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Health Risk Assessment for the Building 3001 Storage Canal at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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EXECUTIVE SUMMARY

This human health risk assessment has been prepared for the Environmental Restoration (ER) Program at the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. The objectives of this risk assessment are to evaluate the alternatives for interim closure of the Building 3001 Storage Canal and to identify the potential health risk from an existing leak in the canal.

The Building 3001 Storage Canal connects Buildings 3001 and 3019. The volume of water in the canal is monitored and kept constant at about 62,000 gal. The primary contaminants of the canal water are the radionuclides ^{137}Cs, ^{60}Co, and ^{90}Sr; a layer of sediment on the canal floor also contains radionuclides and metals. The prime medium of contaminant transport has been identified as groundwater, which, according to dye tracer studies and examination of potentiometric surfaces, flows toward the sump in Building 3042. Sump water is pumped to Fifth Creek via storm drains. Fifth Creek drains into White Oak Creek, which drains into Clinch River.

The primary route for occupational exposure at the canal is external exposure to gamma radiation from the canal water and the walls of the canal. Similarly, the primary exposure route at the 3042 sump is external exposure to gamma radiation from the groundwater and the walls of the sump. Based on the exposure rates in the radiation work permits (Appendix C) and assuming conservative occupational work periods, the annual radiation dose to workers is considerably less than the relevant dose limits.

The potential risk to the public using the Clinch River was determined for three significant exposure pathways: ingestion of drinking water; ingestion of contaminated fish; and external exposure to contaminated sediments on the shoreline, the dominant exposure pathway. The total possible risk due to contamination from the canal leak was found to be within the acceptable risk range of 10^{-4} to 10^{-6} specified by the U.S. Environmental Protection Agency[1] and negligible when compared to the existing risk levels at the Clinch River.

Although the canal poses neither a significant public health risk nor an unacceptable risk to workers, the potential health hazards of the proposed remedial alternatives for the interim corrective measure will have to be evaluated separately.

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[1]*Federal Register*. 1990. Volume 55, No. 46, Mar. 8, 1990, pp. 8715–8717.

1. INTRODUCTION

This human health risk assessment has been prepared for the Environmental Restoration (ER) Program at the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, and is meant to aid in evaluating alternatives for interim closure of the Building 3001 Storage Canal located beneath the Oak Ridge Graphite Reactor (Building 3001). The interim closure has been planned to meet the requirements of the Resource Conservation and Recovery Act (RCRA) interim status regulations, as outlined in the Rules of the Tennessee Department of Environment and Conservation (TDEC), Chapter 1200-1-11-05 (10)(g)4. The objective of this risk assessment is to identify the potential health risk to the surrounding occupational population from an existing leak in the canal. The potential for any off-site impacts from the leak will also be evaluated.

2. REPORT ORGANIZATION

After the introduction and site background of the Building 3001 Storage Canal, this report will characterize and evaluate the site and contaminants of potential concern. Further sections will examine the possible pathways for potential migration and exposure, followed by a detailed exposure assessment. The report will conclude with a characterization of the possible risk associated with the exposure scenarios. Relevant information for this report has been gathered from ORNL documents and personal communication with ORNL personnel.

3. SITE BACKGROUND

The Building 3001 Storage Canal is L-shaped (Figs. 1 and 2) and runs south and then west to the Radiochemical Processing Plant (Building 3019). During pilot operation of the reactor, between 1943 and 1963, the canal was used to transport irradiated fuel from Building 3001 to Building 3019. First the spent uranium fuel slugs were collected in a pit at the head of the canal. Then they were transported underwater by means of an overhead crane to Building 3019. An estimated 200 slugs ruptured in the reactor core and were subsequently transferred through the canal. The contents of some of these slugs can be expected to be present in the sediment at the bottom of the canal. After shutdown of the reactor, the canal was used to store radioisotopes. An estimated 600 to 700 slugs of ^{60}Co and 14 capsules of ^{90}Sr were in the canal, but they have recently been removed.

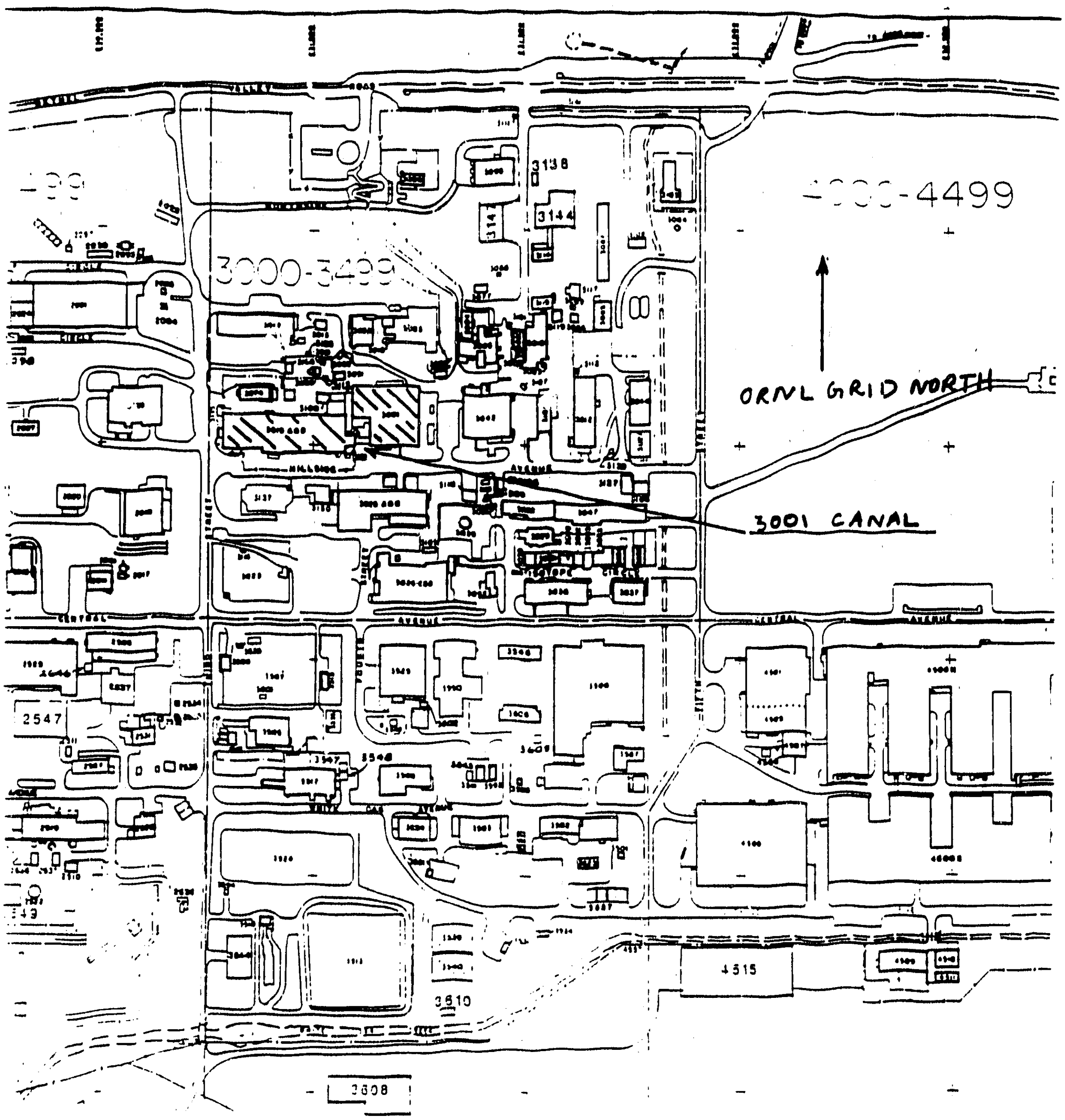

Fig. 1. Location of the Building 3001 Storage Canal.

