TRANSFER OF SLIGHTLY CONTAMINATED SEDIMENT TO THE H.B. ROBINSON ASH POND VIA THE ASH SLUICE SYSTEM

Safety Analysis Report

Date: September 19, 1983

Table of Contents

	Page
List of Tables	ii
List of Figures	iii
1.0 Purpose	1
2.0 Background	1
3.0 Proposed Method for Sediment Transfer	3
4.0 Radiological Impacts	5
5.0 Conclusions	9
References	10

List of Tables

Tables Page

1 Average Concentrations (μCi/g Wet) of Man-Made Radionuclides in Settling Basin Sediment.................. 11

2 Comparison of Impacts and Costs of Sediment Disposal Methods.. 12

List of Figures

Figure		Page
1	H.B. Robinson Settling Basins...........................	13
2	H.B. Robinson Ash Pond and Environs.....................	14

TRANSFER OF SLIGHTLY CONTAMINATED SEDIMENT TO THE H.B. ROBINSON ASH POND VIA THE ASH SLUICE SYSTEM

1.0 Purpose

In accordance with 10CFR20.302, this report provides an analysis of potential radiological safety concerns associated with a new transfer method for coal fly ash and dust that is slightly contaminated, mainly with Co-60. The transfer is from the East and West settling basins on the H.B. Robinson (HBR) Plant grounds to the ash collection pond via the ash sluice system; thus the entire transfer will take place within the owner-controlled perimeter.

During July and August of 1983, the basins were incompletely emptied by a hydrovacuum truck with NRC approval. The proposed new transfer method will employ a temporary pump and piping system to move the fly ash/dust as a slurry to the Unit 1 ash hopper. From there, the slurry will be pumped through the in-place ash sluice system to the ash collection pond. This method will be referred to as the "direct piping" method. It is the purpose of this report to delineate and assess specific radiological safety concerns regarding this transfer method.

2.0 Background

The H.B. Robinson Plant utilizes two basins to collect and treat water from the Unit 1 (coal-fired) and Unit 2 (nuclear) storm drains. The basins are located south of the Unit 1 switchyard and are shown in Figure 1. The basins permit the settling of suspended solids and removal of waste oil to meet National Pollutant Discharge Elimination System (NPDES) requirements. The suspended solids and sediment in the two basins include coal fly ash and dusts that are slightly contaminated with Co-60. The source of this contamination is trace amounts of radioactivity from primary to secondary coolant leaks which occasionally enter the Unit 2 storm drains.

In the period between July 20 through August 4, 1983, the two basins were partially emptied when about 5000 m^3 of wet sediment were transferred to the HBR ash collection pond. The operation utilized four hydrovacuum trucks with two men per truck. Since two 10-hour shifts per day were required, a total of 16 workers spent 16 work days to finish the task. Thus 2560 man-hours were required to complete the sediment removal using the hydrovacuum truck method. In the transfer, the trucks traversed off of the owner-controlled perimeter for no more than a total of 24 hours.

The ash pond is located 1.25 miles WNW of the plant. Approximately 34 mCi of Co-60 was also moved in the sediment transfer. The operation was approved by the USNRC[1] under the auspices of a CP&L safety analysis report[2].

The safety analysis report provided detailed analyses and discussion of (1) the physical, chemical, and radiological characteristics of the sediments in the settling basins; (2) the HBR environment including topography, geology, hydrology, meteorology; and (3) dosimetric estimates from direct exposure, inhalation, and ingestion due to the hydrovacuum truck removal method and disposal in the ash pond. The report concluded that (1) the impacts of contaminated sediment removal were minimal and (2) direct radiation exposure from deposited contaminated sediments in the ash pond provided the largest contribution to the potential dose for the maximum individual. The estimated dose rate was 0.024 mrem/hr to an individual who was standing on an infinite slab of pond sediment containing a uniformly distributed Co-60 design basis concentration of 9.72 E-6 μCi/g.

The maximum credible exposure pathway was from ground plane irradiation to an individual from the public and to the occupational worker. It was found that such direct exposure would occur maximally to a teenager who spent 67 hours per year on the shoreline of the ash pond. The resultant dose to this individual was 1.61 mrem/yr. The occupational external dose for two men working 160 hours to effect the transfer was estimated at 7.7 mrem or 3.9 mrem per man. The dose due to inhalation of resuspended, respirable dusts from the ash pond was computed assuming a dust loading of 260 $\mu g/m^3$ and applying the methods of Regulatory Guide 1.109[3]. It was

found that the lung was the critical organ and that about 83 percent of the lung dose was due to Co-60. It was noted that the estimated airborne activity concentrations for Mn-54, Co-58, Co-60, Nb-95, Cd-109, Cs-134, Cs-137, and Ce-144 were a million to one billion times lower than their corresponding MPC values found in 10CFR20 (Appendix B, Table II, and Column 1) for insoluble particulates. The ingestion pathway was also considered and it was found that the forage-to-deer-to-man pathway would deliver the largest dose to the gastrointestinal tract and that 96 percent of the dose was due to Co-60.

3.0 Proposed Method for Sediment Transfer

The following safety analysis applies to a different method for removal of sediment from the settling ponds. The method entails (1) slurrying of the sediment with an external source of water, (2) pumping the sediment into the Unit 1 ash hopper, and (3) utilizing the in-place ash sluice system to pump the contents of the ash hopper to the HBR ash collection pond. This direct piping method is different from the previous removal method whereby the sediment in the basins was slurried and hydrovacuumed for removal by truck. The proposed new method (1) is more cost-effective and (2) has the same small probability for radiological impact.

3.1 Operations

In the direct piping method, the sediment in the settling basins is slurried by addition of water. There are two sources of external water available for this task. The first source is to cross pump standing water from one basin into the other basin for slurrying purposes. The other source of external slurry water can be obtained from a fire hydrant in the Unit 1 switchyard. In this case, flow rates will be adjusted as needed and will be well within the fire system capacity. No fire equipment other than the hydrant will be used. A solids handling pump will be used to pump the sediment/ash slurry to the ash hopper. A flexible hose will be placed on the suction end of the pump. The flexibility will permit the hose to be placed easily in either East or West basins. The sediment slurry is moved to the outer door of the Unit 1 ash hopper through

polybutylene (PB) pipe. The PB pipe will be laid on the ground. Additional flexible hose will be attached to the output end of the PB pipe so that it can be inserted into the ash hopper door.

It should be noted that the direct piping method does not require the permanent emplacement of this equipment. In fact, after the pumping operation is completed, all piping, restraints, supports, and pump will be flushed clean and stored for future use. Due to the abrassive quality of the ash slurry, the ash piping from Unit 1 to the ash pond is essentially self-cleaning and would not require any decontamination. As shown in the enclosed analysis, there is insufficient material and contamination being transferred to cause any form of a radiological hazard. Therefore, cleaning would not be necessary.

The slurried sediment will be transported about 500 feet from the settling basins to the ash hopper; the route of travel is marked in Figure 1. Once in the ash hopper, the Unit 1 ash sluice system will pump the slurry through the in-place ash line 1.25 miles to the ash collection pond. The ash sluice system provides two pumps (A and B) to move ash slurry accumulated during normal Unit 1 operations to the ash pond. Only one pump is used at a time and the other one serves as a backup. Both pumps are maximally rated at 3200 gpm; although under normal operations, a flow rate of 2400 to 2500 gpm is typically maintained.

The ash line from the hopper to the ash collection pond is constructed of 12-inch diameter pipe. The first, approximately 1000 feet, is underground and made of fiberglass with a ceramic liner. The remainder of the line is above ground and, with the exception of the last 80 feet, is made of cast iron. The route of travel is shown in Figure 2. The last 80 feet is the portion of the line that actually enters the ash pond and is made of PB pipe. The route that is taken by the ash line is parallel and west of the HBR discharge canal. From the ash hopper to the outfall in the ash pond, there is a gradual 45-foot lift required. The entire transfer of slurried fly ash from settling basins to ash pond takes place within the owner-controlled perimeter at HBR.

The transfer operation will involve approximately four workers. Three workers will be located at the settling basins to manipulate the pump and suction line. The fourth individual will monitor the ash slurry as it enters the ash hopper. Since each settling basin has an active volume of about 3000 m^3, it will require 18 work days to empty two full basins. This assumes a conservatively slow pump rate of 200 gpm. To account for contingencies, 30 work days are assumed to be required to complete the job. Thus (30 work days) (8 hours/work day) (4 men) = 960 man-hours of occupational exposure.

3.2 Operational Precautions

Appropriate health physics concerns will be addressed for the above operations in the form of an implementation procedure. Installation of the temporary piping system from the settling basins to the ash hopper can be effected with Unit 1 either shutdown or at power. However, during the actual transfer of the slurried sediment to the ash hopper, the ash sluice system will not be used by Unit 1 Operations. In addition, Unit 1 Operations has the authority to cease all work in the sediment transfer at any time. Similarly, Plant Fire Protection has the authority, at any time, to deny use of the fire water in the event that it is used for slurrying the sediment in the settling basins. In either event, the sediment transfer operation will be halted.

To assure the smallest impact possible on Unit 1 Operations, transfers of sediment from the settling basins are anticipated only during periods of extended outage for the unit. Since Unit 1 is used only to supplement peak power requirements, sediment transfer will occur during nonpeak periods.

4.0 Radiological Impacts

As noted in Section 3.1, transfer of the contaminated sediment to the ash pond will take place entirely within the owner-controlled area at HBR. Although CP&L has the right to restrict access to owner-controlled areas, this supporting safety analysis assumes that public access to the ash pond is not restricted. This same assumption was used in the previous

safety analysis report. In the previous analysis, the man-made radioactivity was characterized in both East and West settling basins by means of grab samples and core samples. The results of these analyses, expressed as mean concentrations (μCi/g wet), are reproduced in Table 1. The weighted average Co-60 concentration permitted a simplification of the ground plane exposure calculation in that all of the 9.72 E-6 μCi/g of man-made radioactivity was assumed to be due solely to Co-60 (see Section 2.0).

4.1 Dose to Man

Since it has already been demonstrated to the satisfaction of the NRC that there are insignificant radiological impacts to biota and the environment from disposal of the contaminated sediment in the ash pond[1], it remains to only consider the potential radiological impact to man associated with the new, proposed method of sediment transfer. In this analysis, it is assumed that both basins are filled to capacity with sediment and that, again, about 6000 m^3 will have to be removed to the ash pond. This is a hypothetical situation at present since the basins currently contain about 1000 m^3 of sediment in the West basin and $\sim$ 290 m^3 of sediment in the East basin. However, using the 6000 m^3 volume and assuming the same sediment radiological characteristics as in the previous removal operation will permit a comparison of the two methods and would provide the most conservative, maximum possible, dose to man from future disposal operations.

A major advantage of the proposed sediment removal method over that of hydrovacuum truck removal is that the slurried sediment is contained at all times within a piping system that is completely within the owner-controlled perimeter. In the hydrovacuum truck method, the truck was required to traverse off plant grounds in order to transport the sediment to the ash pond.[2] The possibility of breaks or leaks in the piping system were considered, and it was concluded that there was the possibility for an undetected break in the in-place ash line that connects the ash hopper to the ash pond. An undetected leak or break in the temporary piping system from the settling basins to the ash hopper is unlikely since the

route of travel is short and the entire line is more or less in view at all times during this phase of the transfer operation.

Experience has shown that leaks in the in-place ash line occurs about seven times per year or on average about once every 50 days. The leaks vary in severity and the amount that can be spilled into the environment generally depends on the rapidity with which the leak is detected. The ash line is inspected periodically for leaks. Eight hours is the longest period of time that a leak has gone undetected.

To assess the radiological impact of a significant pipe break, a worst-case scenario was considered. It was assumed that all 6000 m^3 of sediment from the two settling basins was pumped to the ash hopper and that this volume was then pumped at the maximum capacity of the ash sluice system; i.e., 3200 gpm toward the ash pond. It was further assumed that there was an undetected break in the ash line pipe that allowed the entire 6000 m^3 of sediment to be released to the environment. The last assumption was that the sediment spread so as to form an infinitely thick, homogenous, and infinite slab with a uniformly distributed Co-60 concentration of 9.72 E-6 μCi/g.

