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50-270 Oconee Nuclear Station, Unit 2, Duke Power Co. 05000270
50-287 Oconee Nuclear Station, Unit 3, Duke Power Co. 05000287

AUTH.NAME AUTHOR AFFILIATION
TUCKER,H.B. Duke Power Co.
RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. Office of Nuclear Reactor Regulation, Director
STOLZ,J.F. Operating Reactors Branch 4

SUBJECT: Forwards application for disposal of very low level radwaste.If approval not obtained by 841201,util will ship matl to Barnwell.

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	NRR/DSI/RAB		1	1	REG FILE	04	1	1
	RGN2		1	1				
EXTERNAL:	ACRS	09	6	6	LPDR	03	1	1
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	NTIS		1	1				
NOTES:			1	1				

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DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

September 18, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. John F. Stolz, Chief
Operating Reactors Branch No. 4

Re: Oconee Nuclear Station
Docket Nos. 50-269, 50-270, and 50-287

Dear Mr. Denton:

Pursuant to 10 CFR 20 §20.302, please find attached an application for the disposal of very low-level radioactive waste. Duke Power Company hereby requests NRC approval of the proposed disposal method described in the attached application.

This application proposes to bury the slightly contaminated portions of five pressure feedwater heaters after sectioning of the heaters and separation of the tube assemblies and shells. The proposed burial site is to be located within the company controlled area.

For 1985, Duke has established for Oconee Nuclear Station a goal to substantially reduce the amount of radwaste to be disposed of. In order to achieve this goal, the feedwater heaters would need to be disposed of in 1984. Currently, Oconee is significantly below its 1984 radwaste goal and the disposal of this material in 1984 will not impact this goal.

Thus, Duke intends to dispose of this material in 1984. The preferred approach is on-site burial; however, if approval is not obtained by December 1, 1984, Duke will ship this material to Barnwell low level burial site for disposal. Therefore, Duke requests that the NRC review and approve this proposal prior to December 1, 1984.

Your assistance in achieving our goals to effectively manage Oconee's radwaste is greatly appreciated.

Duke Power has determined that pursuant to 10 CFR 170.21 a license fee is required for this approval; therefore, please find attached a check in the amount of $150.00.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

RFH:slb

A001 w/check $150.00
1/1 # 755577

Attachment

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Mr. J. C. Bryant
NRC Resident Inspector
Oconee Nuclear Station

Ms. Helen Nicolaras
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

OCONEE NUCLEAR STATION
APPLICATION FOR THE APPROVAL TO DISPOSE OF
VERY LOW-LEVEL RADIOACTIVE WASTE

1.0 Purpose

Pursuant to 10CFR20, §20.302 Duke Power Company requests NRC Approval of the proposed method for the disposal of five feedwater heaters contaminated at very low-levels of radioactivity. This application addresses the specific information requested in §20.302.

2.0 Waste Description

Five (5) feedwater heaters were replaced during the Oconee outage between June and October 1983. Three (3) feedwater heaters were from unit 1 facility and two (2) feedwater heaters were from unit 2 facility. The feedwater system is designed to provide adequate feedwater flow at the required pressure and temperature to the steam generators for all unit operating conditions. The closed feedwater cycle condenses the steam and the heated feedwater is returned to the steam generators.

Figure 1 is a vertical cross section drawing of a pressure feedwater heater. The shells of the feedwater heater are fabricated from steel and attached at one end to the stationary tube sheet. The feedwater heater tube bundles are composed of a large number of U-tubes roller expanded at each end into a single tube. The physical dimension of the feedwater heater is approximately 35 feet long and 5 feet in diameter.

The smear surveys showed that the contamination levels were less than 200 dpm/100 cm^2 on the heaters' exterior surfaces and were ranging from 200 to 2000 dpm/100 cm^2 on the heaters' interior surfaces with the exception of two smears; of these, one smear indicated 8,800 dpm/100 cm^2 and another smear showed 10,500 dpm/100 cm^2. The survey results from the Eberline RASCAL Na(I) survey instrument indicated that the contact dose rate from the accessible surfaces inside the heaters were ranging from 0.01 to 0.2 mr/hr. These survey results are comparable for all heaters including those recently opened for maintenance (those not being replaced in 1983 Oconee outages).

