Impact of Cooling Tower Blowdown Line Leak upon a Member of the Public

Prepared by: ______________________ Date 1-20-10
Heather Baxter
Groundwater Program Lead

Approved by: ______________________ Date 1/20/10
Mike Robinson
Superintendent

Reviewed by: Don Edwards, Contractor
Mike Millinor, Brunswick Nuclear Power Plant

J-45

Impact of Cooling Tower Blowdown Line Leak upon a Member of the Public

Heather Baxter and Don Edwards

Summary:

In 2009, the buried Cooling Tower Blowdown Line was discovered to be releasing water containing tritium into the surrounding soil. All of the leaking water and plume is contained within the site boundary, and based on studies performed by an independent hydrologist, offsite migration is not anticipated. A bounding estimate of the dose to a hypothetical individual member of the public was performed. In this theoretical calculation, if a child was to ingest a full year of drinking water from the Cooling Tower Blowdown Line they would receive 2.14 mrem total body dose. Since 2.14 mrem total body dose is less than the 10CFR50 Appendix I limits of 3 mrem total body, the hypothetical exposure would not violate any regulatory limits.

On April 1, 2009, a hydrology study, conducted as part of the voluntary Industry Groundwater Protection Initiative, revealed that the buried Cooling Tower Blowdown Line was releasing water containing tritium into the surrounding soil. The maximum tritium activity level discovered was 2,120 picocuries per liter (pCi/L). Since the pipe is buried, the leak rate could not be determined; but appeared to be small.

According to Regulatory Guide 1.21 Revision 1 *"Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases or Radioactive Material in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants"* the information on the identity and quality of radionuclides is needed to ascertain whether regulatory limits have been exceeded. While Reg Guide 1.21 Rev 1 discusses abnormal release pathways it does not address monitoring for a leak or spill. Regulatory Guide 1.21 was recently revised (Reg Guide 1.21 Revision 2) and includes guidance for monitoring leaks and spills. While Harris Nuclear Plant is not committed to the actions and statements in Reg Guide 1.21 Rev 2, this document provides a framework to address the impact of the Cooling Tower Blowdown Line leak.

The first element in Regulatory Guide 1.21 Rev 2 Section 1.5 is to obtain the necessary information for the Annual Radioactive Effluent Release Report.

> "Leaks or spills to the ground will be diluted on contact with soil and water in the environment. Samples of the undiluted liquid (from the source of the leak or spill) and samples of the affected soil (or surface water or groundwater) should be analyzed." (RG 1.21 Rev 2 Sec 1.5 page 11)

The Cooling Tower Blowdown Line is used for liquid effluent dilution as part of permitted radioactive releases. The permitted liquid effluent release point is the discharge from the Cooling Tower Blowdown Line into Harris Lake. The concentration of the water inside the Cooling Tower Blowdown Line varies depending upon permitted radioactive releases, secondary waste discharges, and the concentration of tritium in Harris Lake. For 2008 the annual average tritium concentration of the undiluted liquid from the source of the leak was 20,516 pCi/L.

During the hydrogeologic evaluation of the impacted area, soil, surface water, and vegetation samples were obtained. The soil samples were analyzed for gamma emitters by the Harris Nuclear Plant Count Room to the environmental lower limit of detection. Only naturally occurring, non plant related, gamma emitters were identified, consistent with background radiation. The surface water samples were analyzed for tritium by the Harris Energy and Environmental Center to an *a priori* lower limit of detection of 250 pCi/L. The concentration of tritium was less than the lower limit of detection. Finally, vegetation i.e. grass, weeds, tree leaves, were analyzed for tritium by General Engineering Lab to a minimum detectible concentration of 250 pCi/kg and no tritium was detected, indicating there was little plant uptake of the contaminated liquid.

The second element in Regulatory Guide 1.21 Rev 2 Section 1.5 is to identify the extent of the plume.

> "The location and estimated volume of the leak or spill should be recorded to identify the extent of the impacted area and predict size or extent of the contaminated plume". (RG 1.21 Rev 2 Sec 1.5 page 11)

The leak is located onsite, on a peninsula, surrounded on three sides by Harris Lake, upstream of the permitted release point. The nearest site boundary is 1.79 miles away, with the closest residence nearly 2.0 miles away. All of the leaking water and plume is contained within the site boundary, and based on studies performed by an independent hydrologist, offsite migration is not anticipated. The location is not accessible to the public and there are no drinking water sources, crops, or irrigation in the vicinity of the leak.

