1, CA 2 and CAPR 1 have been generated to correct specific maintenance issues associated with the vacuum breakers. CA 4 has been generated to review a sample of preventive maintenance templates to look for additional instances of incorrectly assigned templates.

B. <u>Design/Application</u> – **Components utilized in plant construction should be of appropriate design for a given application to ensure acceptable service.** *The barrier was challenged when system operation was changed without changing the design or configuration of the vacuum breaker assemblies.*

Original CW blowdown system operation provided for controlling blowdown flow using valves at the river screen house, thus the system would always remain full of water. This method of operation was abandoned within the first two years of operation due to repetitive failures of the control valves. Current operation of the system provides for controlling blowdown flow using valves located in the plant near the main condensers and when flow is secured, the blowdown line will depressurize and partially drain resulting in a potential pressure surge when flow is reinitiated. Discussion with the valve manufacturer revealed that if the valves are subjected to significant pressure surges, they should be equipped with surge protection. The current configuration has no surge protection. This issue is discussed more fully in the section titled **Root Cause #2.**

The reason why the system operation was changed rather than correcting the material condition of the valves at the river screen house will not be pursued since that decision was made so long ago. Similarly, the reason the change was made without considering impact on the vacuum breaker design/configuration cannot be determined. CAPR 2 has been generated to replace the current design vacuum breaker assembly with a surge-protected configuration.

In developing corrective actions, consideration was given to replacing the vacuum breakers with a totally passive standpipe system. However, some of the vacuum breakers are under pressure and the resulting stagnant column of water in the associated standpipe would necessitate installation and maintenance of heat tracing to prevent freezing in winter weather. Therefore, this potential solution will not be pursued any further.

Additionally, consideration was given to restoring control to the 0CW018A/B valves at the river screen house. These valves are abandoned in the full open position, which reduces head loss and provides for maximum flow. During operation currently, most of the blowdown piping is not water solid and the valves would have to be throttled down to maintain the system full, which would also reduce blowdown flow. Reduced blowdown flow is not desirable from a cooling lake chemistry control standpoint. The valves <u>could</u> be used to bottle up the blowdown system when shutting it down. However, this would require closing the valves prior to securing blowdown flow in order to fill the piping, potentially resulting in damaging water hammer to the system. Therefore, this potential solution will also not be pursued any further.

C. **<u>Operating Procedures</u> - Procedures provide the appropriate instructions to ensure actions are carried out correctly with appropriate limits and acceptance criteria.** *This barrier failed when the procedure was modified to allow operation of the system that could result in significant pressure surges (fatigue cycles) on the vacuum breaker valves.*

The CW Blowdown System Startup, Operation and Shutdown procedure, BwOP CW-12 allows opening the blowdown isolation valves with power following "short duration shutdowns" such as routine daily chemical biocide additions. However, during a typical 2-hour shutdown of the system for biocide injection, the blowdown system can partially drain and thus a significant surge (water hammer) can result when flow is rapidly restored using the motor operators. This issue is discussed more fully under the section titled **Significant Contributing Cause.**

CA 3 has been developed to change the blowdown procedure to always require opening the isolation valves in stages over a few minutes to prevent water hammer.

Failure Modes and Effects Analysis

This technique was used to develop and analyze potential failure modes for the failed vacuum breaker assembly. A fishbone diagram used in this analysis is provided as Attachment 3.

Brittle Failure. This mode was eliminated due to the valve float being constructed of Stainless Steel and not susceptible to brittle failure in the system operating environment.

Manufacture. This mode was eliminated due to lack of any noted manufacturing defects in the failed valve.

Preventive Maintenance. Failure to perform adequate preventive maintenance certainly contributed to failure of the valve, and in fact lack of an adequate preventive maintenance program is one of the root causes. However, there is no evidence that any preventive maintenance ever performed on the valve contributed to the failure, therefore improper performance of preventive maintenance was eliminated as a failure mode.

Corrective Maintenance. Similarly, lack of any significant corrective maintenance history rules this out as a failure mode.

Aging. The failed valve was examined closely and did not show signs of stress corrosion cracking or other corrosion mechanisms. There was evidence of age related wear in the valve bushings, however this is not considered a contributor to failure. The length of service does come into consideration when coupled with the fatigue mechanism.

Design. The lack of surge protection, given the way the system is operated, is a strong contributor to valve failure. This information was provided via interview with the valve manufacturer. Beyond that, the valve design, specifically that of a float operated vacuum breaker, is an appropriate application for protection of the CW blowdown system.

Fatigue. Post failure analysis shows that the most probable failure mechanism was low stress high cycle fatigue. Visual inspection reveals a large fatigue and small fracture cross section, consistent with this failure mechanism.

System Operation. This mode is a strong contributor to failure, due to the fatigue cycles caused by operation. System operation is discussed in great detail in other sections of the report and therefore will not be elaborated on in this section.

B. Summary of Causes and Corrective Actions

<u>Root Cause #1</u>

The preventive maintenance program for the CW Blowdown vacuum breaker valves is inadequate. The valves, with one exception, had all been in service since initial construction of the plant prior to the failure and subsequent replacement of the 0CW136 Valve. The other valve replacement was due to problems with the pilot valve sensing line failing (due to general corrosion), and not with the main vacuum breaker valve itself. Preventive Maintenance essentially consisted of an annual walkdown of the valves by the system engineer, and if no leakage was observed, the valves were deemed to be OK; results of the walkdowns were not logged.

A preventive maintenance template for the valves was adopted from Performance Centered Maintenance (PCM) standard templates in July 1999. The template chosen was for "Spring Actuated Pressure Relief Valves" which was the closest match from the choices available. The "why" given for this was time pressure to complete the preventive maintenance templates. This cause will not be pursued further because the project is completed and therefore no relevant CAPR would be developed. CA 4 has been generated to sample for additional inappropriate preventive maintenance templates.

CA 1 has been generated to replace all vacuum breaker valves and thus restore current material condition

CA 2 has been generated to develop an adequate preventive maintenance program for the valves which includes periodic inspection of the valves including internals or provides for valve replacement at appropriate intervals. This item will also include the development of system walkdown inspection requirements including specified frequency of walkdowns and documentation/reporting of walkdown results.

CAPR 1 has been generated to implement the revised preventive maintenance program and system walkdown inspection requirements.

Root Cause #2

The configuration of the current vacuum breaker valve assembly is inappropriate. The current valve assembly (Attachment 4) consists of an integral butterfly isolation valve and vacuum breaker float valve with an attached pilot or "air release" valve. Discussion with the valve manufacturer revealed that the current configuration would be susceptible to premature failure if the valves were subjected to significant repetitive pressure surges during operation, such as would be experienced during startup with rapid filling/pressurization of the system. The manufacturer stated that with pressure surge conditions, a valve with built in surge protection (Attachment 5) would be required.

The original system operation provided for controlling blowdown flow using valves at the river screen house, thus the system would always remain full of water. This method of operating the system was abandoned within the first two years of operation due to repetitive failures (caused principally by freezing) of the control valves at the river screen house, and difficulty in remotely controlling the valves at the river screen house. Current operation of the system provides for controlling blowdown flow using valves located in the plant near the main condensers, and thus when flow is secured, the blowdown line will depressurize and at least partially drain resulting in a potential pressure surge when flow is re initiated. The reason for why system operation was changed as opposed to correcting the material condition of the valves at the river screen house is beyond the scope of this investigation due to the large time interval from initial construction and will not be evaluated further.

CAPR 2 has been generated to replace the current design vacuum breaker assembly with a surge protected (Attachment 5) configuration. This action can be performed coincident with CA 1, but is listed separately to provide a definite link of CAPRs to root causes.

Significant Contributing Cause

A significant contributing cause, if in fact not a third root cause, is system operating methodology. As stated earlier, blowdown flow is controlled using valves in the plant located near the condensers, specifically the 1/2CW018 valves, which are 24-inch motor, operated butterfly valves. If blowdown flow is initiated by opening these valves using the motor operators, a significant pressure surge can result.

The Chemical Feed System configuration was modified in 1997, changing the injection point where chemicals are added to the CW system, and now CW blowdown flow must be secured whenever chlorination of the CW system is accomplished. This is done to comply with NPDES permits, which forbid discharging of biocide to the river. Chlorination is performed for each unit on a daily basis and therefore it is necessary to alter blowdown flow on a daily basis to ensure there is no blowdown from the unit being chlorinated.

The CW Blowdown System Startup, Operation and Shutdown procedure, BwOP CW-12, contains a note that states in part "Slowly opening MOV CW018, Units 1 & 2 CW Blowdown Isol Vlv, in stages over a few minutes will prevent damage to the CW Blowdown piping/components due to water hammering of the drained piping." To provide some relief to the operators from having to manually operate the isolation valves on a daily basis in support of chorination operations, the procedure was changed in 1998 to also state "For short duration shutdowns of CW blowdown (i.e.: routine daily chemical biocide additions, etc.), reopening with power from MCR is acceptable." This change was authorized without sufficient technical analysis, and in fact following a typical two hour shutdown for chlorination there is a significant surge when flow is restored, particularly if only single unit blowdown is in operation and blowdown is totally secured (as opposed to shifting to the opposite unit) for chlorination.