The radioactivity of the feedwater heaters was determined to be very low. The radionuclides and the concentrations obtained from two samples of the scrappings from the heater tubings were identified as follows:

Radionuclide	Concentration (PCi/gm)	% Abundance
MN-54	3.464E-1	2.71
CO-60	1.008E+1	78.68
CS-134	5.194E-1	4.05
CS-137	1.865E+0	14.56

These sampling results are considered as qualitative analyses due to the irregular shape of the sample scrappings. For conservatism, the highest concentration found in these two samples is used for calculating the projected dose rate.

The waste volume to be buried is approximately 4525 cubic feet from these feedwater heaters.

3.0 Proposed Disposal Method

Figure 2 indicates the location of the proposed burial site within the owner controlled area. These feedwater heaters are currently stored at a temporary storage area on site. The proposed disposal procedures are as follows:

3.1 Cutting and Segregation

- The feedwater heaters will be cut into manageable lengths (approximately 8 feet long sections), the shells and tubes will be separated and placed in metal or wooden box containers.
- After cutting, heater sections will be segregated at the storage location with clean sections (per IE Circular No. 81-07 Guidance: Control of Radioactivity Contaminated Material) being disposed of through normal material section procedures and contaminated sections being transported to the proposed disposal site for burial.
- The preparation and transportation of contaminated sections will be in accordance with station Health Physics Procedures and station directives.

3.2 Disposal Procedure

- During the cutting and burial process access to the processing area and the burial site will be controlled.
- The workers handling the cutting, segregating and burial process will be properly dressed in accordance with station Health Physics Procedures and station directives, as needed.
- The contaminated sections (shells and tubes) will be placed into a 7 to 12 feet deep trench at the proposed burial site and covered with approximately 3 feet of uncontaminated soil.
- The clean sections or uncontaminated material (per IE Circular No. 81-07 Guidance: Control of Radioactivity Contaminated Material) will be disposed of via normal methods for non-contaminated scrap or as determined by Mechanical Maintenance.

3.3 Administration Procedure

- Scrapping samples from the feedwater heater tube where the highest fixed contamination is suspected will be taken for radiological analysis and the results will be documented.
- The total waste volume and radioactivity inventories will be documented, and the total accumulated dose will be periodically evaluated.

4.0 Evaluation of Environmental Impact

4.1 Proposed Site Characteristics

4.1.1 Topography

The proposed burial site is located about 1000 feet east from Oconee Nuclear Station outside the security fence but within company controlled area. Figure 2 indicates the proposed burial site location. The dimension of this burial site is about 7 feet to 12 feet deep, 30 to 50 feet wide and about 70 feet long. Oconee FSAR Figure 2.1-1 through 2.1-4 illustrates the topography in various detail from within 1 mile to within 50 miles of the site. There are no industry, commercial, institutional, recreational or residential structures within the Oconee site boundary. There will be no impact on topography in this area by the proposed method of disposal.

4.1.2 Geology

The ground surface residual soil consists of a variable thickness of soil underlaid by partially weathered rock. The residual soils primarily are silty sands or sandy silts. The rock is a granite gneiss that contains the interlayered biotite-hornblende gneiss. The fill soils classify primarily as micaceous silty sands which include clay layers of low to moderate plasticity. There will be no impact on geology in this area by the proposed method of disposal. For more geological information see the Oconee FSAR, Volume 1, Section 2.5.1.

4.2 Area Characteristics

4.2.1 Meteorology

Western South Carolina is far south of major storm tracks but experiences higher precipitation amounts than the east coast due to its location in the lee of the Appalachian Mountains. A semipermanent belt of high pressure usually influences the regional climate. During the fall season, the area has a high probability of experiencing atmospheric stagnation. The topography in the vicinity of the site is hilly and the local air flow is influenced to some extent by the contour of the lake. The prevailing winds are divided between the southwest and northeast quadrants due to the lake orientation and large scale pressure effects. There will be no impact on meteorology in this area by the proposed method of disposal. For more meteorological information, see the Oconee FSAR, Volume 1, Section 2.3.

4.2.2 Hydrological Characteristics

The hydrological characteristics in the site vicinity are detailed in the Oconee FSAR, Section 2.4 titled Hydrologic Engineering.

