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This document consists of 49 pages.

WASTE MANAGEMENT PLANS

BY

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1. Identification of facility; brief description of functions and environs; schematic diagrams of processes which generate radioactive wastes. Discussion of process characteristics which determine quantity and quality of wastes.

Douglas United Nuclear, Inc., operates for the AEC at the Hanford reservation four production reactors and their fuel preparation facilities. The production reactor plants are located on the south bank of the Columbia River approximately 30 miles northwest of Richland. The fuel preparation plants, located about 5 miles north of Richland are also on the Columbia River.

The reactors are graphite-moderated, thermal spectrum reactors, containing horizontal fuel columns cooled by light water. The reactors are converters; the principal nuclear processes are the transmutation of U-238 to Pu-239 and the fissioning of U-235. They are fueled predominantly with natural or slightly enriched uranium for the production of weapons grade plutonium.

Three of the reactors, C, KE and KW, are single-pass water cooled reactors. That is, treated Columbia River water is passed at a high rate through the reactor process tubes over the fuel element surfaces where it absorbs fission-liberated heat and after a brief retention in basins is returned to the river. The temperature of the water returned to the river is below atmospheric boiling and no attempt is made to recover the heat energy.

The fourth reactor, N, is a recirculating water cooled reactor. That is, high purity deionized water is circulated at a high rate through the reactor process tubes, over the fuel element surfaces where it absorbs fission-liberated heat energy, to heat exchangers where the heat is removed by a secondary recirculation water loop and then back to the reactor to complete the loop. Heat energy in the secondary loop is removed by flashing a portion of the flow into steam. The steam is either delivered to WPPSS for electric power generation or condensed by river water.

Two types of fuel elements are fabricated for the reactors: one type for the single pass reactors and the other for N Reactor. The single-pass reactor fuel elements are produced by the AISi canning process. Bare, machined uranium cores are received from offsite. The uranium cores are dipped in a molten

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aluminum-silicon alloy bath and inserted into aluminum cans. The aluminum-silicon alloy forms a very tight and complete bond between the surface of the uranium cores and the inner surface of the aluminum can walls, promoting high heat transfer rates between the coolant water and fuel elements in the reactor.

Fuel elements for N Reactor are produced by the coextrusion process. Bare, machined uranium billet cores are received from offsite. The uranium cores are placed in Zircaloy-2 tubes and then canned in a copper jacket. The prepared billets are heated and extruded through a hydraulic press. The extrusions are cut in fuel element lengths, the copper jacket is dissolved off and end caps are applied to form the finished Zircaloy-2 clad fuel element. The coextrusion of the uranium and Zircaloy-2 jacket forms a tight bond between the two materials.

Radioactive wastes evolved from the reactors and the fuel preparation plants are dependent upon the processes employed. With respect to C, KE and KW Reactors, a single-pass coolant process is utilized. The water is treated and its composition adjusted to assure moderate process tube and fuel element in-reactor life. The effluent water contains low concentrations of a number of radionuclides.

N Reactor employs a recirculating coolant process and operates at a higher temperature level. Ultra pure water must be used in the coolant system to reduce corrosion rates so that activated corrosion products in the water and deposited on the coolant system surfaces outside the reactor do not increase the radioactivity level to such a point that maintenance cannot be performed because of high personnel exposure. A feed and bleed system is employed to aid in maintaining modest radioactive levels in the system. The bleed water which contains long-lived corrosion product radionuclides is directed to a crib for disposal. The water percolates through the ground and is essentially freed of ^{radioactive} radionuclides by the soil before entry into the Columbia River.

Radioactive wastes generated in the fuel fabrication processes consist principally of alpha emitting material (uranium and thorium). Recovery of most of the waste materials is an inherent part of the processes utilized. Inventory control also greatly assists management of radioactive wastes in fuel fabrica-

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tions as all waste streams are processed for maximum practical material recovery before release to the environs.

Fabrication of special fuel materials (plutonium) where toxicity is also present is performed under even stricter control. Such work is performed in glove boxes where all wastes are kept inside a closed system.

Schematic diagrams of the various operations are shown in Figures 1 - 4.

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2. Identification of waste streams

- a. Categorization as to high, intermediate, or low; solid, liquid, or gas; released to the environment, buried, stored (interim), or stored (long-term).

Waste Classification

Solid Wastes

The basis for the DUN classification includes identification, dose rate, physical half life and toxicity of the radionuclides, allowable population (nonoccupational) exposure (AECMC 0524) and allowable periods of decay time. In addition an infinite source has been used in dose calculations for the limiting radionuclide (Co-60).

<u>Classification</u>	<u>Conc. $^{60}\text{Co/g}$ Matrix</u>	<u>Components and Average Conc. Ci $^{60}\text{Co/g}$ Matrix</u>
Nonradioactive	0 - 2 nanocuries (2×10^{-9})	
Low Level	>2 nanocuries - 1 microcurie (2×10^{-9}) (1×10^{-6})	Combustible contaminated items (5×10^{-8})
Intermediate Level	>1 microcurie-1 millicurie (1×10^{-6}) (1×10^{-3})	Al Spacers 5×10^{-6} H Steel Spacers 5×10^{-5} Zr Tubes 1×10^{-4} Al Tubes 2×10^{-4} Horizontal Rods 2×10^{-4} Al Thimbles 2×10^{-4} Vert Rod Tips 2×10^{-4}
High Level	>1 millicurie (1×10^{-3})	Stainless Steel 2×10^{-2} Nickel Alloys 2×10^{-2} Constantine Stringers 9×10^{-2} Germinal Stringers 2×10^{-1}

Nonradioactive wastes are releasable. Radioactive wastes require radiological control, low level for up to 25 years; intermediate level up to 100 years and high level for more than 100 years (in practice approximately 145 years).