CA 3 has been developed to change the blowdown procedure, BwOP CW 12, to always require slowly opening the isolation valves in stages over a few minutes when initiating flow from a no blowdown flow condition. This CA does not apply when shifting blowdown from one unit to another as long as blowdown is not secured.

C. Equipment Failures (EF)

EF #	Summary of EF	Associated Causal Factor
1.	0CW136 vacuum breaker float assembly failure (date of failure estimated to be between 10/27/2000 and 10/30/2000)	1, 2, and 3
2.	0CW058 vacuum breaker float assembly failure (date of failure estimated to be 11/20/2000)	1, 2, and 3

Both the failed CW blowdown valves, 0CW136 and 0CW058 (failed 11/20) were analyzed to determine failure mode, and both were determined to have failed from low stress high cycle fatigue. This type of failure mode is consistent with the causes listed above.

D. Causal Factors (CFs)

(Root Causes are identified by Asterisks)

CF #	Summary of Causal Factors	Associated Corrective Action
1*	Root Cause – The preventive maintenance programs for the CW Make-Up and Blowdown System vacuum breakers are inadequate. An effective preventive maintenance program needs to be developed and implemented for both systems.	CAPR1, CA1, and CA2
2*	Root Cause – The design configuration of the current vacuum breaker valve assembly is inappropriate. The current valve assembly (Attachment 4) consists of an integral butterfly isolation valve and vacuum breaker float valve with an attached pilot or "air release" valve. Discussion with the valve manufacturer revealed that the current configuration would be susceptible to premature failure if the valves were subjected to significant repetitive pressure surges during operation, such as would be experienced during startup with rapid filling/pressurization of the system. The manufacturer stated that with pressure surge conditions, a valve with built in surge protection (Attachment 5) would be required.	CAPR2 and CA1
3	Significant Contributing Cause – Current system operating procedure (BwOP CW-12) allows initiating CW blowdown flow by opening the isolation valves using the motor operators if blowdown flow has only been shutdown for a short duration (i.e. routine daily chemical biocide additions, etc.). Operating the blowdown system in this manner can result in significant pressure surges.	CA3
4	Contributing Cause – In July 1999, a preventive maintenance template from STANDARD NES-G-08, ComEd Performance Centered Maintenance (PCM) Templates, was adopted for application to the vacuum breaker valves. The particular template chosen is specifically applicable to spring actuated safety relief valves, and contains no discussion of applicability to float type valves. Time pressure to complete the project was given as the reason for choosing this default as opposed to developing an appropriate template applicable to the vacuum breakers.	CA2 and CA4

E. **Corrective Actions**
(Corrective Actions to Prevent Recurrence are labeled CAPRs)

Immediate Corrective Actions: *

- The CW blowdown system was isolated to stop the leak
- A team was assembled to recover from the leak and restore the system
- Appropriate notifications were made
- The leaking vacuum breaker valve was replaced
- Spilled water was pumped back into the CW Blowdown System
- Radioactivity samples were taken to comply with 10CFR50.75(G).
- A root cause investigation was commenced

* These are all listed as immediate actions even though some occurred over several days.

Actions	Corrective Action	Assignee	Due Date
CAPR 1	Description of corrective action to be taken: **Implement a revised preventive maintenance program for the float operated vacuum breaker valve assemblies for the CW Blowdown and Makeup Systems. This PM will be developed by CA 2 and will include specific intervals for inspection of valve internals or provide for periodic replacement of the valves. This item will also include the implementation of system walkdown inspection requirements including specified frequency of walkdowns and documentation/reporting of walkdown results.**	A8930TT	03/01/01
CAPR 2	Description of corrective action to be taken: **Replace the current design vacuum breaker assembly with a surge-protected configuration, Valve and Primer Company Cat. ID 1036974 (6 inch), 1036975 (8 inch), 1036976 (10 inch). This CAPR should be accomplished coincident with CA 1 to minimize the number of valve replacements.**	A8930TT (design approval/doc) A8922MM (physical work)	03/01/01

Actions	Corrective Action	Assignee	Due Date
CA1	Description of corrective action to be taken: **Replace all vacuum breaker valve assemblies in the CW Blowdown and Makeup Systems to restore system material condition. This CA should be accomplished coincident with CAPR 2 to minimize the number of valve replacements.**	A8922MM	03/01/01
CA2	Description of corrective action to be taken: **Develop an adequate preventive maintenance program for the CW Blowdown and Makeup System vacuum breaker valve assemblies which includes periodic inspection of the valves including valve internals or provides for valve replacement at appropriate intervals. This item will also include the development of system walkdown inspection requirements including specified frequency of walkdowns and documentation/reporting of walkdown results. This program will be implemented by CAPR 1.**	A8930TT	02/01/01
CA3	Description of corrective action to be taken: **Revise BwOP CW-12 to always require slowly opening the blowdown isolation valves (1/2CW018) in stages over a few minutes when initiating blowdown flow from a no blowdown flow condition. This CA does not apply when shifting blowdown from one unit to another as long as blowdown is not secured. This procedure revision shall be identified as a corrective action per this AT item.**	A8910OP	01/05/01

Actions	Corrective Action	Assignee	Due Date
CA4	Description of corrective action to be taken: **Perform a review of a representative sample of preventive maintenance templates to determine if there are additional inappropriately assigned preventive maintenance templates.**	A8930TZ	05/01/01
EFR1	Description of corrective action to be taken: **Perform an effectiveness review of the CAPRs.**	A8930TT	08/01/01

F. Extent of Condition

Other Exelon/Amergen Nuclear sites were contacted to determine how those plants are configured for circ water blowdown and makeup and if they have experienced any similar problems with vacuum breaker float assembly failures. Byron and LaSalle stations were the only stations confirmed to have circ water blowdown and makeup systems that utilize vacuum breakers in their design. For CW blowdown and makeup systems, the extent of condition is limited to Byron and LaSalle.

Byron Station replaced their fiberglass blowdown and makeup piping in 1987 with carbon steel due to a line failure associated with ground shifting. 12" Golden Anderson's model GH-7K vacuum breakers with line surge protection were installed at that time. System Engineering walkdowns are conducted annually and Operations regularly drives down the lines when they make River Screen House rounds. No vacuum breaker failures have been identified and only minor amounts of water have been discovered contained within the valve vaults.

LaSalle's Operating Department performs inspections on their circ water blowdown and makeup systems on a semi annual basis. The inspections consist of leak checks and flushing the air release valve of any debris. The vacuum relief float is also checked and cleaned. The majority of the problems they experience are related to plugging and freezing. The smaller air release valve float is the component that has frozen and it only affected the air release and not the vacuum relief. Corrosion has also been identified as an issue on the piping from the vacuum break to the air release valve. There is no history of vacuum breaker float assembly failures at LaSalle.

There are differences in system operation among the sites. In general, LaSalle operates their system continuously, whereas Byron and Braidwood must cycle their blowdown systems to accommodate chemical feed additions. Additionally, Byron still controls blowdown flow using the 0CW18A/B spray valves at their river screen house, thus their blowdown system is maintained full at all times. Byron's spray valves are typically throttled to 20-22% open to maintain 12-13k gpm blowdown flow. The Byron spray valves are reportedly difficult to control and require frequent maintenance to remain operable.

Other potential off site release paths were evaluated for extent of condition. The summary of the evaluation is as follows:

NPDES Outfalls

001(a) - Wastewater Treatment Plant
This system discharges to the U-2 Circ Water return line (to the lake)
-Discharge of 'waste' water from the non-radiological portion of the plant. This discharge consists mainly of:
Turbine Building Drains (TE,TF), Fire and Oil sump, Tendon Tunnel sumps, Aux Blr blowdown, Secondary side drains, Pretreatment drains and can be alternate discharge path for regenerant waste from Muds and CPs.

001(d) - Demineralizer Regenerant Waste
-Discharge of regenerant waste. This discharge consists mainly of:
Muds and CP regenerant waste, Regenerant chemical area drains (acid & caustic) and portable demineralizer regenerant waste (RO waste)
This discharges to the cooling lake via the circ water return to the lake

001(e) - River Intake screen backwash
-river screen house backwash is directed to the make-up pump suction (forebay) only during pump operation and is ultimately pumped to the lake with the make-up. This is includes as a point source only with no monitoring required.

002 - North Site Stormwater Runoff
This discharge consists mainly of stormwater from the Parking lots, Transformer areas, Station and North Site area as well as Station roof drains. The discharge path is via the runoff ditch along the west side of the property and is ultimately discharged to the Mazon River. No monitoring is required for stormwater

003 - South Site Stormwater Runoff
This discharge consists of stormwater runoff from the area south and east of the main site (near the LSH). The discharge path is via the runoff ditch along the west side of the property and is ultimately discharged to the Mazon River. No monitoring is required for stormwater

004 - Switchyard Area Runoff
This discharge consists of stormwater runoff from the switchyard area. An oil separator exists in this area to remove oil in the event of leakage from the switchyard equipment.
The discharge path is via the runoff ditch along the west side of the property and is ultimately discharged to the Mazon River. No monitoring is required for stormwater

There are two special conditions that identify flowpaths not included as 'normal' discharges.