4.3 Water Usage

4.3.1 Ground Water Usage

Preliminary Studies indicate that groundwater in this area should continue to migrate downslope through the saprolite soil on a slightly steeper gradient in a southeasterly direction toward the Keowee River base datum. Oconee FSAR, Section 2.4.7 discusses area and regional groundwater conditions. Oconee FSAR, Section 2.4.7.2.1 details groundwater uses in the general area. There will be no impact on groundwater usage by the proposed method of disposal.

4.3.2 Surface Water Usage

Subsurface water is typical of Piedmont area. The top of the zone of saturation, or water table, follows the topography, but is deeper in the uplands and more shallow in valley bottoms. It migrates through the pores of the weathered rock, where the feldspars have disintegrated and left intersticial spaces between the quartz grains. Additional water is contained in the deeper fractures and joints below the sound rock line. The water table is not stationary, but fluctuates continually as a reflection of seasonal precipitation. Surface water users in the Oconee area are detailed in the Oconee FSAR in Section 2.4.1.2. There will be no impact on surface water usage by the proposed method of disposal. For more information, see the Oconee FSAR, Volume 1, Sections 2.4 and 2.5.

4.4 Nearby Facilities

There are no railroads, pipelines, industrial or military facilities within five miles of the Oconee site. There are no other potentially affected facilities in the vicinity of the proposed burial site.

4.5 Radiological Impact

The annual dose rate to the total body for a person continuously occupying the area is estimated to be 0.13 mrem/yr and if only occupied for 2000 hours during the year the estimated whole body dose would be 0.03 mrem. The actual occupancy time of the proposed burial site is expected to be significantly less than 2000 hours per year. Detailed calculations of dose rate estimation is included in Appendix 2.

5.0 Radiation Protection

The operational procedure to minimize the risk of unexpected or hazardous exposures will follow the guidelines provided by System Health Physics Manual and station directives on radiation exposure control and radioactive material control. All radioactive-waste release and disposal operations will be performed under the technical guidance and review of the Station Health Physicist.

6.0 Evaluation of Overall Benefit

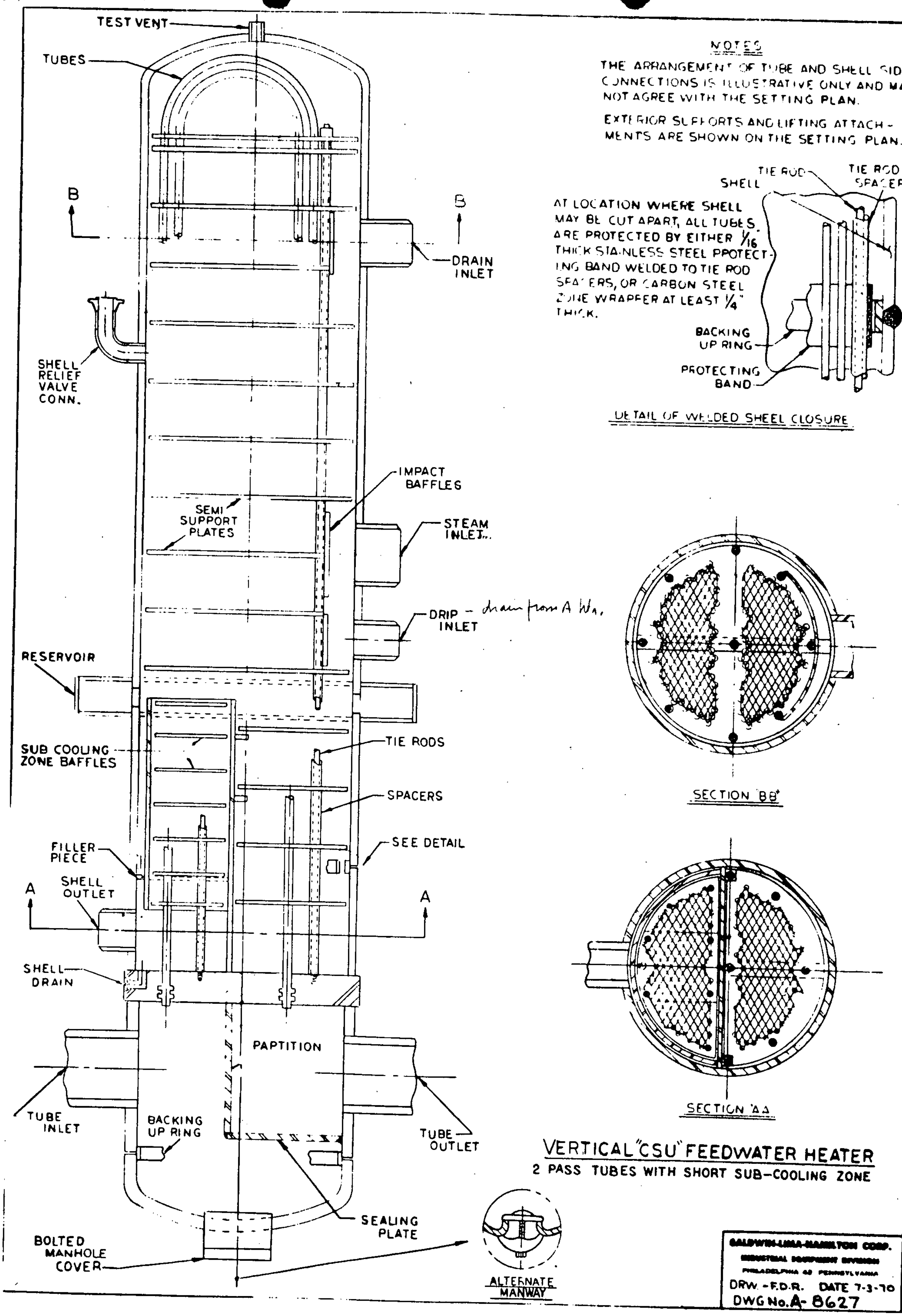
The disposal of these feedwater heaters, if they are packaged and disposed of as radioactive waste, will result in a cost of approximately $160,000 and use the burial space of approximately 4525 ft^3 in the licensed low-level radioactive waste burial site at Barnwell, S.C. The annual dose rates for both public and workers are much less than 1 mrem/yr assuming that they continuously occupy the proposed burial site.