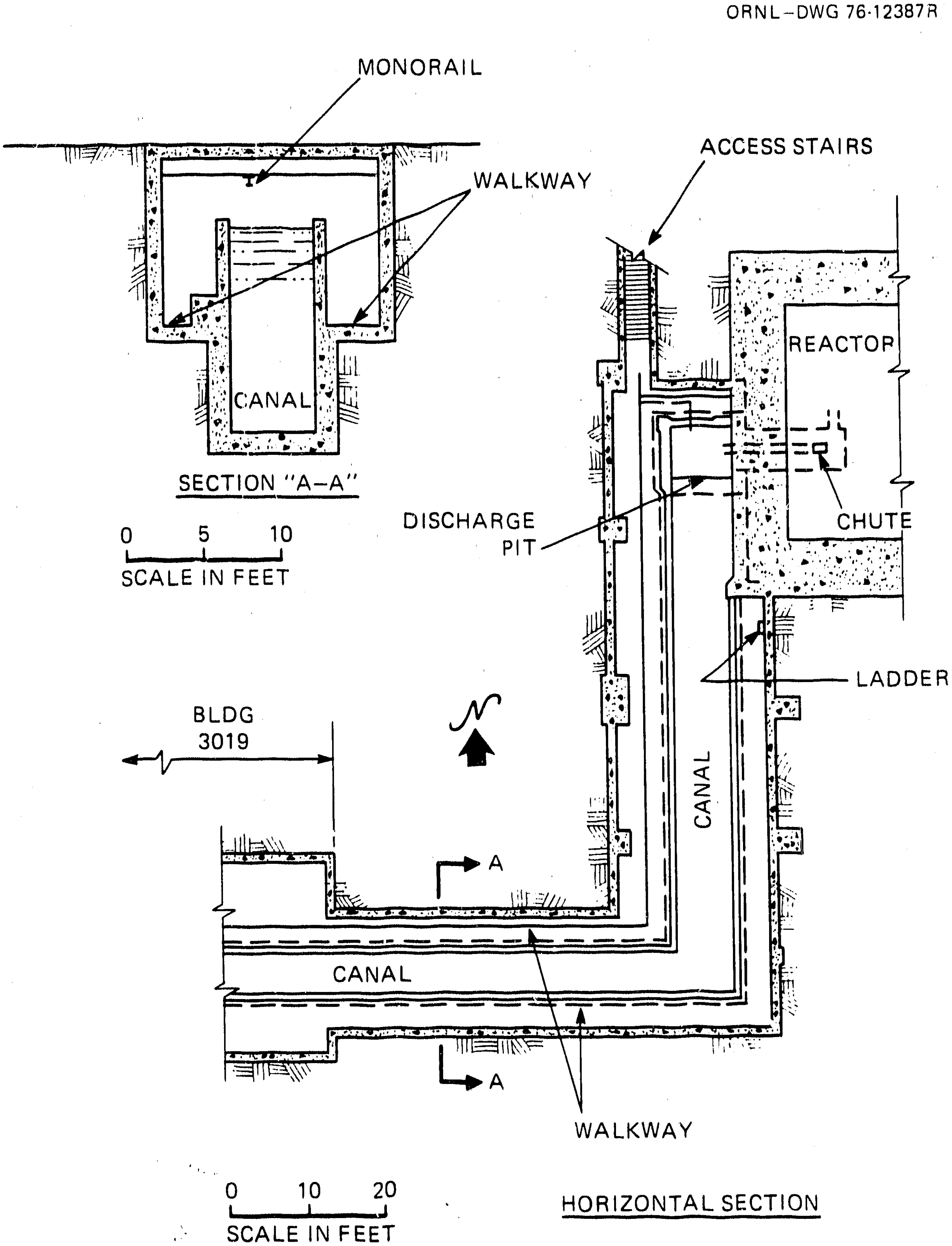

Fig. 2. The Building 3001 Storage Canal.

4. SITE CHARACTERIZATION

The Building 3001 Storage Canal is located beneath Buildings 3001 and 3019 (Fig. 2). The depth of water ranges from 10.5 ft at the head of the canal to 11.5 ft at the other end. A pit, approximately 22 ft deep, at the head of the canal connects the canal to the vertical chute from the reactor. It is believed that the canal leaks at the junction of the side walls and the bottom slab (V. Chidambariah, personal communication with M. Ford, ORNL, June 1990). The total volume of water is maintained at about 62,000 gal, and any volume lost due to the leak and evaporation is automatically replaced.

The primary contaminants of the canal water are the radionuclides ^{137}Cs, ^{60}Co, and ^{90}Sr. Although metal concentrations in the canal water are very low (Appendix A), a layer of sediment (about 1/2 in. thick) on the canal floor also contains radionuclides and metals. Some of the metals are regulated under RCRA. The canal water is passed through an ion exchange column periodically, which removes radionuclides in addition to other ions. Liquid wastes from regeneration of the ion exchange column are sent to the liquid low-level waste system.

5. CONTAMINANT CHARACTERIZATION

Appendix A lists concentrations of metals and radionuclides found in the canal water. The radionuclides—^{137}Cs, ^{60}Co, and ^{90}Sr—were identified as primary contaminants and were selected based on their concentrations (or activities) in the medium of concern, the canal water, and their relative toxic characteristics. The source of contaminant migration is the canal water because it has a much higher tendency to migrate by way of the leakage than does the sediment. Although the concentrations of metals in the canal water are below the Maximum Contaminant Levels (MCLs) for drinking water (see Appendix A), the sediment at the canal bottom does contain significant concentrations of radionuclides and metals. The sampling results for the canal water, the sediment, and the groundwater sump at the Oak Ridge Research Reactor Building (3042) are presented in Appendix B. The maximum possible contaminant concentrations in the canal water (Appendix B) are presented below.

Contaminant	Concentration (Bq/L)
^{137}Cs	840 (750 + 90)
^{60}Co	290 (260 + 30)
^{90}Sr	310 (240 + 70)

6. ENVIRONMENTAL PATHWAYS

The following section evaluates the possible pathways by which the contaminants in the canal water can migrate and reach potential receptors in the surrounding environment. The pathways that are possibly contaminated and potentially carry contaminants to receptors are the groundwater, surface water, and regolith in the vicinity of the canal. Evaluation of these pathways will include descriptions of the groundwater and surface-water flows, soil characteristics, and contaminant-specific characteristics that might affect the migration of the contaminants. Additionally, the likelihood that contaminants may be transported through the air and foodchain will be examined.

6.1 GROUNDWATER

Primarily, groundwater transports the leak and its contaminants. The groundwater table in the vicinity of the canal is at roughly the same elevation as the bottom of the canal. Since the canal is believed to be leaking at the junction of the side walls and the bottom slab, it is likely that the leak reaches the groundwater table without much percolation through the soil.

Dye tracer studies (D. D. Huff, ORNL, personal communications to T. E. Myrick, ORNL, Oct. 7, 1985, and June 27, 1986) have shown that when a pulse dose is injected near Building 3019, it takes a relatively short time to travel the distance to the groundwater sump in Building 3042. The dye concentration was also the highest in the groundwater sump at Building 3042, which indicates that most of the dye had travelled in that particular direction. Therefore, it can be concluded that the groundwater flows eastward in the vicinity of the canal (Fig. 3). An examination of the potentiometric surfaces in the region supports this observation. The selective flowpath is also believed to include a solution cavity along geologic strike in that region. The observed groundwater flow velocity at the sump in Building 3042 is higher than what could be expected because it assumes a pure granular flow, which indicates the presence of preferred flow in the region.

Groundwater movement has also been indicated in more permeable backfill along the various trench lines and pipeline cavities in the Building 3001 region. The steepest water table gradients are generally south toward White Oak Creek. However, the dye tracer studies have shown that this pathway is minor when compared with the pathway to the groundwater sump at Building 3042.