Special Condition 9: Discharge of station cooling pond water to adjacent impoundments owned by the permittee, to replace water which is withdrawn from these impoundments for station operation during periods of low flow in the Kankakee River when the station must decouple its operation from the river, is hereby permitted for these emergency periods.
No monitoring is required however the Agency (IEPA) must be notified if this occurs.
This simply says we can refill Monster Lake if we have to pump it down during drought conditions.

Special Condition 12: An emergency cooling pond overflow exists tributary to an unnamed drainage ditch that is tributary to the Mazon River. Discharges to this overflow shall be subject to the bypass provisions of 40 CFR 122.41(m)
-This states that monitoring of 001 (Cooling Pond Blowdown) parameters must be performed daily during discharge.

Additionally the Make-up to the lake (river water) would be a potential source of 'discharge' should we develop a leak in that line.

The NPDES related treatment systems discharge either directly into the blowdown line or to the Circ Water return to the lake and then ultimately discharge through the blowdown.

The Wastewater Treatment and Sewage Treatment processes are separated from the Main Plant or Turb/Aux buildings. Any leakage or failures within these systems would be contained within their respective buildings and/or general area. The Demineralizer Waste process is contained within the Turbine Bldg and the Radwaste systems are located primarily within the Aux Bldg., however some components (release tanks) are located in the Turbine building. Any leakage or failures within these systems would be contained within their respective areas.

The connections to the Circ Water return to the lake (Wastewater and Demin Waste) are located underground in the area west of the Turb Bldg. The Sewage Treatment Plant connection is underground in the area north of the Sewage Plant and the radwaste tank discharge ties in to the blowdown within the Turb/Aux Bldg. Any catastrophic failure of these connections should be visible by localized bubbling or saturation of the ground in which case the discharge could be isolated. This would prompt investigation by excavation to determine cause of failure and initiation of repairs. Preventive measures could be taken at that time (berms or other barriers) to prevent this leakage from entering the runoff ditches.

Periodic rounds of these systems should provide the early detection of any unusual conditions. Preventive measures could then be taken to eliminate potential for release of water from these systems.

G. Risk Assessment

There were no plant specific risks associated with this issue. There were no risks to the CW Blowdown system as a result of this issue, since in the failed condition the vacuum breaker assembly would still function to prevent a vacuum from forming and causing damage to the blowdown piping.

PREVIOUS EVENTS:

Search of CAP, EWCS, OPEX, etc. was conducted. The OPEX search was limited to the previous 2 years and confined to the variables of "unplanned releases of liquids", "vacuum breaker failure and releases", and "blowdown vacuum breaker". The EWCS search was limited to both Circ Water Makeup and Blowdown vacuum breaker failures. The CAP system search was limited to the Circ Water System. No similar vacuum breaker float failure events were identified via these searches.

EVALUATOR COMMENTS:

The station was slow to implement Event Response Guidelines, CWPI-NSP-AP-1-1, or NGG Issues Management, OP-AA-191-503. The initial facts of water in the ditch on Smiley Road and the source of the water being a leaking vacuum breaker on CW blowdown piping were known at approximately 1600 on 11/06/00. NGG Issues Management was not entered until sometime on 11/09/00 after results of radioactive sampling showed both isotopic and Tritium samples above LLD, a delay of about 3 days. The decision to form a root cause team to investigate the issue was not made until 3 days after the event. The station did establish separate teams for event recovery and root cause.

Interviews with station management personnel responding to the initial event reports revealed there was no consideration for use of the Event Response Guidelines or NGG Issues Management procedures for general guidance. OP-AA-101-503, NGG Issues Management was developed as a corrective action to the Braidwood Oil Spill Event in order to respond appropriately to significant issues, including those that have potential media or public interest. Since it was known that the blowdown line had most likely been leaking for more than a week (based on the information from the resident who reported the water in the Smiley Road ditch) and that radioactive releases from the Site are conducted via the blowdown line, the potential for radioactivity in the Smiley Road ditch should have prompted entry into the NGG Issues Management Procedure due to the possibility of public and media interest.

Entry into the NGG Issues and Management Procedure did eventually occur on 11-9-00, three days following the initial event. The station did determine that a prompt investigation was not required.

The establishment of separate teams for event recovery and root cause is an apparent lesson learned from the Oil Separator event (CR # A2000-2683) which occurred in June 2000.

Condition Report #A2000-04465 has been written to document slow station response in implementing NGG Issues Management or Event Response Guidelines.

Braidwood Nuclear Station Discharge Pipe Vacuum Breaker Leak Dose Assessment

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February 19, 2001
Rev. 1

Braidwood Nuclear Station
Discharge Pipe Vacuum Breaker Leak
Dose Assessment

Introduction:

In the fall of 2000, a vacuum breaker on the main discharge pipe was found to be leaking. The discharge pipe directs a high volume of non-radioactive effluent as a result of normal station operations. The discharge line also serves as a dilution volume for normal station radioactive discharges. These discharges are made in accordance with the station technical specifications following sampling and analysis, and confirmation that adequate dilution flow is available. Following discovery of the vacuum breaker leak, soil samples were obtained in the vicinity of the leak. The samples were obtained and analyzed by Braidwood Station personnel. The sampling program was designed to determine the extent of surface soil that may have been contaminated with low levels of radioactive material. The vacuum breaker is housed in a concrete vault. The bottom of the vault is not sealed. Water was observed running from the manway cover and onto the surface of the ground. A sampling grid was established in the vicinity of the vault. Soil samples were obtained from the top 6 inches of soil at the approximate center point of each grid. No core bores were obtained in the sampling grids or within the vault. The primary purpose of this assessment is to evaluate the potential dose due to the reported radioactivity if no remedial actions are taken. Additionally, this report evaluates compliance with certain regulations, and may be used to document findings in accordance with 10CFR50.75(g).

Methodology:

Soil samples were obtained and analyzed by Braidwood Nuclear Station personnel. A sampling grid consisting of 10 meter by 10 meter grids was established around the vault. Soil samples of the top 6 inches were obtained from the approximate center point of the grids. Samples were taken in all directions, radially outward, until analysis results showed less than minimum detectable activity (MDA). The maximum MDA for the soil analysis was 1.5E-07 µCi/g for isotopes considered. This MDA value will result in a lower MDA for more easily identified isotopes (e.g. Co-60). Figure 1 provides a simplified layout of the sampling grid. Grids with white backgrounds indicate those grids having sample analysis results indicating at least one isotope greater than MDA. Those grids with dark backgrounds indicate those grids with no results greater than MDA. Table 1 provides the isotopes and activity level for each analyzed isotope with reported results greater than MDA, by grid location.

The quantity of each reported radionuclide was estimated to determine the need for posting the area in accordance with 10CFR20.1902(e). Each sample result was assumed to be representative of the grid area. For samples with positive results, the concentration of each reported isotope was assumed to be uniformly distributed over the 100 m^2 grid areas to a depth of 15 cm. Table 2 provides the calculations and the summation of activity in the area.

A dose assessment was performed using RESRAD 6.0, created August 25, 2000. The RESRAD Version 6.0 computer code was developed under the joint sponsorship of the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy for site-specific dose assessment of residual radioactivity. The computer code was developed at the Environmental Assessment Division of Argonne National Laboratory. The RESRAD list of isotopes includes both Co-60 and Mn-54, but does not contain either Co-58 or Te-123m. Co-58 and Te-123m were assessed using factors from other codes as described below.

RESRAD provides default parameters for dose calculations, but allows for site specific parameters for a specific situation to be applied. RESRAD will evaluate the dose associated with all pathways, including direct radiation, water pathway, food pathway, etc. For the specific isotopes identified in the soil samples, the direct radiation pathway is dominant, accounting for more than 98% of the dose in the critical first year. Therefore for all pathways other than the direct radiation pathway, the default parameters were used, since little impact on the dose would result from site-specific parameters.

To evaluate the dose associated with the direct radiation from the radioactivity in the soil, the critical parameters are the average activity of each isotope in the contaminated zone, the surface area affected (square meter area containing the material), the depth of the contamination, and depth of clean cover material, if any. No clean cover material was assumed. The depth of the contaminated zone was set at 15 cm. To provide a conservative estimate of the activity, the average radioactivity of each isotope identified was calculated, using only those samples with positive values. For example, the value for Co-60 was the average of the four samples with positive values for Co-60, for Mn-54 two positive values were used, etc. Although not including the samples with values less than MDA will introduce a conservative bias, this approach is not considered overly conservative. The bias is not considered to be substantial since the areal distribution of contamination, with minimum grid size of 10 meters by 10 meters (100 m^2), does not have a significant impact on the dose. The affected surface area was considered to be 60 meters by 60 meters (3600 m^2), an area that encompasses the full extent of grids with sample analysis results indicating greater than MDA. Again, assuming this area introduces a conservative bias. The bias introduced by assuming 3600 m^2 rather than a minimum area of 100 m^2 is approximately 20%.