The overall benefit from the proposed method for the disposal of these five slightly contaminated feedwater heaters will be a cost saving of approximately $160,000 and a saving of burial site space of approximately 4525 ft^3, which can be used for other radwaste. There will be no environmental impact for the proposed method of disposal and the associated annual dose, based on the most conservative calculation, will be only 0.1 mrem contributed to the general background radiation level.

APPENDIX:

(1) Feedwater Heater Scrapping Sample Analysis Results

(2) Annual Dose Rate Estimations



TEST VENT
TUBES
B
B
DRAIN INLET
SHELL RELIEF VALVE CONN.
IMPACT BAFFLES
SEMI SUPPORT PLATES
STEAM INLET
DRIP INLET
RESERVOIR
SUB COOLING ZONE BAFFLES
TIE RODS
SPACERS
FILLER PIECE
SEE DETAIL
SHELL OUTLET
A
A
SHELL DRAIN
PAPTITION
TUBE INLET
BACKING UP RING
TUBE OUTLET
SEALING PLATE
BOLTED MANHOLE COVER
ALTERNATE MANWAY
NOTES
THE ARRANGEMENT OF TUBE AND SHELL SIDE CONNECTIONS IS ILLUSTRATIVE ONLY AND MAY NOT AGREE WITH THE SETTING PLAN.
EXTERIOR SUPPORTS AND LIFTING ATTACHMENTS ARE SHOWN ON THE SETTING PLAN.
SHELL
TIE ROD
TIE ROD SPACER
AT LOCATION WHERE SHELL MAY BE CUT APART, ALL TUBES ARE PROTECTED BY EITHER 1/16 THICK STAINLESS STEEL PROTECTING BAND WELDED TO TIE ROD SPACERS, OR CARBON STEEL ZONE WRAPPER AT LEAST 1/4" THICK.
BACKING UP RING
PROTECTING BAND
DETAIL OF WELDED SHEEL CLOSURE
SECTION 'BB'
SECTION 'AA'
VERTICAL "CSU" FEEDWATER HEATER
2 PASS TUBES WITH SHORT SUB-COOLING ZONE
BALDWIN-LIMA-HAMILTON CORP.
DRW. - F.D.R. DATE 7-3-70
DWG No. A-8627

FIGURE 1.