The third element in Regulatory Guide 1.21 Rev 2 Section 1.5 is to evaluate a bounding exposure to a member of the public.

> "For leaks for spills involving the discharge of radioactive material to the unrestricted area, the dose to members of the public from the leak or spill should be evaluated using realistic or bounding exposure scenarios. However, for leaks or spills that occur on site, a realistic dose assessment to an offsite member of the public may become complicated especially if (1) no radioactive material has entered the unrestricted area and (2) there are no members of the public on site..." (RG 1.21 Rev 2 Sec 1.5 page 12)

A realistic dose assessment to an offsite member of the public is difficult because this is no real exposure pathway. An independent hydrologist concluded that offsite migration was unlikely. The leak and contamination plume are isolated to a wooded region on-site were very few people go. The contamination plume is below the ground surface and does not impact the atmosphere. The water is not used to irrigate crops or drink. Neither meat nor milk producing livestock feed or forage upon the site's vegetation. Finally, the groundwater is not a source of potable water.

According to Regulatory Guide 1.21 Rev 2:

> "For leaks and spills, licensees may choose to use bounding assessments to estimate the potential hazard. For example, if a leak occurs on site and radioactive material is released at or below the ground surface, the licensee may choose to assess the potential hazard by assuming that a conservatively large (e.g bounding) volume of water is part of an assumed exposure pathway (e.g. drinking water). "(RG 1.21 Rev 2 Sec 1.5 page 12)

So, in order to establish a bounding estimate of dose, it is assumed that a hypothetical member of the public will "stick a straw" into the Cooling Tower Blowdown Line discharge and consume their total annual intake of water from that source.

Because of permitted radioactive releases, secondary waste discharges, and Harris Lake water reuse, the concentration of tritium in the Cooling Tower Blowdown Line fluctuates. In order to give a more realistic picture of the pipe contents, the radioactive release permits and secondary waste discharge data from 2008 were evaluated and the weighted average of tritium concentration during the discharges was determined.

The tritium concentration in the Cooling Tower blowdown is due to the reuse of Harris Lake water. Weather conditions and previous radioactive discharges will cause lake tritium to vary. Per the Off-site Dose Calculation Manual, a composite sample from the Cooling Tower's blowdown weir is obtained and analyzed for tritium monthly. Table 1 shows the 2008 monthly tritium composite results.

Liquid effluent discharges from the radioactive waste system are permitted prior to release to ensure compliance with 10CFR Part 20 limits. In 2008 there were 28 liquid release permits. Table 1 shows the average concentration of tritium for the liquid release permits in a given month. In February, March, and December 2008 there were no radioactive liquid releases. Typically, the discharge flows 23-28 gallons per minute into a Cooling Tower Blowdown Line dilution flow.

The plant's secondary waste is discharged through the secondary waste treatment system. Diffusion of the Steam Generator tubing causes secondary waste to contain low levels of tritium, as seen in Table 1. Roughly 1-1½ million gallons of secondary waste is batch released monthly from the plant's Settling Basin at 600 gpm into the Cooling Tower Blowdown flow.

The combination of the Cooling Tower blowdown and makeup water pumps generates a discharge flow of 10,000 to 12,000 gallon per minute along the pipe. The Cooling Tower's blowdown provides a significant dilution of radioactive and secondary releases. As a result, the typical concentration of tritium in the Cooling Tower Blowdown Line is approximately a magnitude larger than the Cooling Tower Blowdown Composite. Table 1 shows the calculated weighted average for a given month.

Table 1 – Resulting Tritium Concentration in Cooling Tower Blowdown Line

	Cooling Tower Blowdown Composite (pCi/L)	Radioactive Release (pCi/L)	Secondary Waste(pCi/L)	Monthly Average CTBD Tritium Conc (pCi/L)
January	5320	8.90E+07	10,125	20,061
February	7690	no releases	20,574	7,720
March	5440	no releases	21,008	5,478
April	6020	2.52E+07	32,410	8,979
May	5090	1.37E+08	35,067	30,729
June	3690	5.82E+07	31,797	11,044
July	3870	1.04E+07	28,270	5,292
August	5060	3.03E+08	26,898	66,224
September	4470	2.73E+08	13,591	43,508
October	4060	3.15E+08	13,394	30,039
November	6510	1.04E+08	16,171	11,786
December	5280	no releases	14,996	5,297

Regulatory Guide 1.109 *"Calculation of Annual Dose to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I"* provides the equations for estimating radiation exposure for the principle effluent pathways.