Calculations were made using the parameters described above to determine a conservative estimate of dose. Calculations were also made using the maximum concentrations for each isotope to determine a bounding value to show compliance. The results are presented in the "Results" section below. The RESRAD calculations provide the annualized dose due to Co-60 and Mn-54. Co-58 and Te-123m are not included in RESRAD suite of nuclides, apparently due to their relatively short half-lives. To determine the dose due to these isotopes comparisons were made to Co-60 using the NRC default values from NUREG/CR-5512 and the NRC computer code for screening values in soil, DandD2. The ratios derived from each of these methods and the relative dose contribution from Co-58 and Te-123m are presented in Table 3.

Results:

The output of the RESRAD computer code dose calculations are provided as Appendix 1 and are summarized in Table 4. Table 4 presents the dose from each isotope for the average activity and for the bounding condition using the maximum activity measured for each nuclide. The best estimate, based on the average values of Co-60 and Mn-54 result in a maximum dose in the first year of <u>1.225</u> mrem. Additional dose in the first year, due to the short lived nuclides, based on their average concentration and dose factor as related to Co-60 are: Co-58, <u>0.121</u> mrem, and Te-123m, <u>0.030</u> mrem. The total dose during the critical first year is <u>1.376</u> mrem. 98.6% of that dose is due to direct radiation from the radioactivity in the soil to the receptor on the surface. Due to the short half lives of all isotopes identified, the dose in subsequent years is a fraction of the first year dose, and is due almost entirely to Co-60. The dose due to Co-60 and Mn-54 during the second year is 0.995 mrem. Contribution from Co-58 and Te-123m are less than 1% during the second year due to their short half-lives. Dose during subsequent years will decrease consistent with the half-life of Co-60. The subsequent year dose values are provided in Appendix A, page 8 of the RESRAD output report. Note that the dose value designated means the integrated dose in the year following the year designated. Figure 2 provides a graph of the dose due to Co-60 and Mn-54 as a function of time. Note that Figure 2 is the standard RESRAD graphic output and does not include the initial year dose estimate. The dose due to Co-58 and Te-123m following the first year is less than 0.01 mrem for each isotope, and essentially zero following the second year.

The doses due to pathways other than direct exposure, i.e. water and food pathways, etc. is less 1.4% of the total dose estimate, resulting in a maximum dose of less than 0.019 mrem in the first year. Exposure due to the activity in the soil will be predominantly to individuals within the owner-controlled area. Only portions of the non-direct exposure pathways are capable of resulting in exposure to individuals beyond the site boundary. Therefore, there is no potential for violation of 10CFR50, Appendix I limits, even if the entire non-direct exposure pathway dose was assumed to be beyond the site boundary, and occurring within a single quarter.

The bounding dose calculation assumes that all of the 3600 m^2 area contains radioactivity at the maximum concentration measured for each isotope. This calculation is a conservative approach used for compliance evaluation, and is not considered to be the best estimate of the dose. The bounding value, using RESRAD Version 6.0, uses the same parameters other than isotope concentration as used in the previous calculations, and ratios for Co-58 and Te-123m as previously established, yields a bounding dose value of 2.21 mrem in the first year.

An estimate of the total activity was also performed for comparison with the quantities requiring posting under 10CFR20.1902(e). The activity of each isotope was determined by multiplying the concentration of that isotope measured in each grid, in µCi per gram of soil, by the mass, in grams, of the soil in the grid. The soil was assumed to be uniformly contaminated to a depth of 15 cm. Each grid is 10 meters by 10 meters. The density of soil is assumed to be 1.6 gm/cc, consistent with the default value of RESRAD.

The total activity of each isotope and a comparison with the limits specified in 10CFR20 are provided in Table 2. The Co-60 activity exceeds the level requiring posting as a Radioactive Materials Area.

Summary:

The assessment of the effluent discharge line vacuum breaker leak resulted in the following:

- The dose assessment for the reported radioactivity in the soil surrounding the vacuum breaker access vault results in a maximum dose of ~~1.204~~ 1,376 KA 3-2-01 mrem in the first year. 98.6% of the dose is due to direct radiation exposure form the gamma radiation.

- The relatively short half-lives of the nuclides present results in a dose reduction in subsequent years. Following the second year, the dose reduction is consistent with the half-life of Co-60, 5.26 years.

- The results of this assessment indicate that the non-direct exposure pathway doses are less than the limits specified in 10CRF50, Appendix I.

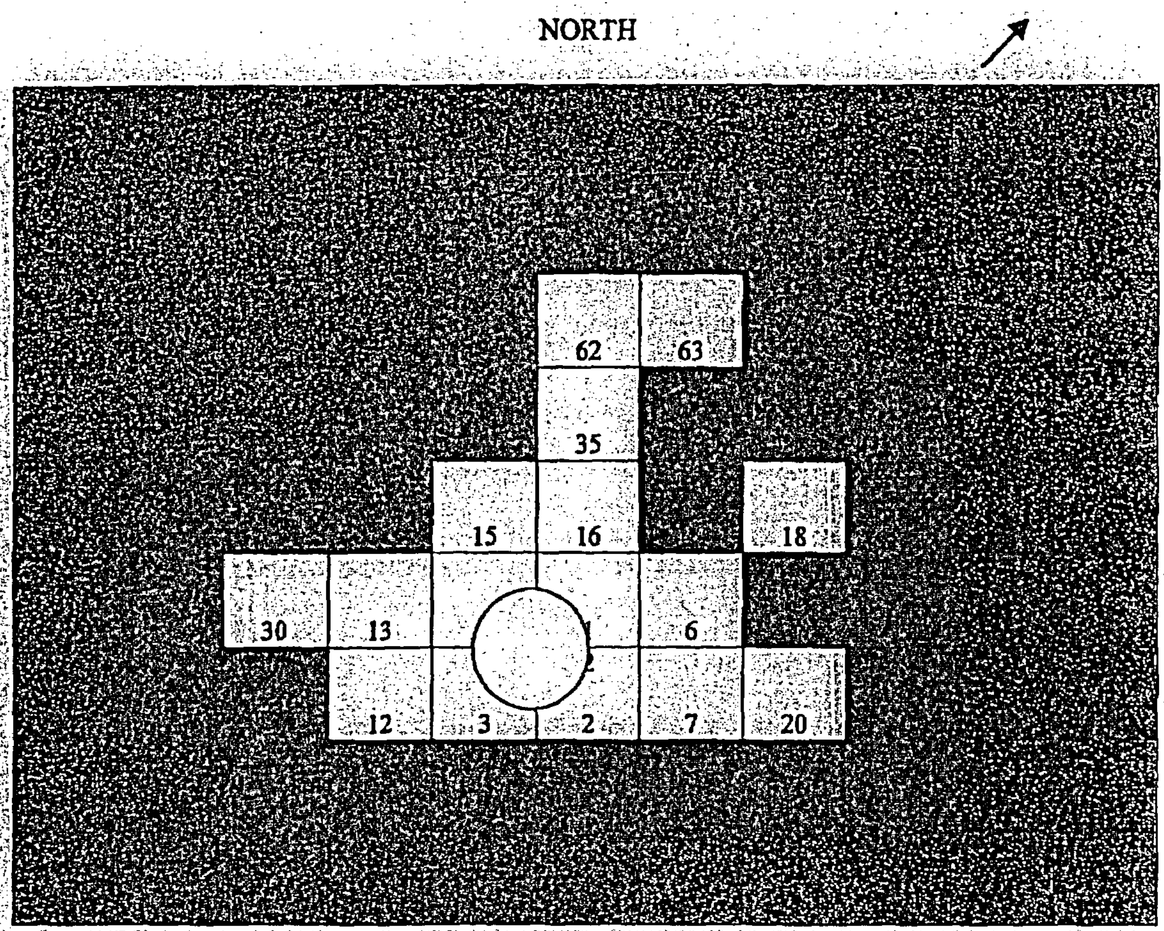
- The results of this assessment indicate that the direct exposure rate in the vicinity of the vacuum breaker access vault is in compliance with 10CFR20.1301 and 20.1302.

- The quantity of radioactive material in the soil surrounding the vacuum breaker access vault exceeds 10 times the values specified in Appendix C to 10 CFR20. The area requires posting in accordance with 10CFR20.1902(e).

- The licensee should evaluate the requirements of Subpart I, Storage and Control of Licensed Material.