With the assumption of the infinite slab model, the dose to an individual standing on the slab can be estimated from Beck and de Planque (1968).[4] This approach is the same as that used in the previous safety analysis report that estimated the dose to an individual standing on ash pond sediment under similar circumstances.[2] Since the analogy and all conditions are the same, exposure rate was again computed to be 0.027 mR/hr or 0.024 mrad/hr to air. The conversion of absorbed dose in air to absorbed dose in muscle assumed that the ratio of mass-energy absorption coefficients for air and muscle was unity over the energy range of interest. Thus, the dose rate at 1 meter under these assumptions was 0.024 mrem/hr. This dose rate is 1.2 and 2.4 percent of the limits set forth in 10CFR20.105(b)(1) and (2), respectively, for an unrestricted area.

In the unlikely event that a member of the public observed the pipe break for eight hours, the resulting dose would be 0.19 mrem from this

occurrence. As the sediment would be wet, inhalation of contaminated, respirable particulate from wind resuspension is not a credible pathway of exposure. Also, no credible ingestion pathway can be found in this scenario, even if all of the radioactivity of the spill were assumed to be immediately leached into Lake Robinson.[2] Furthermore, there are no drinking water supplies within 50 miles of the site that could be affected by the liquid effluents or seepage from such an accident.

The mitigating actions that the plant would take in the event of such an accident would include collection of the wet fly ash sludge and hauling to the ash pond by truck for disposal. In this effort, the fly ash will be kept wet, if necessary, to prevent any possible resuspension during cleanup. The occupational exposure during this task can be estimated assuming the job took 40 hours and 4 workers. With no credit taken for shielding by trucks and loading equipment and using the infinite slab model, the total dose received in the cleanup is estimated at 3.8 mrem or about 1 mrem per worker.

A more credible occupational exposure from the direct gamma radiation pathway would be from the nonaccident, sediment removal task itself. The estimated 960 man-hours required to complete the job would result in a total dose of 23.0 mrem for the 4 workers or about 5.8 mrem per worker. This compares favorably to the 61.4 mrem total dose estimated for the hydrovacuum truck removal method or about 3.9 mrem per worker for the 16-man crew. As in the case with hydrovacuum truck removal, the sediment is expected to always to be in a slurry; thus no inhalation of fugitive dusts is possible, thereby eliminating this pathway of exposure during the removal operation.

In summary, the radiological impacts from the proposed method of sediment removal from the settling basins to the ash pond are small. In the sediment transfer operation itself, the estimated occupational dose is 23.0 mrem. In the event of the worst-case accident, additional occupational exposure during cleanup operations would be 3.8 mrem. A member of the public exposed at the scene of the worst-case accident for 8 hours would receive an estimated 0.19 mrem. No credible inhalation or ingestion

pathways of exposure could be identified for either the sediment removal operation or the worst-case accident situation.

4.2 Costs

As noted in the safety analysis report supporting the hydrovacuum truck removal method, the estimated cost for the project was $100,000.[2] In the new proposed method of removal and transfer, the estimated cost is $30,000. Table 2 compares the estimated impacts and costs of the two sediment removal methods.

5.0 Conclusions

From the results of this safety analysis, it is found that the direct piping method has minimal radiological impact. This method is also clearly preferred for its cost-effectiveness. Moreover, impacts to the environment and members of the general public are demonstrably negligible even in the worst-case accident where there occurred a major, undetected break of the ash line. Therefore, on the basis of these conclusions, approval is requested for use of the direct piping/sluice method in the transfer of slightly contaminated fly ash sediment from the HBR settling basins to the ash collection pond.

References

1. Letter of February 18, 1983, from Mr. S. A. Varga to Mr. E. E. Utley, transmitting "Environmental Impact Appraisal in the Matter of the H.B. Robinson Unit 2 Disposal of Licensed Materials."

2. Letter of January 17, 1983, from Mr. E. E. Utley to Mr. S. A. Varga, transmitting "Request for Approval of Transfer of Contaminated Sediment to the H.B. Robinson Ash Pond," Safety Analysis Report.

3. U.S. Nuclear Regulatory Commission, 1977. Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR, Part 50, Appendix I. Regulatory Guide 1.109.

4. Beck, H. and G. de Planque, May 1968. The Radiation Field in Air Due to Distributed Gamma-Ray Sources in the Ground. USAEC Health and Safety Laboratory Report HASL-195.

Table 1 Average Concentrations (μCi/g Wet) of Man-Made Radionuclides in Settling Basin Sediment

	Routine Samples				Core Sample From			
Nuclide	**East Settling Basin**		**West Settling Basin**		**West Settling Basin**		**Weighted Average**	
Mn-54	2.16E-7[a]	(8)[b]	1.18E-7	(2)		(0)	1.96E-7	(10)
Co-58	5.29E-7	(18)	2.85E-7	(11)		(0)	4.36E-7	(29)
Co-60	1.55E-5	(47)	3.06E-6	(45)	5.59E-6	(27)	8.55E-6	(119)
Nb-95	3.31E-7	(9)	1.77E-7	(9)		(0)	2.54E-7	(18)
Cd-109	2.54E-6	(11)	2.46E-6	(15)	1.79E-6	(2)	2.44E-6	(28)
Cs-134	4.13E-7	(1)	1.40E-7	(1)		(0)	5.53E-7	(2)
Cs-137	4.41E-7	(39)	2.43E-7	(28)	9.88E-7	(13)	4.61E-7	(80)
Ce-144		(0)	5.16E-7	(2)		(0)	5.16E-7	(2)
Total	1.68E-5	(47)[c]	4.08E-6	(46)	7.12E-6	(28)	9.72E-6	(121)

[a] $2.16E-7 = 2.16 \times 10^{-7}$

[b] Number of samples in which nuclide was detected.

[c] Total number of samples.

Table 2 Comparison of Impacts and Costs of Sediment Disposal Methods

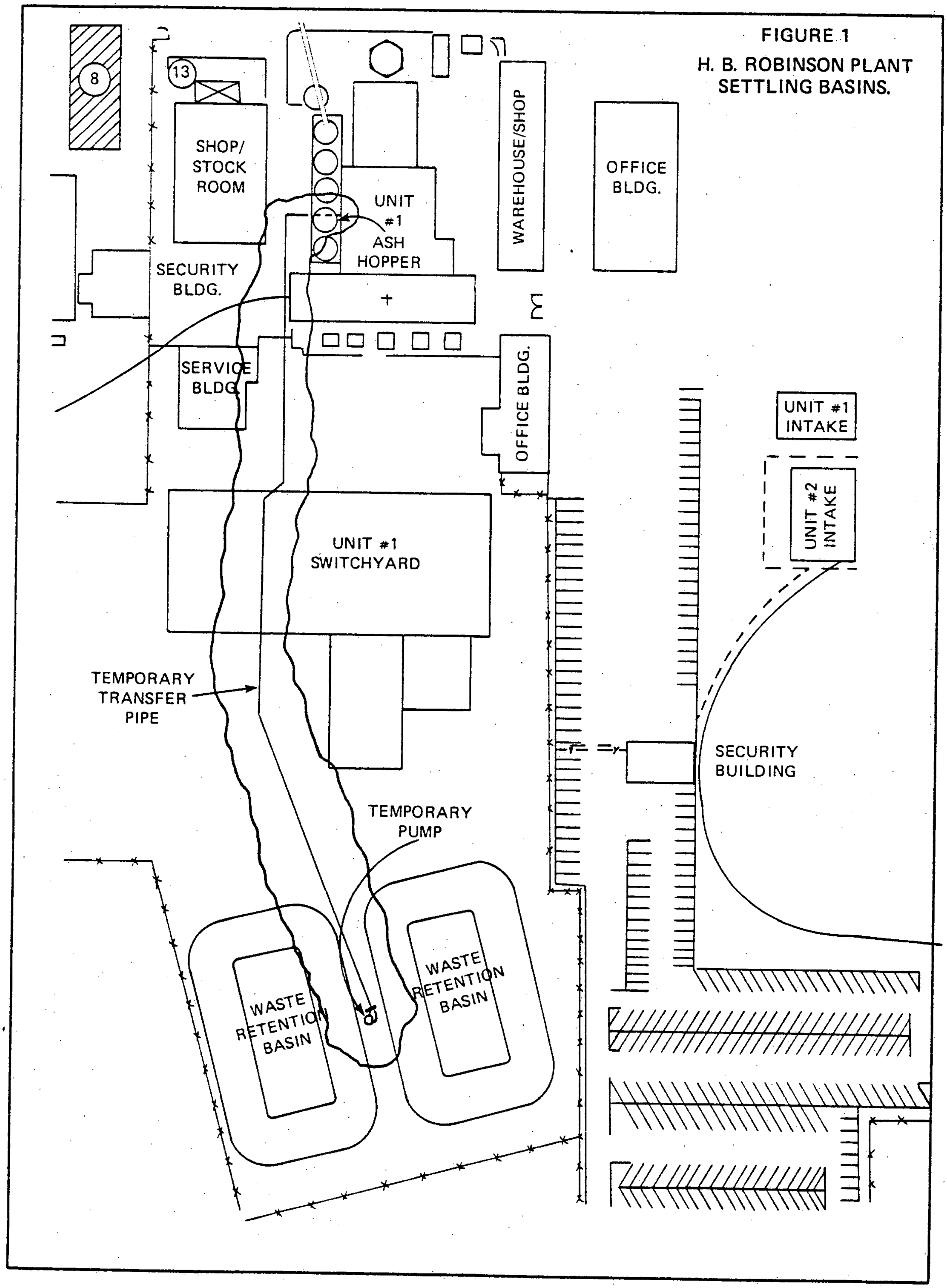
Impact	Hydrovacuum Truck	Direct Piping System
Occupational Exposure (mrem)	61.4[a]	23.0[b,c]
Cost	$100,000	$30,000

[a]Sixteen-man crew

[b]Four-man crew

[c]In the event of the worst-case accident, this exposure could be increased to 26.8 mrem.

FIGURE 1
H. B. ROBINSON PLANT
SETTLING BASINS.



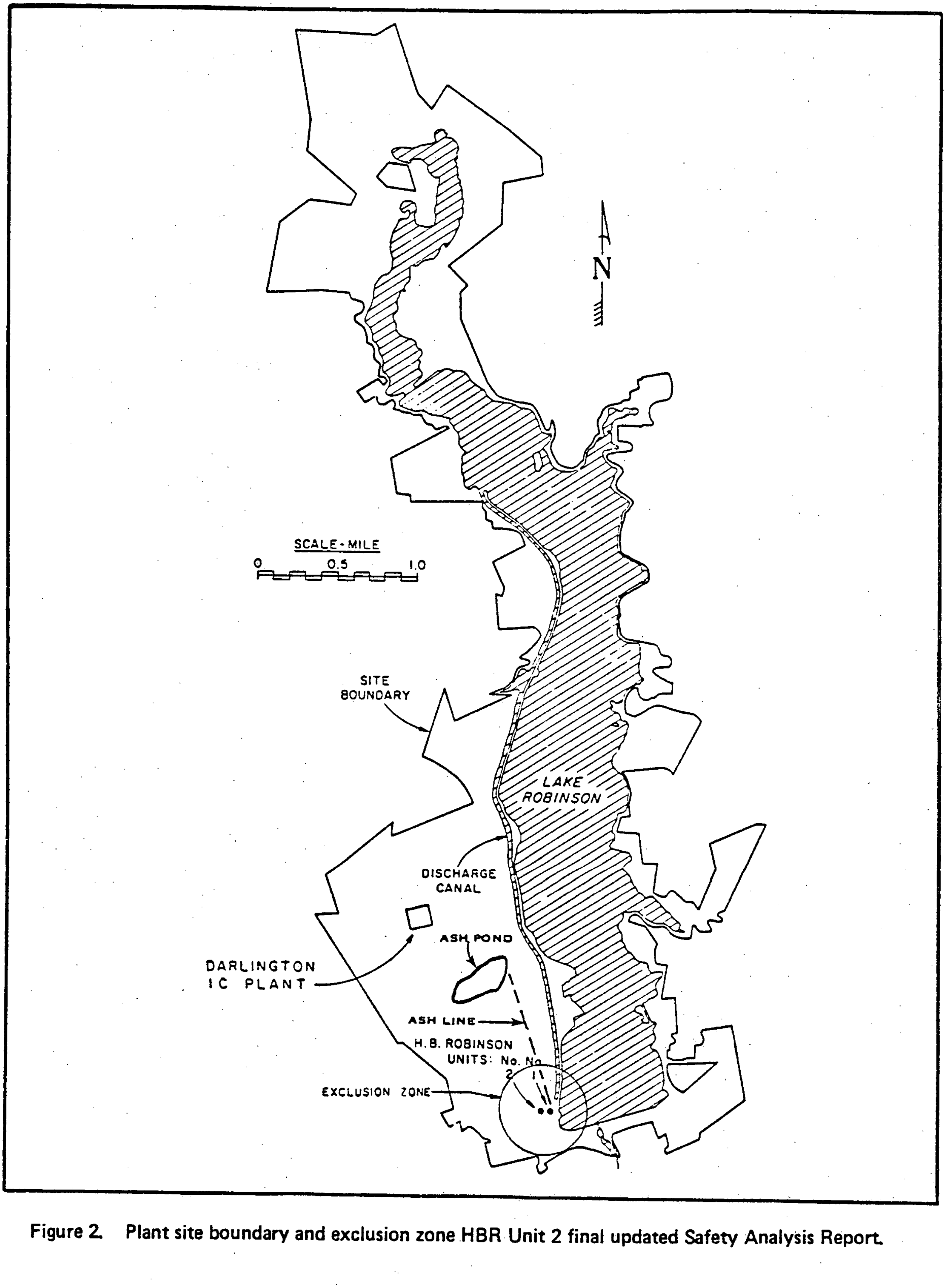


Figure 2. Plant site boundary and exclusion zone HBR Unit 2 final updated Safety Analysis Report.