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Liquid Wastes

Sources of

The basis for the DUN classification of liquid wastes released to drinking water is the human radionuclide intake range used in FRC report Number 2, as applied collectively to all the Hanford releases of isotopes contributing to organ dose.

*Reference
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in terms of dose.
90% level in
in reference to
not specifically
related to dose,
where the table
statement might
read:
"basis ... is
determined by
range of effects
on population dose,
equivalent to action
guide as used
in FRC #2."*

COMPOSITE WASTE CLASSIFICATION SCHEME

<u>Classification</u>	<u>(Dose in mrem)</u>				
	<u>Whole Body</u>	<u>Gonads</u>	<u>Thyroid</u>	<u>Bone</u>	<u>GI Tract</u>
Nonradioactive	<1	<1	<1	<1	<1
Low Level (Range I)	1-17	1-17	1-50	1-50	1-50
Intermediate Level (Range II)	18-170	18-170	51-500	51-500	51-500
High Level (Range III)	>170	>170	>500	>500	>500

The releases, both gaseous and liquid, from all AEC-RL contractor facilities must not result in radiation exposure in excess of Range II. In general, population exposure is in or below Range I in the Tri-Cities.

Radionuclides that do not reach the Columbia River but do become associated with soil in a nonliquid status are considered to be solid waste.

Gaseous Wastes

Douglas United Nuclear, Inc., gaseous wastes do not contribute to nonoccupational dose in a measurable manner. To date all wastes thus released to the environs are considered nonradioactive, except the gaseous cloud of Ar-41 released from the 107 basin; this gaseous waste contributes to occupational exposure (1 to 500 mrem whole body dose) and is thus considered to be low level activity (dose approximately 1/10 of the occupational standard AECMC 0524). Filters containing particulates are considered solid waste when they are buried.

*Justified
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Waste Definitions

See AEC-RL Chapter 0510. Interim storage relates to a defined period of planned storage, and long-term storage relates to an undefined storage period either planned (e.g., solid wastes) or unplanned (e.g., effluent line leaks to ground).

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2. Identification of Waste Streams

- b. Identity, and physical and chemical form of radionuclides affecting or influencing the method of treatment.

Liquids

The liquid streams containing radioactivity released from facilities operated by Douglas United Nuclear, Inc., are shown in Figures 5-9. The radionuclide concentrations in the effluent to the river from C Area and K Area are shown in Table 1. The concentrations of radionuclides in the individual streams making up the overall effluent have been previously reported¹, as well as the concentrations of radionuclides in the streams disposed of to trenches. The effluent disposal piping and retention basins develop leaks from time to time, and the leakage to ground in those instances would have the same composition as the overall effluent. The radionuclide concentrations in the N Area release to crib and to the river are shown in Table 2, and the concentrations of radioactivity in the 300 Area effluent to the pond are shown in Table 3.

In all cases the radionuclides are largely soluble with only a small fraction being colloidal, particulate or particulate associated. Analytical measurements made on the residue and filtrate from samples of K reactor effluent water showed the following:

<u>Radionuclide</u>	<u>Colloidal, Particulate and Particulate Association Percent</u>
²⁴ Na	0.7 %
³² P	4
⁵¹ Cr	3
⁴⁶ Sc	73
⁶⁴ Cu	26
⁶⁵ Zn	28
⁷⁶ As	3
²³⁹ Np	1

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¹DUN-1213, "Special Effluent Sampling and Analysis Program,"
F. E. Owen, June 23, 1966

The colloids and particulates are very small; the diameter being on the order of 0.1 micron or less.

The process for entrapment of the radionuclides in colloids in particles is primarily physical, and for that reason, those nuclides, as well as the soluble ones, are in the ionic state. Electrophoretic migration experiments have demonstrated that As-75 exists both as arsenious acid and an equilibrium mixture of monohydrogen arsenate and dihydrogen arsenate. P-32 exists during reactor operation as an equilibrium mixture of monohydrogen phosphate and dihydrogen phosphate. During shutdowns the concentration of a polymer more condensed than the tetrameta phosphate builds up. Chromate ion is the chemical form of Cr-51. Mn-56 exists as either Mn(III) or Mn(II); however, it is apparently not a simple ion of either one but possibly a complex. Na-24 exists as the sodium ion.

Gases

The radionuclides in the gaseous streams are either particulate associated or gases in their own right, e.g., argon. The release from the facilities operated by Douglas United Nuclear, Inc., are less than 1 curie per year of particulate radioactivity and 500,000 curies per year of Ar-41, which has a 1.8 hour half life.

Solids

The burial ground near the 300 Area receives the solid waste from the fuel manufacturing facilities. The radioactivity associated with the wastes is almost exclusively uranium or thorium. They exist either as metallic powder, the oxide or other dry uranyl compounds.