Figure 1

SAMPLING GRID



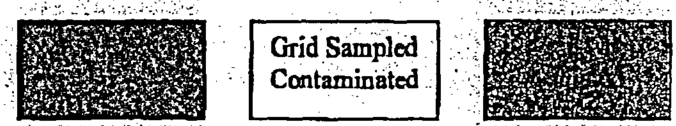


Table 1

Soil Sampling Isotopic Results

Grid	Isotope	Results (µCi/g)
3	Co-58 Co-60 Te-123m	2.5E-07 2.3E-07 1.2E-07
4	Co-58 Te-123m	9.8E-08 1.2E-07
6	Mn-54 Co-58 Co-60 Te-123m	9.9E-08 3.3E-07 1.9E-07 3.7E-07
12	Co-58	7.6E-08
13	Co-60	6.0E-08
15	Te-123m	2.8E-08
16	Co-58	5.3E-08
18	Co-58 Te-123m	1.0E-07 5.5E-08
20	Co-58	4.9E-08
30	Co-58	5.0E-08
35	Mn-54 Co-58 Co-60 Te-123m	1.4E-07 8.9E-07 2.2E-07 8.1E-07
62	Co-58	1.0E-07
63	Co-58	9.5E-08

Table 2

Total Activity Calculation

Isotope Grid #	Mn-54 pCi/g	Total Mn-54 µCi	Co-58 pCi/g	Total Co-58 µCi	Co-60 pCi/g	Total Co-60 µCi	Te-123m pCi/g	Total Te-123m µCi
3			0.25	6.00	0.23	5.52	0.12	2.88
4			0.098	2.35			0.12	2.88
6	0.099	2.38	0.33	7.92	0.19	4.56	0.37	8.88
12			0.076	1.82				
13					0.06	1.44		
15							0.028	0.67
16			0.053	1.27				
18			0.1	2.40			0.055	1.32
20			0.049	1.18				
30			0.05	1.20				
35	0.14	3.36	0.89	21.36	0.22	5.28	0.81	19.44
62			0.1	2.40				
63			0.095	2.28				
Total		5.74		50.18		16.8		36.07
Limit		1000		1000		10		100

Soil density =	1.6	g/cc
Mn-54 App. C =	100	uCi
Co-58 App. C =	100	uCi
Co-60 App. C =	1	uCi
Te-123m App. C =	10	uCi

Table 3

Relative Dose Contribution from Co-58 and Te-123m

Isotope	NUREG/CR-5512 Screening Values (pCi/gm)	Ratio to Co-60 Note (1)	DandD2 Normalized Dose (mrem/yr/pCi/gm)	Ratio to Co-60 Note (2)
Co-60	3.79	1	6.6	1
Co-58	34.7	0.109	0.72	0.109
Te-123m	185	0.0205	.135	0.0205

Note 1: Co-60 screening value divided by individual isotope screening value from NUREG/CR-5512

Note 2: Individual isotope calculated dose divided by dose due to Co-60.
Calculations performed using DandD2, 1 pCi/gm, 1 year period, default parameters.

Table 4

Dose Assessment

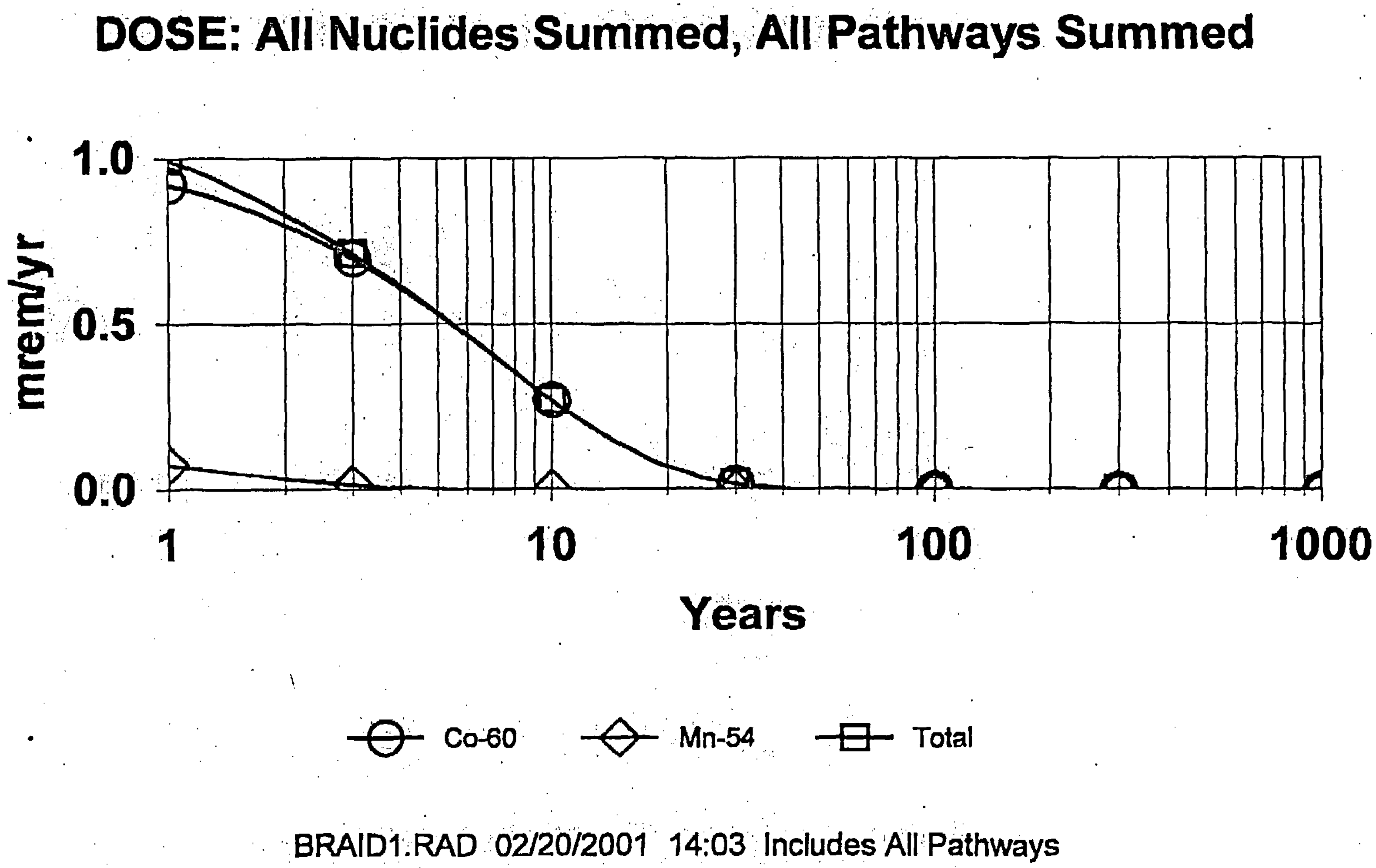
Isotope	Half-Life	Average Conc.	Dose Assessment (Note 1)	Maximum Conc.	Bounding Dose Assessment (Note 2)
Co-60	5.26 years	0.18 pCi/gm	**1.056 mrem/yr**	0.23 pCi/gm	1.350 mrem/yr
Mn-54	303 days	0.12 pCi/gm	**0.169 mrem/yr**	0.14 pCi/gm	0.197 mrem/yr
C0-58	71.3 days	0.19 pCi/gm	**0.121 mrem/yr**	0.89 pCi/gm	0.569 mrem/yr
Te-123m	117 days	0.25 pCi/gm	**0.030 mrem/yr**	0.81 pCi/gm	0.097 mrem/yr
		Total	**1.376 mrem/yr**	Total	2.21 mrem/yr

Note 1: All doses are for year 1, maximum dose year. Co-60 and Mn-54 dose from RESRAD Version 6.0. Factors applied for C0-58 and Te-123m as ratio to Co-60 dose from Table 3.

Note 2: Bounding values are based on maximum measured concentration for each isotope applied over entire area (3600 m^2).

Figure 2

Time Dependent Dose Due to Co-60 and Mn-54



Appendix 1

RESRAD 6.0 Calculation

Output Report

Table of Contents
AAAAAAAAAAAAAAAAA

Part I: Mixture Sums and Single Radionuclide Guidelines
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Dose Conversion Factor (and Related) Parameter Summary
File: Default.LIB

Menu	Parameter	Current Value	Default	Parameter Name
-1	Dose conversion factors for inhalation, mrem/pCi:			
-1	Co-60	2.190E-04	2.190E-04	DCF2(1)
-1	Mn-54	6.700E-06	6.700E-06	DCF2(2)
-1	Dose conversion factors for ingestion, mrem/pCi:			
-1	Co-60	2.690E-05	2.690E-05	DCF3(1)
-1	Mn-54	2.770E-06	2.770E-06	DCF3(2)
-34	Food transfer factors:			
-34	Co-60 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF(1,1)
-34	Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF(1,2)
-34	Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(1,3)
-34				
-34	Mn-54 , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(2,1)
-34	Mn-54 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-04	5.000E-04	RTF(2,2)
-34	Mn-54 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(2,3)
-5	Bioaccumulation factors, fresh water, L/kg:			
-5	Co-60 , fish	3.000E+02	3.000E+02	BIOFAC(1,1)
-5	Co-60 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC(1,2)
-5				
-5	Mn-54 , fish	4.000E+02	4.000E+02	BIOFAC(2,1)
-5	Mn-54 , crustacea and mollusks	9.000E+04	9.000E+04	BIOFAC(2,2)