ATTACHMENT 3

Environmental Surveillance
At the H.B. Robinson
Ash Pond

I. Background and Purpose

In a letter from Mr. E. E. Utley of CP&L to Mr. S. A. Varga of the U.S. NRC dated January 17, 1983 (Reference 1), blanket approval was requested for transfer of slightly contaminated sediments from the H.B. Robinson (HBR) settling basins to the ash collection pond whenever the average Co-60 concentration does not exceed 3.0 E-5 μCi/g wet. The blanket approval was withheld (letter from Mr. S. A. Varga to Mr. E. E. Utley dated February 18, 1983, Reference 2) pending receipt and evaluation by the staff of environmental surveillance data from the ash pond. In accordance with this request and pursuant to 10CFR20.302, the environmental surveillance data is presented in this report in support of the blanket approval request.

II. Methods and Data Presentation

Table 1 lists the man-made radionuclide concentrations found in sediments (SS), raw water (SW), and aquatic vegetation (AV) from the HBR ash collection pond. Sampling and processing follow CP&L environmental monitoring and analytical procedures. Data are available from January 1981 through September 1983.

Sediments are collected along the shoreline of the NW bank. Collection is by shovel with penetration to at least one inch below the surface. Surface water samples are collected by weekly grab sampling. Samples are composited into a monthly 4-l volume. One liter is aliquoted from this volume and taken for gamma spectrometric analysis. Aquatic vegetation is collected using a rake to achieve collection of both aerial and root portions of the plants. Raw water and aquatic vegetation are also collected near the NW bank of the ash pond. Sediments and aquatic vegetation are oven dried to a constant weight (at ~ 130°C) prior to gamma spectrometric analysis.

The typical lower limits of detection for the Ge (Li) gamma spectrometric systems at HBR are provided in Table 2.

III. Analysis and Evaluation

In ash pond sediments, only Co-60 and Cs-137 are above the Lower Limit of Detection (LLD). Cobalt-60 concentrations range from 6.03 E-7 μCi/g dry to 9.32 E-6 μCi/g dry for four samples. The mean Co-60 concentration is 3.49 E-6 μCi/g dry. Cobalt-60 was not detectable in the remaining two sediment samples. The mean Cs-137 concentration was 1.25 E-6 μCi/gm dry in six samples.

Cesium-137 was detectable in only one surface water sample (November 1982) at 5.64 E-6 μCi/l. All other nuclides were below LLD.

Aquatic vegetation showed varying concentrations principally of Co-60, Cs-137, and Mn-54. Cesium-137 was the most commonly found radionuclide being detectable in 5 of 10 samples at an average concentration of 2.40 E-7 μCi/gm dry. Cobalt-60 was detectable in only 2 of 8 samples with a mean concentration of 8.30 E-7 μCi/gm dry.

The data suggest the following:

A. Since radionuclide concentrations in the sediments are calculated on a dry-weight basis, these concentrations are larger than would be expected on the basis of wet sediment analysis.

B. The mean Co-60 concentration (dry) in the sediment is ~ 2.5 times lower than the weighted mean Co-60 concentration (wet) observed in the flyash/dust that was transferred from the HBR settling basins to the ash pond by hydrovacuum truck during July and August of 1983. This would indicate that sediment mixing in the ash pond is diluting the Co-60.

C. Since concentrations of man-made radionuclides in the ash pond water were typically below LLD, it is likely that there is minimal desorption of activity from the sediment into the water column.

D. The ratio of the mean Co-60 and Cs-137 concentrations in aquatic vegetation to those in sediment, respectively, on a dry-weight basis, gives concentration factors of 0.24 and 0.19. This indicates these radionuclides are not significantly reconcentrating in this environmental pathway.

These observations permit the following conclusions:

1. Slightly contaminated sediment transferred to the HBR ash pond is being mixed with sediment already located in the pond.

2. The mixing, in addition to continuous input of sluice ash from HBR Unit 1 (coal fired), effectively disperses and dilutes radionuclides in the ash pond bed.

3. Although some radionuclides are detectable in the pond's rooted vegetation, the concentrations are not above sediment concentration.

4. Since pond water was observed to contain less than detectable concentrations of radionuclides, environmental transport by leaching is not readily apparent.

5. The data are consistent with the conservative calculations (see Reference 1) that predicted low radionuclide concentrations in ash pond water and vegetation upon introduction of contaminated settling basin sediment into the ash pond.

IV. References

1. Letter from Mr. E. E. Utley to Mr. S A. Varga transmitting "Request for Approval of Transfer of Contaminated Sediment to the H.B. Robinson Ash Pond," Safety Analysis Report dated January 5, 1983.

2. Letter from Mr. S. A. Varga to Mr. E. E. Utley transmitting "Environmental Impact Appraisal in the Matter of the H.B. Robinson Unit 2 Disposal of Licensed Materials," dated February 14, 1983.

Environmental Surveillance
at the
H.B. Robinson Ash Pond
(Sample Point 50)

Table 1

I. Sediment (SS)*

	Radionuclide Concentration (pCi/gm)	Error (pCi/gm)
Date Sampled: 03/08/81 Dry Weight: 415.8 gm		
Co-60 9.32 E+00	1.50 E-01	
Cs-137	2.23 E-1	7.10 E-02
Date Sampled: 10/27/81 Dry Weight: 682.3 gm		
Co-60 6.03 E-01	2.90 E-02	
Cs-137	1.67 E-01	2.70 E-02
Date Sampled: 03/10/82 Dry Weight: 741.9 gm		
Co-60 3.40 E+00	8.00 E-02	
Cs-137	2.48 E-01	3.10 E-02
Date Sampled: 08/20/82 Dry Weight: 662.3 gm		
Co-60 6.37 E-01	3.70 E-02	
Cs-137	2.17 E-01	2.40 E-02
Date Sampled: 01/27/83 Dry Weight: 715.0 gm		
Cs-137	1.23 E-01	1.30 E-02
Date Sampled 04/14/83 Dry Weight: 976.6 gm		
Cs-137	5.61 E+00	2.20 E-02

II. Surface Water (SW)* Analysis volume: 1 liter

Date	Radionuclide Concentation (pCi/liter)	Error (pCi/liter)
02/15/81	No detectable activity	
03/15/81	No detectable activity	
04/15/81	No sample	
05/15/81	No detectable activity	

II. Surface Water (continued)

Date	Radionuclide Concentation (pCi/liter)	Error (pCi/liter)
06/15/81	No detectable activity	
07/15/81	No detectable activity	
08/15/81	No detectable activity	
09/15/81	No detectable activity	
10/15/81	No detectable activity	
11/15/81	No detectable activity	
12/15/81	No detectable activity	
01/15/82	No detectable activity	
02/15/82	No detectable activity	
03/15/82	No detectable activity	
04/15/82	No detectable activity	
05/15/82	No detectable activity	
06/15/82	No detectable activity	
07/15/82	No detectable activity	
08/15/82	No detectable activity	
09/15/82	No detectable activity	
10/15/82	No detectable activity	
11/15/82	Cs-137 5.64 E+00	1.53 E+00
12/15/82	No detectable activity	
01/15/83	No detectable activity	
02/15/83	No detectable activity	
03/15/83	No detectable activity	
04/15/83	No detectable activity	
05/15/83	No detectable activity	
06/15/83	No detectable activity	
07/15/83	No detectable activity	
08/15/83	No detectable activity	
09/15/83	No detectable activity	

III. Aquatic Vegetation (AV)* Sample weights are dry weights.

	Radionuclide Concentration (pCi/gm)	Error (pCi/gm)
Date: 03/23/81	Sample Wt. 50.8 gm	
Co-60 1.54 E+00	1.00 E-01	
Cs-137	3.33 E-01	7.00 E-02
Mn-54 2.34 E-01	8.10 E-02	
Date: 04/30/81	Sample Wt. 42.2 gm	
Mn-54 3.66 E-01	6.70 E-02	
Date: 10/26/81	Sample Wt. 72.6 gm	
Mn-54 2.10 E-01	4.60 E-02	

III. Aquatic Vegetation (continued)

	Radionuclide Concentration (pCi/gm)	Error (pCi/gm)
Date: 03/10/82	Sample Wt. 63.7 gm	
Co-58 8.23 E-01	7.90 E-02	
Cs-137	1.16 E-01	2.90 E-02
Date: 05/06/82	Sample Wt. 68.2 gm	
Co-60 1.19 E-01	5.80 E-02	
Mn-54 9.28 E-02	4.10 E-02	
Date: 08/20/82	Sample Wt. 30.2 gm	
No detectable activity		
Date: 10/19/82	Sample Wt. 45.8 gm	
Cs-137	5.26 E-1	9.00 E-02
Date: 01/27/83	Sample Wt. 45.0 gm	
Cs-137	1.88 E-01	5.30 E-02
Date: 04/14/83	Sample Wt. 31.7 gm	
No detectable activity		
Date: 07/11/83	Sample Wt. 49.1 gm	
Cs-137	3.91 E-02	1.32 E-02

---

*Naturally occurring radionuclides are omitted.

TABLE 2
TYPICAL LOWER LIMITS OF DETECTION (LLD)
FOR Ge (Li) GAMMA SPECTROMETRY SYSTEMS

H.B. Robinson

Media Sample Size Count Time Units Nuclide	Air Filters 3,000 M^3 3,000 Sec. pCi/M^3	Surface Water Milk 0.5 Liters 40,000 Sec. pCi/l	Sediment Soil Groundwater 1.0 Liters 20,000 Sec. pCi/l	Fish Sand 500 g Dry 5,000 Sec. pCi/g	Vegetation 500 g Wet 20,000 Sec. pCi/g	Resin 2,000 l 2,000 Sec. pCi/g	Glasswool 2,000 l 1,000 Sec. pCi/g
Be-7	.009	44	18	.109	.056	.075	.064
Na-22	.002	7	3	.030	.009	.011	.010
K-40	.024	83	59	.390	.167	.153	.096
Cr-51	.008	48	16	.091	.051	.067	.053
Mn-54	.001	6	2	.018	.007	.006	.006
Co-57	.001	4	2	.013	.005	.004	.002
Co-58	.001	5	3	.018	.007	.008	.006
Fe-59	.002	13	5	.028	.016	.015	.012
Co-60	.002	7	4	.033	.010	.006	.007
Zn-65	.004	14	6	.054	.017	.036	.016
Nb-95	.002	7	3	.020	.008	.013	.006
Zr-95	.003	14	6	.038	.016	.024	.017
Ru-103	.001	5	2	.013	.007	.006	.005
Ru-106	.014	50	25	.162	.076	.087	.050
Ag-110m	.001	6	3	.019	.008	.010	.007
Sn-113	.001	4	2	.012	.005	.006	.002
Sb-125	.004	12	6	.042	.018	.020	.010
I-131	.001	13	2	.017	.007	.010	.002
Cs-134	.002	6	3	.024	.008	.014	.004
Cs-136	.002	16	4	.027	.011	.018	.010
Cs-137	.002	6	3	.021	.008	.011	.006
Ba-140	.004	31	7	.046	.021	.025	.017
La-140	.001	11	3	.023	.008	.008	.012
Ce-141	.001	7	2	.017	.008	.011	.004
Ce-144	.005	25	10	.089	.037	.049	.023
Hg-203	.001	5	2	.010	.006	.008	.005
Bi-212	.017	76	37	.250	.111	.136	.110
Pb-212	.003	16	5	.026	.017	.019	.008
Bi-214	.004	14	7	.045	.022	.027	.015
Pb-214	.003	15	5	.037	.017	.023	.007
Ra-226	.022	155	59	.207	.200	.126	.085
Ac-228	.006	27	13	.104	.038	.048	.035
Np-239	.009	7	13	.084	.040	.045	.034