Burial grounds exist in both 100-C and 100-K Areas to dispose of solid wastes from both of those areas, as well as the solids from 100-N Area. The solids include a minute percentage of the dried salts of the activation products associated with the coolant stream. In the case of the cationic radionuclides, these would be expected to be sulfates, and in the case of anionic nuclide, calcium salts would be anticipated. The solids removed from the reactor con-

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tain activation products within the metallic matrix that is formed in situ. For example, ZrNb-95 is formed in Zircaloy process tubes; Zn-65 and Co-60 are formed in aluminum process tubes, and Fe-59 is formed in steel.

Small burial pits at N Area are used to store steel spacers, highly contaminated with Fe-59, until they have decayed sufficiently to be buried in 100-K Area.

- c. Physical and chemical properties of any carrier streams if they influence dispersion of the radionuclides.

Liquids

The carrier stream for the radioactivity bearing liquid wastes is water. In the case of the N Reactor secondary coolant, Columbia River water is used. It has a composition as shown in Table 4 and has a pH of 8.3. For most other streams including the coolant for the C and K Reactors, the carrier is treated river water. The treated river water is essentially of the same composition shown in Table 4. However, the water treatment process increases the sulfate concentration to from 20 to 30 ppm and reduces the pH as low 6-6 in some cases. The carrier for the radioactivity in the N Reactor primary loop bleed is deionized water having a pH of 10.

Gases

The carrier of gaseous radioactivity is air.

Solids

The carriers for buried solid wastes range over a broad span. Included are paper, rags, structural concrete and steel, wood and a variety of metals, such as aluminum, steel and Zircaloy. The solids have diverse configurations ranging from small tools through 8 inch long fuel element spacers to large equipment pieces typified by stringers, control rods and portions of test facilities. More than 99% of all solid activity is contained in the matrix of these solids having diverse configurations, and for this reason can not be easily dispersed.

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d. Average and maximum rates of generation of each waste stream.Liquids

Although the liquid waste streams carrying radioactivity contain a large number of curies, the radionuclides having relatively long half lives comprise only a minuscule fraction of the total. The long-lived radionuclide content of all the liquid streams is shown in the following table.

<u>Radionuclide</u>	<u>Half Life Years</u>	<u>Curies Per Year</u>
^{90}Sr	28	15
^{137}Cs	30	5
^{152}Eu	13	150
^{60}Co	5	400
^3H	12	10,000

Nonetheless, there are several short-lived radionuclides in the liquid streams which are of potentially significance for the following reasons:

1. P-32 and Zn-65 are the nuclides of Hanford origin which are concentrated in fish, shellfish and foodstuffs.
2. As-76 and Np-239 are responsible for most of the GI tract dose received by drinking water derived from the Columbia River.
3. Cr-51 is the nuclide released in the greatest quantity that gets downstream of the Hanford plant, but its contribution to dose is relatively small.
4. I-131 concentrates in the thyroid gland *and would probably be the critical nuclide in the event of a severe release of fission products.*

Only the transport rates of the above six radionuclides will be addressed.

The average transport rates are shown in Table 5.

In general the flow rate of the streams is essentially constant during reactor operation. During shutdowns the coolant flow for the C and K Reactor coolant stream is reduced to about 10 percent or less of the operating flow. N Reactor

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condenser coolant flow is reduced to about one half the operating level. Thus depending upon operating schedule, the radionuclide release rates fluctuate widely.

Even during operation a substantial variation in radionuclide generation rate can occur. Some of the radionuclide concentrations in the C and K Reactor effluent are influenced by the composition of the river water. Those such as As-76, Np-239, P-32 and Zn-65 can reach maximum transport rates a factor of three higher than shown in Table 5. Cr-51, whose source is the sodium dichromate added at a constant rate for corrosion inhibition, is generated at an essentially constant rate. On the other hand the transport rate of I-131, which is liberated when a fuel element fails, can reach a maximum at 10 times the rate shown in Table 5.

Gases

The average transport rate of gaseous radioactivity is shown in Table 6. The transport rate for particulate radionuclides is exceedingly low. Thus, the establishment of a maximum rate is difficult, but such a rate is not expected to exceed 1 curie per year. The gaseous radionuclides are formed from the neutron activation of the air-saturated coolant passing through the reactor. In as much as the effluent streams are thermally hot, essentially all of the gaseous material is released. The generation rate, then, is dependent upon the inlet coolant temperature and the reactor operating power level. In no case would the rate be expected to exceed that shown in Table 6.

Solids

The average rate of generation of solid wastes is shown in Table 7. In as much as the generation and disposal of solid waste is not a continuous process but is dependent upon reactor operating schedules, work schedules and the type of work being done, the rate of generation is subject to unpredictably large fluctuations. In fact the range covered is such that a maximum generation rate would have no useful meaning.

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2. Identification of waste streams

e. Location of points of release or storage.