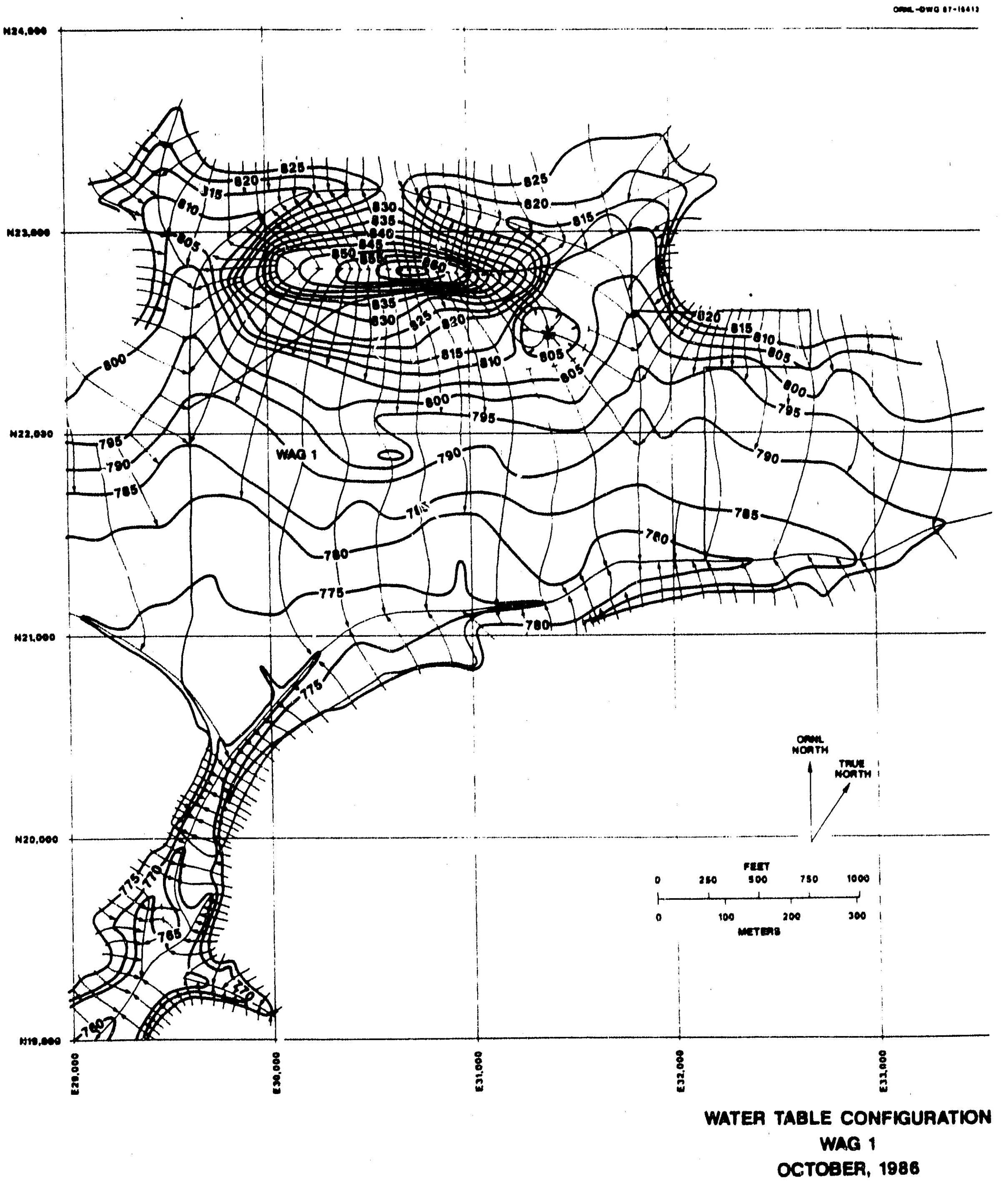

Fig. 3. Water table configuration in the Building 3001 area.

6.2 SURFACE WATER

The groundwater collected in the sump at Building 3042 is pumped to Fifth Creek through the storm drains in that region, which also collect water from other outfalls in the region. Further, these storm drains collect waste water from other buildings as the water heads southward to join White Oak Creek, which drains into White Oak Lake. Eventually, White Oak Lake empties into Clinch River by way of White Oak Dam.

6.3 REGOLITH

As the contents of the leak are transported by the groundwater flow to the groundwater sump at Building 3042, the regolith between Buildings 3001 and 3042 probably become contaminated. Because the regolith may be expected to contain significant concentrations of radionuclides and metals, the contaminant concentrations need to be monitored in the event of future excavation.

6.4 AIR

In the event of excavation of the soil between Buildings 3001 and 3042, the contaminants in the regolith could be resuspended into the air. Then the air in the immediate vicinity of the excavation site can become a pathway to transport the contaminants to the receptors at the site. The potential receptors would include the working personnel at the site and in the surrounding buildings, as well as, the transient worker population in the vicinity of the site.

6.5 FOOD CHAIN

Under some circumstances, the food chain can provide an indirect route for contaminants to reach the public by way of the biological uptake by agricultural products such as grain, milk products, beef, and game animals. Bioaccumulation of contaminants through the food chain would be a significant migration pathway for the contaminants coming from a source like the ORNL plant in its entirety. But since the canal is one small unit of the ORNL complex, this pathway will not be considered.

7. EXPOSURE PATHWAYS

This section will evaluate the current and potential environmental pathways of exposure to the contaminants in the canal water and will identify potential receptors. Also, assumptions and calculations will be made for the exposure assessment and the probability of exposure to receptors.

7.1 EXPOSURE ANALYSIS

The principal pathway of worker exposure—radiation from the stored slugs in the canal, the canal water, and the walls of the canal—is external. (Since the slugs have been removed, the exposure will be from the canal water and the canal walls.) Exposure to contaminants in the canal sediment is unlikely because of effective shielding provided by the canal water. Inhalation, another potential environmental pathway, which is dependent upon excavation of the regolith in the area between Buildings 3001 and 3042, will also be considered because of public exposure at the Clinch River to the contaminants.

The existence of an exposure pathway (i.e., a link between the contaminated medium and the receptor) establishes the probability of exposure, regardless of the contaminant concentrations in the medium. However, the presence of a completed exposure pathway does not necessarily imply adverse health effects, which are also dependent upon exposure factors and the concentrations and toxicological properties of the contaminants involved. (The likelihood of the occurrence of adverse health effects will be discussed in the Risk Characterization section.)

Following are descriptions of human exposure routes for each environmental pathway identified in the previous section. Each exposure route is delineated with regard to current or potential exposures that may result from each of these environmental pathways.

7.2 BUILDING 3001 CANAL

The canal is a potential source of occupational exposure, which could occur through direct radiation from the stored slugs in the canal, the canal water, and the canal walls. (With the slugs removed, exposure is only from the canal water and the canal walls.)

7.3 BUILDING 3042 SUMP

Maintenance personnel are the potential receptors of external radiation exposure that could occur at the groundwater sump in Building 3042. The principal sources of radiation would be the groundwater collected in the sump and the walls of the sump.

7.4 SURFACE WATER

The groundwater from the sump in Building 3042 is pumped to Fifth Creek through the storm drains, which carry water from other sources in the Building 3001 area. Although it is unlikely that external exposure could occur at any point along the line of travel—Building 3042 to Fifth Creek, into White Oak Creek and White Oak Lake, and finally draining into the Clinch River—exposure could possibly occur through ingestion of contaminated fish in the Clinch River and through external exposure to contaminated sediment on the shoreline.

7.5 REGOLITH

If the area between Buildings 3001 and 3042 is excavated, exposure could occur through inhalation of resuspended dust and through direct radiation from the excavated soil. To assess the exposure to potential receptors (i.e., excavation personnel, the working population in the immediate vicinity, and the transient worker population), contaminant concentrations in the soil will have to be determined. Currently, concrete pavement makes this scenario irrelevant; however, this potential for exposure should be evaluted before any future soil-disturbing activities are initiated.

8. EXPOSURE ASSESSMENT

To quantify the exposures to the potential receptors described in the previous section, a series of exposure scenarios are developed and evaluated to conservatively estimate the exposure to contaminants originating from the leak in the canal. Quantitative estimates of exposure are derived from contaminant concentrations in the environmental media, assumptions about frequency of exposure, and estimates of human intake for the pertinent exposure pathways.

8.1 EXPOSURE SCENARIOS

Exposure scenarios have been developed to define current plausible situations in which potential exposure to the contaminants from the canal could take place. To assess the potential exposure, the following scenarios will be used.