The generalized equation for calculating radiation dose is:

$$R_{aipj} = C_{ip} U_{ap} D_{aipj}$$

Where:

C_{ip} the concentration of nuclide i in the media of pathway p, in pCi/l

D_{aipj} the dose factor, specific to age group a , radionuclide I, pathway p and organ j, in mrem/pCi from Reg Guide 1.109 Table E-11

U_{ap} the exposure time or ingestion rate (usage) associated with pathway p for age group a, in liter/yr from Reg Guide 1.109 Table E-5

R_{aipj} the annual dose to organ j of an individual of age group a from nuclide i via pathway p, in mrem/yr

Age group	Drinking Water Ingestion Rate (L/yr) (Using Reg Guide 1.109 Table E-5)	Single Day Ingestion Rate (L/day) using Reg Guide 1.109 Table E-5)	Dose Factors (mrem/pCi) (Reg Guide 1.109 Table E-11 total body and all organs except bone) [1]
Adult	730	730/365 = 2.0	1.05E-07
Teen	510	510/365 = 1.4	1.06E-07
Child	510	510/365 = 1.4	2.03E-07
Infant	330	330/365 = 0.9	3.08E-07

Note 1 – bone does not have a dose factor for tritium

Using the generalized equation and the monthly concentrations from Table 1, the dose to hypothetical members of the public can be computed. The tables below show monthly and annual hypothetical dose for each of the different receptor age groups.

Table 2 – Adult Total Body and All Organs Dose from Ingestion of Cooling Tower Blowdown Line Water

Month	Monthly Average CTBD Tritium Conc (pCi/L)	Number of Days per Month (days/month)	Adult Daily Water Consumption (liters/day)	Adult Dose Factor From H-3 (mrem/pCi)	Adult Monthly Drinking Water Total Body Dose (mrem/month)
January	20,061	31	2.00	1.05E-07	1.31E-01
February	7,720	28	2.00	1.05E-07	4.54E-02
March	5,478	31	2.00	1.05E-07	3.57E-02
April	8,979	30	2.00	1.05E-07	5.66E-02
May	30,729	31	2.00	1.05E-07	2.00E-01
June	11,044	30	2.00	1.05E-07	6.96E-02
July	5,292	31	2.00	1.05E-07	3.45E-02
August	66,224	31	2.00	1.05E-07	4.31E-01
September	43,508	30	2.00	1.05E-07	2.74E-01
October	30,069	31	2.00	1.05E-07	1.96E-01
November	11,786	30	2.00	1.05E-07	7.43E-02
December	5,297	31	2.00	1.05E-07	3.45E-02
Total Annual					**1.58 mrem**

Table 3 – Teen Total Body and All Organs Dose from Ingestion of Cooling Tower Blowdown Line Water

Month	Monthly Average CTBD Tritium Conc (pCi/L)	Number of Days per Month (days/month)	Teen Daily Water Consumption (liters/day)	Teen Dose Factor From H-3 (mrem/pCi)	Teen Monthly Drinking Water Total Body Dose (mrem/month)
January	20,061	31	1.40	1.06E-07	9.23E-02
February	7,720	28	1.40	1.06E-07	3.21E-02
March	5,478	31	1.40	1.06E-07	2.52E-02
April	8,979	30	1.40	1.06E-07	4.00E-02
May	30,729	31	1.40	1.06E-07	1.41E-01
June	11,044	30	1.40	1.06E-07	4.92E-02
July	5,292	31	1.40	1.06E-07	2.43E-02
August	66,224	31	1.40	1.06E-07	3.05E-01
September	43,508	30	1.40	1.06E-07	1.94E-01
October	30,069	31	1.40	1.06E-07	1.38E-01
November	11,786	30	1.40	1.06E-07	5.25E-02
December	5,297	31	1.40	1.06E-07	2.44E-02
Total Annual					**1.12 mrem**

Table 4 – Child Total Body and All Organs Dose from Ingestion of Cooling Tower Blowdown Line Water