<u>On-Plant Environmental Release Points and Tank Storage</u>	<u>100-B</u>	<u>100-D</u>	<u>100-F</u>	<u>100-H</u>	<u>100-K</u>	<u>100-n</u>	<u>300</u>
(1) Solid radioactive waste burial grounds & storage sites	6	6	4	4	1	1	6
(2) Waste storage tank (underground)	1	1				1	
(3) Radioactive contaminated soil from liquid to ground depositing solid radioactivity							
(a) Leaks from reactor effluent lines	3	3	3	2	4		
(b) Leaks from effluent retention basins	3	2	1	1	6		
(c) Effluent water flow to trenches and pits	8	3	5	3	2	1	2
(d) Decontamination solutions to underground drain	3	2	2	2			
(e) Liquid waste from tritium extraction facility	1						
(f) Retired reactor facilities							
• Reactor facility	1	2	1	1			
• Metal Storage Basin	1	2	1	1			
• Retention Basin		2	1	1			
• Effluent Lines	1	3	3	1			
• Effluent Outfall		1	1	1			
<u>Off-Plant Environmental Release Points</u>							
(1) End of effluent water line into Columbia River	2				1		
(2) River bank springs from effluent trenches	1				1	1	1
(3) Facility ventilation stack (for exhaust air from operating reactors)	1				2	1	5

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2. Identification of waste streams

f. Approximate inventories of stored wastes.

<u>Location</u>	<u>Radioactive Inventory</u>	
	<u>Half Life < 1 Year</u> (Ci)	<u>Half Life > 1 Year</u> (Ci)
<u>100-B</u>		
1 B Reactor	30,000	15,000(⁶⁰ Co)
2 Metal Storage Basins	--	20(⁹⁰ Sr ¹³⁷ Cs Pu)
3 107 Basins and Soil	--	150(¹⁵² Eu)
Solid Wastes	10,000	4,000(⁶⁰ Co)
<u>100-D</u>		
2 D-DR Reactors	15,000	25,000(⁶⁰ Co)
2 Metal Storage Basins	--	20(⁹⁰ Sr ¹³⁷ Cs Pu)
2 107 Basins and Soil	--	100(¹⁵² Eu)
Solid Wastes	--	4,500(⁶⁰ Co)
<u>100-H</u>		
1 H Reactor	1,000	10,000(⁶⁰ Co)
1 Metal Storage Basin	--	10(⁹⁰ Sr ¹³⁷ Cs Pu)
1 107 Basin and Soil	--	50(¹⁵² Eu)
Solid Wastes	--	4,000(⁶⁰ Co)
<u>100-K</u>		
2 Metal Storage Basins	--	100(⁹⁰ Sr ¹³⁷ Cs Pu)
6 107 Basins and Soil	--	300(¹⁵² Eu)
Solid Wastes	60,000	15,000(⁶⁰ Co)
<u>100-N</u>		
Crib	6,500	500(⁶⁰ Co)
Spacer Storage	150,000	2,000(⁶⁰ Co)
<u>300</u>		
Ponds	--	2(U)
Solid Waste	--	<1

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It is interesting to note that there are 80,000 curies of Co-60 being "stored" and 50,000 of these curies are located in the deactivated reactor 105 buildings. Concern over the buried activity (30,000 Ci) is less when viewed in this perspective.

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3. For wastes released to the environment:

- a. Conclusions of past studies on fate of radionuclides in the environment; projection of radionuclide content in the environment.

1. Fate of Radionuclides

a. Gaseous Effluent

Exhaust air from the reactor buildings passes through a confinement filter system of absolute filters that remove 99% of the particulates and charcoal filters that would remove 95% of any halogens released. This confinement system, then, prevents escape of measurable activity to the atmosphere, and the particulate and halogen gases are trapped in filters and will be buried at some future date as solid waste.

Radioactive gases, however, are released to the atmosphere through effluent line leaks, vents and from the retention tanks. These gases emanate dose rates that seldom exceed a few tenths of a mrem per hour in the manufacturing area from their point of release. The fate of these gases (largely Ar-41) is release to the local atmosphere and decay at rates rapid enough not to cause measurable offsite exposure.

In the 300 Area [REDACTED] uranium and thorium are handled. If these nuclides are apt to contaminate breathing air, hoods that exhaust through absolute filters are used. Released activity is, for practical purposes, zero, and therefore the ultimate fate of these radionuclides is burial as solid waste with the filter as needed.

b. Solid Wastes

More than 99% of the radioactivity in DUN solid wastes results from activation of impurities in the metallic matrices of "inpile" components. These components consist primarily of steel, aluminum and nickel alloys. The only radionuclide of any appreciable inventory in the components is Co-60. The other radionuclides have such short half lives or are in such insignificant quantity that they do not

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warrant future concern. Less than 1% of the solid waste activity is of fission product origin, and the long lived portion is not considered to be of future concern. Therefore, the waste of concern is in a homogeneous matrix of metal alloys and as such is insoluble and can not percolate through the soil into potable water supplies even if inundation of burial sites occurs.

c. Liquid Effluents

The bulk of the reactor cooling water effluent is discharged into the middle of the Columbia River. A small percentage of this effluent is discharged into an elongated open trench in 100-K Area and a covered pit in C Area. The effluent thus discharged percolates through the soil to reach the river, and much of the activity is retained in the soil. Additionally, leaks from the effluent system result in small depositions of radionuclides in the soil column. Thus, 99%+ of the activity is discharged into the Columbia River. P-32 and Zn-65 are reconcentrated through the food chain into spiny-rayed fish and oysters respectively. In this manner they can be ingested by man in higher concentrations than found in drinking water. The ultimate fate of these radionuclides is decay to natural states; however, man receives small amounts of radiation exposure prior to such decay.