REQUEST FOR APPROVAL OF

TRANSFER OF CONTAMINATED SEDIMENT

TO THE H. B. ROBINSON ASH POND

Safety Analysis Report

January 5, 1983

8301180392

Table of Contents

Page

List of Tables.. ii

List of Figures... iii

Introduction.. iv

1.0 Background.. 1

2.0 Summary and Conclusions 3

3.0 Sediment Characteristics.. 6

4.0 Site and Environment.. 10

5.0 Preferred Disposal Method... 17

6.0 Alternate Disposal Methods.. 33

7.0 Request for Extension of NRC Approval to Possible Future Sediment Transfer.. 36

References.. 40

Appendix.. A-1

List of Tables

Tables		Page
2-1	Comparison of Impacts and Cost of Sediment Disposal Options.....	5
3-1	Average Concentration (μCi/g Wet) of Man-Made Radionuclides in Settling Pond Sediment....................................	9
5-1	Radionuclide Concentrations in Dry Sediment and in Air..........	25
5-2	Doses Due to Inhalation of Maximized Airborne Particulate Concentrations for 24 Hours..................................	25
5-3	Radionuclide Concentrations in Environmental Media for the Ingestion Pathway...	28
5-4	Doses from Ingestion of Contaminated Deer Meat..................	32
6-1	Estimated Costs of Commercial Disposal of Cement-Solidified Sediment..	35
7-1	Radiological Monitoring of the Robinson Ash Pond................	39
A-1	Concentrations (μCi/g Wet) of Man-Made Radionuclides in Routine Grab Samples Collected from East Settling Pond..........	A-3
A-2	Concentrations (μCi/g Wet) of Man-Made Radionuclides in Routine Grab Samples Collected from West Settling Pond..........	A-4
A-3	Concentrations (μCi/g Wet) of Man-Made Radionuclides in Cores of Sediment Collected from West Settling Pond in April 1982.....	A-5

List of Figures

Figures		Page
4-1	H. B. Robinson Plant and Envions	11
5-1	H. B. Robinson Ash Pond	19

INTRODUCTION

This report is submitted to the Commission pursuant to the requirements of 10CFR20.302, Method for Obtaining Approval of Proposed Disposal Procedures. The proposed disposal procedure is for transfer by hydrovacuum truck of slightly contaminated sediment from two settling ponds within the H. B. Robinson Plant restricted area to the fossil unit Ash Pond in the owner-controlled area. Carolina Power & Light (CP&L) requests that such transfers be allowed as needed for sediments not exceeding an average concentration of 3.0 E-5 μCi/g wet for Co-60.

1.0 BACKGROUND

Two settling ponds were constructed at the H. B. Robinson Plant in 1976 to meet National Pollutant Discharge Elimination System (NPDES) permit limits. These ponds are used to treat water collected by the Unit 1 (coal-fired) and Unit 2 (nuclear) storm drains. Treatment consists of retention to settle particulates (coal ash and dust) and skimming to remove oil. Clean effluent is released to Black Creek via a drainage ditch.

Over a period of time, particulates accumulate in the settling ponds and must be removed to ensure proper functioning of the settling ponds. Experience to date indicates that the ponds become filled with sediment about every two years. The accumulated sediment is contaminated by very low levels of man-made radioactivity, primarily Co-60. The source of this contamination is trace amounts of radioactivity from primary to secondary coolant leaks which occasionally enter the Unit 2 storm drains. This contamination can come into contact with ash in the drains themselves since there are several cross-ties between the two drain systems. In addition, any clean sediment in the settling ponds can also become contaminated since both drains enter a common splitter box which can divert flow to either pond.

Steps being considered to separate the two storm drain systems are briefly discussed in Section 5.1. While these modifications should eliminate contamination of the sediment in the future, the problem of disposing of the sediment now in both ponds has become critical. The West Settling Pond has

already filled with sediment and has been taken out of service and drained. The East Settling Pond is filled to near capacity, and its effluent will soon exceed NPDES permit limits for suspended solids if the sediment is not removed. It is anticipated that the East Pond will be filled by the end of February 1983.

A similar situation existed in the summer of 1980, and in July of that year, about 3,000 cubic meters of sediment were transferred from the East Settling Pond to the Ash Pond. Although the sediment contained only 20 millicuries of Co-60, the transfer was made without prior approval of NRC and resulted in a citation for violation of 10CFR20.302. The situation was complicated by the fact that the Ash Pond is located in the owner-controlled area. CP&L responded to this violation by committing to obtain the required approval prior to any future transfers of sediment. Accordingly, the purposes of this report are to request NRC approval for the immediate transfer of an additional 6,000 cubic meters of contaminated sediment containing 75 millicuries of Co-60 to the Ash Pond and for future transfers of sediment in which the concentration of man-made gamma emitters does not exceed a specified level. Although CP&L has the right to restrict access to owner-controlled areas, the supporting safety analysis assumes that public access to the Ash Pond is not restricted.

2.0 SUMMARY AND CONCLUSIONS

The impacts of contaminated sediment disposal are minimal regardless of the method of disposal; however, costs vary by two orders of magnitude. These impacts and costs are summarized in Table 2-1. An expenditure of $13 million and use of nearly 300,000 cubic feet of valuable disposal space to prevent a hypothetical exposure of 1.6 mrem/yr is totally unreasonable and provides compelling support for disposal by transfer to the Ash Pond.

It is expected that contaminated sediment will continue to accumulate in the settling ponds for some time even if all of the modifications being considered for the storm drain system are implemented. These additional accummulations would occur as any residual contaminated sediments are gradually flushed from the system. Although smaller volumes of sediment are anticipated, the cost of commercial disposal is still expected to be on the order of several million dollars.

In view of these circumstances and the mimimal impacts associated with transfer of the present 6000 m^3 of sediment to the Ash Pond, it would be beneficial to establish a concentration limit for man-made radioactivity in sediment to be transferred to the Ash Pond which would simplify screening the sediment while providing adequate protection to the general public. Since this safety analysis shows that direct gamma exposure is by far the largest contribution to the potential dose for the maximum individual and since Co-60 is the largest contributor to the direct gamma exposure pathway, it would be convenient to use Co-60 to determine the suitability of

sediment for transfer. The general public would be protected by limiting the total potential dose to the critical individual to 5 mrem/yr. A dose of 5 mrem/yr corresponds to a Co-60 concentration in sediment of 3.0 E-5 μCi/g wet. Based on these considerations, CP&L requests that the Commission grant approval for transfer of sediment to the Ash Pond whenever the average Co-60 concentration does not exceed 3.0 E-5 μCi/g wet. Records of such transfers would be maintained in accordance with 10CFR20.401(b).

Table 2-1 Comparison of Impacts and Costs of Sediment Disposal Options

Impact	Transfer to Ash Pond	Cement Solidification
Exposure to Critical Individual (mrem/yr)	1.6[a]	Negligible
Occupational Exposure (mrem)	7.7[b]	11.7[c]
Cost (Dollars)	$100,000	$13,148,000

---

[a] Whole body dose to maximum teenager

[b] Two-man crew

[c] Three-man crew

3.0 SEDIMENT CHARACTERISTICS

3.1 Physical & Chemical Characteristics

The sediment consists mainly of ash from the combustion of coal in Unit 1 and also contains some coal dust. In this regard it is similar to, if not identical to, the ash and coal dust routinely discharged directly from Unit 1 to the Ash Pond.

The chemical composition of fly and bottom ash can be highly variable reflecting the variability in the composition of coal. The average chemical composition (weight percent) based on nine samples of ash from Unit 1 is given below.

Fe_2O_3	CaO	Na_2O	Al_2O_3	MgO	K_2O	SiO_2	P_2O_5	SO_3
18.9	3.3	0.8	20.5	1.2	2.2	47.5	0.3	3.9

Trace amounts of compounds of other elements are also present in fly ash from Robinson and other coal-fired plants. These elements include Sr, Cr, Mn, Co, Ni, Zn, Cd and Ce as well as U, Th, and their daughters.

Fly ash can be separated into three fractions - glass beads, mullite-quartz, and magnetic spinel (HU 80). Particle sizes depend on the method of ash collection but frequently are in the range of 0.3 to 100 micrometers (GR 78). These particles tend to be spherical. Particle sizes in bottom ash are expected to be larger.

Fly ash exhibits varying degrees of affinity for cations which is attributable to its relatively high content of Fe_2O_3 (ferric oxide) and Al_2O_3 (alumina). This affinity is probably responsible for retention of man-made radioactivity in the Robinson settling ponds and suggests that this radioactivity is not readily released. Metals are known to leach from fly ash; however, since leaching of radioactive isotopes competes with leaching of nonradioactive isotopes of the same element, the presence of stable metals would tend to reduce introduction of their radioactive counterparts into the environment.

3.2 Radiological Characteristics

The sediment in the settling ponds contains both man-made radionuclides from Unit 2 and naturally occurring radionuclides from the coal burned in Unit 1. The latter group of radionuclides, members of the uranium and thorium decay chains, emit a large number of gamma photons and can interfere with the determination of man-made radionuclides since computer programs available for state-of-the-art counting systems cannot separate the contributions of more than one radionuclide to a single gamma peak. As a result, each radionuclide contributing to the peak is validated as being present and its concentration calculated as if it were the only radionuclide present. Since Bi-214 and Pb-214 were detected in most sediment samples analyzed, this type of interference is believed to have affected all man-made radionuclides reported in sediment except Co-60. Other interfering natural radionuclides are Ac-228, Th-228, and Tl-208.

Because of the pressing need to remove the sediment, CP&L has elected to use the available data as is rather than perform hand calculations for the large number of samples involved. This course of action is conservative since man-made radionuclides not believed to be present have been retained and concentrations of other man-made radionuclides have probably been overestimated. Methods of correcting for this type of interference, either automatically or by hand, are now being evaluated.

The results of analysis of two types of samples are tabulated in the appendix and summarized in Table 3-1. The two types of samples are (1) routine grab samples collected from each settling pond and (2) core samples collected from the West Settling Pond after it was taken out of service and drained. As shown in Table 3-1, Co-60 is clearly the principal man-made radionuclide in the sediment in spite of any interference in the analysis. The weighted average Co-60 concentration in the sediment is 8.55 E-6 μCi/g wet compared to a weighted average total concentration of man-made radionuclides of 9.72 E-6 μCi/g wet. No significance is attached to the slightly higher concentrations seen in the West Settling Pond since the counting error is relatively large at these low concentrations.

Most samples were also found to contain Bi-214 and Pb-214. If secular equilibrium is assumed, the resulting Ra-226 concentration is comparable to that of Co-60. Radium-226 and other naturally occurring radionuclides have been excluded from consideration since they are already present in the Ash Pond in similar concentrations and since their presence in the Ash and Settling Ponds is independent of the operation of Unit 2 and whether the sediment is transferred.

Table 3-1 Average Concentrations (μCi/g Wet) of Man-Made Radionuclides in Settling Pond Sediment

Nuclide	Routine Samples: East Settling Pond	Routine Samples: West Settling Pond	Core Sample From West Settling Pond	Weighted Average
Mn-54	2.16E-7[a] (8)[b]	1.18E-7 (2)	(0)	1.96E-7 (10)
Co-58	5.29E-7 (18)	2.85E-7 (11)	(0)	4.36E-7 (29)
Co-60	1.55E-5 (47)	3.06E-6 (45)	5.59E-6 (27)	8.55E-6 (119)
Nb-95	3.31E-7 (9)	1.77E-7 (9)	(0)	2.54E-7 (18)
Cd-109	2.54E-6 (11)	2.46E-6 (15)	1.79E-6 (2)	2.44E-6 (28)
Cs-134	4.13E-7 (1)	1.40E-7 (1)	(0)	5.53E-7 (2)
Cs-137	4.41E-7 (39)	2.43E-7 (28)	9.88E-7 (13)	4.61E-7 (80)
Ce-144	(0)	5.16E-7 (2)	(0)	5.16E-7 (2)
Total	1.68E-5 (47)[c]	4.08E-6 (46)	7.12E-6 (28)	9.72E-6 (121)

[a] 2.16E-7 = 2.16×10^{-7}

[b] Number of samples in which nuclide was detected.