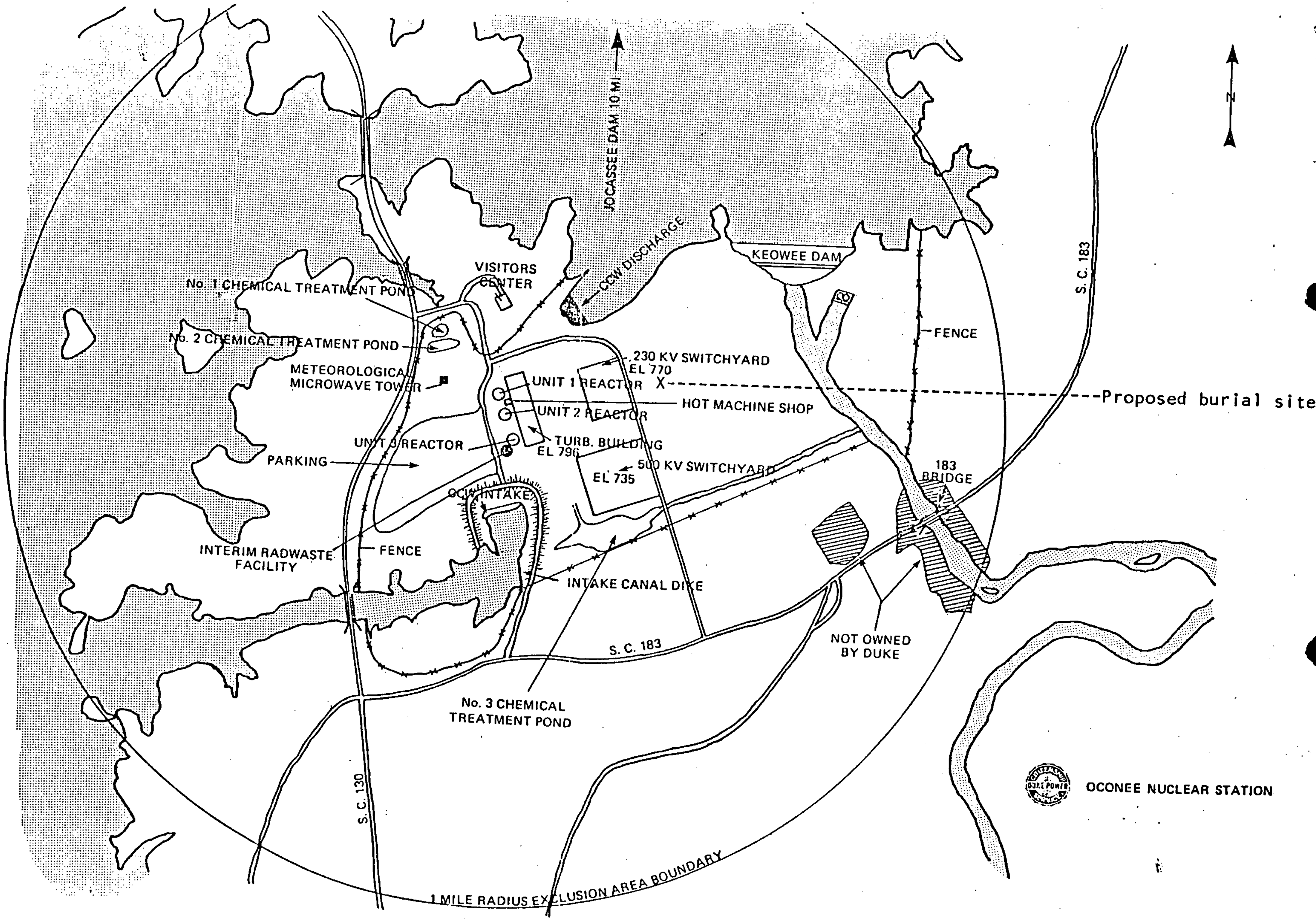


FIGURE 2 PROPOSED BURIAL SITE LOCATION

APPENDIX 1

Feedwater Heater Scrapping Sample Analysis Results

****
******************* 28-AUG-84 06:28:17 *******************
****

WB

FEEDWATER HEATER SAMPLE #2 SRWP-24

Qualitative analysis only

SAMPLE DATE: 27-AUG-84 10:30:00
SAMPLE IDENTIFICATION: FILTER PAPER
TYPE OF SAMPLE: SOLIDS
SAMPLE QUANTITY: 500.0000 UNITS: GRAM
SAMPLE GEOMETRY: FILTER @ 0 CM
EFFICIENCY FILE NAME: EFF.AFILO,,

****

ACQUIRE DATE: 28-AUG-84 06:17:50 * FWHM(1332) 1.978
PRESET TIME(LIVE): 600. SEC * SENSITIVITY: 5.000
ELAPSED REAL TIME: 601. SEC * SHAPE PARAMETER : 35.0 %
ELAPSED LIVE TIME: 600. SEC * NBR ITERATIONS: 10.

