DOE-0291-FP
Revision 0

Hazard Categorization of Environmental Restoration Sites at Hanford, Washington

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

5-1-01

INFORMATION CLEARANCE FORM

A. Information Category

- [ ] Abstract
- [ ] Summary
- [ ] Visual Aid
- [x] Full Paper
- [ ] Other
- [ ] Journal Article
- [ ] Internet
- [ ] Software
- [ ] Report

B. Document Number DOE-0291-FP

C. Title Hazard Categorization of Environmental Restoration Sites at Hanford, Washington

D. Internet Address

E. Required Information

1. Is document potentially Classified? [x] No [ ] Yes (MANDATORY)

See below for Signature
Manager's Signature Required

If Yes NA [ ] No [ ] Yes Classified
ADC Signature Required

2. Internal Review Required? [x] No [ ] Yes
If Yes, Document Signatures Below

Counsel

Program

3. References in the Information are Applied Technology [x] No [ ] Yes
Export Controlled Information [x] No [ ] Yes

4. Does Information Contain the Following: (MANDATORY)
   a. New or Novel (Patentable) Subject Matter? [x] No [ ] Yes
   If "Yes", Disclosure No.:
   b. Information Received in Confidence, Such as Proprietary and/or Inventions? [x] No [ ] Yes If "Yes", Affix Appropriate Legends/Notices.
   c. Copyrights? [x] No [ ] Yes If "Yes", Attach Permission.
   d. Trademarks? [x] No [ ] Yes If "Yes", Identify in Document.

5. Is Information requiring submission to OSTI? [x] No [ ] Yes
If Yes UC- and B&R-

6. Release Level? [x] Public [ ] Limited

7. Charge Code

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting Safety Analysis Working Group Annual Meeting
2. Group Sponsoring Energy Facility Contractor Group (EFCOG)
3. Date of Conference June 18-21, 2001
4. City/State Milwaukee, Wisconsin
5. Will Information be Published in Proceedings? [ ] No [x] Yes
6. Will Material be Handed Out? [ ] No [x] Yes

H. Author/Requestor
Gary E. Bishop [signature]
(Print and Sign)

Responsible Manager
Pete J. Garcia Jr. [signature] for C J Bosted
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	[ ]	N/A		Y / N
Office of External Affairs	[ ]	N/A		Y / N
DOE-RL	[x]	P. J. Garcia	See Above for signature	Y / N
Other	[ ]			Y / N
Other	[ ]			Y / N

J. If Information Includes Sensitive Information and is not to be released to the Public indicate category below.

- [ ] Applied Technology
- [ ] Personal/Private
- [ ] Proprietary
- [ ] Business-Sensitive
- [ ] Predecisional
- [ ] UCNI
- [ ] Protected CRADA
- [ ] Export Controlled
- [ ] Procurement-Sensitive
- [ ] Patentable
- [ ] Other (Specify)

Information Clearance Approval

APPROVED FOR RELEASE
OFFICIAL DOCUMENT
Date 5-1-01

K. If Additional Comments, Please Attach Separate Sheet

A-6001-401 (02/98)

DOE-0291-FP
Revision 0

Hazard Categorization of Environmental Restoration Sites at Hanford, Washington

G.E. Bishop
U.S. Department of Energy, Richland,WA

Date Published
May 2001

To Be Presented at
Safety Analysis Working Group Annual Meeting

Energy Facility Contractor Group (EFCOG)
Milwaukee, WI

June 18, 2001

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

Chris Willingham 5-1-01
Release Approval Date

Hazards Categorization of Environmental Restoration Sites at Hanford, Washington

Guy E. Bishop, III

Department of Energy, Richland Field Office, Richland, Wa.
509-372-1856
guy_e_iii_bishop@rl.gov

Abstract:

Environmental restoration activities, defined here as work to identify and characterize contaminated sites and then contain, treat, remove or dispose of the contamination, now comprises a significant fraction of work in the DOE complex. As with any other DOE activity, a safety analysis must be in place prior to commencing restoration. The rigor and depth of this safety analysis is in part determined by the site's hazard category. This category in turn is determined by the facility's hazardous material inventory and the consequences of its release. Progressively more complicated safety analyses are needed as a facility's hazard category increases from radiological to hazard category three (significant local releases) to hazard category two (significant on-site releases). Thus, a facility's hazard category plays a crucial early role in helping to determine the level of effort devoted to analysis of the facility's individual hazards. Improper determination of the category can result in either an inadequate safety analysis in the case of underestimation of the hazard category, or an unnecessarily cumbersome analysis in the case of overestimation.

Contaminated sites have been successfully categorized and safely restored or remediated at the former DOE production site at Hanford, Washington. This paper discusses various means used to categorize former plutonium production or support sites at Hanford. Both preliminary and final hazard categorization is discussed. The importance of the preliminary (initial) hazard categorization in guiding further DOE involvement and approval of the safety analyses is discussed. Compliance to DOE direction provided in "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports", DOE-STD-1027-92, is discussed.

DOE recently issued 10 CFR 830, Subpart B which codifies previous DOE safety analysis guidance and orders. The impact of 10 CFR 830, Subpart B on hazard categorization is also discussed.