[c] Total number of samples.

4.0 SITE AND ENVIRONMENT

This section is intended to provide an overview of the site and its environs and presents information taken from the Updated Final Safety Analysis Report and preliminary results of studies now being conducted in connnection with its revision.

4.1 Site

The H. B. Robinson Plant is located in the western corner of Darlington County, South Carolina, on the southwest shore of Lake Robinson about 4.5 miles WNW of Hartsville and 56 miles ENE of Columbia. The plant consists of a 182 MWe coal-fired unit (Unit 1) and a 665 MWe nuclear unit (Unit 2). Lake Robinson is an impoundment which was constructed to provide cooling water for Unit 1 and future units at the site. The site was originally planned to generate 1200 MWe.

Figure 4-1 shows the relative locations of the facilities of interest. The Ash Pond is located approximately 1 1/4 miles WNW of the H. B. Robinson Plant. The Darlington County Electric Plant, which supplies auxiliary power at peak loads, is located at the northern tip of the Ash Pond and is within the CP&L property boundary. The settling ponds are located about 500 feet south of the H.B. Robinson Plant and are not visible in Figure 4-1.

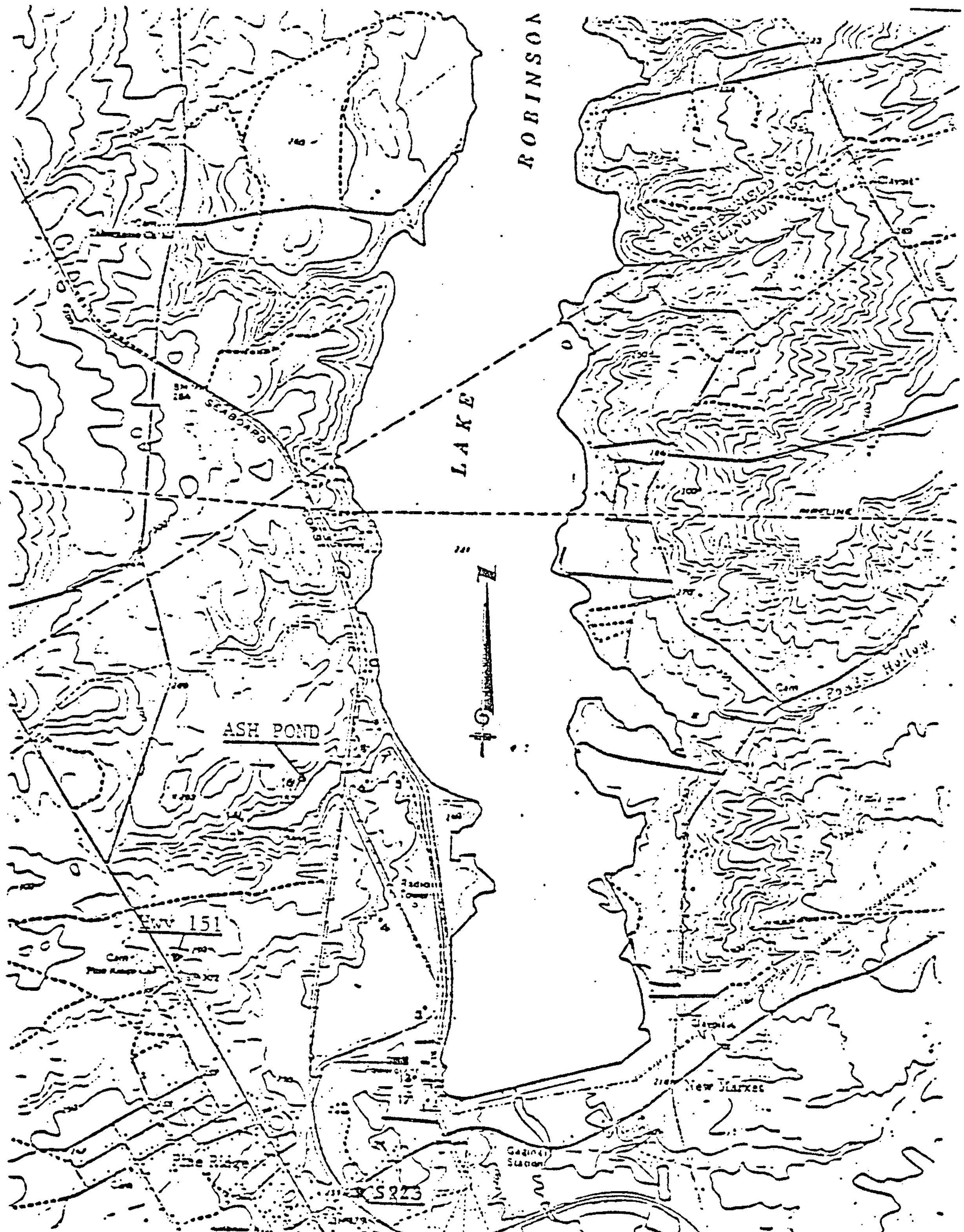


Figure 4-1. H. B. Robinson Plant and Environs

4.2 Topology

The site is on the southern edge of the Sandhills Region of South Carolina. This region is typified by rolling hills interspersed with water courses and wooded areas. The terrain becomes flatter and marshy in the coastal plain to the south and east of the site.

Lake Robinson is about 4,000 feet wide at the plant site and about 7.5 miles long at its maximum water level of 222 feet mean sea level (MSL). The land surface surrounding the lake rises to about 40-50 feet above the maximum lake elevation, and the surrounding terrain rises to 510 feet MSL about 5 miles northeast of the site.

The Ash Pond lies in a depression about 1,000 feet west of Lake Robinson. The current maximum water level in the pond is 256 feet MSL, and as discussed in Section 5.1, this level will be increased to 264 feet MSL. The land surrounding the Ash Pond rises about 290 feet MSL.

4.3 Geology

Surficial materials at the Robinson site are recent sands or soils developed from the Middendorf formation. This formation consists of light-colored feldspathic and slightly micaceous quartz sand interbedded with red, purple, gray, and brown silty and sand clay. Because of the high quartz content of the sands and the climatic environment, surficial soils may not weather sufficiently to be distinguishable from the parent material.

The Middendorf is about 400 feet thick and overlies an eroded, slightly sloping surface of the piedmont crystallines. This formation is also referred to as the Tuscaloosa formation. In general, the upper alluvial sands and gravels are moderately compact with layers of compressible material occurring in the upper 30 to 50 feet. Because of the quantity of fines in the sand and gravel, they cannot be considered to be free draining. The underlying Middendorf contains generally compact sands and firm-to-hard clayey soils. Several strata of cemented sandstones were encountered in borings at roughly 90 to 100 feet.

4.4 Hydrology

4.4.1 Descriptive Hydrology

The major surface water feature in the vicinity of the site is Lake Robinson. The water level in the lake is quite constant with a typical wet season level of 221 feet MSL and dry season level of 220.7 feet MSL. The present Ash Pond water level is 256 feet MSL. Since the Lake Robinson dam and spillway structures are designed to prevent the lake level from exceeding 222 feet MSL to protect the plant site from flooding, lake water could not reach the Ash Pond.

It is conceivable that contaminated sediment could be transported from the Ash Pond by flooding of the pond itself during heavy rains. Since 8 feet of freeboard is normally maintained and the drainage area of the pond is relatively small, the possibility of such flooding is extremely remote. If it should occur, the topography of the pond area is such that water would flow over the dike and into Lake Robinson. Since dilution in Lake Robinson is so

large (Section 4.4.3) and since even instantaneous leaching of all man-made radioactivity in the sediment would not cause maximum permissible concentrations to be exceeded in the much smaller Ash Pond (Table 5-3), potential impacts of flooding are not considered further.

4.4.2 Groundwater

The drainage area of Black Creek above the dam site is underlain and bounded by the Tuscaloosa (Middendorf) formation, a sequence of unconsolidated and semiconsolidated, cross-bedded, micaceous, feldspathic quartz sand and gravel beds. These beds are intercolated with clayey sands and impure clays and lenses of white kaolin. These kaolin lenses can extend laterally for quite some distance and have a maximum thickness of about 35 feet. These lenses are frequently responsible for the existence of perched groundwater in the overlying sands. The sand and clay beds of the Tuscaloosa are lenticular and grade laterally into one another or pinch out within comparatively short distances.

The Tuscaloosa is a permeable formation and in several areas of the Coastal Plain yields up to 2000 gpm from individual wells. Groundwater occurs under both water table and artesian conditions. In the former, the water surface is unconfined (under atmospheric pressure) and is free to move in a vertical direction. Under artesian conditions, the water in the aquifer is confined under a relatively impermeable bed and hydrostatic pressure causes the water to rise above the bottom of the confining bed when the aquifer is penetrated or exposed to the surface. Water in shallow aquifers is generally unconfined, and in deeper aquifers it is under artesian conditions. Since here the water table is fairly close to the surface, the

shallow aquifers are recharged by direct accretion from precipitation. Recharge to the artesian aquifers is mainly controlled by the difference in head between the water in the artesian aquifer and that in the water aquifers and also by that in other artesian aquifers above and below.

Preliminary results of a hydrological investigation now in progress at Robinson generally confirm the information just presented. The clay lenses are present in the immediate vicinity of the Ash Pond and grade laterally into each other. Grades are rather steep with a given lens rising or falling tens of feet in a relatively short distance. These lenses are not continuous so that the aquifers are generally unconfined. Preliminary results indicate that vertical permeabilities are roughly 1/10 the horizontal permeabilities. The horizontal groundwater velocity is estimated at 2-20 feet/day. Since the water table slopes toward Lake Robinson, seepage may eventually reach the lake.

4.4.3 Dilution in Lake Robinson

The available hydrogeologic information indicates that water can readily seep from the Ash Pond. This seepage would migrate towards Lake Robinson where any radioactivity would be diluted. The Updated Final Safety Analysis Report for the Robinson Plant estimates that the concentration in Lake Robinson at one mile from the Unit 2 discharge is 2.4 E-13 $\mu Ci/cm^3$ per µCi discharged for short-term releases. It is reasonable to assume a similar dilution factor should contamination from the Ash Pond reach the lake. At this dilution, roughly 125 Ci of Co-60 could be released exclusive of plant releases without exceeding the maximum permissible concentration for Co-60 in unrestricted areas.

4.5 Meteorology

The climate of the region is relatively temperate with the Appalachian Mountains acting as a buffer from most winter storms. Winters are usually mild with a few cold waves during which the temperature drops below 20°F. Summers are hot with temperatures in excess of 100°F occurring during a few days.

The H.B. Robinson site lies in a potential hurricane area but sustained hurricane force winds (> 74 mph) have never been recorded by the Columbia (South Carolina) Weather Service. Prevailing winds are from the north and northeast. During the period 1976-1981, the on-site average wind speed was 6.2 mph and the maximum wind speed was 28 mph which was recorded in February 1981. Both the average and maximum wind speeds are 15-minute averages recorded at 10 meters. A maximum one-minute average wind speed of 60 mph was recorded by the Columbia Weather Service during a hurricane in March 1954.

Hurricanes are also responsible for the maximum 24-hour precipitation at the site during the period 1976-1981. The maximum on-site 24-hour maximum precipitation of 4.76 inches occurred during September 1979 and was associated with Hurricane David. The maximum 24-hour precipitation in the site vicinity of 7.61 inches was recorded at Columbia, South Carolina in August 1949. This amount of precipitation is comparable to that produced by thunderstorms.

The probability that a tornado will strike a given location in the site vicinity is 0.00195. This is equivalent to one tornado every 513 years.

5.0 PREFERRED DISPOSAL METHOD

The section discusses the preferred method of disposal—transfer to the Ash Pond. Section 5.1 describes the current settling and ash ponds and the modifications planned for each. Section 5.2 briefly describes the proposed method for sediment handling. Section 5.3 discusses impacts of these operations and Section 5.4 discusses costs.