1. Maintenance worker at the canal: Occupational exposure to external radiation at the Building 3001 canal.
2. Maintenance worker at the Building 3042 sump: Occupational exposure to external radiation at the Building 3042 sump.
3. Public exposure at the Clinch River: Drinking water, fish ingestion, sediment exposure.

8.2 METHODOLOGY

The health effects associated with occupational exposures at the canal and the Building 3042 sump will be determined by estimating and comparing the annual whole-body dose in mrem with the relevant health-based standards. Also, the relative risks associated with the exposures and the standard will be calculated and compared. For example, the possible health effects from public exposure at the Clinch River will be determined by estimating the lifetime excess cancer risk. A comparison will be made between the total dose estimate and the Nuclear Regulatory Commission (NRC) standard for continuous public exposure from the management of high-level and transuranic radioactive waste at U.S. Department of Energy (DOE) facilities.

1. ***Maintenance worker at the canal: Occupational exposure to external radiation from canal water***

This scenario conservatively estimates the possibility of exposure to personnel working at the Building 3001 Storage Canal site. Even though maintenance workers are in the canal area only to perform particular tasks, they are required to obtain radiation work permits and are monitored for radiation exposure before and after the job (V. Chidambariah, personal communication with M. Ford, ORNL, 1991). The estimated exposure readings from the radiation work permits (Appendix C) indicate an exposure rate of less than one mrem/h in the canal area.

If we assume an exposure rate of one mrem/h and a normal occupational work period of 2,000 h/year (40 h/week × 50 week/year), the total annual radiation dose would amount to 2000 mrem, which is less than the annual occupational dose limit of 5480.11 set by the DOE for its radiation workers. The annual radiation dose limit for occupational exposures set by the NRC (10 CFR 20, 1960 and 1986) is 5000 mrem. Since the actual exposure period is considerably smaller than 2000 h/year, the total annual radiation dose to workers is considerably less than 2000 mrem.

2. *Maintenance worker at the Building 3042 sump: Occupational exposure to direct radiation from groundwater*

This scenario conservatively estimates the possible exposure to maintenance workers in the sump at Building 3042. Again, there are no maintenance workers at the sump on a continuous basis; hence, when entering the sump area for a specific task, workers are monitored for radiation exposure before and after the job. Typically, radiation exposures on such occasions have been in the range of 0–1 mrem (V. Chidambariah, personal communication with G. Coleman, ORNL, 1991).

Assuming a typical occupational period of 2000 h/year and an exposure rate of 1 mrem/h, the total annual dose would be 2000 mrem, which is within the relevant safety limits for radiation exposure. The actual radiation dose to a worker at the sump is expected to be considerably less than 2000 mrem/year because of smaller exposure periods.

3. *Public exposure at the Clinch River*

In this scenario, the possible public exposure to the contaminants from the canal through ingestion of drinking water and contaminated fish from the Clinch River and external exposure to sediments on the shoreline will be evaluated. Since drinking water from the Clinch River undergoes treatment before distribution, it will not be considered in the exposure and risk computations.

In evaluating the contaminant concentrations in the Clinch River, three assumptions will be made: the leak enters the groundwater system in the Building 3001 area and is carried to White Oak Creek and subequently to the Clinch River; the contaminants undergo successive dilution with no sorption to any solid particles as they travel to the Clinch River; and these contaminants concentrate in the sediments and bioaccumulate in the fish.

To calculate the contaminant concentrations in the Clinch River, the flow in Fifth Creek will be assumed to consist entirely of the groundwater flow from the Building 3001 area. The following steps illustrate the process:

$$\text{X0 (Bq/L)} \times \frac{\text{canal leak rate}}{\text{groundwater flow}} = \text{X1 (Bq/L)}$$

$$X1\ (Bq/L) \times \frac{\text{groundwater flow}}{\text{WOC flow}} = X2\ (Bq/L)$$

$$X2\ (Bq/L) \times \frac{\text{WOC flow}}{\text{CR flow}} = X3\ (Bq/L)$$

where
X0 = contaminant concentration in the canal,
X1 = contaminant concentration at the Building 3042 sump and Fifth Creek,
X2 = contaminant concentration in White Oak Creek,
X3 = contaminant concentration in the Clinch River,
WOC = White Oak Creek,
CR = Clinch River.

The estimated values for the various flow rates are listed below. The flow rates for White Oak Creek and Clinch River are the estimated average daily flows for the year 1987 (Rogers et al., 1987).

Canal leak	400 gpd
Groundwater flow	10,000 gpd
WOC flow	2.6E+07 gpd
Clinch River flow	11.3E+09 gpd

The calculated contaminant concentrations (Bq/L) are presented below:

Contaminant	X0	X1	X2	X3
^{137}Cs	840	33.6	1.3E-02	2.8E-05
^{60}Co	290	11.6	4.5E-03	9.8E-06
^{90}Sr	310	12.4	4.8E-03	1.1E-05

8.2.1 Sediment Concentrations in the Clinch River

To estimate exposure to canal contaminants on the shoreline of the Clinch River, the sediment concentrations resulting from the settling of dissolved contaminants needs to be determined. These concentrations can be conservatively estimated as the product of the dissolved concentration and the distribution coefficient, K_d, for the particular contaminant (assuming that all suspended particles will settle down).

$$\text{sediment concentration (pCi/kg)} = K_d\ (L/kg) \times \text{river concentration (pCi/L)}\ .$$

Strontium-90 will not be considered for this pathway because it is a beta emitter and would not be a significant source of external exposure.

The estimated average values of the distribution coefficients (K_ds) for the contaminants at the mouth of the Clinch River (Olsen et al., 1990) and their calculated concentrations in the sediments are presented below:

Contaminant	K_d (L/kg)	X3 (pCi/L)	$X3_s$ (pCi/kg)
^{137}Cs	2.7E+05	7.6E-04	205
^{60}Co	3.3E+04	2.7E-04	9

8.2.2 Contaminant Concentrations in Fish

Contaminant concentrations in whole fish can be calculated as the product of the dissolved equilibrium concentration of the contaminant and the bioconcentration factor (BCF) for the contaminant in a particular species of fish. For the Clinch River system, the generic bioconcentration factors for freshwater fish (International Atomic Energy Agency Series: 57) will be considered as representative factors for the contaminants of concern.

Contaminant	BCF (L/kg)	X3 (pCi/L)	$X3_f$ (pCi/kg)
^{137}Cs	2000	7.6E-04	1.5E+00
^{60}Co	300	2.7E-04	8.1E-02
^{90}Sr	60	3.0E-04	1.8E-02

8.3 POTENTIAL EXPOSURE SCENARIOS

Public exposure to contaminants in the Clinch River can occur through several pathways. The three most significant are

- ingestion of drinking water from the Clinch River,
- ingestion of fish from the Clinch River, and
- external exposure to contaminated sediments on the shoreline.

8.3.1 Ingestion of Drinking Water from the Clinch River

A person is assumed to consume 2 L of untreated water per day from the Clinch River for a period of 70 years, which is the average lifetime of a person living in the United States. The lifetime intake in picocuries is calculated as the product of the contaminant concentration in the river and the lifetime intake of water, in liters, as follows:

2 (L/d) $\times$ 365 (d/year) $\times$ 70 (years) = 51,100 L ;

lifetime contaminant intake (pCi) = contaminant concentration (pCi/L) $\times$ lifetime water intake (L) ;

lifetime dose (mrem) = lifetime contaminant intake (pCi) × dose conversion factor (mrem/pCi) .

The lifetime intakes and the corresponding doses for the contaminants are listed below.

Contaminant	Lifetime intake (pCi)	Dose conversion factor (mrem/pCi)		Lifetime Dose (mrem)
^{137}Cs	39	5.0E-05		2.0E-03
^{60}Co	14	2.7E-05		3.8E-04
^{90}Sr	16	1.4E-04		2.2E-03
			Total Dose	4.6E-03

This dose compares to the EPA drinking water standard of 4 mrem/year (280 mrem lifetime).