Background:

Hanford has recently adopted a strategy to clean up the Columbia River corridor as a priority in environmental restoration (ER) work. This corridor is a narrow swath of land paralleling the river's course through the reservation. See Figure One. Nine production reactors and many support facilities were located there along with several ground disposal sites. The hazards posed by the production reactors are not the same as for support facilities, which are in turn different from disposal sites.

DOE requires that all hazardous sites be characterized and that controls be implemented to adequately protect the facility and site workers, the public, and the environment.[1] This assessment of a facility's hazards is typically included in a safety analysis report (SAR). The rigor and depth of the SAR's analysis should be proportional to the magnitude of the hazards. DOE stipulates four categories of hazards, depending on the consequences of release of the hazardous inventory (source term). In practice, Hanford has no active sites in the highest hazard category--hazard Category One--and environmental restoration (ER) sites are, in descending order of concern, either hazard Category Two, Three, or Radiological.

Prior to the issuance of 10 CFR 830, Subpart B, DOE required all sites to have an approved hazard analysis, including categorization. Radiological sites do not require a SAR at all. Hazard Category Two and Three sites require a SAR as described in DOE Order 5480.23, "Nuclear Safety Analysis Reports" (or its associated standard, "Preparation Guide for US DOE Nonreactor Nuclear Safety Analysis Reports", DOE-Std-3009-94). The rigor and depth of this SAR's analysis should be proportional to the site's specific hazards. This is the famously misapplied "graded approach", defined in paragraph 8.a of Order 5480.23. However, as discussed in paragraph 4.f.(4) of Attachment One to the Order, an additional factor that should be considered (although it seldom is) in determining the sophistication of the analysis and thoroughness of the documentation of each SAR should be the hazard category (the Order uses the term hazard "classification"). Hazard category should not just be used to determine the approval authority for the SAR (although that is often the only thing it is used for).

Categorization of a site's hazards and characterization (i.e., determination) of the hazardous inventory on which the categorization is based is a fundamental preparatory step to completion of the site's safety analysis, no matter what form that analysis eventually assumes. DOE has issued formal guidance for the categorization process, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports", DOE-STD-1027-92, referred to as Standard 1027.

---

[1] – DOE Order 5480.23, "Nuclear Safety Analysis Reports", paragraph 8.c requires that all nuclear facilities and operations be categorized, the hazards characterized and evaluated, and the analysis submitted to DOE for approval. The recently issued 10 CFR 830 Subpart B requires the same thing on a Federal regulation level for facilities in hazard category one, two, or three.