****

DETECTOR: IGEA S/N: 995 * LIBRARY: NUCL. MASTER
CALIB DATE: 27-AUG-84 08:44:52 * ENERGY TOLERANCE: 1.750KV
KEV/CHNL: 0.4995210 * HALF LIFE RATIO: 8.00
OFFSET: 0.2265353 KEV * ABUNDANCE LIMIT: 80.00%

****

****

COLLECTED BY: Doug B. * COUNTED BY: WB

RWP/SRWP/LWR/GWR: * COMMENTS:

RESPIRATORY EQUIP USED:
(CONTROL GROUP USE)

****

DEAD TIME: 0 17%
ACTION REQUIRED: NONE

****

ENERGY WINDOW 32.70 TO 2043.27

PK	IT	ENERGY	AREA	BKGND	FWHM	CHANNEL	LEFT	PW	CTS/SEC	%ERR	FIT
1	0	428.00	24.	80.	0.80	856.37	852	10	4.00E-02	56.5	
2	0	605.16	86.	224.	1.43	1211.02	1205	28	1.44E-01	26.8	
3	0	661.61	266.	90.	1.51	1324.03	1317	15	4.43E-01	7.9	
4	0	795.65	59.	106.	1.03	1592.37	1586	17	9.80E-02	28.0	
5	0	834.71	43.	70.	1.61	1670.56	1662	14	7.19E-02	31.4	
6	0	1173.02	848.	60.	1.70	2347.83	2338	17	1.41E 00	3.7	
7	0	1332.18	763.	17.	1.85	2666.46	2657	33	1.27E 00	3.7	
8	0	1460.53	53.	0.	2.00	2923.42	2917	22	8.83E-02	13.7	

PEAK SEARCH COMPLETED (REV 11)

NUCLIDE IDENTIFICATION SYSTEM (REV 5/80)
NUCLIDE LINE ACTIVITY REPORT

FISSION GAS

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI /UNIT	1 SIGMA ERROR
KR-88	FG	165.98	0.	0.	3.10	0.000E-01	0.000E 0	0.000E 0
		196.32	0.	0.	26.30*	0.000E-01	0.000E 0	0.000E 0
		362.23	0.	0.	2.30	0.000E-01	0.000E 0	0.000E 0
		834.83	43.	70.	13.10	1.124E 00	3.379E -4	1.060E -4
		1518.39	0.	0.	2.20	0.000E-01	0.000E 0	0.000E 0
		1529.77	0.	0.	10.90	0.000E-01	0.000E 0	0.000E 0
		2029.84	0.	0.	4.60	0.000E-01	0.000E 0	0.000E 0
		2035.41	0.	0.	3.80	0.000E-01	0.000E 0	0.000E 0

ACTIVATION PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI /UNIT	1 SIGMA ERROR
MN-54	AP	834.83	43.	70.	100.00*	1.124E 00	3.464E -7	1.087E -7
CO-60	AP	1173.22	848.	60.	100.00	7.893E-01	9.681E -6	3.550E -7
		1332.49	763.	17.	100.00*	6.823E-01	1.008E -5	3.726E -7
SB-125	AP	427.89	24.	80.	29.30*	2.361E 00	3.127E -7	1.767E -7
		600.56	0.	0.	17.80	0.000E-01	0.000E 0	0.000E 0

FISSION PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI /UNIT	1 SIGMA ERROR
CS-134	FP	563.23	0.	0.	8.40	0.000E-01	0.000E 0	0.000E 0
		569.32	0.	0.	15.40	0.000E-01	0.000E 0	0.000E 0
		604.70	86.	224.	97.60	1.657E 00	4.806E -7	1.289E -7
		795.85	59.	106.	85.40*	1.195E 00	5.194E -7	1.455E -7
		801.93	0.	0.	8.70	0.000E-01	0.000E 0	0.000E 0
CS-137	FP	661.65	266.	90.	85.10*	1.510E 00	1.865E -6	1.480E -7