8.3.2 Ingestion of Fish from the Clinch River

A person is assumed to consume contaminated fish at an average rate of 6.5 g/d (EPA, 1989) for a lifetime period of 70 years. (The loss of contaminants through dressing and cooking the fish will not be considered in the exposure estimation.) The lifetime dose of exposure from this pathway is computed as follows:

lifetime fish intake = 6.5 (g/d) × 365 (d/year) × 70 (year) = 166,075 g = 166 kg ;

lifetime contaminant intake (pCi) = contaminant concentration in fish (pCi/kg) × lifetime fish intake (kg) ;

lifetime dose (mrem) = lifetime intake (pCi) × dose conversion factor (mrem/pCi) .

The lifetime intakes and the corresponding doses for the contaminants are listed here.

Contaminant	Lifetime intake (pCi)	Dose conversion factor (mrem/pCi)		Lifetime Dose (mrem)
^{137}Cs	252	5.0E-05		1.3E-02
^{60}Co	14	2.7E-05		3.8E-04
^{90}Sr	3	1.4E-04		4.2E-04
			Total Dose	1.4E-02

8.3.3 External Exposure to Contaminated Sediments on the Shoreline

The source of contamination for sediments on the shoreline is assumed to be of infinite lateral extent with a uniform depth of 10 cm. The exposure concentrations of the contaminants in units of picocuries per kilogram will be converted to units of picocuries per square meter by assuming a uniform surface density of 143 kg/m^2 (EPA, 1989). The resulting Committed Effective Dose Equivalent will be calculated using the appropriate dose conversion factor. The duration of exposure will be conservatively assumed to be 1000 h/year (Hoffman et al., 1990) for a period of 70 years.

The modifying exposure factor (EF) = 1000 h / (365 × 24) h = 0.11 .

The following equation describes the lifetime dose calculation:

committed effective dose equivalent (mrem) = exposure concentration (pCi/m^2) × 1/10,000 (m^2/cm^2) × dose conversion factor (mrem·year^{-1}/pCi-cm^{-2}) × exposure period (year) × exposure factor .

The contaminant concentrations accompanied by their dose calculations are presented below.

Contaminant	Exposure concentration (pCi/cm^2)	Dose conversion factor (mrem-year^{-1}/pCi-cm^{-2})		Lifetime Dose (mrem)
^{137}Cs	2.9	5.98E-01		13
^{60}Co	0.1	2.31E+00		2
			Total Dose	15

This dose compares to the NRC standards of 25 mrem/year at DOE disposal facilities and 100 mrem/year public exposure from all sources at DOE facilities (40 CFR 191, 1985).

9. RISK CHARACTERIZATION

This section integrates the toxicological properties of the contaminants of concern, estimates and compares risks from these contaminants to the acceptable cancer risk range specified by the EPA, and analyzes the risk to the receptors in each exposure scenario. This risk estimation will be limited to the public use of Clinch River.

9.1 TOXICOLOGICAL EFFECTS OF THE CONTAMINANTS OF CONCERN

The contaminants of concern are the radionuclides ^{137}Cs, ^{60}Co, and ^{90}Sr. The radiation from the disintegrations of these radionuclides consists mainly of beta and gamma radiation. Because this form of radiation has greater penetration than alpha particles, a person can be exposed to it without actually coming in direct contact with the source (e.g., inhalation, ingestion, or dermal contact).

The primary adverse biological effects associated with ionizing radiation exposures from radioactive substances in the environment are carcinogenicity, the ability to produce cancer; mutagenicity, the ability to cause mutations in somatic and germ cells; and teratogenicity, the ability to cause permanent structural or functional deviations during the growth of the embryo.

The studies on carcinogenicity are the most quantitative and well documented. Studies on human populations and laboratory animals have shown that as radiation doses increase, so too does the cancer incidence or mortality. Ionizing radiation can be considered a complete carcinogen in that it acts both as initiator and promoter; it can induce cancer in nearly every tissue and organ. In the estimation of cancer risk, it is assumed that no threshold exists for radiation carcinogenesis.

9.2 RISK ASSESSMENT METHOD

This section describes the methodology for estimating the lifetime excess fatal cancer risk due to exposure to the contaminants by different pathways. The lifetime excess fatal cancer risk for occupational and public exposures is calculated as the product of the nominal probability coefficient [7.5E-07 mrem^{-1} for the public (ICRP, 1991)] and the lifetime dose (mrem). This coefficient represents the probability of total cancer fatality (weighted sum of fatal and nonfatal cancers) per unit effective dose equivalent. The data from which this factor is derived, represents a whole population consisting of different age groups and equal numbers of men and women. The sum of risks from all pathways will represent the total possible excess fatal cancer risk to an individual using the Clinch River.

9.3 RISK ESTIMATION

For occupational exposures at the canal, the annual dose to an average worker would be considerably less than 2000 mrem because of considerably smaller exposure periods. Also, ALARA (As Low As Reasonably Achievable) practices at DOE facilities would keep the dose rates to workers considerably lower than the dose limits.

For public exposures, it can be seen that the total dose due to external exposure to the sediments dominates the dose received through the drinking water and fish ingestion pathways. Therefore, the lifetime excess fatal cancer risk due to external exposure to contaminated sediments will also dominate the risk from other pathways. The lifetime excess fatal cancer risk for all pathways is presented below.

Pathway	Total dose (mrem)	Risk factor ($mrem^{-1}$)		Lifetime risk
Drinking water	4.6E-03	5.0E-07		2.3E-09
Fish ingestion	1.4E-02	5.0E-07		7.3E-09
External exposure	15	5.0E-07		7.3E-06
			Total Risk	7.3E-06

10. CONCLUSIONS

There appears to be no significant health risk from the Building 3001 Storage Canal. The annual occupational radiation dose at the canal is well below relevant health based limits for occupational exposures. The potential lifetime excess cancer risk estimated for the hypothetical worker is at an acceptable level. The potential risk to the public using the Clinch River was estimated for three significant exposure pathways using conservative exposure assumptions. The public risk due to external exposure to contaminated sediments on the shoreline was found to dominate the risk from other exposure pathways. The potential public risk resulting from contamination from the canal leak is (1) within the acceptable risk range of 10^{-4} to 10^{-6} specified by the EPA (*Federal Register*, 1990) and (2) negligible when compared to the existing risk levels at the Clinch River (Hoffman et al., 1990, Appendix C). However, the health risks associated with each of the proposed remedial alternatives for the interim corrective measure will have to be evaluated before deciding upon the final remedy.

REFERENCES

EPA (Environmental Protection Agency). 1989. *Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual.* U.S. Environmental Protection Agency, Washington D.C.

Federal Register. 1990. Vol. 55, No. 46, Mar. 8, 1990, pp. 8715–8719.

Gilbert, T. L., et al. 1985. *A Manual for Implementing Residual Radioactivity Guidelines.* September 1985 review draft. Prepared for the U.S. Department of Energy. Tables 3.1 and 3.2.

Hoffman, F. O., et al. 1990. *Preliminary Screening of Contaminants in the Off-Site Surface Water Environment Downstream of the U.S. Department of Energy Oak Ridge Reservation.* ORNL/ER-9 (March 1990 review draft). Table 2.2.

ICRP (International Commission on Radiological Protection). 1991. *Annals of the ICRP.* Vol. 21, No. 1–3. Tables 3 and 5.3.

Olsen, C. R., et al. 1990. *Transport and Accumulation of Cesium-137 and Mercury in the Clinch River and Watts Bar Reservoir System.* ORNL/ER-7 (March review draft). Table 5, p. 24.

Rogers, J. G., et al. 1988. *Environmental Surveillance of the U.S.D.O.E. Oak Ridge Reservation and Surrounding Environs During 1987, vol 1: Narrative, Summary, and Conclusions.* ES/ESH-4/V1. Table 2.2.8, p. 60.