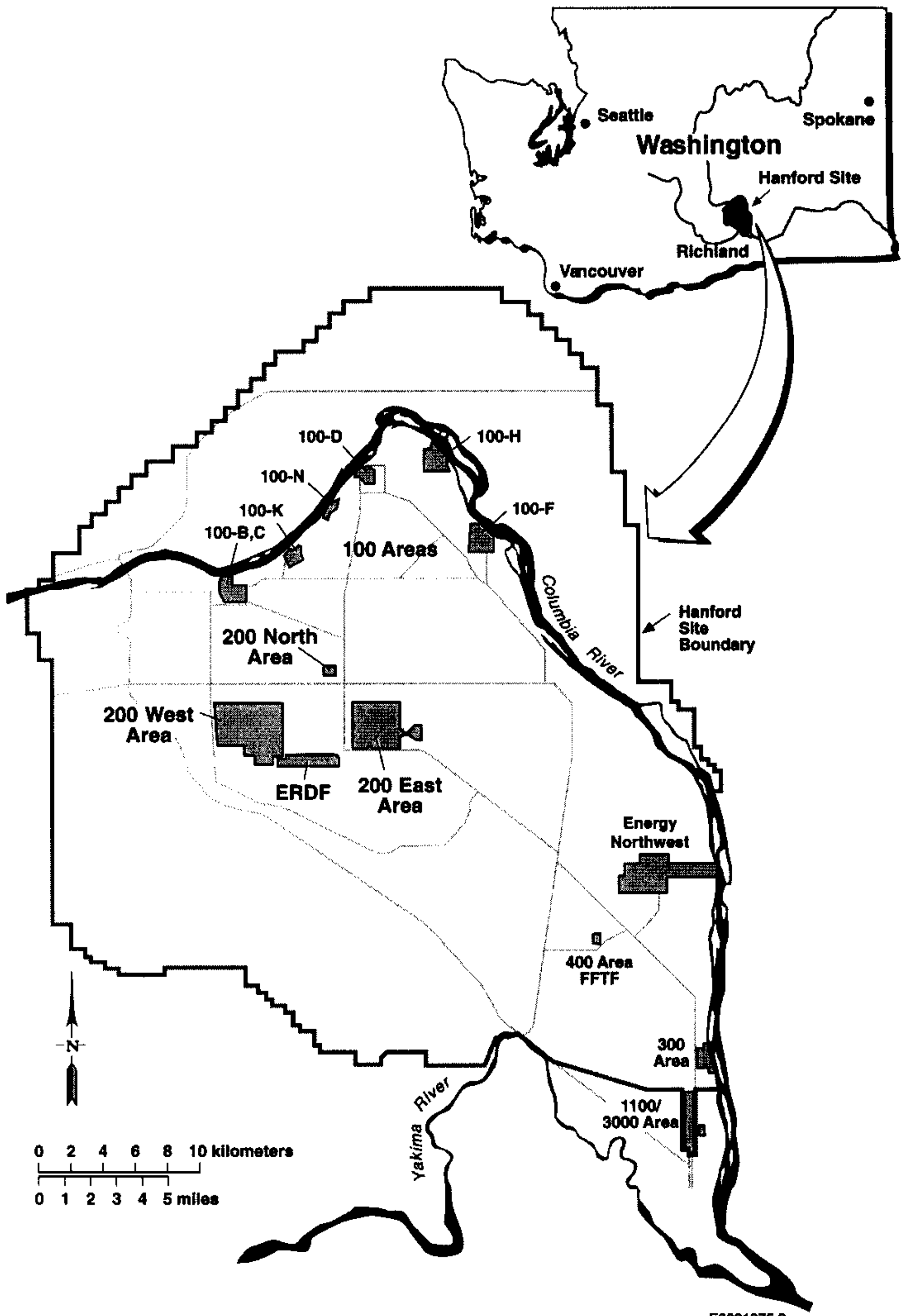

Seattle
Spokane
Washington
Hanford Site
Richland
Vancouver
100-D
100-H
100-N
100-K
100-F
100-B,C
100 Areas
Columbia River
Hanford Site Boundary
200 North Area
200 West Area
ERDF
200 East Area
Energy Northwest
400 Area FFTF
300 Area
1100/ 3000 Area
Yakima River
N
0 2 4 6 8 10 kilometers
0 1 2 3 4 5 miles
E9801075.3

FIGURE ONE

In practice, categorization of Hanford ER sites has proven difficult. Lack of definitive (or even partially reliable) characterization of a particular site's hazards is the biggest obstacle. It is impossible to categorize or analyze hazards of unknown composition or concentration. In addition, radically different radiological or toxic source terms (when known with fair accuracy), radionuclide quantity, form, and location, dispersibility, interaction with release energy sources, and the facility's passive barriers to release all complicate categorization. While Hanford sites are often significantly different from each other, the goal for each remains determination of a valid hazard inventory and implementation of effective controls on those hazards to protect the site workers, the public, and the environment.

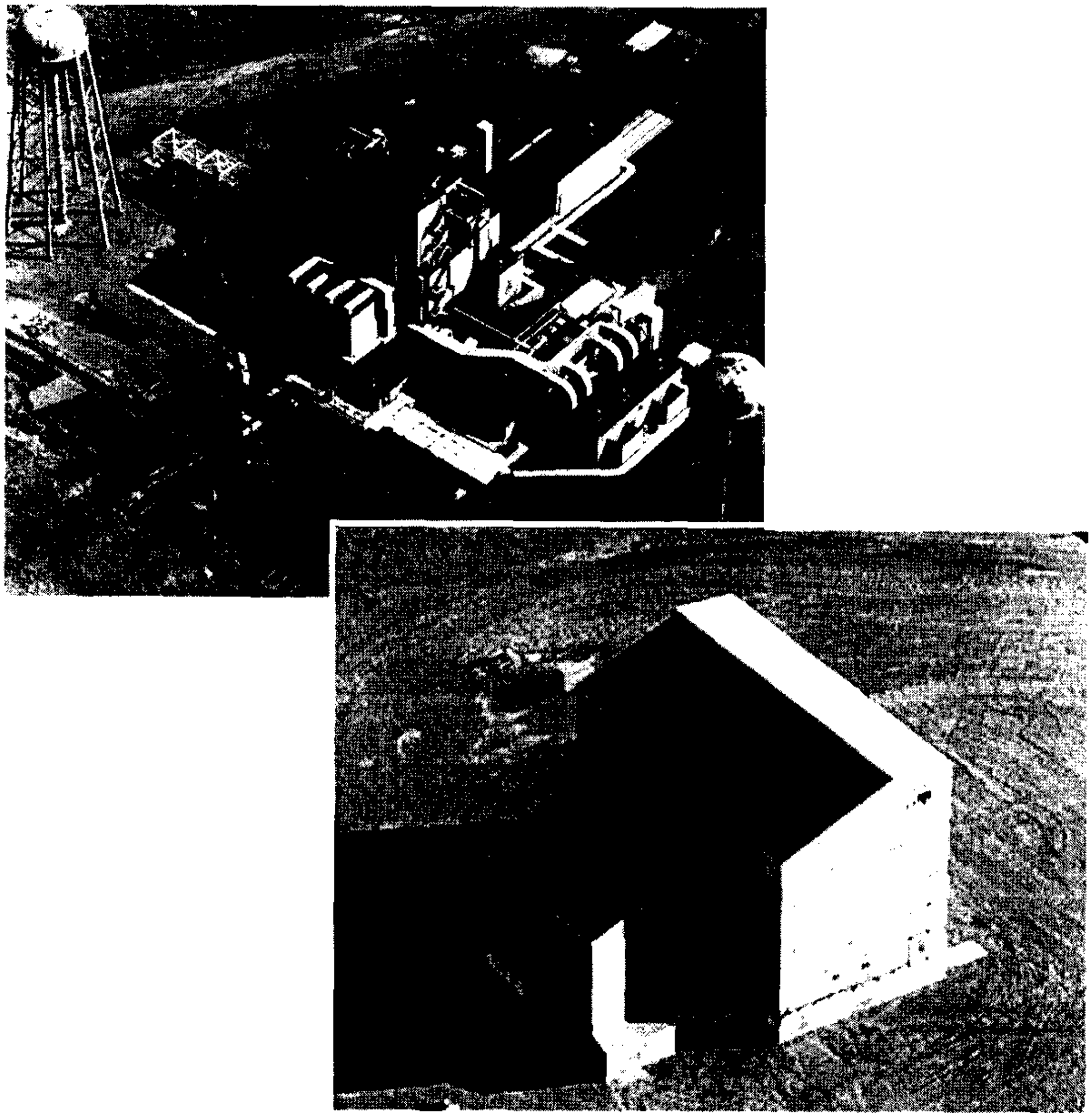
Four sites at Hanford are presented as illustrative of the complexities of hazard categorization. These sites are two production reactors, the "327" Irradiated Fuel Rod Examination and Testing Building, and the "116-N-3" Ground Disposal Crib and Trench. 10 CFR 830, Subpart B had not been implemented nor was in force during preparation of any of the four safety analyses for these facilities.