The 300 Area liquid wastes contain uranium. These wastes are discharged to ponds to the north of the 300 Area. A very small amount of activity is discharged to ponds in the form of activation products when aluminum spacers are anodized. Ultimately, most of pond activity is discharged into the Columbia River. Using nearly any scheme available, however, the pond water can be considered nonradioactive. Once the activity from the pond enters the Columbia River, it can no longer be measured.

2. Projection of Radionuclide Content in the Environment

a. Gaseous Effluents

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All studies that have been conducted regarding release of gaseous effluents from Douglas United Nuclear, Inc., facilities have shown that the radioactivity released is of absolutely no concern. Normal operation will never contribute to measurable activity in the atmosphere outside the plant boundary.

b. Solid Wastes

The disposal of wastes contaminated with [REDACTED] uranium and thorium will add less than 0.5 Ci to the ground in the next 25 years.

Disposal of irradiated reactor components to the ground will be at such a rate in the future that it will not increase the total curies in the ground over the next 10 years. The rate of decay of the radioactivity of that which is now in the ground will more than compensate for the radioactivity in the material that will be added.

c. Liquid Effluents

The continued operation of DUN facilities at current rates of production will not increase the dose rates to living organisms which result from the disposal of radioactive liquid wastes. The inventory of longer-lived nuclides found in the soil, river or ocean is now decaying away at rates faster than they are being added.

Unproven.

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3. For wastes released to the environment:

b. Onsite monitoring

Solid Wastes

Solid wastes are controlled by procedures. In the case of irradiated metal components, control involves exposure to workers and centers around fixed radiation monitoring instruments. This instrumentation also prevents disposal of irradiated fuel elements into the 100 Area burial grounds.

Atmospheric Wastes

At the reactor facilities, ventilation exhaust air is continuously sampled and monitored.

In the 300 Area 3708 Building, the exhaust ventilation and process hood air is continuously sampled and monitored for alpha emitters. The thorium handling facilities use continuous sampling with weekly monitoring. The uranium facilities use occasional sampling and monitoring to assure that uranium concentrations continue to be released at levels much below the guides in AEC-RL 0510.

Liquid Wastes

In the single pass reactors, a 13 minute cycle time monitoring system is used to check for fission product activity that may be released from minute fuel cladding failures. Both daily grab and continuously composited samples are taken from reactor effluent water and analyzed for specific activation products and I-131. The effluent pipeline is continuously monitored for gross gamma radiation to detect significant releases of fission products. Periodically effluent water samples are analyzed in a comprehensive manner for all detectable nuclides to reaffirm the relationships between concentrations.

N Reactor primary loop water is continuously monitored for fission products. Should a tube contain a leaking fuel element, it would be valved to the diversion header which is continuously monitored. In addition, the water going to the crib, in river bank springs and in wells is sampled on a scheduled basis. The crib sample is composited and the others are periodic grab samples.

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The water in the 300 Area ponds is sampled with a composite sampler and analyzed for gross alpha and beta. Should unusual beta counts be found, a detailed analysis would be made. Water collected in the 3708 Building (Transuranium facility) underground tank is sampled and analyzed prior to release to the 300 Area pond. If alpha activity is detected, it will be sent to the 200 Areas for disposal.

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3. For wastes released to the environment:b. Offsite monitoring programs1. Air Sampling - Radionuclide Analysisa. Southeast Quadrant

Pasco, Kennewick, Richland, Benton City, Eltopia
Mesa, Othello, Ringold

b. Perimeter Communities

Umatilla, Walla Walla, Wastucna, Moses Lake,
Ellensburg, Yakima, Sunnyside

2. Columbia River Control Monitoring - Radionuclide Analysisa. River Samples

Priest Rapids Dam, Richland, McNary Dam, Bonneville Dam

b. Drinking Water Samples

Richland, Kennewick, Pasco

c. Fish and Waterfowl

Samples taken both on and off the reservation

d. Humans - Whole Body Counts

Specific persons from outside reservation chosen

e. Marine Organisms

Oysters at Willapa Bay

f. Milk and Produce

Farms irrigated with Columbia River water

(Redundant)

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3. For wastes released to the environment:

- c. Administrative criteria, such as "plant release limits," on concentrations or quantities of radioactivity released; bases for deriving these limits.

All Hanford contractors use AEC-RL Chapter 0510 criteria. In the case of the single pass reactors operated by Douglas United Nuclear, Inc., the Release Guides have become operating limits. AEC-RL Chapter 0510 recognizes radiation dose received by people as the basis for limiting releases, and AECMC 0524, Exposure Standards, provides the occupational and nonoccupational limits.

The Hanford environmental surveillance program continues to demonstrate that site-wide releases result in offplant people exposure to radiation at or below FRC Range I (1/10 of the limits). In addition, it should be noted that whole body counting of school children and fishermen have recently shown that actual exposure of people to radiation is considerably less than postulated by the environmental surveillance scientists.