Site-Specific Parameter Summary

enu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
011	Area of contaminated zone (m**2)	3.600E+03	1.000E+04	---	AREA
011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
)11	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
)11	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
)11	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
)11	Times for calculations (yr)	not used	0.000E+00	---	T(9)
)11	Times for calculations (yr)	not used	0.000E+00	---	T(10)
)12	Initial principal radionuclide (pCi/g): Co-60	1.800E-01	0.000E+00	---	S1(1)
)12	Initial principal radionuclide (pCi/g): Mn-54	1.200E-01	0.000E+00	---	S1(2)
)12	Concentration in groundwater (pCi/L): Co-60	not used	0.000E+00	---	W1(1)
)12	Concentration in groundwater (pCi/L): Mn-54	not used	0.000E+00	---	W1(2)
)13	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
)13	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
)13	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
)13	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
)13	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
13	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
13	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
13	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
13	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
13	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
13	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
13	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
13	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
13	Irrigation (m/yr)	5.000E-01	2.000E-01	---	RI
13	Irrigation mode	overhead	overhead	---	IDITCH
13	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
13	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
13	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
14	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
14	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
14	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
14	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
14	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
14	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
14	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
14	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
14	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
14	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
14	Well pumping rate (m**3/yr)	1.180E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

enu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
015	Number of unsaturated zone strata	1	1	---	NS
015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
016	Distribution coefficients for Co-60				
016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(1)
016	Unsaturated zone 1 (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCU(1,1
016	Saturated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCS(1)
016	Leach rate (/yr)	0.000E+00	0.000E+00	2.888E-03	ALEACH(1)
016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
016	Distribution coefficients for Mn-54				
016	Contaminated zone (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCC(2)
016	Unsaturated zone 1 (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCU(2,1
016	Saturated zone (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCS(2)
016	Leach rate (/yr)	0.000E+00	0.000E+00	1.443E-02	ALEACH(2)
016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
017	Inhalation rate (m**3/yr)	1.169E+04	8.400E+03	---	INHALR
017	Mass loading for inhalation (g/m**3)	3.140E-06	1.000E-04	---	MLINH
017	Exposure duration	3.000E+01	3.000E+01	---	ED
017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
017	Shielding factor, external gamma	5.512E-01	7.000E-01	---	SHF1
017	Fraction of time spent indoors	6.571E-01	5.000E-01	---	FIND
017	Fraction of time spent outdoors (on site)	1.101E-01	2.500E-01	---	FOTD
017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
017	Radii of shape factor array (used if FS = -1):				
017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD SHAPE(
017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD SHAPE(
017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD SHAPE(
17	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD SHAPE(1
17	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD SHAPE(1
17	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD SHAPE(1

Site-Specific Parameter Summary (continued)

enu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
017	Fractions of annular areas within AREA:				
017	Ring 1	not used	1.000E+00	---	FRACA(1)
017	Ring 2	not used	2.732E-01	---	FRACA(2)
017	Ring 3	not used	0.000E+00	---	FRACA(3)
017	Ring 4	not used	0.000E+00	---	FRACA(4)
017	Ring 5	not used	0.000E+00	---	FRACA(5)
017	Ring 6	not used	0.000E+00	---	FRACA(6)
017	Ring 7	not used	0.000E+00	---	FRACA(7)
017	Ring 8	not used	0.000E+00	---	FRACA(8)
017	Ring 9	not used	0.000E+00	---	FRACA(9)
017	Ring 10	not used	0.000E+00	---	FRACA(10)
017	Ring 11	not used	0.000E+00	---	FRACA(11)
017	Ring 12	not used	0.000E+00	---	FRACA(12)
18	Fruits, vegetables and grain consumption (kg/yr)	1.120E+02	1.600E+02	---	DIET(1)
18	Leafy vegetable consumption (kg/yr)	2.140E+01	1.400E+01	---	DIET(2)
18	Milk consumption (L/yr)	2.330E+02	9.200E+01	---	DIET(3)
18	Meat and poultry consumption (kg/yr)	6.510E+01	6.300E+01	---	DIET(4)
18	Fish consumption (kg/yr)	2.060E+01	5.400E+00	---	DIET(5)
18	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
18	Soil ingestion rate (g/yr)	1.826E+01	3.650E+01	---	SOIL
18	Drinking water intake (L/yr)	4.785E+02	5.100E+02	---	DWI
18	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
18	Contamination fraction of household water	not used	1.000E+00	---	FHHW
18	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
18	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
18	Contamination fraction of aquatic food	1.000E+00	5.000E-01	---	FR9
18	Contamination fraction of plant food	1.000E+00	-1	---	FPLANT
18	Contamination fraction of meat	1.000E+00	-1	---	FMEAT
18	Contamination fraction of milk	1.000E+00	-1	---	FMILK
19	Livestock fodder intake for meat (kg/day)	2.710E+01	6.800E+01	---	LFI5
19	Livestock fodder intake for milk (kg/day)	6.325E+01	5.500E+01	---	LFI6
19	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
19	Livestock water intake for milk (L/day)	6.000E+01	1.600E+02	---	LWI6
19	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
19	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
19	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
19	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
19	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
19	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
19	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
19	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
9B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
9B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
9B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
9B	Growing Season for Non-Leafy (years)	2.500E-01	1.700E-01	---	TE(1)
9B	Growing Season for Leafy (years)	1.230E-01	2.500E-01	---	TE(2)
9B	Growing Season for Fodder (years)	1.500E-01	8.000E-02	---	TE(3)
9B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)

Site-Specific Parameter Summary (continued)

nu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
9B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
9B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
9B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
9B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
9B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
9B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
9B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
9B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
9B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
4	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
4	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
4	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
4	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
4	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
4	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
4	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
4	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
4	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
4	DCF correction factor for gaseous forms of C14	not used	1.234E+02	---	CO2F
OR	Storage times of contaminated foodstuffs (days):				
OR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR T(1)
OR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR T(2)
OR	Milk	1.000E+00	1.000E+00	---	STOR T(3)
OR	Meat and poultry	2.000E+01	2.000E+01	---	STOR T(4)
OR	Fish	7.000E+00	7.000E+00	---	STOR T(5)
OR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR T(6)
OR	Well water	1.000E+00	1.000E+00	---	STOR T(7)
OR	Surface water	1.000E+00	1.000E+00	---	STOR T(8)
OR	Livestock fodder	0.000E+00	4.500E+01	---	STOR T(9)
21	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
21	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
21	Total porosity of the cover material	not used	4.000E-01	---	TPCV
21	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
21	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
21	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
21	Diffusion coefficient for radon gas (m/sec):				
21	in cover material	not used	2.000E-06	---	DIFCV
21	in foundation material	not used	3.000E-07	---	DIFFL
21	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
21	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
21	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
21	Height of the building (room) (m)	not used	2.500E+00	---	HRM
21	Building interior area factor	not used	0.000E+00	---	FAI
21	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
21	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
21	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TL	Number of graphical time points	32	---	---	NPTS
TL	Maximum number of integration points for dose	17	---	---	LYMAX

Site-Specific Parameter Summary (continued)

enu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

ESRAD, Version 6.0   T« Limit = 0.5 year   02/20/2001 14:03 Page   8
ummary : Braidwood with NRC Recomended Default Parameters   File: BRAID1.RAD

Contaminated Zone Dimensions	
Area:	3600.00 square meters
Thickness:	0.15 meters
over Depth:	0.00 meters

Initial Soil Concentrations, pCi/g	
Co-60	1.800E-01
Mn-54	1.200E-01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 25 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	1.225E+00	9.951E-01	7.148E-01	2.686E-01	1.715E-02	8.695E-07	0.000E+00	0.000E+00
M(t):	4.901E-02	3.981E-02	2.859E-02	1.074E-02	6.860E-04	3.478E-08	0.000E+00	0.000E+00

ximum TDOSE(t): 1.225E+00 mrem/yr   at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

adio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
o-60	1.040E+00	0.8492	7.670E-08	0.0000	0.000E+00	0.0000	8.035E-03	0.0066	5.068E-03	0.0041	2.828E-03	0.0023	6.326E-05
n-54	1.672E-01	0.1365	1.139E-09	0.0000	0.000E+00	0.0000	1.507E-03	0.0012	1.364E-05	0.0000	5.780E-05	0.0000	3.162E-06
otal	1.208E+00	0.9857	7.784E-08	0.0000	0.000E+00	0.0000	9.542E-03	0.0078	5.081E-03	0.0041	2.886E-03	0.0024	6.643E-05

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

adio-	Water		Fish		Radon		Plant		Meat		Milk		All Path
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.056E+00
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.688E-01
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.225E+00

ùum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

adio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ
o-60	9.074E-01	0.9118	6.660E-08	0.0000	0.000E+00	0.0000	6.978E-03	0.0070	4.401E-03	0.0044	2.456E-03	0.0025	5.494E-05
o-54	7.316E-02	0.0735	4.960E-10	0.0000	0.000E+00	0.0000	6.562E-04	0.0007	5.943E-06	0.0000	2.517E-05	0.0000	1.377E-06
ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ
otal	9.806E-01	0.9854	6.710E-08	0.0000	0.000E+00	0.0000	7.634E-03	0.0077	4.407E-03	0.0044	2.481E-03	0.0025	5.632E-05