Hazard Categorization of the Production Reactors:

"F" Reactor:
A former production reactor located at the 100-F area in which slightly enriched uranium fuel rods were irradiated to produce plutonium which was then removed at other facilities. The irradiated fuel rods were manually extracted from the water and gas cooled, graphite-block "pile" type reactor during operation and dropped into a water basin by the reactor's side. See Figure Two. The rods decayed for a period before being taken to a plutonium separation facility. F Reactor operated from 1945 until June, 1965. It was then defueled and partially cleaned up. The fuel storage basin was filled in with sand and contains an unknown (although expected to be small) number of irradiated fuel rods. Interim ER consists of demolition and removal of the facility except for the reactor block, over which a weather enclosure will be constructed. "Before" and "after" pictures from a similarly disposed reactor site are shown in Figure Three.

"D" Reactor:
Similar to F Reactor in construction, the D Reactor at the 100-D site operated from 1944 until June, 1967. D Reactor was then defueled. However, its storage basin was thoroughly cleaned and essentially decontaminated. No fuel rods were left in it. Similar to F Reactor, ER consists of demolition and removal of the facility except for the reactor block, over which a weather enclosure will also be constructed.

Thus, the primary difference between the F and D Reactors is the state of the fuel rod storage basin (FSB).



E9805055.1

FIGURE TWO

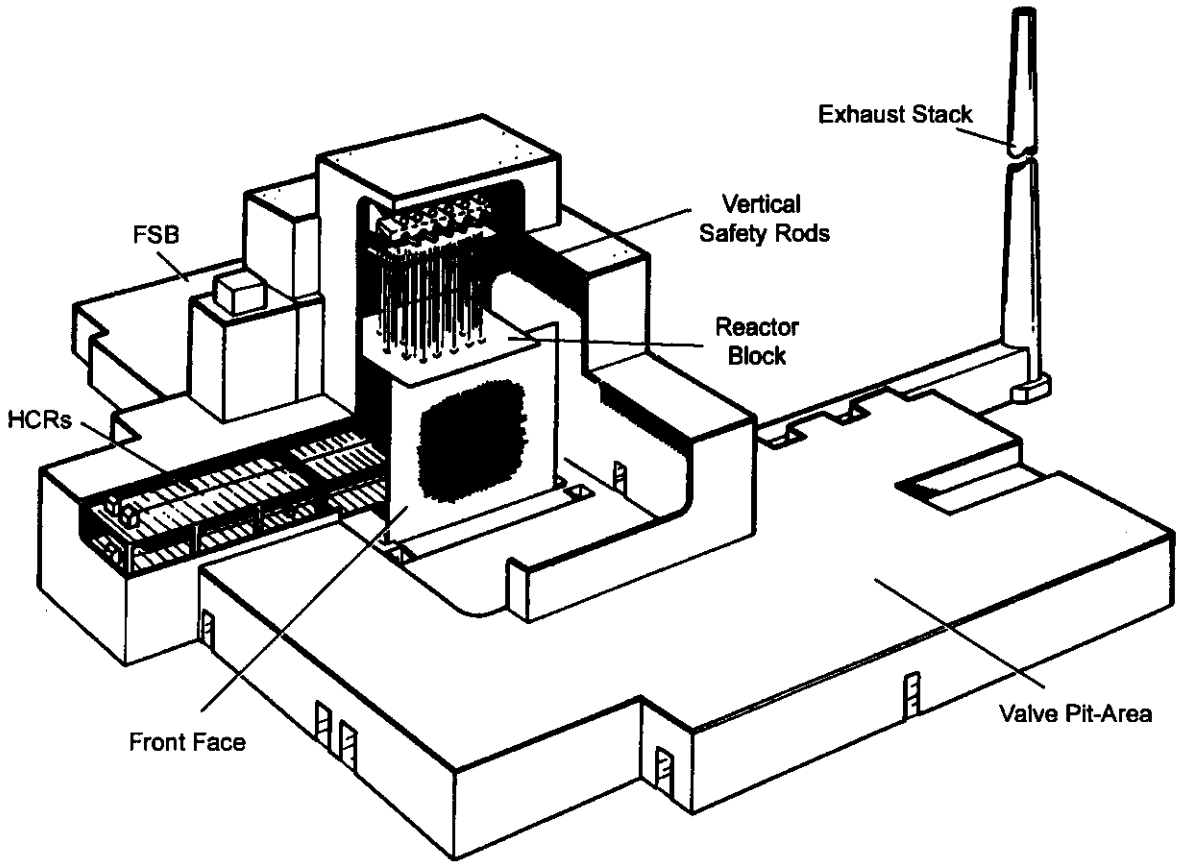


FIGURE THREE

The reactor pile is the largest component of the facility's source term. The unknown radiologic inventory of the graphite blocks complicated categorization of both reactor sites. Direct measurement of a core's remaining radionuclide inventory was done on only one of the eight single-pass reactors (SPR's). A limited characterization, reference one, was conducted on the DR Reactor's pile in 1976 and 1977, consisting of four cores taken through the graphite blocks. DOE questioned the rather broad assumption in reference one (UNI-3714) that the analysis from DR Reactor could be applied to the other production reactors because:

1. UNI-3714 applied correction factors to activation product inventories (e.g., Co-60) to account for varying neutron flux. However, no correction was applied for the difference in local core power (flux) level which could easily match and likely exceed variations in total power levels.
2. UNI-3714 assumed that the core inventory of the remaining seven SPR's was identical to the DR Reactor. No basis for this assumption existed.
3. A single concentration for Am-241 was obtained from one DR core sample and that value was assumed for the entire core. A single sample for such a critical radionuclide was not adequate.

However, dwarfing all other concerns with reference one's data was the largely unknown role that fuel rod failures had in contaminating the piles. Reviewing the DR core data from UNI-3714, it was obvious that the principal contributor to pile inventory was fission product and TRU contamination. Such contamination of the graphite core was a function of the number of coincident fuel cladding/process tube failures experienced by that reactor during its operation. During reactor operation, contamination of the piles would occur from coincident failure of a fuel rod's cladding and simultaneous downstream failure of the cooling water tube containing that rod. Hanford experienced numerous documented fuel rod failures during the period of production reactor operation. Such coincident failures would contaminate the piles with fission products (e.g., cesium, strontium) and transuranic (e.g., plutonium, americium) radionuclides.

Reference one assumed the data from four core samples taken from the DR reactor applied to all eight SPR's. In other words, all reactors had the same number of coincident fuel cladding/tube failures and consequent contamination. No basis for that assumption exists.