Does not belong here

The bases underlying the release guides and limits include:

1. Environmental surveillance data used to predict population and individual exposure to radiation,
2. Curies released by each contractor and the radionuclide pathway to man, if needed,
3. Several years of experience relating dose received by people to curies released by operations,
4. AECMC 0524 nonoccupational dose limits,
5. FRC, Radiation Protection Guide (Range II),
6. ICRP, ways to convert intake to dose mathematically, and
7. Ease of administration and practicality.

Concentration limitations are applied only when calculating dose or controlling environmental contamination by limiting the long-lived activity nuclides (fission products) released to levels below those that will cause environmental contamination spreads. Additionally all Hanford contractors are pledged to minimizing radioactive environmental releases to the lowest practical level.

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3. For wastes released to the environment:

d. Engineered systems

1. Liquid In-Line Monitoring Systems

a. 105 Gamma Rupture Monitoring System

Effluent water from each rear crossheader and rear riser of the single pass reactors is periodically sampled and the gross gamma count measured by an ion chamber and recorded. At N Reactor the gross gamma and gamma energies emanating from the water out of each process tube and the diversion system header are periodically measured and compared with similar measurements from adjacent tubes. Both systems are used primarily for detection of fuel ruptures.

b. N Reactor Diversion System Monitoring System

The gross gamma radiation from the diversion piping system is continuously measured and recorded downstream of the cooling and depressurization equipment.

c. Effluent Water Gamma Monitoring System

Gross gamma radiation in the C and K Reactor effluent lines immediately upstream of the retention basins is continuously measured and recorded in the 105 Building control rooms. Range of the detection equipment is from 1 mR/hr to 1,000 R/hr. At a preset critical radiation level, readout is also provided at the 100 Area Central Fire Station.

d. Iodine to River Monitoring System

A construction project has been authorized, DAE-518, to install equipment to measure I-131 concentration in the effluent water at the retention basins of the single pass reactors. The equipment will measure instantaneous rates and integrate these rates over the period of iodine release. Readout will be provided in the 105 Building control room.

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e. Fuel Preparation Facilities

There are no in-line monitoring systems presently installed in the radioactive waste streams from the fuel preparation facilities. Grab and accumulative samples are routinely taken and delivered to the laboratory for chemical and radioactivity analysis.

2. Air In-Line Monitoring Systems

a. Radioactive Particulate Sampler System

The radioactivity of airborne particulate matter in the exhaust ventilation air, upstream and downstream of the confinement filter banks, is continuously measured and recorded at all reactor buildings. Representative samples of the exhaust air are passed through a continuously moving tape of high efficiency filter paper. The gross radiation of the particulate matter deposited on the tape is measured.

b. Halogen Charcoal Sampler System

A continuous sample of the exhaust ventilation air downstream of the charcoal filter bank at all reactor buildings is passed through an activated charcoal bed to remove potential halogen vapors from the stream. Gamma radiation from any absorbed I-131 would be measured and recorded. The sampler is an accumulative system requiring periodic replacement of the activated charcoal bed.

c. Iodine Monitoring System

This system monitors the presence of I-131 in the exhaust air stream upstream of the confinement filter bank in the single pass reactor buildings to trip the rear face fog spray systems and place the building ventilation systems in the confinement mode.

d. Fuel Preparation Facilities

There are no in-line monitoring systems in the fuel preparation process buildings. Portable monitoring equipment is utilized.

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3. Diversion Systems

a. K Reactors

Effluent water in the retention basins can be diverted to the K ditch from the 105 Building control rooms by remotely operated valving.

b. C Reactor

At present, effluent water cannot be diverted to the C crib from the retention basins because grounding of the electrical control cables running from 105-C Building to the valves. A design change is in preparation to replace these cables.

c. N Reactor

Water from any process tube can be diverted from the primary loop to a high pressure diversion system with ultimate disposal to C crib while the reactor is operating. Process Standards limits specify that no more than five tubes can be simultaneously diverted while operating. This system is also used during reactor refueling.

d. H Reactor Single Pass Diversion System

The reactor can be diverted to single-pass cooling with either demineralized water or filtered water when shutdown. Valving is partly manual requiring some time to changeover. The system is rarely used because of the possible primary loop corrosion that could occur, especially from filtered water.

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e. Summary of wastes released:

	<u>Volume of Carrier</u>	<u>Radioactivity Curies/Year</u>	<u>Radioactivity Inventory</u>
Liquid to River	4×10^{11} gal/yr	8×10^6	100,000
Liquid to Ground	2×10^9 gal/yr	80,000	~300
Gases	3×10^{11} cuft/yr		
Particulate		<1	Not measurable offsite
Other		~500,000	Not measurable offsite
Solids	60,000 cuft/yr	100,000	<30,000*

Handwritten note:
 → *Lead
 what
 include*

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*⁶⁰Co

f. Pre-release treatment and longer range planning

1. Liquid Streams

a. C and K Reactors

The radionuclides in the reactor effluent are formed by neutron activation of Columbia River water salts not removed in the water treatment process, water treatment additives, corrosion products from the water system and fuel surfaces and impurities left on/or embedded in fuel elements jacket surfaces. The parent materials are absorbed in the film which forms on the fuel element and reactor tube surfaces and adheres for extended periods of time to further increase radionuclide production. Extensive studies have been made to reduce the radionuclide generation rate by increasing the efficiency of parent isotope removal during the coolant treatment process and to reduce or eliminate the in-reactor residence time of the parent isotopes. Water treatment process innovations are already in place which reduce the radionuclide generation rate by a factor of up to 10 depending on the radionuclide in question. The studies are expected to continue.