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

idio-	Water		Fish		Radon		Plant		Meat		Milk		All Path
iclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
ÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ	ÄÄÄÄÄÄ	ÄÄÄÄÄÄÄÄÄ
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.213E-01
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.384E-02
ÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ	ÍÍÍÍÍÍ	ÍÍÍÍÍÍÍÍÍ
ıtal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.951E-01

um of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

adio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
o-60	6.902E-01	0.9656	5.022E-08	0.0000	0.000E+00	0.0000	5.262E-03	0.0074	3.318E-03	0.0046	1.852E-03	0.0026	4.143E-05
n-54	1.400E-02	0.0196	9.406E-11	0.0000	0.000E+00	0.0000	1.244E-04	0.0002	1.127E-06	0.0000	4.773E-06	0.0000	2.612E-07
otal	7.042E-01	0.9852	5.031E-08	0.0000	0.000E+00	0.0000	5.386E-03	0.0075	3.320E-03	0.0046	1.856E-03	0.0026	4.169E-05

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

adio-	Water		Fish		Radon		Plant		Meat		Milk		All Path
iclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
)-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.007E-01
1-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.413E-02
otal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.148E-01

ium of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

dio- clide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr
-60	2.646E-01	0.9853	1.867E-08	0.0000	0.000E+00	0.0000	1.956E-03	0.0073	1.233E-03	0.0046	6.882E-04	0.0026	1.540E-05
-54	4.293E-05	0.0002	2.789E-13	0.0000	0.000E+00	0.0000	3.690E-07	0.0000	3.342E-09	0.0000	1.415E-08	0.0000	7.744E-10
tal	2.647E-01	0.9855	1.867E-08	0.0000	0.000E+00	0.0000	1.956E-03	0.0073	1.233E-03	0.0046	6.882E-04	0.0026	1.540E-05

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

dio- clide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Path mrem/yr
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.685E-01
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.332E-05
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.686E-01

ım of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

adio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil
uclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
ɔ-60	1.692E-02	0.9868	1.088E-09	0.0000	0.000E+00	0.0000	1.140E-04	0.0066	7.189E-05	0.0042	4.011E-05	0.0023	8.973E-07
ı-54	2.799E-12	0.0000	1.645E-20	0.0000	0.000E+00	0.0000	2.177E-14	0.0000	1.972E-16	0.0000	8.349E-16	0.0000	4.568E-17
ɔtal	1.692E-02	0.9868	1.088E-09	0.0000	0.000E+00	0.0000	1.140E-04	0.0066	7.189E-05	0.0042	4.011E-05	0.0023	8.973E-07

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

ıdio-	Water		Fish		Radon		Plant		Meat		Milk		All Path
ıclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.715E-02
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.822E-12
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.715E-02

um of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

adio-nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr
>-60	8.618E-07	0.9911	3.701E-14	0.0000	0.000E+00	0.0000	3.879E-09	0.0045	2.447E-09	0.0028	1.365E-09	0.0016	3.053E-11
1-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
otal	8.618E-07	0.9911	3.701E-14	0.0000	0.000E+00	0.0000	3.879E-09	0.0045	2.447E-09	0.0028	1.365E-09	0.0016	3.053E-11

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

idio-iclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Path mrem/yr
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.695E-07
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.695E-07

um of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

idio-iclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr
›-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ı-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ıtal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

dio-clide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Path mrem/yr
-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
tal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00

um of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

adio- uclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr
ɔ-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ı-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ɔtal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

adio- iclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Path mrem/yr
›-60	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ı-54	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00
ıtal	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00

ium of all water independent and dependent pathways.

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:SRAD, Version 6.0      T« Limit = 0.5 year          02/20/2001  14:03  Page  17
ımmary : Braidwood with NRC Recomended Default Parameters      File: BRAID1.RAD

                              Dose/Source Ratios Summed Over All Pathways
                    Parent and Progeny Principal Radionuclide Contributions Indicated

.rent  Product  Branch                                       DSR(j,t)   (mrem/yr)/(pCi/g)
i)       (j)    Fraction* t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03
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-60    Co-60    1.000E+00    5.869E+00 5.118E+00 3.893E+00 1.492E+00 9.528E-02 4.831E-06 0.000E+00 0.000E+00

-54    Mn-54    1.000E+00    1.406E+00 6.154E-01 1.178E-01 3.610E-04 2.352E-11 1.289E-36 0.000E+00 0.000E+00
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ranch Fraction is the cumulative factor for the j't principal radionuclide daughter:  CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
e DSR includes contributions from associated (half-life ó 0.5 yr) daughters.

                          Single Radionuclide Soil Guidelines G(i,t) in pCi/g
                               Basic Radiation Dose Limit =  25 mrem/yr

clide
(i)     t= 0.000E+00    1.000E+00    3.000E+00    1.000E+01    3.000E+01    1.000E+02    3.000E+02    1.000E+03
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-60        4.260E+00    4.884E+00    6.422E+00    1.676E+01    2.624E+02    5.175E+06   *1.131E+15   *1.131E+15
-54        1.777E+01    4.063E+01    2.123E+02    6.926E+04    1.063E+12   *7.744E+15   *7.744E+15   *7.744E+15
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t specific activity limit

          Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
          and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
       at tmin = time of minimum single radionuclide soil guideline
   and at tmax = time of maximum total dose = 0.000E+00 years

:lide  Initial          tmin          DSR(i,tmin)  G(i,tmin) DSR(i,tmax) G(i,tmax)
(i)     pCi/g          (years)                      (pCi/g)               (pCi/g)
ÄÄÄÄÄ ÄÄÄÄÄÄÄÄÄ  ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ   ÄÄÄÄÄÄÄÄÄ   ÄÄÄÄÄÄÄÄÄ   ÄÄÄÄÄÄÄÄÄ   ÄÄÄÄÄÄÄÄÄ
-60   1.800E-01      0.000E+00       5.869E+00   4.260E+00   5.869E+00   4.260E+00
-54   1.200E-01      0.000E+00       1.406E+00   1.777E+01   1.406E+00   1.777E+01
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                        Individual Nuclide Dose Summed Over All Pathways
                          Parent Nuclide and Branch Fraction Indicated

uclide Parent   BRF(i)                                     DOSE(j,t), mrem/yr
 (j)      (i)           t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03
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o-60   Co-60   1.000E+00    1.056E+00 9.213E-01 7.007E-01 2.685E-01 1.715E-02 8.695E-07 0.000E+00 0.000E+00

n-54   Mn-54   1.000E+00    1.688E-01 7.384E-02 1.413E-02 4.332E-05 2.822E-12 0.000E+00 0.000E+00 0.000E+00
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RF(i) is the branch fraction of the parent nuclide.


                             Individual Nuclide Soil Concentration
                          Parent Nuclide and Branch Fraction Indicated

uclide Parent   BRF(i)                                       S(j,t), pCi/g
 (j)      (i)           t= 0.000E+00 1.000E+00 3.000E+00 1.000E+01 3.000E+01 1.000E+02 3.000E+02 1.000E+03
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o-60   Co-60   1.000E+00    1.800E-01 1.574E-01 1.203E-01 4.695E-02 3.194E-03 2.623E-07 5.569E-19 0.000E+00

n-54   Mn-54   1.000E+00    1.200E-01 5.261E-02 1.011E-02 3.149E-05 2.168E-12 1.858E-37 0.000E+00 0.000E+00
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RF(i) is the branch fraction of the parent nuclide.