Because fuel rod/tube failures contributed so heavily to the core inventory, DOE performed a more intensive review of the subject. It was found that cladding failures did not occur during the early period of plutonium production (1944-1949). The first significant cladding failures occurred in 1951, coincident with higher operating reactor power levels and core temperature which caused cladding blistering and swelling. Prior to 1951, there had been only five cladding failures. There were 115 failures in 1951. On average, there were 228 cladding failures per reactor through 1963, or 18 per reactor per year.[2]

There is no means of determining the number of such failures that occurred coincident with a

[2] - 2,036 documented cladding failures occurred from 1948 through 1968, with an unknown (although likely quite small) number before 1948.

process tube leak, which was required in order to contaminate the core. The only core data available (the core samples from DR Reactor) clearly showed at least two fuel rod contaminations in the four samples taken. Such a failure rate was high and showed that significant contamination of the graphite core should be expected for all eight SPR's. The consequent actual radionuclide inventory inside the core was much higher than predicted by UNI-3714. However, as stated, there is no known means of qualitatively estimating the actual contamination inventory of any reactor pile, including DR. The unique operational history of each reactor along with the unpredictable failure characteristics of the process tubes themselves made any such estimates strictly conjectural. Process tube failures (apart from fuel rod/tube failures) would be a function of water chemistry control, operating practices (e.g., testing or experiments), localized power level and temperature, size and location of the respective leaks, and many other variables that could not be recovered or estimated with any certainty.

DOE concluded that the methodology used by UNI-3714 to predict the expected fission product/TRU inventory of the pile was not valid. Therefore, the isotopic inventory of the graphite was largely unknown. Without knowing this significant component of the reactor's source term, how could the facility's hazard category be determined? Further, if the hazard category was not known, how could the necessary rigor, depth, and content of the attendant safety analysis (let alone the approval authority for it) be ascertained?

DOE solved this conundrum by the simple expedient, consistent with Standard 1027, of segmenting the facility and placing controls on any work which could violate the graphite pile. In essence, the pile was separated from the remainder of the facility and placed off-limits to intrusive work which could disturb the graphite blocks or their unknown contamination. In practice, this was easily accomplished since thick concrete and steel shields surround the core. No work was allowed which could in any way damage the reactor biologic and thermal shields or intrude into the core through connecting piping, such as the cooling water tubes. Once the reactor pile itself was segmented from the facility, the remaining source term could be determined with acceptable accuracy.

For the reactors' fuel rod storage basins, the D Reactor pool was clean and contributed negligible additional inventory. The F Reactor pool was filled with sand in 1970, burying contaminated equipment and gear of uncertain radioactivity along with an unknown number of irradiated fuel rods. The radionuclide content of any fuel rods would dominate the F storage basin inventory. A reasonably conservative assumption was made that five irradiated fuel rods remained in the F pool.[3] The associated source term for the rods was then calculated and included with the F Reactor inventory.[4]

---

3 – Five fuel rods were found in the D and DR Reactor storage basins when cleaned (i.e., five rods were found in two basins). Based on that experience, assuming five rods could be found in the F basin was believed reasonably conservative.