The effluent flows from the reactor to a retention basin where it is held up for one-half to one hour prior to release into the river. This permits decay of the very short half lived radionuclides. Studies are also underway to investigate methods of removing the radionuclides from the effluent. One promising method appears to be ground disposal. In this way percolation into the soil and radionuclide retention by ion exchange with the soil would provide long-time periods for decay before the water reached the river.

b. N Reactor

The primary N Reactor coolant is deionized water. This limits radionuclides generation to corrosion products. The formation and transport and deposition characteristics of the corrosion produced radionuclides are under investigation with the expectation of reducing the quantities currently in existence.

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As indicated above, the coolant from a tube containing a rupture can be diverted to a crib. One feature of the Effluent Control Project involves the diversion to a tank and, then, to an ion exchange system prior to release.

c. 300 Area

The liquid wastes from the 300 Area go into seepage ponds which provide at a minimum particulate removal prior to the liquids reaching the river. No additional treatment is planned.

2. Gaseous

Gases leaving the reactors pass through absolute filters for particulate removal and then through charcoal beds for halogen removal. The efficiencies of the filters and charcoal beds are 99% and 95% respectively. No additional treatment is planned with respect to normal operation. The gaseous effluents from 300 Area stacks potentially containing radioactivity are also filtered.

3. Solids

Incineration, compaction and segregation are already practiced in the burial of solid wastes. Studies are underway to improve the efficiency of volume reduction methods.

4. General

A comprehensive effort is currently being made to examine in depth all aspects of waste disposal. The program will develop the economics and practicality of modifications to current practices which might reduce the amount of radioactivity released to the environment.

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COLUMBIA RIVER

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BU N-5200 RD
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COLUMBIA RIVER

PROCESS TUBES

IRRADIATION
PROCESS

MAKE UP
WATER

REACTOR

COOLING
WATER

STEAM

COOLING
WATER

HEAT
EXCHANGERS

STEAM
GENERATORS

CONDENSATE

WPPSS
TURBIN
GENERATOR

RADIOACTIVE LIQUID WASTE

CONTROL ROD COOLING WATER.
PRIMARY LOOP PURITY BLEED.
RUPTURE MONITOR SAMPLE WATER.
PRIMARY LOOP SPILL.
MODERATOR COOLING LOOP BLEED.
FUEL STORAGE BASIN OVERFLOW.
MISC. FLOW & HOT LAB. DRAINS.
PROCESS TUBE DIVERSION
WATER.

RADIOACTIVE
GASEOUS WASTE
ZONE 1 & 2 VENT. AIR.
REACTOR GAS
SYSTEM PURGE.

PARTICULATE & CHARCOAL
FILTERS

EXHAUST
STACK

N REACTOR

~ 2500 GPM

→ CRIS → COLUMBIA RIVER

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C, KE AND KW

N REACTOR FUEL MANUFACTURE

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*PASSES THROUGH 105 METAL
STORAGE BASIN 107 BASIN

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TABLE I
COMPOSITION OF C AND K
REACTOR EFFLUENT

<u>Radionuclide</u>	<u>Concentration</u> <u>pCi/ml</u>	<u>Radionuclide</u>	<u>Concentration</u> <u>pCi/ml</u>
⁵⁶ Mn	7000	⁶⁵ Ni	2
³¹ Si	700	⁴⁶ Sc	2
²⁴ Na	550	⁵⁹ Fe	1
⁶⁴ Cu	450	¹⁴⁰ Ba	1
⁵¹ Cr	350	¹⁴³ Ce	1
²³⁹ Np	150	¹⁴¹ Ce	1
⁷⁶ As	100	¹³¹ I	0.7
¹³⁹ Ba	100	⁸⁹ Sr	0.5
¹³⁴ I	90	¹⁴⁹ Pm	0.6
^{152m} Eu	60	⁴⁵ Ca	0.7
⁹² Sr	50	⁶⁰ Co	0.5
^{69m} Zn	40	¹⁴³ Pr	0.5
⁷² Ga	25	⁵⁴ Mn	0.4
¹⁵³ Sm	25	¹⁴⁷ Nd	0.4
³² P	18	¹⁵¹ Pm	0.4
¹³² I	17	¹⁴⁴ Ce	0.3
¹⁴⁰ La	15	¹⁵⁶ Eu	0.3
³ H	10	¹²⁴ Sb	0.3
¹³⁵ I	10	¹⁵² Eu	0.2
⁶⁵ Zn	10	¹⁶⁰ Tb	0.09
⁹¹ Sr	10	¹⁴⁷ Pm	0.07
¹²² Sb	10	¹⁶¹ Tb	0.06
¹³³ I	8	¹⁰³ Ru	0.04
^{87m} Sr	6	⁹⁰ Sr	0.02
¹⁴² Pr	5	¹⁰⁶ Ru	0.01
		¹³⁷ Cs	0.006