SMAIN5.EXE execution time =   21.86 seconds
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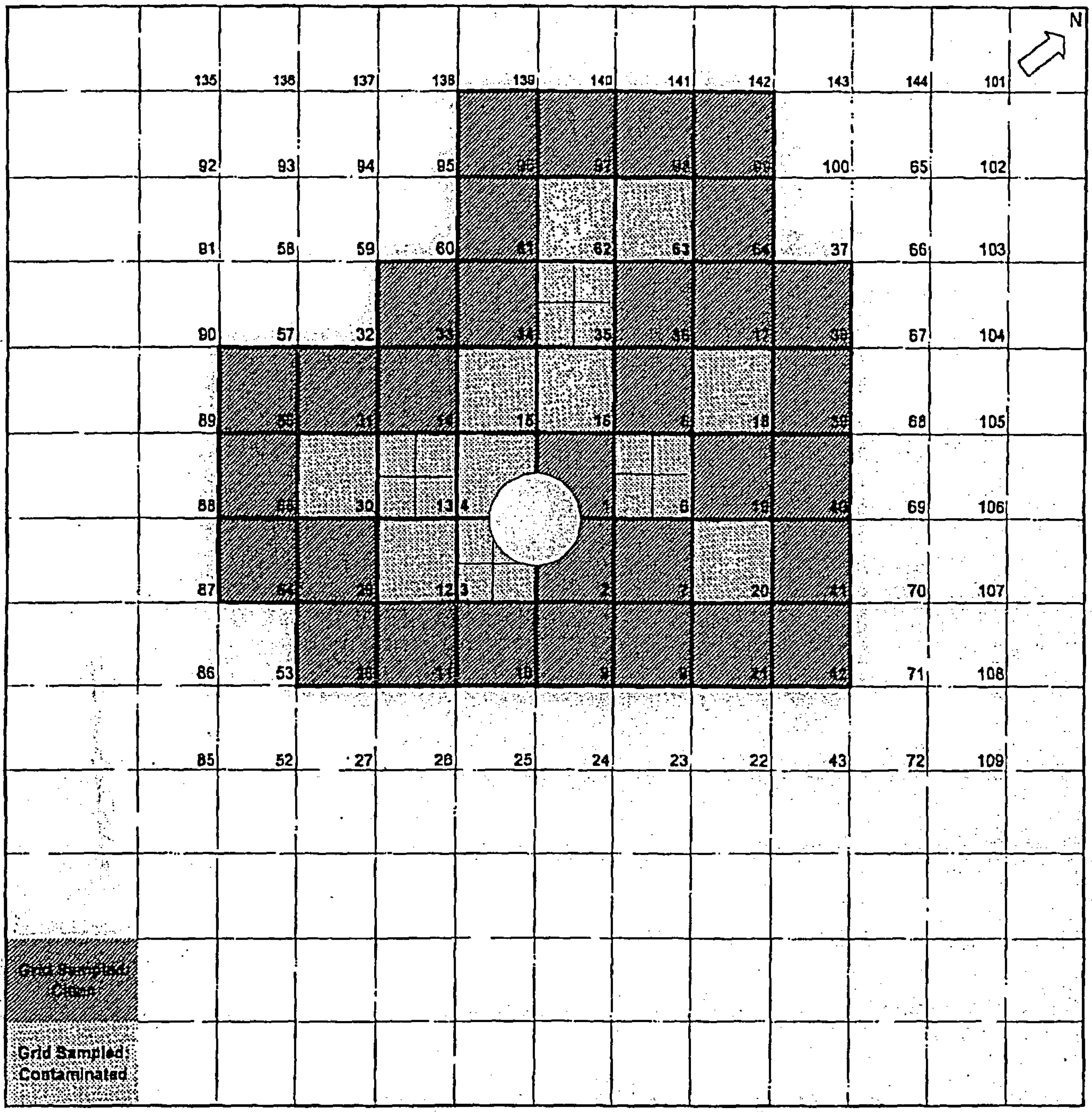
Based upon the evaluation from Millennium Services, Inc. which provided a recommendation to post the area of soil contamination (due to Co-60) resulting from the vacuum breaker leak, those sample grids containing Co-60 were subdivided and sample. The attached drawing indicates those grids sampled (Grids 3, 6, 13, and 35). Isotopic analyses of the samples are attached.

Grid 3 indicated one quadrant with Co-60 at a concentration of 2.931E-7 uCi/g. Based on a quadrant size of 5m x 5m (depth of 6 inches) and a soil density of 1.6 g/cc, the total uCi of Co-60 is determined to be 1.78E+0 uCi, which is well below the limit of 10 uCi which would require radiological posting.

Additionally, in one quadrant of Grid 3, isotopic results indicated the presence of Mn-54 at a concentration of 1.838E-7 uCi/g and in one quadrant of Grid 13 isotopic results indicated the presence of Te-123m at a concentration of 5.818E-8 uCi/g. Neither of these isotopes was present in the initial grid samples. The activity of these quadrants, when added to the original totals, was evaluated against the posting criteria of 10CFR20.1902(e) and determined that posting of the spill area is not required.

Sampling Grid



QUESTIONS FROM SENATOR DURBIN'S
STAFF REGARDING THE DRESDEN STATION TRITIUM LEAK

Background

The licensee identified on August 30, 2004, through sampling of shallow wells on site that there were elevated levels of tritium in some locations. Onsite deep well samples were not at elevated levels nor were elevated levels of tritium identified offsite in either surface or well water samples. The source of the leakage was identified as a buried common suction line from the condensate storage tanks to the Unit 2 and 3 High Pressure Coolant Injection (HPCI) systems. The leakage was largely confined to a small shallow area outside an adjoining plant building and has posed no environmental hazard. Tritium contaminated water was identified in the storm drain system but has not traveled offsite . Measurements at the storm drain outflow in onsite locations showed concentrations that were less than half of the EPA drinking water limit. Although the condensate storage tank is the normal source of water to the HPCI systems, the torus is the safety related source of water and the HPCI systems for both units are currently aligned to the torus. Therefore, HPCI system function is not impaired by the line leak from the condensate storage tanks. No EPA tritium drinking water or NRC effluent release limits have been exceeded as a result of this leak.

The licensee started excavating on September 3, 2004, to attempt to identify the exact location of the leak. Difficulties with contractor expertise resulted in the inability to identify the exact source of the leak and personnel safety issues within the excavation. The licensee stopped work due to the second issue and hired a different excavation contractor. Due to difficulties with excavation near existing equipment and the inability to identify the exact location of the leak the licensee has decided to reroute a 75-foot section of the piping and abandon portions of the underground piping in place. The work is ongoing.

Question # 1:

What requirements exist for informing the public about leaks like this ?

Response:

Title 10 of the Code of Federal Regulations (CFR) Part 20, "Standards for Protection Against Radiation," provide many of the reporting and notification requirements for radiological issues. These requirements are contained in Subpart M, "Reports," which provides the reports of most radiological issues that NRC licensees are required to make to the NRC. 10 CFR Part 50 in 50.72, "Immediate Notification Requirements for Operating Nuclear Power Plants" and 50.73, "Licensee Event Reporting System," provide emergency notification requirements and those for reporting events that relate primarily to reactor operating conditions.

While the regulations in 10 CFR Part 20 include NRC notification requirements in case of releases of radioactive material above prescribed limits and for radiation doses to the public in excess of specified limits, the tritium leakage that recently occurred at the Dresden Station is not reportable to the NRC because none of the reporting thresholds were reached.

The licensee is required by their operating license to implement a program for radioactive effluent controls and for monitoring the potential impact of radioactive effluents on the environment through a radiological environmental monitoring program (REMP). The REMP requires sampling of various environmental pathways including waterborne pathways at required intervals, which are to be analyzed for the presence of specified radiological constituents. Reporting levels for radioactivity concentrations in environmental samples are specified in the REMP and include reporting levels for tritium in water. Should the "reporting levels" specified in the REMP be exceeded, the licensee would be required to prepare and submit a report to the NRC that identifies the problem and defines its corrective actions. The problem would also be required to be reported to the NRC in the license's Annual Radiological Environmental Operating Report. The reporting level for tritium required by the REMP was not approached for this Dresden leak.

There are no requirements for licensees to directly inform the public of leaks or to inform the public of other radiological issues that may not otherwise be reportable to the NRC under 10 CFR Part 20 or Part 50. However, should licensees make required reports to the NRC, such reports are made available to the public (absent safeguards information) on the NRC's external web site.

Question # 2:

What NRC requirements are there for licensee's to fix, monitor and contain a leak (like this)?

Response:

Should leaks occur, a licensee would be required by 10 CFR Part 20 (20.1501) to evaluate (i.e., monitor) the extent of the leak so as to assess its potential radiological hazard and assess its radiological impact. Following that evaluation, the licensee would be required to correct the problem to ensure the leak would not result in effluent releases or radiation dose to members of the public in excess of regulatory limits.

Question # 3:

What are the statistics on how often such tritium leaks have occurred at Dresden?

Response:

The NRC does not maintain statistics or records of leaks that occurred at Dresden that are below the reportability criteria . However, if a leakage problem or other radiological issue was reportable under 10 CFR Part 20 or Part 50, the licensee's required report would be maintained along with the report of any NRC inspection that evaluated the issue.

The licensee has conducted a REMP since the early 1970s. Through this program, radiological impacts to workers, the public, and the environment are monitored, documented and compared to the applicable standards. As part of the NRC's inspection program, we routinely evaluate the adequacy of the licensee's REMP and ensure that the appropriate environmental pathways are sampled and analyzed as required. These inspections are currently performed on a biannual basis and have not identified significant problems with either the development or the implementation of the Dresden Station REMP.

The potential environmental impact of radiological releases from the plant are required to be summarized in the Annual Radiological Environmental Operating Report and the Annual

Radioactive Effluent Release Report. These reports are also reviewed as part of the NRC's routine inspection program. These reports have shown no discernable radiological impact on the environment from Dresden Station operations. These reports are also available for public review on the NRC's external web site.

Question # 4:

Will remediation of the dirt where the tritium leaked be necessary?

Response:

No immediate remediation of the soil is required unless the licensee plans to relocate any of the soil that was excavated to repair the line leak to another location at their facility or dispose of the soil as radioactive waste. In that instance, NRC approval would be required under the disposal provisions of 10 CFR 20.2002. Should the licensee return the excavated soil back into the excavated area or otherwise have not disturbed the soil, then the licensee would be required to maintain a record of any contamination in and around its facility for future decommissioning purposes pursuant to 10 CFR 50.75(g). Dresden plans to opt for the 50.75(g) methodology.