Month	Monthly Average CTBD Tritium Conc (pCi/L)	Number of Days per Month (days/month)	Child Daily Water Consumption (liters/day)	Child Dose Factor From H-3 (mrem/pCi)	Child Monthly Drinking Water Total Body Dose (mrem/month)
January	20,061	31	1.40	2.03E-07	1.77E-01
February	7,720	28	1.40	2.03E-07	6.14E-02
March	5,478	31	1.40	2.03E-07	4.83E-02
April	8,979	30	1.40	2.03E-07	7.66E-02
May	30,729	31	1.40	2.03E-07	2.71E-01
June	11,044	30	1.40	2.03E-07	9.42E-02
July	5,292	31	1.40	2.03E-07	4.66E-02
August	66,224	31	1.40	2.03E-07	5.83E-01
September	43,508	30	1.40	2.03E-07	3.71E-01
October	30,069	31	1.40	2.03E-07	2.65E-01
November	11,786	30	1.40	2.03E-07	1.00E-01
December	5,297	31	1.40	2.03E-07	4.67E-02
Total Annual					**2.14 mrem**

Table 5 – Infant Total Body and All Organs Dose from Ingestion of Cooling Tower Blowdown Line Water

Month	Monthly Average CTBD Tritium Conc (pCi/L)	Number of Days per Month (days/month)	Infant Daily Water Consumption (liters/day)	Infant Dose Factor From H-3 (mrem/pCi)	Infant Monthly Drinking Water Total Body Dose (mrem/month)
January	20,061	31	0.90	3.08E-07	1.72E-01
February	7,720	28	0.90	3.08E-07	5.99E-02
March	5,478	31	0.90	3.08E-07	4.71E-02
April	8,979	30	0.90	3.08E-07	7.47E-02
May	30,729	31	0.90	3.08E-07	2.64E-01
June	11,044	30	0.90	3.08E-07	9.18E-02
July	5,292	31	0.90	3.08E-07	4.55E-02
August	66,224	31	0.90	3.08E-07	5.69E-01
September	43,508	30	0.90	3.08E-07	3.62E-01
October	30,069	31	0.90	3.08E-07	2.58E-01
November	11,786	30	0.90	3.08E-07	9.80E-02
December	5,297	31	0.90	3.08E-07	4.55E-02
Total Annual					**2.09 mrem**

In this scenario the hypothetical critical receptor is a child who received 2.14 mrem of total body and organs dose.

A second more realistic scenario, but equally hypothetical, would be for a member of the public to drink from a groundwater well located within the contaminant plume. The source water will be diluted on contact with soil and water in the environment. While the 2008 the annual average tritium concentration of the undiluted source liquid was 20,516 pCi/L; the highest observed concentration of tritium in the groundwater was only 2,120 pCi/L, roughly a tenth of the source concentration.

Table 6 shows the annual dose a member of the public would receive if they were to consume their full annual intake from the tritiated groundwater.

Table 6 –Total Body and All Organs Dose from Ingestion of Groundwater

Age group	Drinking Water Ingestion Rate (L/yr) (Using Reg Guide 1.109 Table E-5)	Dose Factors (mrem/pCi) (Reg Guide 1.109 Table E-11 total body and all organs except bone)[1]	Concentration (pCi/L)	Annual Dose (mrem)
Adult	730	1.05E-07	2120	0.162
Teen	510	1.06E-07	2120	0.115
Child	510	2.03E-07	2120	0.219
Infant	330	3.08E-07	2120	0.215

Note 1 – bone does not have a dose factor for tritium

In this case, the critical receptor in the case is a child who would receive 0.22 mrem from this exposure pathway.

In 2008, the total body dose from all pathways was 0.351 mrem. 10CFR50 Appendix I limits for liquid effluents for any individual in an unrestricted area from all pathways of exposure is 3 mrem total body or 10 mrem to any organ. The total dose received by a child in the first bounding calculation would be 2.491 mrem total body (2.14 mrem + 0.351 mrem). While the total dose received in the second bounding calculation would be 0.57 mrem (0.219 mrem + 0.351 mrem). Since these doses are less than the 10CFR50 Appendix I limits the exposure to the leaking Cooling Tower Blowdown Line does not violate any regulatory limits.

Despite the calculated doses, there is no real exposure pathway to a member of the public. The hazard assessments presented above are bounding estimates of the dose to a hypothetical individual member of the public. No actual exposure was received by a member of the public and the Annual Radioactive Effluent Release Report does not need to be revised to include these dose.