5.1 Facility Description

5.1.1 Settling Ponds

The settling ponds are located inside the controlled area and are identical in their construction. The ponds are 56 feet wide and 136 feet long at their bottoms and 134 feet wide and 234 feet long at their tops (ground elevation, 225 feet MSL). Each pond is equipped with a weir which maintains a combined water and sediment depth of 3 feet with 5 feet of free-board. The slopes of the ponds are covered with rip-rap. The active volume of each pond is 3000 cubic meters. Each pond discharge is equipped with an automatic compositing water sampler, pH and radiation monitors, and an oil skimmer. A junction box/splitter equipped with an oil skimmer is located just north of the ponds and receives flow from both storm drain systems.

Modifications planned for the settling ponds include installation of sluice gates on the discharges. These gates will allow the discharges to be

closed and water levels raised so that the ponds can be used as temporary impoundments to better control release of effluents. Plans are also being developed to reduce or eliminate accumulation of contaminated sediments. Actions being considered include elimination of cross-ties between Units 1 and 2 storm drains and elimination of the splitter box.

5.1.2 Ash Pond

The Ash Pond was formed by building a dike across one end of a natural depression. Currently, the water level is maintained at 256 feet MSL. As shown in Figure 5-1, slurried ash from Unit 1 is pumped into the east end of the pond. The slurry is carried by a 12-inch line and pumped at a rate of 2000 gpd. A baffle dike just north of the slurry pipe aids in phase separation. An overflow pipe and oil skimmer are located to the north of the baffle dike. Any overflow would enter Lake Robinson.

Figure 5-1 also shows a relatively flat shelf at 260 feet MSL on the northern shore due west of the baffle dike. The rise to 270 feet MSL occurs in a short distance forming a small bluff. Current plans are to raise the main and baffle dikes by 8 feet in early 1983. The new water level of 264 feet MSL would submerge this shelf.

5.2 Operations

Sediment would be removed from the settling ponds and transported to the Ash Pond using hydrovacuum trucks. Since the west pond is out-of-

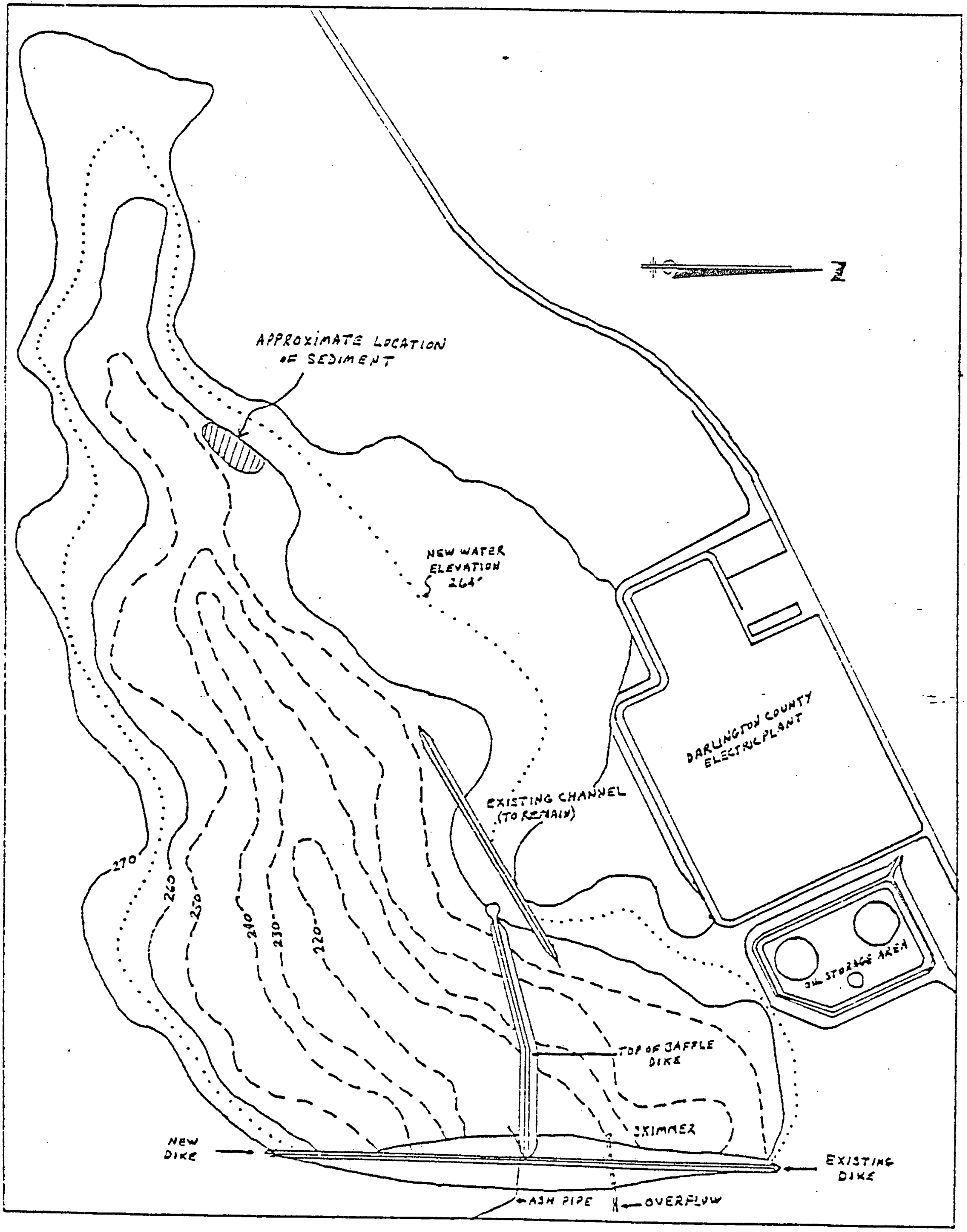


Figure 5-1. H. B. Robinson Ash Pond

service and has been drained, it may be necessary to add water to obtain a suitable consistency. This water is readily available from the east pond. Once the west pond is emptied and returned to service, the east pond would be hydrovacuumed.

The loaded hydrovacuuming trucks would travel approximately 1.3 miles on public roads (Route 23 and Highway 151, see Figure 4-1) to reach the shelf on the northern shore of the Ash Pond. The contaminated sediment would be slurried down the face of the bluff and washed into the pond using pond water. Since the sediment will be handled as a slurry, there will be no airborne releases of particulates.

5.3 Impacts

This section discusses the impacts of the proposed transfer of contaminated sediment to the Ash Pond. Although direct exposure is considered to be the only credible exposure pathway, very conservative analyses of the ingestion and inhalation pathways have also been included. All radiological impacts are based on the contribution of man-made radionuclides now contained in the settling ponds since the proposed transfer will not affect the concentration of naturally occurring radionuclides already in the Ash Pond.

5.3.1 Direct Exposure

Although the Ash Pond is in an owner-controlled area, it is assumed for purposes of analysis that members of the general public could gain

access and receive a direct radiation exposure by standing on the shoreline of the pond. Several simplyfying and conservative assumptions can be made in estimating this exposure. To simplify calculations, it is assumed that the weighted average total man-made concentration of activity of 9.72E-6 µCi/g wet is due to Co-60 alone. For the radionuclides detected in the sediment, this is a conservative assumption. It is also assumed that the contaminated sediment forms a homogeneous, infinitely thick, infinite slab after being transferred to the Ash Pond. This assumption is very conservative since the sediment would be deposited in a small area and, as a result, no exposure would occur unless an individual were near this area. On the other hand, if the sediment were uniformly distributed over the entire area of the pond, the layer of contaminated material would be less than 2 inches thick and would yield a much lower flux than the infinite slab model. The final conservative assumption is to ignore the shielding effect of the several feet of water which would normally cover the contaminated sediment.

The dose to an individual standing on this infinite slab can be estimated using Table 2 of HASL-195 (BE 68). This table gives the total exposure rate in air at one meter above the slab as 0.364 MeV/g · sec per gamma photons/cm^3 · sec for an energy of 1.25 MeV and soil density of 1.6 g/cm^3. The gamma flux in sediment with a Co-60 concentration of 9.72 E-6 µCi/g and a density of 1.3 g/cm^3 is 0.9324 photons/cm^3 · sec. After correcting for the lesser density of the sediment, an exposure rate in air of 0.0273 mR/hr is obtained. The conversion of exposure rate to absorbed dose is complicated by the fact that the energy distribution of the incident photons is unknown; however, if it is assumed that the ratio of mass-energy

absorption coefficients for air and muscle is unity over the energy range of interest, the maximum possible error is 5%. Applying this assumption yields a dose rate at one meter of 0.0241 mrem/hr. This dose rate is 1.2% and 2.4% of the limits set forth in 10CFR20.105 (b)(1) and (2), respectively.

Since the Ash Pond is accessible to the general public, it is appropriate to estimate the annual direct gamma exposure. Although the Ash Pond is readily recognizable as a waste disposal area and not suitable for recreational use, these exposures can be conservatively estimated using the shoreline usage factors for maximum individuals given in Table E-5 of Regulatory Guide 1.109 (NRC 77). These usage factors and the corresponding doses are given below.

Age Group	Shoreline Usage (hr/yr)	Dose (mrem/yr)
Adult	12	0.29
Teenager	67	1.61
Child	14	0.34
Infant	-	-

A more credible direct gamma exposure pathway is occupational exposure of the contractor personnel who would transfer the sediment. Based on previous experience, it is assumed that a two-man crew would require 160 hours to effect the transfer. The dose to these workers can be quickly and conservatively estimated by ignoring shielding provided by the trucks and using the infinite slab dose rate of 0.0241 mrem/hr. The resultant occupational dose is 7.7 mrem.

5.3.2 Inhalation

It is conceivable that the contaminated sediment could dry out after transfer to the Ash Pond and become airborne. This scenario is considered very improbable for several reasons. For example, sediment in the West Settling Pond which was pumped dry in early 1982 has remained too moist to become airborne. In addition, once transferred to the Ash Pond, the sediment would normally be submerged under several feet of water and would soon be covered by uncontaminated sediment. Raising the Ash Pond dike will increase the depth of covering sediment and water. Thus an extended outage of Unit 1 combined with dry weather would be required to dry the sediment and expose it to wind.

In spite of the factors just mentioned, dusting from the Ash Pond has been observed at least once during its lifetime. Thus an estimate of an upper bound for the dose to the maximum individual due to inhalation of suspended contaminated sediment is included here. It is conservatively assumed that only contaminated sediment becomes airborne and that the EPA maximum particulate loading of 260 $\mu g/m^3$ for fugitive emissions is maintained for a period such that the maximum individual is exposed for 24 hours. The respirable fraction can be conservatively estimated from data obtained during filtration of oil collected from the settling pond skimmer pits since the size distribution of these particulates are expected to be shifted towards smaller sizes. Because of the size of filters available, it is necessary to use 25 rather than 30 μm as the cutoff for respirable particles and 250 rather than 300 μm as the cutoff for suspended particles. These

filtration experiments showed that 3% by weight of the particles passing a 250 µm filter also passed a 25 µm filter. The respirable fraction is obtained by assuming the same size distribution for suspended particulates. Since the available radionuclide concentration data is in units of wet weight, it is necessary to correct for the concentration increase as the sediment dries. It is assumed that all the activity is retained by the sediment (i.e., none has been leached) and that the suspended particles have a density of 2.6 g/cm^3. This doubles the concentration relative to wet sediment. Concentrations in dry sediment and in air are summarized and compared to maximum permissible concentrations (MPC) for unrestricted areas in Table 5-1. Airborne concentrations of each radionuclide are approximately a million to a billion times less the applicable MPC values and the total airborne concentration is only 6.7 E-5 percent of MPC for this mixture of isotopes.

Doses to the maximum individual in each age group can be calculated by multiplying the airborne concentration of each radionuclide given in Table 5-1 by each age group's total air inhalation during the assumed 24-hour exposure (derived from Table E-5) and by the dose conversion factors taken from Tables E-7 through E-10 of Regulatory Guide 1.109 (NRC 77) and summing over all radionuclides for each organ. Dose conversion factors for Cd-109 uptake by the reference man were taken from ICRP 30 (ICRP). Dose factors for the other age groups were obtained by multiplying these values by 1.5 for teenagers, 2.5 for children, and 4.5 for infants. These multipliers were arbitrarily selected after inspection of ratios of dose conversion factors for these age groups for other isotopes found in the sediment. The results of these calculations are presented in Table 5-2 and identify the lung as the critical organ. About 83 percent of the lung dose is due to Co-60.