APPENDIX A
COMPARISON OF CONTAMINANT CONCENTRATIONS WITH THEIR MCLs FOR DRINKING WATER

COMPARISON OF CONTAMINANT CONCENTRATIONS WITH THEIR MCLs FOR DRINKING WATER

Contaminant	Canal water surface concentration (mg/L)	ORR groundwater sump concentration (mg/L)	Drinking Water MCL (mg/L)[a]
Ag	< 5.0E-03	<5.0E-03	5.0E-02
As	< 5.0E-02	<5.0E-02	5.0E-02
Ba	< 2.0E-03	4.9E-02	1.0E+00
Cd	< 7.0E-03	<7.0E-03	1.0E-02
Cr	< 4.0E-03	1.1E-02	5.0E-02
Pb	< 5.0E-02	<5.0E-02	5.0E-02
Se	< 4.0E-02	<4.0E-02	1.0E-02
Hg	2.4E-04		2.0E-03
^{137}Cs	680±60 Bq/L	< 2 Bq/L	100 pCi/L[b]
^{60}Co	260±30 Bq/L	< 1 Bq/L	200 pCi/L
^{90}Sr			50 pCi/L

[a]*Superfund Health Effects Assessment Summary Tables and User's Guide*, Office of Emergency and Remedial Response, USEPA, Washington, D.C., October 1989.

[b]Based on 4 mrem annual dose for drinking water pathway. *Federal Register*, vol. 51, pp. 34836–34862.

APPENDIX B
CURRENT SAMPLES

Current Samples

Analyses	Surface H_2O	7' depth H_2O	ORR process sump	ORR ground-water sump	Bldg. 3026 sump	Units
<u>3/27/90</u>						
Gross alpha	13 ± 3	15 ± 3	<2	<2	.7 ± 2	Bq/l
Gross beta	1120 ± 30	1170 ± 30	10 ± 4	6 ± 4	.9 ± 8	Bq/l
Gross gamma			3	2	<10	cpm/ml
Cs-137	680 ± 60	750 ± 90	<1	<2	6 ± 3	Bq/l
Co-60	260 ± 30	250 ± 30	2.5 ± 0.5	<1	<3	Bq/l
Sr-90	190 ± 70	240 ± 70			0.08 ± 0.51	Bq/l
Ag	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	mg/l
As	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	mg/l
Ba	$<2.0 \times 10^{-3}$	7.3×10^{-3}	5.6×10^{-2}	4.9×10^{-2}	1.5×10^{-2}	mg/l
Cd	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	mg/l
Cr	$<4.0 \times 10^{-3}$	$<4.0 \times 10^{-3}$	$<7.8 \times 10^{-3}$	1.1×10^{-2}	1.1×10^{-2}	mg/l
Pb	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	mg/l
Se	$<4.0 \times 10^{-2}$	$<4.0 \times 10^{-2}$	$<5.1 \times 10^{-2}$	$<4.0 \times 10^{-2}$	$<4.0 \times 10^{-2}$	ug/ml
Hg	2.4×10^{-4}	2.4×10^{-4}				
<u>3/29/90</u>						
Gross alpha	12 ± 5	12 ± 4	<2	<2	0.7 ± 2	Bq/l
Gross beta	682 ± 40	695 ± 40	10 ± 4	6 ± 4	0.9 ± 8	Bq/l
Gross gamma	<10	15	3	2	<10	cpm/ml
Cs-137	360 ± 10	350 ± 10	<1	<1	6 ± 3	Bq/l
Co-60	31 ± 2	30 ± 2	2.5 ± 0.5	<2	<3	Bq/l
Sr-90	140 ± 10	130 ± 10				Bq/l
Ag	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	$<5.0 \times 10^{-3}$	mg/l
As	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	mg/l
Ba	$<2.0 \times 10^{-3}$	$<2.0 \times 10^{-3}$	5.6×10^{-2}	4.9×10^{-2}	1.5×10^{-2}	mg/l
Cd	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	$<7.0 \times 10^{-3}$	mg/l
Cr	$<4.0 \times 10^{-3}$	$<4.0 \times 10^{-3}$	7.8×10^{-3}	1.1×10^{-2}	1.1×10^{-2}	mg/l
Pb	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	$<5.0 \times 10^{-2}$	mg/l
Se	$<4.0 \times 10^{-2}$	$<4.0 \times 10^{-2}$	5.1×10^{-2}	$<4.0 \times 10^{-2}$	$<4.0 \times 10^{-2}$	mg/l
Hg	2.3×10^{-4}	2.4×10^{-4}	$<5.0 \times 10^{-5}$	$<5.0 \times 10^{-5}$	3.6×10^{-4}	mg/l
<u>2/22/89</u>	Sludge*	Sludge**				
Gross alpha	3.61×10^{4}	0.2				Bq/g
Gross beta	8.57×10^{5}	23.13				Bq/g
Cs-137	2.16×10^{7}	26.15				Bq/g
Co-60	7.21×10^{6}	0.2				Bq/g
Eu-152	1.51×10^{5}	0.5				
Eu-154	2.29×10^{5}	0.1				
Eu-155	1.35×10^{5}	0.4				
Ag	4.88					
As	7.98					
Ba	--					
Cd	270					
Cr	415					
Pb	6.1×10^{3}					
Se	0.96					

*Averaged from residue.
**Averaged from filtrate.

APPENDIX C
RADIATION WORK PERMITS

RADIATION WORK PERMIT (RWP)

DATE AND TIME	FROM 8:00 ~~AM~~ (circled) 9/8/88	TO 4:30 PM (circled)	EXTENDED BY ___ AM/PM TO ___ AM/PM	WORK PERMIT NO. R- 77028

BLDG	ROOM, CELL OR AREA	EQUIPMENT OR PROCESS BEING WORKED ON
3001	Canal	

OPERATION BEING PERFORMED: Removal of miscellaneous material from Canal

RADIATION SURVEY DATA (To be filled in by Health Physicist)

LOC CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR 20 mrem	CONTAMINATION TYPE	CONTAMINATION MEASUREMENT	RADIATION SURVEY BY	RADIATION SURVEY DATE & TIME
A	Source Can	B Y	1,000	USE			JFR	9-8-88 0900
B				Visual				
C				Dosimeter				
D								

INSTRUCTIONS*

HEALTH PHYSICS MONITORING REQUIRED: ☐ START OF JOB ☐ INTERMITTENT ☑ CONTINUOUS ☐ END OF JOB

CONTACT HP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION		PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	
TAPE COVERALLS TO GLOVES AND FOOTWEAR		MONITOR BREATHING ZONE	
CHECK TOOLS AT END OF JOB		NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB	✓	BIOASSY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE-STANDBY OBSERVER REQUIRED	✓

REMARKS:

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)	✓	SHOE COVERS		DIRECT READING POCKET METER	✓
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES			
SAFETY GLASSES		GLOVES: CANVAS		RUBBERS		TLD RING	
EYE SHIELD		GLOVES: LEATHER		RUBBER BOOTS		DOSE RATE ALARM	
HALF MASK**		GLOVES: SURGEON'S		PLASTIC BOOTIES	✓	DOSE ALARM	
FULL FACE MASK**		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	✓
MASK WITH CHARCOAL FILTER**		GLOVES: RUBBERIZED CANVAS	✓	SPECIAL METERING		GMS METER	
AIR-LINE HOOD**		GLOVES: HOUSEHOLD RUBBER	or ✓				
AIR-LINE SUIT**							

REGULAR APPROVALS	SPECIAL APPROVALS
HEALTH PHYSICS CERTIFICATION: J. L. Rutherford	DIVISION DIRECTOR
SUPERVISION	E & OS DIVISION DIRECTOR
SUPERVISION: Mark K. Ford	LAB EXECUTIVE DIRECTOR

(OVER)

UCN 2779 (3 1 87)

*Only items checked (✓) apply.

**Certification by Industrial Hygiene necessary for those required to wear respiratory protection

1. Health Physicist shall be present for line breaks or removal of shielding.
2. Notify Health Physics of any deviations from instructions and changes in working conditions.
3. Personnel survey is required when leaving contamination zones.
4. Return work permit to Health Physicist upon completion of job or expiration of permit.

TIMEKEEPING BY ______

DEPARTMENT ______

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS							Planned Exposure (mrem)	TIME RECORD							Estimated Exposure (mrem)
Name	Job* Class.	Dept.	P.R. No.	Location Code	Dose Rate Used	Working Time		Begin	End	Begin	End	Begin	End	Total Time	
K L Rogers		3330	668												6
WJE Russell		3330	695												6

**Job Classification such as Welder, Electrician, Chemical Operator, Health Physicist, Etc., should be recorded in this column.*

1. **Radiation Work Permit is required when:**
   (a) expected dose is > 20 mrem to the body or 300 mrem to extremities for an individual during a single work assignment;
   (b) exposure of an individual to a dose rate > 5 rem/hr (total body); > 25 rem/hr (extremities)
   (c) airborne radioactivity in work environment is > $(CG)_a$ for a 40-hour week;
   (d) specified by divisional operating rules and procedures or by posted regulations.