NATURAL PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI /UNIT	1 SIGMA ERROR
K-40	NP	1460.81	53.	0.	1.10*	6.297E-01	6.893E -5	9.469E -6

NUCLIDE IDENTIFICATION SYSTEM (REV 5/80)
UNKNOWN LINE REPORT
NONE

LINES NOT MEETING SUMMARY CRITERIA

PK	NUCLIDE	ENERGY	HLFE	DECAY	UCI /UNIT	ABNDIFF	FAILED	
1	~~SB-125~~	~~427.99~~	~~2.77Y~~	~~1.001E 0~~	~~3.127E -7~~	~~62.21%~~	~~ABN~~	No peak
5	~~KR-88~~	~~834.83~~	~~2.84H~~	~~1.280E 2~~	~~3.379E -4~~	~~19.76%~~	~~ABN~~	MN-54

TOTAL LINES IN SPECTRUM	8	
LINES NOT LISTED IN LIBRARY	0	
IDENTIFIED IN SUMMARY REPORT	7	87.50%

ACTIVATION PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI /UNIT	1-SIGMA ERROR	%ERR
MN-54	AP	312.70D	1.002	3.464E -7	1.087E -7	31.37
CO-60	AP	5.27Y	1.000	1.008E -5	3.726E -7	3.70

FISSION PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI /UNIT	1-SIGMA ERROR	%ERR
CS-134	FP	2.06Y	1.001	5.194E -7	1.455E -7	28.02
CS-137	FP	30.17Y	1.000	1.865E -6	1.480E -7	7.94

NATURAL PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI /UNIT	1-SIGMA ERROR	%ERR	
~~K-40~~	~~NP~~	~~*********Y~~	~~1.000~~	~~6.893E -5~~	~~9.469E -6~~	~~13.74~~	Bkg

****
******************** 28-AUG-84 06:32:49 ********************
****

WB

FEEDWATER HEATER SAMPLE #1 SRWP-24

qualitative analysis only

SAMPLE DATE: 27-AUG-84 10:30:00
SAMPLE IDENTIFICATION: FILTER PAPER
TYPE OF SAMPLE: SOLIDS
SAMPLE QUANTITY: 500.0000 UNITS: GRAM
SAMPLE GEOMETRY: FILTER @ 0 CM
EFFICIENCY FILE NAME: EFF.BFILO,,

****

ACQUIRE DATE: 28-AUG-84 06:19:55 * FWHM(1332) 1.686
PRESET TIME(LIVE): 600. SEC * SENSITIVITY: 5.000
ELAPSED REAL TIME: 599. SEC * SHAPE PARAMETER : 35.0 %
ELAPSED LIVE TIME: 600. SEC * NBR ITERATIONS: 10.

****

DETECTOR: GELIB S/N:1692 * LIBRARY: NUCL. MASTER
CALIB DATE: 27-AUG-84 09:29:09 * ENERGY TOLERANCE: 1.750KV
KEV/CHNL: 0.4996644 * HALF LIFE RATIO: 8.00
OFFSET: 0.3107011 KEV * ABUNDANCE LIMIT: 80.00%

****

****

COLLECTED BY: Doug B * COUNTED BY:

RWP/SRWP/LWR/GWR: * COMMENTS:

RESPIRATORY EQUIP USED:
(CONTROL GROUP USE)

****

DEAD TIME: -0 17%
ACTION REQUIRED: NONE

****

ENERGY WINDOW 32.79 TO 2046.94

PK	IT	ENERGY	AREA	BKGND	FWHM	CHANNEL	LEFT	PW	CTS/SEC	%ERR	FIT
1	0	662.98	73.	21.	1.37	1326.23	1318	28	1.22E-01	14.6	
2	0	1173.04	239.	7.	1.39	2347.03	2340	14	3.98E-01	6.7	
3	0	1332.33	192.	21.	1.86	2665.82	2658	28	3.20E-01	8.0	
4	0	1460.44	88.	0.	2.51	2922.23	2915	23	1.47E-01	10.7	

PEAK SEARCH COMPLETED (REV 11)

NUCLIDE IDENTIFICATION SYSTEM (REV 5/80)
NUCLIDE LINE ACTIVITY REPORT

ACTIVATION PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI/UNIT	1 SIGMA ERROR
CO-60	AP	1173.22	239.	7.	100.00	1.043E 00	2.064E -6	1.374E -7
		1332.49	192.	21.	100.00*	9.172E-01	1.888E -6	1.503E -7