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TABLE 2

RADIOACTIVITY IN N REACTOR

EFFLUENT STREAMS

Discharge To Crib

<u>Nuclide</u>	<u>Mean Value Crib Influent</u>	<u>Concentration Range</u>	
		<u>Minimum</u>	<u>Maximum</u>
¹³¹ I	3.5×10^{-5}	6.0×10^{-7}	3.1×10^{-4}
⁹⁰ Sr	5.2×10^{-7}	1.2×10^{-7}	1.5×10^{-6}
¹³⁷ Cs	4.8×10^{-6}	4.5×10^{-7}	3.2×10^{-5}
³² P	1.7×10^{-6}	5.2×10^{-7}	1.6×10^{-6}
¹⁴⁰ Ba	2.7×10^{-5}	1.0×10^{-6}	1.0×10^{-4}
⁶⁰ Co	1.8×10^{-5}	1.4×10^{-6}	1.0×10^{-4}
⁵⁹ Fe	6.1×10^{-5}	1.0×10^{-6}	2.7×10^{-4}
⁵⁴ Mn	8.2×10^{-5}	6.0×10^{-6}	9.0×10^{-5}
⁶⁵ Zn	5.7×10^{-6}	2.0×10^{-7}	4.5×10^{-5}
⁹⁵ Zn	3.5×10^{-5}	4.0×10^{-6}	1.4×10^{-4}
⁵¹ Cr	5.2×10^{-5}	6.0×10^{-6}	1.2×10^{-3}
⁷⁶ As	3.4×10^{-4}	5.0×10^{-10}	1.4×10^{-4}
²⁴ Na	1.8×10^{-4}	2.3×10^{-6}	3.9×10^{-4}

Discharge to River

<u>Nuclide</u>	<u>Mean Value River Influent</u>
¹³¹ I	2.4×10^{-7}
⁹⁰ Sr	4.3×10^{-8}
¹³⁷ Cs	4.0×10^{-7}
³² P	2.6×10^{-7}
¹⁴⁰ Ba	1.7×10^{-6}
⁶⁰ Co	3.4×10^{-6}
⁵⁹ Fe	5.0×10^{-7}
⁵⁴ Mn	2.3×10^{-7}
⁶⁵ Zn	3.2×10^{-7}
⁹⁵ Zn	7.6×10^{-7}
⁵¹ Cr	1.0×10^{-5}
⁷⁶ As	5.8×10^{-6}
²⁴ Na	8.2×10^{-6}

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TABLE 3

RADIOACTIVITY IN 300 AREA

POND INFLUENT

Beta, pCi/ml

500

Uranium, pCi/ml

500

Principle Gamma Emitter

⁵¹Cr

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TABLE 4

COLUMBIA RIVER WATER ANALYSIS

	<u>ppm</u>
Sulfate	8 - 12
Phosphate	0.02 - 0.10
Silica	3 - 5
Calcium	20 - 25
Magnesium	3 - 5
Iron	0.02 - 0.30
Chlorine	0.5
Sodium	1.5
Bicarbonate	75
Total Dissolved Solids	100
Turbidity	10 - 200

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TABLE 5

AVERAGE RADIONUCLIDE TRANSPORT RATE--LIQUID STREAMS

Nuclide	<u>Curies/Year in Stream</u>						
	<u>100-K Trench</u>	<u>100-K Leakage</u>	<u>100 C & K to River</u>	<u>100-C Leakage</u>	<u>100-N Crib</u>	<u>100-N to 300 Area River to Pond</u>	
⁷⁶ As	50	550	95,000	200	1,500	4,000	
²³⁹ Np	50	650	80,000	250	*	*	
¹³¹ I	5	5	800	2	100	150	[1,500 beta Ci/yr]
⁵¹ Cr	150	1,000	175,000	500	250	6,500	
⁶⁵ Zn	50	50	10,000	25	30	200	
³² P	10	50	10,000	25	10	150	

*No data

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TABLE 6

AVERAGE RADIONUCLIDE TRANSPORT RATE

GASEOUS STREAMS

<u>Area</u>	<u>Curies Per Year</u>	
	<u>Particulate</u>	<u>Gaseous</u>
300	<1 ¹	0
100 C and K	<1	600,000 ²
100-N	<1	<1,000 ²

¹Uranium-238
²Argon-41

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TABLE 7

AVERAGE RADIONUCLIDE GENERATION RATE

SOLID WASTES

<u>Area</u>	<u>^{60}Co Ci</u>	<u>Curies Per Year</u> <u>Other Activity*</u>
300		<1
100-C	100	<3,000
100-K	1,000	<30,000
100-N	500	<30,000

*Short half life nuclides

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< 1 Ci / YR

NORTH PROCESS POND
4,546,000 GPD
\$21,000 / YEAR
TOTAL MAINT. COST

SOUTH PROCESS POND
(ALTERNATE USE)

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ANALYSIS

URANIUM PPM 0.48
TOTAL ALPHA BETA &
GAMMA EMITTERS

URANIUM PROCESSES

ANALYTICAL LABORATORY

THORIA FACILITIES

TRANSURANIUM FACILITY

100N AREA

b. RADIOACTIVE DRAIN SYSTEM

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*KE ONLY CHEMICAL ADDITIVES FOR TESTS INCLUDE:
SODIUM SULFATE, NITRIC ACID, SULFURIC ACID,
SODIUM SILICATE AND OTHERS AS TESTED