2. **Supplementary Time Sheet**
   To be used if extra space is needed for the timing of individuals into and out of an area, etc.

3. **Special Approvals**
   (a) Dose Rate rem/hr (total body)
   - > 5 Division Director in charge of work area — Oral or written; noted and initialed on the permit by the person obtaining the approvals
   - > 20 Above and Environmental & Occupational Safety Division Director
   - > 50 Above and Laboratory Executive Director

   (b) Dose (total Body)
   - > 60 mrem/hr for nonoperating personnel, or > 300 mrem/wk for operating personnel — Division Director in charge of individual
   - > 1 rem — Above and Laboratory Executive Director

4. **Copies**
   - White - The RWP must be posted or available at work site.
   - Yellow - The Health Physicist maintains a copy for record and reference purposes.
   - Blue - A copy must be distributed to appropriate line supervision.
   - Pink - Health Physics Dept. maintains for HPIMS record.

*Posted regulations may be used in lieu of an RWP for *operating personnel* under specified conditions. (See Regulation 8, Procedure No. 3.6, ORNL Health Physics Manual.)

BACK UCN 2779

RADIATION WORK PERMIT (RWP)

DATE AND TIME 11-1-88 FROM 8:00 AM TO 4:30 PM | EXTENDED BY ___ AM/PM TO ___ | WORK PERMIT NO. R- 77083

BLDG 3001 - 01C | ROOM, CELL OR AREA Canal | EQUIPMENT OR PROCESS BEING WORKED ON Carrier (OD-2) loaded w/ Cobalt

OPERATION BEING PERFORMED Cobalt slugs loaded into carrier - under water

RADIATION SURVEY DATA (To be filled in by Health Physicist)

LOC CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR 20 mrem	CONTAMINATION TYPE	CONTAMINATION MEASUREMENT	RADIATION SURVEY BY	RADIATION SURVEY DATE & TIME
A	Slugs	β γ	Max. 1000	Use Visual Dosimeter as guide			J.R.	11-1-88 0900
B								
C								
D								

INSTRUCTIONS*

HEALTH PHYSICS MONITORING REQUIRED: ☐ START OF JOB ☐ INTERMITTENT ☑ CONTINUOUS ☐ END OF JOB

CONTACT HP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION		PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	
TAPE COVERALLS TO GLOVES AND FOOTWEAR		MONITOR BREATHING ZONE	
CHECK TOOLS AT END OF JOB		NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB	✓	BIOASSY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE- STANDBY OBSERVER REQUIRED	✓

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)	✓	SHOE COVERS	✓	DIRECT READING POCKET METER	✓
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES			
SAFETY GLASSES	✓	GLOVES: CANVAS		RUBBERS		TLD RING	
EYE SHIELD		GLOVES: LEATHER		RUBBER BOOTS		DOSE RATE ALARM	
HALF MASK**		GLOVES: SURGEON'S		PLASTIC BOOTIES		DOSE ALARM	
FULL FACE MASK**		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	✓
MASK WITH CHARCOAL FILTER**		GLOVES: RUBBERIZED CANVAS	✓	SPECIAL METERING		GMS METER	
AIR-LINE HOOD**		GLOVES: HOUSEHOLD RUBBER					
AIR-LINE SUIT**							

REMARKS: High-activity cobalt slugs are to be loaded - not to exceed 19.2 Ci/ft³. Activated metal will be used if number above is exceeded.

REGULAR APPROVALS

HEALTH PHYSICS CERTIFICATION: J. L. Rutherford

SUPERVISION: M. K. Ford

SUPERVISION

SPECIAL APPROVALS

DIVISION DIRECTOR

E & OS DIVISION DIRECTOR

LAB EXECUTIVE DIRECTOR

(OVER)

UCN 2779 (3 1 87)

*Only items checked (✓) apply.

**Certification by Industrial Hygiene necessary for those required to wear respiratory protection

1. Health Physicist shall be present for line breaks or removal of shielding.
2. Notify HealthPhysics of any deviations from instructions and changes in working conditions.
3. Personnel survey is required when leaving contamination zones.
4. Return work permit to Health Physicist upon completion of job or expiration of permit.

TIMEKEEPING BY

DEPARTMENT ______

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS							Planned	TIME RECORD							Estimated
Name	Job* Class.	Dept.	P.R. No.	Location Code	Dose Rate Used	Working Time	Exposure (mrem)	Begin	End	Begin	End	Begin	End	Total Time	Exposure (mrem)
W.E. Russell 11811								80	86						6
H.R. Williams 13779								69	76						7

**Job Classification such as Welder, Electrician, Chemical Operator, Health Physicist, Etc., should be recorded in this column.*

1. Radiation Work Permit is required when:

(a) expected dose is > 20 mrem to the body or 300 mrem to extremities for an individual during a single work assignment;

(b) exposure of an individual to a dose rate > 5 rem/hr (total body); > 25 rem/hr (extremities)

(c) airborne radioactivity in work environment is > $(CG)_a$ for a 40-hour week;

(d) specified by divisional operating rules and procedures or by posted regulations.

2. Supplementary Time Sheet

To be used if extra space is needed for the timing of individuals into and out of an area, etc.

3. Special Approvals

(a) Dose Rate rem/hr (total body)

> 5 Division Director in charge of work area — Oral or written; noted and initialed on the permit by the person obtaining the approvals.

> 20 Above and Environmental & Occupational Safety Division Director

> 50 Above and Laboratory Executive Director

(b) Dose (total Body)

> 60 mrem/hr for nonoperating personnel, or > 300 mrem/wk for operating personnel — Division Director in charge of individual

> 1 rem — Above and Laboratory Executive Director

4. Copies

White - The RWP must be posted or available at work site.

Yellow - The Health Physicist maintains a copy for record and reference purposes.

Blue - A copy must be distributed to appropriate line supervision.

Pink - Health Physics Dept. maintains for HPIMS record.

*Posted regulations may be used in lieu of an RWP for *operating personnel* under specified conditions. (See Regulation 8, Procedure No. 3.6, ORNL Health Physics Manual.)

BACK UCN 2779

RADIATION WORK PERMIT (RWP)

EFFECTIVE TIME FROM 0930 AM TO 0430 PM | EXTENDED BY ... TO ... AM/PM | WORK PERMIT NO. R - 79096

BUILDING	ROOM, CELL OR AREA	EQUIPMENT OR PROCESS BEING WORKED ON
3001	Canal Storage Area	

OPERATION BEING PERFORMED: LOADING SHIPPING CASK WITH MATERIAL FROM STORAGE AREA

RADIATION SURVEY DATA (To be filled in by Health Physicist)

LOC. CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR 20 mrem	CONTAMINATION TYPE	CONTAMINATION MEASUREMENT	RADIATION SURVEY BY	RADIATION SURVEY DATE & TIME
A	Work Area	β,γ	≤ 1000	Use visual dosimeters as guide			JFF	10-23-89 0930
B								
C								
D								

INSTRUCTIONS *

RADIATION PROTECTION MONITORING REQUIRED: [✓] START OF JOB [✓] INTERMITTENT [ ] CONTINUOUS [✓] END OF JOB

CONTACT RP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION	✓	PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	✓
TAPE COVERALLS TO GLOVES AND FOOTWEAR	✓	MONITOR BREATHING ZONE	
CHECK TOOLS AT END OF JOB	✓	NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB	✓	BIOASSY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE-STANDBY OBSERVER REQUIRED	
PRE-JOB ALARA BRIEFING REQUIRED		POST-JOB DEBRIEFING REQUIRED	