4 – DOE was unable to recover the data base for the fuel rod inventory presented in reference one. The inventory did not appear to be based on ORIGIN, but used a code developed by the reference's authors. It was believed reasonably correct when compared to other fuel rod inventories that were calculated by ORIGIN.

The final major radiologic inventory for the D and F Reactors is shown in Table One. Note the substantial contribution of the assumed five irradiated fuel rods to the F inventory.

Table 1
Production Reactor Major Radionuclide Inventory
(exclusive of core inventory)

D Reactor		F Reactor		Haz Cat 3 TQ's (Ci)
Radionuclide	**Inventory (Ci)**	**Radionuclide**	**Inventory (Ci)**	
Sr-90	2.2	Sr-90	39.5	16
Cs-137	4.5	Cs-137	41.6	60
Pu-238	Not found	Pu-238	.3	.62
Pu-239/240	1.2	Pu-239/240	3.8	.52
Pu-241	Not found	Pu-241	11.0	32
Am-241	.4	Am-241	.9	.52
Co-60	.5	Co-60	2	280

For the F Reactor, radiologic inventory exceeded the Category Three threshold quantities (TQ's) in Table A-1 of Standard 1027 for strontium-90, plutonium-239, and americium-241. The D Reactor exceeded TQ's for plutonium-239. Both the F and D Reactor facilities were therefore given an preliminary hazard categorization (PHC) of nuclear, Category Three.

Standard 1027 states that once a facility exceeds hazard category three TQ's, a SAR consistent with DOE order 5480.23 (specifically, paragraph 8.b, "Scope and Content of Safety Analysis Reports") is required. Alternative direction was provided to the contractor to develop the full hazards analysis (which used a preliminary hazards analysis methodology, following the guidance of Standard 3009, Section 3.3) and the bounding accidents and release consequences derivative from the identified hazards. The outcome would be the final hazard categorization (FHC) for the facility. If the FHC was below Category Three--i.e., the facility's FHC was non-nuclear, Radiological--then the safety analysis would follow the form and content guidance of an "Auditable Safety Analysis", which is briefly described in DOE Standard 5502-94, "Hazard Baseline Documentation." In effect, DOE program direction "front loaded" determination of the FHC with the expectation of avoiding the attendant extensive analysis and program descriptions required for SAR's (e.g., criticality analysis, derivation of technical safety requirements, programmatic discussions, etc). However, if the FHC remained Category Three, a SAR consistent with DOE Order 5480.23 would have been required. This program direction assumed that criticality was incredible and that no accident releases would require on-site emergency planning activities.

Determining the FHC prior to commencing preparation of a full SAR was not inconsistent with direction provided in DOE Order 5480.23, "Nuclear Safety Analysis Reports". The Order allows considerable latitude in the sequence of events to prepare a SAR. While a hazards analysis and categorization is required (paragraph 8.b.(3).(e)), paragraph 8.c can be interpreted to imply that the hazards inventory, analysis, and categorization is completed first and submitted to DOE for approval before the full SAR is completed or even started. Thus, program direction did not violate DOE safety analysis requirements. However, the categorization process was not entirely consistent with Standard 1027.

For the F Reactor, DOE accepted a FHC of non-nuclear, Radiological. The significant inventory was almost entirely due to the inventory of the (assumed) five irradiated fuel rods in the fuel storage basin. Contrary to the guidance in Standard 1027, the FHC was not based on radionuclide inventory. Rather, an interpretation was made to the Standard based on how the TQ limits in Table A-1 were derived. Exposure to Category Three TQ's would result in a 10 REM whole body dose using an EPA model assuming a distance of 30 meters from the release point and a 24 hour exposure time. Turning this methodology around, if the worst-case accident dose was shown to be < 10 REM at 30 meters, regardless of the facility's source term compared to Table A-1's Category 3 TQ's, then the facility could be considered below hazard category Three, i.e., non-nuclear Radiological. In effect, this interpretation obviates Table A-1 TQ's and turns the Table on its head. If the facility release didn't exceed the criteria by which the Table was created, then the limits in the Table no longer matter. Some precedence for this interpretation exists.[5]

Such an interpretation was in fact applied to the F Reactor's FHC. Accident release calculations showed that worst-case dose was 3.5 REM to a receptor thirty meters from the facility. Therefore, because the release did not exceed 10 REM, the F Reactor was classified as non-nuclear, Radiological. A SAR consistent with DOE Order 5480.23 was not prepared. The facility's safety analysis contained a facility description and operating history, authorized work description, detailed hazards and accident analysis, and a listing of hazard controls, including programmatic controls, and was called an auditable safety analysis.[6] DOE formally approved the F Reactor's safety basis with a safety evaluation report.

For the D Reactor, DOE also accepted an FHC of non-nuclear, Radiological. However, the FHC was not based on the interpretation used for the F Reactor. Other DOE staff not previously involved with approval of the F Reactor safety basis questioned the technical legitimacy of calculating exposures within 100 meters of the release. Atmospheric dispersion coefficients at Hanford are calculated using the methodology described in Regulatory Guide 1.145, reference three, which truncates the process at 100 meters. Discussions with the Nuclear Regulatory

5 See final paragraph of memorandum, reference two.

6 A general description of an auditable safety analysis is contained in Section 5.2 of "Hazard Baseline Documentation", DOE-EM-STD 5502-94, August, 1994.