Table 5-1. Radionuclide Concentrations in Dry Sediment and in Air

	Dry Sediment (μCi/g)	Airborne (μCi/cm³)	MPC[a] (μCi/cm³)
Mn-54	3.92E-7[b]	3.06E-18	1E-9
Co-58	8.72E-7	6.80E-18	2E-9
Co-60	1.72E-5	1.33E-16	3E-10
Nb-95	5.08E-7	3.96E-18	3E-9
Cd-109	4.88E-6	3.81E-17	3E-9
Cs-134	1.11E-6	8.66E-18	4E-10
Cs-137	9.22E-6	7.19E-17	5E-10
Ce-144	1.03E-6	8.03E-18	2E-10

a From 10CFR20, Appendix B, Table II, and Column 1 for insoluble particulates.

b 3.92E-7 = 3.92×10^{-7}.

Table 5-2. Doses Due to Inhalation of Maximized Airborne Particulate Concentrations for 24 Hours

	Dose (mrem)					
	Bone	Liver	Total Body	Kidney	Lung	GI-LII
Adult	1.79E-7[a]	1.84E-7	1.02E-7	1.72E-7	2.63E-6	1.28E-7
Teenager	2.52E-7	2.44E-7	8.77E-8	2.51E-7	3.90E-6	1.19E-7
Child	3.42E-7	2.38E-7	4.68E-8	2.08E-7	3.17E-6	8.54E-8
Infant	1.88E-7	1.68E-7	1.90E-8	1.32E-7	2.10E-6	1.57E-8

a 1.79E-7 = 1.79×10^{-7}

The potential for occupational exposure is negligible since water would be added to the sediment to achieve the consistency required for hydrovacuuming.

5.3.3 Ingestion

As is the case with inhalation, it is conceivable that radioactivity from the contaminated sediment could enter the food chain and be consumed by humans. Since the Ash Pond can be readily recognized as a waste disposal area, it is assumed that humans would not drink directly from the pond. Because the deep aquifers in the vicinity of the Ash Pond are artesian, it is extremely unlikely that any seepage would enter drinking water supplies. There are no known wells (other than the CP&L test wells shown as numbered dots in Figure 4-1) tapping the unconfined auqifer or known gardens between the Ash Pond and Lake Robinson, the direction of the prevailing hydraulic gradient, as the area is within the owner-controlled area. Thus the normal exposure pathways are not applicable.

There is a significant deer population in the vicinity of the plant, and deer hunting is a popular local activity. To place an upper bound on the ingestion pathway, it is assumed that deer derive their entire food and water intake from the Ash Pond and that the maximum individuals in each age group derive their entire meat intake from these deer. Since exposure from this pathway would occur throughout the year, radionuclide concentrations are corrected for 6 months decay. The following sections discuss each stage of the calculations.

Concentration in Water

The constant influx of water into the Ash Pond combined with fluctuation in pH and dissolved cations will eventually overcome the natural affinity of the ash for the man-made radionuclides it now contains. Since insufficient data is available to evaluate the effects of these parameters, it is conservatively assumed that all of the 75 mCi of radioactivity is instantaneously released to the water in the Ash Pond. The concentrations of each radionuclide given in Table 5-3 are calculated by assuming that 20% of the current pond volume of 385,000 m^3 is occupied by water. In spite of these conservative assumptions, all concentrations are below MPC. These concentrations would be about 25% less if the volume of the pond after the dike is raised were used.

Table 5-3. Radionuclide Concentrations in Environmental Media for the Ingestion Pathway

	Conc. in Water (µCi/ml)	MPC for Water[a] (µCi/ml)	Conc. in Vegetation (µCi/g)	Conc. in Meat[b] (µCi/kg)
Mn-54	1.99E-8[c]	1E-4	5.68E-9	1.54E-1
Co-58	4.42E-8	1E-4	4.10E-9	4.90E+0
Co-60	8.67E-7	5E-5	8.04E-8	9.65E+1
Nb-95	2.57E-8	1E-4	2.39E-9	6.16E+1
Cd-109	2.47E-7	2E-4	7.32E-7	3.38E+0
Cs-134	5.60E-8	9E-6	5.53E-9	1.92E+0
Cs-137	4.68E-8	2E-5	4.61E-9	1.61E+0
Ce-144	5.23E-8	1E-5	1.29E-9	5.11E-1

---

a From 10CFR20, Appendix B, Table II, and Column 2 for soluble species

b Corrected for 6 months decay

c 1.99E-8 = 1.99×10^{-8}

Concentration in Vegetation

Radionuclide concentrations in vegetation can be calculated by multiplying concentrations in sediment (weighted average concentrations from Table 3-1) by soil-to-plant stable element transfer data given in Table E-1 of Regulatory Guide 1.109 (NRC 77). Data for Cd-109 was taken from Table C-5 of the 1976 version of this guide.

Concentration in Wildlife

Radionuclide concentrations in deer meat can be calculated using Equation A-11 from Regulatory Guide 1.109 (NRC 77) as shown below.

$$C_i = F_i (C_{if} Q_f + C_{iw} Q_w) \qquad \text{Eq. 5-1}$$

where:

C_i = concentration of the "i-th" radionuclide in deer meat (pCi/kg).

F_i = food (forage or water) to meat transfer factor for the "i-th" radionuclide (days/kg).

C_{if} = concentration of the "i-th" radionuclide in forage (pCi/kg).

Q_f = forage consumption rate for deer (kg/day).

C_{iw} = Concentration of the "i-th" radionuclide in water (pCi/l).

Q_w = Water consumption rate for deer (l/day)

Using values of F_i from Table E-1 and values of Q_f and Q_w for goats from Table E-3 of Regulatory Guide 1.109 (NRC 77); converting concentrations in vegetation and water to units of pCi/kg and pCi/l, respectively; and correcting for 6 months decay yields the concentrations in deer meat shown in Table 5-3. The value of F_i for Cd-109 was obtained from Table C-5 of the 1976 version of Regulatory Guide 1.109.

Dose to Man

The dose to the maximum individual for each organ and age group from eating deer meat can be calculated following Regulatory Guide 1.109 as indicated below.

$$\sum_i R_{aij} = C_i U_a D_{aij} \qquad \text{Eq. 5-2}$$

where:

R_{aij} = dose to organ "j" and age group "a" for the "i-th" radionuclide (mrem/yr)

C_i = concentration of the "i-th" radionuclide in deer meat (pCi/kg)

U_a = deer meat consumption rate for age group "a" (kg/yr)

D_{aij} = dose conversion factor for organ "j" and age group "a" for the "i-th" radionuclide

Values of U_a and D_{aij} were obtained from Table E-5 and Tables E-11 through 13, respectively, of Regulatory Guide 1.109 (NRC 77). Values of D_{aij} for Cd-109 were obtained as described in Section 5.3.2. The resulting doses are summarized in Table 5-4. The gastrointestinal track is the critical organ for all age groups with Co-60 responsible for about 96% of the dose. As would be expected from the very conservative assumption regarding radionuclide concentrations in water, ingestion of pond water by deer is the major factor in determining the dose to humans.

Table 5-4. Doses from Ingestion of Contaminated Deer Meat

	Dose (mrem/yr)					
	Bone	Liver	Total Body	Kidney	Lung	GI-LII
Adult	2.50E-2[a]	7.46E-2	8.12E-2	5.79E-2	4.98E-3	4.17E-1
Teenager	2.04E-2	5.96E-2	5.23E-2	4.99E-2	4.56E-3	2.26E-1
Child	3.68E-2	7.27E-2	6.64E-2	5.37E-2	5.23E-3	1.17E-1

[a] 2.50E-2 = 2.50×10^{-2}

6.0 ALTERNATE DISPOSAL METHODS

It was originally planned to present two alternate disposal methods. These were to be dewatering in high integrity containers (HICs) and cement solidification is 55-gallon drums. The packaged waste was to be shipped to the Barnwell, South Carolina, site. The site operators have since informed CP&L that the contaminated sediment is not acceptable because it contains Ra-226 in concentrations which are not incidental to that of the man-made activity and because they consider the Ra-226 to be technologically enhanced as a result of volume reduction during coal combustion. In the meantime, the state of Nevada has declined to renew the license for the Beatty site. These circumstances, combined with the fact that the Richland, Washington, site does not accept HICs, somewhat restrict disposal options and emphasize the need for an alternate method of disposal. Only cement solidification in 55-gallon drums and shipment to Richland is considered here.

6.1 Operations

It is envisioned that the sediment would be easiest to handle as a slurry. Thus water would be added to the West Pond which is now drained. The slurried sediment would then be pumped to the cement solidification rig for processing. It is anticipated that a three-man crew would be required. The schedule for solidification would allow time for the construction activities mentioned in Section 5.1.1 and must provide for keeping one pond in service at all times.

6.2 Impacts

Potential impacts are limited to direct exposure of workers during operations and of the general public during transport to Richland. Exposure to the public would be negligible. No occupational exposure to airborne radioactivity would occur since the sediment would be handled as a slurry.

The occupational direct gamma dose can be conservatively estimated using the infinite slab dose rate of 0.0241 mrem/yr (Section 5.3.1) and an assumed exposure time of 160 hrs/man. This yields a total dose of 11.7 mrem or 3.9 mrem/man.

6.3 Costs

The total estimated cost of this disposal option is $13,148,000. A breakdown of costs is given in Table 6-1. These costs assume that the cement-like properties of fly ash in the sediment would allow mixing 75 percent by volume sediment with cement.

Table 6-1 Estimated Costs of Commercial Disposal of Cement-Solidified Sediment

Quantity	Unit	Description	Unit Cost ($)	Cost ($)
37,664	each	55-gallon drums	23	866,000
282,480	cubic feet	Cement solidification	110	4,143,000
738	each	Waste shipments to Richland	5,000	3,690,000
282,480	cubic feet	Disposal fee	15.75	4,449,000
			Total	$13,148,000

7.0 REQUEST FOR EXTENSION OF NRC APPROVAL TO POSSIBLE FUTURE SEDIMENT TRANSFERS

As discussed in Sections 1.0 and 5.1, CP&L is in the process of developing plans to modify both the settling ponds and ash pond to reduce accumulation of contaminated sediment in the settling ponds and mitigate the already small potential impacts of transfer of the sediment to the ash pond. However, all modifications to reduce accumulation of contaminated sediment may not be performed at the same time and may not completely eliminate sediment accumulation. For example, the settling ponds must be cleaned by the end of February 1983 to prevent shutting down both plants to avoid exceeding NPDES permit limits for the settling ponds. It is probable that the ponds will need to be cleaned again in 1983 in connection with modifications to control cross contamination and ash accumulation. It is not unlikely that the ponds will require at least one additional cleaning as residual contaminated sediment is flushed from the storm drains.

In view of the very low levels of radioactivity and the small impacts involved, CP&L requests that the Commission allow transfers of contaminated sediments from the settling ponds to the ash pond to be made without the specific approval of the Commission whenever the average concentration of Co-60 in sediment does not exceed 3.0 E-5 μCi/g wet. The derivation of this limit is discussed below.

The requested concentration limit is based on Co-60 alone for three main reasons. First it is the major, if not the only, radionuclide present. Second, for the critical organ and age group, whole body exposure of the maximum teenager, Co-60 is responsible for virtually all of the dose in the

direct exposure and ingestion pathways. Third, although Co-60 is not the principal contributor to the inhalation whole body dose, the total dose from this pathway is insignificant when compared to that for the direct exposure and ingestion pathways. Thus basing the requested concentration limit on Co-60 alone does not reduce the high degree of conservatism of the pathway analysis presented in Section 5.3 for the existing sediment.

In estimating direct exposure doses in Section 5.3, it was conservatively assumed that the weighted average total activity of 9.72 E-6 μCi/g wet was attributable to Co-60. This assumption is not conservative in the ingestion pathway, so weighted average concentrations for each radionuclide were used. If the teenager whole body ingestion dose is recalculated for Co-60 alone, a value of 4.24 E-2 mrem/yr is obtained. Although this value is 19 percent less than that obtained using average concentrations of each radionuclide, this change causes a negligible reduction (0.6 percent) in total dose for all pathways. The total dose to the critical individual, the maximum teenager, becomes 1.64 mrem/yr if Co-60 at a concentration of 9.72E-6 μCi/g wet is the only radionuclide present.