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)		SHOE COVERS	✓	DIRECT READING POCKET METER	✓
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES			
SAFETY GLASSES		GLOVES: CANVAS		RUBBERS		EXTREMITY MONITOR	
EYE SHIELD	✓	GLOVES: LEATHER		RUBBER BOOTS		DOSE RATE ALARM	
HALF MASK **		GLOVES: SURGEON'S		PLASTIC BOOTIES		DOSE ALARM	✓
FULL FACE MASK **		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	✓
MASK WITH CHARCOAL FILTER **		GLOVES: RUBBERIZED CANVAS		SPECIAL METERING		GMS METER	✓
AIR-LINE HOOD **		GLOVES: HOUSEHOLD RUBBER	✓	UNVENTILATED PLASTIC SUIT			
AIR-LINE SUIT **							

REMARKS:

(OVER)

REGULAR APPROVALS	SPECIAL APPROVALS
RADIATION PROTECTION CERTIFICATION: [signature]	DIVISION DIRECTOR
SUPERVISION: [signature]	EHP DIVISION DIRECTOR
SUPERVISION	LAB ASSOCIATE DIRECTOR

* Only items checked (✓) apply
** Certification by Industrial Hygiene necessary for those required to wear respiratory protection

UCN 2779 (3 10 88)

1. Notify Radiation Protection of any deviations from instructions and changes in working conditions.
2. Personnel survey is required when leaving contamination zones.
3. Return work permit to Health Physicist upon completion of job or expiration of permit.

Timekeeping By

Department

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS							Planned	TIME RECORD							Estimated
Name	Job* Class.	Dept.	P.R. No.	Location Code	Dose Rate Used	Working Time	Exposure (mrem)	Begin	End	Begin	End	Begin	End	Total Time	Exposure (mrem)
K.L. Rodgers	OPR	RR	26128												2
R.C. Conway	OPR	RR	28886												1 mR

* Job Classification such as Welder, Electrician, Chemical Operator, Health Physicist, Etc., should be recorded in this column

1. Radiation Work Permit Is required when:

(a) expected dose is > 20 mrem to the body or 200 mrem to extermities or skin for an individual during a single shift;
(b) exposure of an individual to a dose rate > 1 rem/hr (total body), > 10 rem/hr (extremities)
(c) airborne radioactivity in work environment is > DAC for a 40-hour week;
(d) specified by divisional operating rules and procedures or by posted regulations.

2. Supplementary Time Sheet

To be used if extra space is needed for the timing of individuals into and out of an area, etc.

3. Special Approvals

(a) Dose Rate rem/hr (total body)
> 5 Division Director in charge of work area — Oral or written; noted and initialed on the permit by the person obtaining the approvals
> 20 Above and Environmental & Health Protection Division Director
> 50 Above and Laboratory Associate Director

(b) Dose (total body)
> 60 mrem/day for nonoperating personnel, or > 300 mrem/wk for operating personnel — Division Director in charge of individual
> 1 rem — Above and Laboratory Associate Director for Support and Services

4. Copies

White - The RWP must be posted or available at work site
Yellow - The Health Physicist maintains a copy for record and reference purposes.
Blue - A copy must be distributed to appropriate line supervision
Pink - Radiation Protection Section

UCN-2778 Back

* Posted regulations may be used in lieu of an RWP for operating Personnel under specified conditions (See Regulation 8, Procedure NO 3.6, ORNL Health Physics Manual.)

RADIATION WORK PERMIT (RWP)

DATE AND TIME FROM 0920 AM TO 0430 AM | EXTENDED BY ___ TO ___ AM/PM | WORK PERMIT NO. R - 80336

BUILDING: 3001

ROOM, CELL OR AREA: CANAL AREA

EQUIPMENT OR PROCESS BEING WORKED ON: Stored Materials

OPERATION BEING PERFORMED: Depth of Water where 100MR/HR is attained

RADIATION SURVEY DATA (To be filled in by Health Physics)**

LOC. CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR 20 mrem	CONTAMINATION TYPE	CONTAMINATION MEASUREMENT	RADIATION SURVEY BY	RADIATION SURVEY DATE & TIME
A	Work Area	β,γ	≤ 100	Use Visual Dosimeters as guides			J.R.	12/11/89 0920
B								
C								
D								

INSTRUCTIONS *

RADIATION PROTECTION MONITORING REQUIRED: [✓] START OF JOB [ ] INTERMITTENT [ ] CONTINUOUS [✓] END OF JOB

CONTACT RP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION		PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	✓
TAPE COVERALLS TO GLOVES AND FOOTWEAR		MONITOR BREATHING ZONE	✓
CHECK TOOLS AT END OF JOB		NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB		BIOASSY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE-STANDBY OBSERVER REQUIRED	
PRE-JOB ALARA BRIEFING REQUIRED		POST-JOB DEBRIEFING REQUIRED	

REMARKS: 3001-12C

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)	✓	SHOE COVERS		DIRECT READING POCKET METER	✓
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES			
SAFETY GLASSES		GLOVES: CANVAS		RUBBERS		EXTREMITY MONITOR	
EYE SHIELD		GLOVES: LEATHER		RUBBER BOOTS		DOSE RATE ALARM	
HALF MASK **		GLOVES: SURGEON'S		PLASTIC BOOTIES	✓	DOSE ALARM	✓
FULL FACE MASK **		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	
MASK WITH CHARCOAL FILTER **		GLOVES: RUBBERIZED CANVAS		SPECIAL METERING		GMS METER	
AIR-LINE HOOD **		GLOVES: HOUSEHOLD RUBBER	✓	UNVENTILATED PLASTIC SUIT			
AIR-LINE SUIT **							

REGULAR APPROVALS	SPECIAL APPROVALS
RADIATION PROTECTION CERTIFICATION: J. R. Rutherford	DIVISION DIRECTOR
SUPERVISION: W.A. Duggins	E&P DIVISION DIRECTOR
SUPERVISION	LAB ASSOCIATE DIRECTOR

(OVER)

UCN-2779 (3 10 88)

* Only items checked (✓) apply

** Certification by Industrial Hygiene necessary for those required to wear respiratory protection

1. Notify Radiation Protection of any deviations from instructions and changes in working conditions.
2. Personnel survey is required when leaving contamination zones.
3. Return work permit to Health Physicist upon completion of job or expiration of permit.

Timekeeping By

Department

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS							Planned	TIME RECORD							Estimated
Name	Job* Class.	Dept.	P.R. No.	Location Code	Dose Rate Used	Working Time	Exposure (mrem)	Begin	End	Begin	End	Begin	End	Total Time	Exposure (mrem)
H.R. Williams	OP	RRD	13779				4MR								4
Brian Rolchli	OP	RRD	[illegible]				3MR								3
W.A. Duggins	,	EHP	3562				5MR								5

* Job Classification such as Welder, Electrician, Chemical Operator, Health Physicist, Etc., should be recorded in this column.

1. Radiation Work Permit is required when:
- (a) expected dose is > 20 mrem to the body or 200 mrem to extermities or skin for an individual during a single shift;
- (b) exposure of an individual to a dose rate > 1 rem/hr (total body), > 10 rem/hr (extremities)
- (c) airborne radioactivity in work environment is > DAC for a 40-hour week;
- (d) specified by divisional operating rules and procedures or by posted regulations.

2. Supplementary Time Sheet

To be used if extra space is needed for the timing of individuals into and out of an area, etc

3. Special Approvals

(a) Dose Rate rem/hr (total body)
- > 5 Division Director in charge of work area. — Oral or written; noted and initialed on the permit by the person obtaining the approvals.
- > 20 Above and Environmental & Health Protection Division Director
- > 50 Above and Laboratory Associate Director

(b) Dose (total body)
- > 60 mrem/day for nonoperating personnel, or > 300 mrem/wk for operating personnel — Division Director in charge of individual
- > 1 rem — Above and Laboratory Associate Director for Support and Services

4. Copies

- White - The RWP must be posted or available at work site.
- Yellow - The Health Physicist maintains a copy for record and reference purposes.
- Blue - A copy must be distributed to appropriate line supervision.
- Pink - Radiation Protection Section

* Posted regulations may be used in lieu of an RWP for operating Personnel under specified conditions. (See Regulation 8, Procedure NO. 3.6, ORNL Health Physics Manual.)

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