Commission (NRC) revealed that the NRC no longer employs Reg Guide 1.145 below 100 meters, either. The NRC recommended using NUREG/CR-6331, reference four, to determine dispersion coefficients at short (< 100 meters) distances from the release point. NUREG/CR-6331 contains improved models and other adjustments to the Gaussian equations. Further investigation revealed that Reg Guide 1.145 will substantially <u>overestimate</u> the dispersion coefficient as compared with NUREG/CR-6331.[7] As such, use of Reg Guide 1.145 would result in an overly conservative dose below 100 meters. In summary, other DOE staff rejected use of the "< 10 REM @ 30 meters" interpretation to categorize a facility as Radiological.

Nevertheless, DOE concurred that the FHC for D Reactor should be non-nuclear, Radiological based on the following four conditions:

- criticality was not credible;
- emergency evacuation of nearby facilities would not be required as a result of any ER work;
- no irradiated fuel pieces would be encountered during ER; and
- the hazards analysis did not credit either safety-class or safety-significant SSC's to prevent or mitigate the release of hazardous material.

These four conditions were either derived from Appendix A to Standard 1027, or were provided in an interpretation memorandum on Standard 1027, reference five. These conditions were invoked as operational restrictions on the work.

An FHC of non-nuclear, Radiological for F and D Reactors is supported by the following:

1. <u>Segmentation:</u> Sufficient segmentation of core contaminants away from the rest of the facility exists. The contaminants inside the pile are isolated in the sealed core block, which is also inviolate by specific project controls.
2. <u>Dispersibility:</u> Most of the radionuclides likely adheres to graphite in the central portion of the core. For the most part, reactor power was concentrated in the central core region. Therefore, most cladding failures likely occurred there and little TRU/fission product contamination is expected around the core perimeter. No mechanism exists for migration of contamination from the central graphite blocks toward the periphery. As such, there is little chance for release of contaminants except by catastrophic failure of the core itself. Such a release would require (from outward to inward) failure of the reactor shell, failure of the steel and masonite bioshield, and failure of the steel thermal shield followed by breakup and collapse of the graphite blocks. The analyzed earthquake could not cause such a release.
3. <u>Form:</u> The pile contaminants are solids and not gases. Release requires reducing

---

[7] The degree of overconservatism depends strongly on wind speed. The lower the speed, the greater is the error in the dispersion coefficient compared to what NUREG/CR-6331 would calculate. Above a wind speed of 3.5 meters per second (7.8 MPH), the difference drops significantly and is negligible above 4.5 meters per second (10 MPH).

the graphite to powder and then dispersing it. The graphite core could not be completely contaminated. Rather, irregular spots of contamination exists in the blocks. Therefore, substantial release of contamination would require substantial damage of the graphite, which was judged beyond extremely unlikely.

Section 3.1.2 of Standard 1027 allows considering the above factors in determining the FHC, but the Standard does not specifically allow such factors to be used to downgrade categorization from Three to Radiological. As such, categorization of the D Reactor was not strictly consistent with the Standard.

Hazard Categorization of the "327" Building:

"327" Building, Irradiated Fuel Examination and Testing Facility:
The 327 Building was designed to provide shielded, ventilated, and specially equipped labs for physical and metallurgical examination and testing of irradiated fuel rods (mostly from Hanford, although some work was done on commercial fuel rods and fuel from the Savannah River Site). In addition, concentrated fission products and structural materials from various Hanford facilities were examined. The Building has operated since 1953.

The facility is presently undergoing stabilization and deactivation, including removal of some radioactive source terms. No demolition is planned at this time.

The Building was originally categorized as nuclear, hazard Category Two. A Basis for Interim Operation (BIO) consistent with DOE Standard 3011, "Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans" was prepared for the Building. In reviewing the BIO, DOE noticed that the facility's source term was almost entirely contained in eleven heavily shielded concrete examination and test cells. However, segmentation of the source term had not been done.

Segmenting the source term into the cells allowed easy reclassification of the facility to nuclear, Category Three. Once the hazard category was reduced, DOE questioned why so many safety-class systems were ostensibly needed on a hazard Category Three facility. The lowered hazard category sparked interest into these systems' legitimacy based on actual risk and the attendant technical safety requirements (TSR's) on their operation. Significant overconservatisms were noted throughout the accident analysis and were removed. Thus, the simple act of properly categorizing a facility's hazards led to the thorough examination of the entire safety basis. The end result was the substantial simplification of that safety basis with no assumption of additional operational risk. Table Two summarizes the changes in the safety basis, before and after review.

Table 2
Changes to "327" Building Safety Basis
Following DOE Review

	Before DOE Review	**After DOE Review**
Hazard Category	Two	Three
Ventilation System's safety classification	Safety Class	Not safety-related
Building Structure's safety classification	Safety Class	Not safety-related
Packaging Containers' safety classification	Safety Class	Not safety-related
Ventilation system operation	Covered by TSR	TSR not required
Compactor hydraulic fluid berm for fire control	Safety-class dike required	No barrier needed at all

The lesson is that DOE's review of a submitted safety basis should not be clerical and non-invasive. Detailed independent appraisal and assessment of the basic assumptions and accident models should be done. Substantial benefit can be found by rooting out overconservatisms in the analysis, beginning with the hazard category by the simple expedient of utilizing recognized techniques, e.g., source term segmentation.