Having demonstrated that the use of Co-60 alone has a negligible effect on the total dose, the Co-60 concentration corresponding to a particular dose can now be calculated. A dose limit of 5 mrem/yr to the critical individual provides more than adequate protection to the general public, especially in view of the extreme conservatism of the dose calculations, without placing impractical restrictions on future sediment transfers. A dose of 5 mrem/yr corresponds to a Co-60 concentration of 2.90 E-5 μCi/g wet in sediment. Following the usual practice, the Co-60 concentrations has been rounded 3.0 E-5 for use as a limit.

It should be noted that sampling of the Ash Pond is now part of the H. B. Robinson environmental monitoring program and provides additional assurance that exposure to the public can be minimized. Sample types, frequencies, and analyses are given in Table 7-1.

Table 7-1 Radiological Monitoring of the Robinson Ash Pond

Sample Type	Frequency	Analysis
Surface Water	Monthly	Gross Alpha, Gross Beta, Tritium on Quarterly Composite. Gamma & Sr-89/90 if Gross Beta >100 p Ci/l
Soil (ash)	Semiannual (1 square foot by 1 inch deep)	Gross Beta, K-40, Gamma
Aquatic Vegetation	Semiannual	Gamma

REFERENCES

GR78 Green, J. B. and S. E. Manahan, 1978. "Wastewater Treatment with Humic Acid-Fly Ash Mixtures," Chemistry of Wastewater Technology, A. J. Rubin (ed.), Ann Arbor Science.

HU80 Hulett, Jr., L. D., A. J. Weinberger, K. J. Northcutt, and M. Ferguson, 1980. Science, 210, December 19, 1980.

ICRP International Commission on Radiological Protection, 1980. Limits for Intakes of Radionuclides by Workers. ICRP Publication 30, Supplement to Part 2.

NRC77 U. S. Nuclear Regulatory Commission, 1977. Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10CFR Part 50, Appendix I.

BE68 Beck, H. and G. de Planque, May 1968. The Radiation Field in Air Due to Distributed Gamma-Ray Sources in the Ground. USAEC Health & Safety Laboratory Report HASL-195.

APPENDIX

Radiological Analysis of Contaminated Sediment

This Appendix presents the results of Ge (Li) analysis of samples of contaminated sediment from the two Robinson storm drain settling ponds. The data presented in Tables A-1 and A-2 are for grab samples taken from the surface of sediments in the two ponds. Table A-3 presents the results of analysis of cores samples taken from the West Settling Pond. Each core was 6 inches in diameter and 4 feet deep and was blended to ensure homogeneity. All samples were counted wet.

Table A-1 Concentrations (µCi/g Wet) of Man-Made Radionuclides in Routine Grab Samples of Sediment Collected From the East Settling Pond.

Date	Mn-54	Co-58	Co-60	Nb-95	Cd-109	Cs-134	Cs-137	Total
07/31/80			6.35E-8[a]					6.35E-8
08/27/80			7.51E-5				1.71E-6	7.68E-5
08/28/80		2.44E-7	5.16E-6			4.13E-7	2.83E-6	8.65E-6
09/27/80[b]			1.59E-5				4.00E-7	1.63E-5
09/27/80[c]	2.00E-7	4.04E-7	2.15E-6				1.44E-7	2.90E-6
10/30/80		9.33E-7	3.45E-6				1.69E-7	4.55E-6
11/07/80	2.55E-7	9.59E-7	1.19E-5				8.37E-7	1.40E-5
12/02/80	2.02E-7		8.52E-6				2.30E-7	8.95E-6
01/06/81		9.76E-7	8.40E-7				4.80E-7	2.30E-6
01/20/81			4.48E-5					4.48E-5
01/28/81		1.61E-7	8.26E-6				3.52E-7	8.77E-6
02/02/81	2.67E-7	6.04E-7	9.33E-6				2.46E-7	1.04E-5
02/03/81			4.00E-7					4.00E-7
02/13/81		1.86E-6	4.31E-5				7.19E-7	4.57E-5
02/20/81	1.71E-7	3.62E-7	1.86E-5					1.91E-5
04/03/81			2.59E-5	3.62E-7			3.95E-7	2.67E-5
04/10/81			1.76E-5	4.63E-7				1.81E-5
04/16/81		2.38E-7	1.82E-5		1.61E-6		2.83E-7	2.03E-5
04/23/81	1.59E-7		2.39E-5				1.54E-6	2.56E-5
04/30/81			1.44E-5		2.92E-6		5.84E-7	1.79E-5
05/01/81	9.25E-8		8.82E-6	2.61E-7			2.69E-7	9.44E-6
05/08/81			1.04E-5				2.83E-7	1.07E-5
05/14/81			9.80E-5					9.80E-5
05/19/81			1.61E-5	7.12E-7			3.77E-7	1.72E-5
05/22/81			1.70E-6				7.62E-8	1.78E-6
06/05/81			1.92E-6				4.65E-8	1.97E-6
06/11/81		2.77E-7	1.21E-5	2.95E-7			2.05E-7	1.29E-5
06/19/81			7.44E-6	2.83E-7			8.03E-8	7.80E-6
06/26/81			7.25E-6				9.97E-8	7.35E-6
07/03/81		1.99E-7	1.64E-5	1.66E-7			2.15E-7	1.70E-5
07/16/81		1.73E-6	4.16E-5				7.63E-7	4.41E-5
07/23/81			2.06E-5				4.25E-7	2.10E-5
07/30/81		6.10E-8	3.25E-6				2.50E-7	3.56E-6
08/06/81			1.61E-6		1.96E-6		1.36E-7	3.71E-6
08/13/81		1.20E-7	6.21E-6				1.85E-7	6.52E-6
08/21/81		1.66E-7	9.22E-6		2.52E-6		3.47E-7	1.23E-5
08/28/81			4.84E-7					4.84E-7
09/04/81	3.85E-7		3.22E-5	1.71E-7	2.50E-6		3.16E-7	3.56E-5
09/09/81			1.28E-5				3.79E-7	1.32E-5
09/17/81		1.25E-7	1.54E-5		2.99E-6		1.80E-7	1.87E-5
09/25/81		1.09E-7	6.82E-6		2.76E-6		2.10E-7	9.90E-6
10/01/81			9.25E-6	2.63E-7	1.42E-6		3.12E-7	1.12E-5
10/22/81			1.98E-6		3.58E-6		8.55E-8	5.65E-6
10/29/81			1.93E-5				5.89E-7	1.99E-5
11/06/81			1.36E-5		2.37E-6		2.34E-7	1.62E-5
12/04/81			5.45E-6		3.35E-6		2.17E-7	9.02E-6
01/07/82			1.47E-6					1.47E-6
Average	2.16E-7	5.29E-7	1.55E-5	3.31E-7	2.54E-6	4.13E-7	4.41E-7	1.68E-5

[a] $6.35E-8 = 6.35 \times 10^{-8}$

[b] Sample collected at 0950

[c] Sample collected at 1530

Table A-2 Concentrations (µCi/g Wet) of Man-Made Radionuclides in Routine Grab Samples of Sediments Collected from the West Settling Pond.

Date	Mn-54	Co-58	Co-60	Nb-95	Cd-109	Cs-134	Cs-137	Ce-144	Total
08/27/80			7.36E-6[a]				3.76E-7		7.74E-6
08/28/80		1.19E-7	1.44E-6		3.44E-6		1.90E-7		5.19E-6
09/27/80		4.35E-7	3.30E-6				2.92E-7		4.13E-6
10/30/80			1.09E-5				5.29E-7		1.14E-5
10/31/80			2.41E-6		3.02E-6		7.12E-8		5.50E-6
11/07/80		3.03E-7	1.61E-6				1.78E-7		2.09E-6
12/02/80			1.75E-6				2.84E-7		2.03E-6
01/06/81	2.03E-7	4.09E-7	1.15E-5		3.93E-6		6.21E-7		1.67E-5
01/20/81		2.59E-7	3.74E-6						4.00E-6
01/28/81		1.50E-7	1.53E-6						1.68E-6
02/02/81		4.50E-8							4.50E-8
02/03/81			4.23E-6						4.23E-6
02/13/81		5.16E-7	5.54E-6						6.06E-6
02/20/81		7.82E-7	2.66E-6						3.44E-6
04/03/81			1.72E-6						1.72E-6
04/10/81		7.08E-8	1.76E-6						1.83E-6
04/16/81			2.46E-6						2.46E-6
04/23/81			1.57E-6				7.12E-8		1.64E-6
04/30/81			1.57E-6	9.48E-8	2.51E-6				4.17E-6
05/08/81		4.38E-8	2.76E-6	3.05E-7			2.80E-7		3.39E-6
05/14/81			2.38E-6						2.38E-6
05/22/81			7.24E-7	4.34E-8					7.67E-7
06/06/81			8.95E-7				5.77E-8		9.53E-7
06/11/81			3.23E-7		3.68E-7				6.91E-7
06/19/81			5.53E-7						5.53E-7
06/26/81			3.52E-7						3.52E-7
07/03/81			4.63E-7	5.18E-8			3.41E-8		5.49E-7
07/10/81			2.11E-6				8.81E-8		2.20E-6
07/16/81			6.23E-7				8.39E-8		7.07E-7
07/23/81			1.45E-6		1.45E-6		7.35E-8		2.97E-6
07/30/81			2.22E-6	1.90E-7			2.67E-7		2.68E-6
08/06/81			1.31E-6	7.89E-8			1.25E-7		1.51E-6
08/13/81			5.87E-6	4.11E-7			1.96E-7	4.33E-7	6.91E-6
08/21/81			1.56E-6		2.32E-6		1.55E-7		4.04E-6
08/28/81			2.59E-6	3.02E-7	2.07E-6		2.90E-7	5.99E-7	5.85E-6
09/04/81			5.65E-6			1.40E-7	1.02E-6		6.81E-6
09/09/81			3.01E-6		1.23E-6		3.54E-7		4.59E-6
09/17/81			3.13E-6		4.43E-6		1.09E-7		7.67E-6
09/25/81			1.21E-6		9.58E-7		1.17E-7		2.29E-6
10/01/81	3.23E-8		5.97E-7		3.73E-6				4.33E-6
10/22/81			2.15E-6	1.18E-7	8.52E-7		1.38E-7		3.26E-6
10/29/81			1.33E-6				4.35E-7		1.77E-6
11/06/81			6.95E-6						6.95E-6
12/04/81			1.84E-5				2.88E-7		1.87E-5
01/07/82			7.83E-7		4.46E-6		7.95E-8		5.32E-6
02/04/82			1.47E-6		2.15E-6				3.62E-6
Average	1.18E-7	2.85E-7	3.06E-6	1.77E-7	2.46E-6	1.40E-7	2.43E-7	5.16E-7	4.08E-6

[a] 7.36E-6 = 7.36×10^{-6}

Table A-3 Concentrations (μCi/g Wet) of Man-Made Radionuclides in Cores of Sediment Collected from West Settling Pond in April 1982.

Sample Number	Co-60	Cd-109	Cs-137	Total
1	5.11E-6[a]		3.64E-7	5.47E-6
2	2.46E-5		5.41E-6	3.00E-5
3	3.68E-6		6.53E-7	4.33E-6
4	1.59E-6			1.59E-6
5	6.58E-7			6.78E-7
6	8.05E-6		3.77E-7	8.43E-6
7	2.36E-6		3.74E-7	2.73E-6
8	4.50E-6	1.94E-6		6.44E-6
9	1.01E-6	1.63E-6		2.64E-6
10	2.43E-6		3.25E-7	2.76E-5
11	9.21E-6		9.49E-6	1.02E-5
12	1.57E-5		2.94E-7	1.60E-5
13	1.12E-5			1.12E-5
14	1.67E-5		2.12E-7	1.69E-5
15	5.65E-6		1.76E-6	7.41E-6
16	4.18E-6			4.18E-6
17	3.97E-6			3.97E-6
18	1.01E-6			1.01E-6
19	2.43E-6		1.79E-6	4.22E-6
20	9.50E-7			9.50E-7
21	2.24E-6			2.24E-6
22	2.25E-6		2.40E-7	2.49E-6
23	7.16E-7			7.16E-7
24				b
25	1.01E-6		9.01E-8	1.10E-6
26	8.37E-7			8.37E-7
27	1.44E-6			1.44E-6
28	1.74E-5			1.74E-5
Average	5.59E-6	1.79E-6	9.88E-7	7.12E-6

[a] $5.11E-6 = 5.11 \times 10^{-6}$

[b] Not included in total number of samples for calculation of average total activity.