FISSION PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI/UNIT	1 SIGMA ERROR
CS-137	FP	661.65	73.	21.	85.10*	1.984E 00	3.917E -7	5.734E -8

NATURAL PRODUCT

NUCLIDE	SBHR	ENERGY	AREA	BKGND	%ABN	%EFF	UCI/UNIT	1 SIGMA ERROR
K-40	NP	1460.81	88.	0.	1.10*	8.478E-01	8.501E -5	9.062E -6

UNKNOWN LINE REPORT

NONE

LINES NOT MEETING SUMMARY CRITERIA

NONE

NUCLIDE IDENTIFICATION SYSTEM (REV 5/80)
SUMMARY OF NUCLIDE ACTIVITY

TOTAL LINES IN SPECTRUM	4	
LINES NOT LISTED IN LIBRARY	0	
IDENTIFIED IN SUMMARY REPORT	4	100.00%

ACTIVATION PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI/UNIT	1-SIGMA ERROR	%ERR
CO-60	AP	5.27Y	1.000	1.888E -6	1.503E -7	7.96

FISSION PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI/UNIT	1-SIGMA ERROR	%ERR
CS-137	FP	30.17Y	1.000	3.917E -7	5.734E -8	14.64

NATURAL PRODUCT

NUCLIDE	SBHR	HLIFE	DECAY	UCI/UNIT	1-SIGMA ERROR	%ERR
~~K-40~~	~~NP~~	~~*********Y~~	~~1.000~~	~~8.501E -5~~	~~9.062E -6~~	~~10.66~~ Blg

APPENDIX 2

Annual Dose Rate Estimations

ANNUAL DOSE RATE ESTIMATIONS

Waste Description: Oconee Feedwater Heater

Waste Volume: 4525 cubic feet

Radionuclides & Concentration:

MN-54	0.35 PCi/gm
CO-60	10.08 PCi/gm
CS-134	0.52 PCi/gm
CS-137	1.86 PCi/gm

Cover Soil: Approximately 3 feet

Consider that waste will be buried as semi-infinite source

Cover with 3 feet uncontaminated soil.

1) Dose rate on surface of semi-infinite source

$$D = \tfrac{1}{2}\sum_i A_i \times \bar{E}_i \times (2.22 \frac{\text{dis.}}{\text{PCi-min}}) \times (60 \frac{\text{min}}{\text{hr}}) \times (1.602 \times 10^{-6} \frac{\text{erg}}{\text{Mev}}) \times (\frac{1}{100 \text{ ergs/g-rad}})$$

Where D = Dose rate at surface in R/hr

A_i = Radionuclide "i" Concentration in PCi/gm

$\bar{E}_i$ = Radionuclide "i" effective energy in Mev

$$D = \tfrac{1}{2}[(0.35 \times 0.835) + (10.08 \times 2.62) + (0.52 \times 1.76) + (1.86 \times 0.81)] \frac{\text{PCi-Mev}}{\text{gm-dis}}$$

$$\times (133.2 \frac{\text{dis.}}{\text{PCi-hr}}) \times (1.602 \times 10^{-6} \frac{\text{ergs}}{\text{Mev}}) \times (\frac{1}{100 \text{ ergs/gm-rad}})$$

$\therefore$ D = 0.0311 (mr/hr)

2) For attenuation, convert 3 feet soil (density $\cong$ 1.9 g/cm³) to equivalent concrete thickness (density $\cong$ 2.3 g/cm³).

$$\text{Equivalent concrete thickness} = \frac{1.9 \text{ g/cm}^3}{2.3 \text{ g/cm}^3} \times 36'' = 29.7''$$

From Radiological Hand Book, transmission factor "B" through concrete

29.7" of gamma rays from CO-60 is equal to approximately 0.0005.
∴ Dose rate = 0.03 mr/hr x 0.0005 = 1.5×10^{-5} mr/hr.

3) Annual dose rate estimation
∴ Dose = (1.5×10^{-5} mr/hr) x (8760 hr/yr) x (1 mrem/mrad) = 0.13 mrem/yr.

For 2000 hr/yr continuously exposure
∴ Dose = (1.5×10^{-5} mr/hr) x (2000 hr/yr) x (1 mrem/mrad) = 0.03 mrem/yr.