Hazard Categorization of the 116-N-3 Crib and Trench:

This disposal site received radioactively contaminated effluent cooling water from the large "N" Production Reactor. The site consisted of a buried concrete lateral assembly covered with concrete shield blocks which dispersed the water into the ground. See Figures Four and Five. Overflow residual water was directed into a long straight trench. The site operated from 1985 until April, 1991. Radiation above the shield blocks measured from 100 to 250 mREM/hour, beta-gamma. ER consists of completely removing the crib and trench, removing contaminated dirt to a depth agreed to by the EPA, and then replanting after covering the site with clean dirt.

Limited sampling was performed on the crib dirt. Cobalt-60 is a major contributor, along with the fission products cesium and strontium. Minor amounts of TRU radioisotopes are also present. In addition, the crib has minor amounts of metals, principally barium, cadmium, lead, and silver. The significant radionuclide inventory is shown in Table Three.

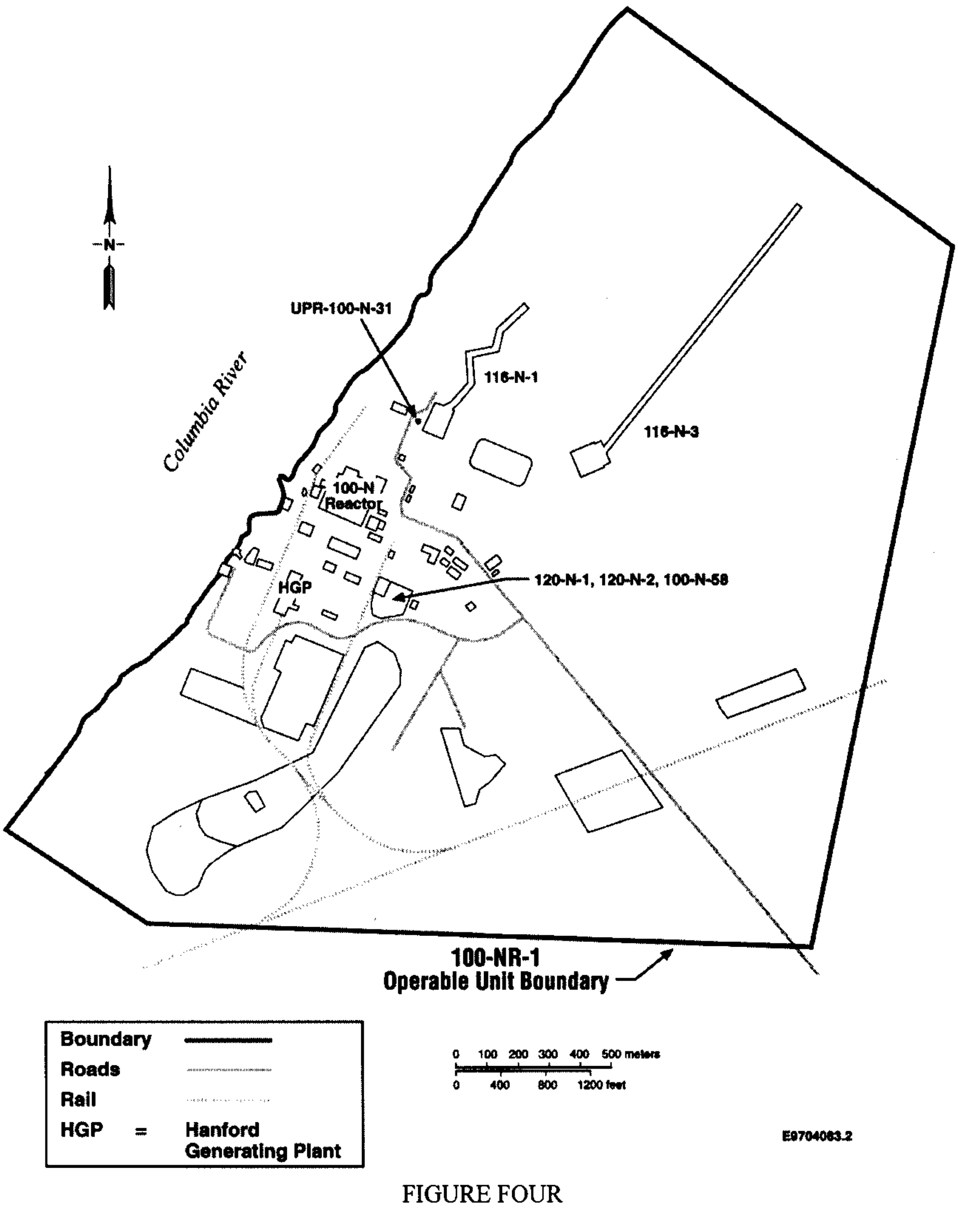

N
UPR-100-N-31
116-N-1
116-N-3
Columbia River
100-N Reactor
HGP
120-N-1, 120-N-2, 100-N-58
100-NR-1
Operable Unit Boundary
Boundary
Roads
Rail
HGP = Hanford Generating Plant
0 100 200 300 400 500 meters
0 400 800 1200 feet
E9704063.2

FIGURE FOUR

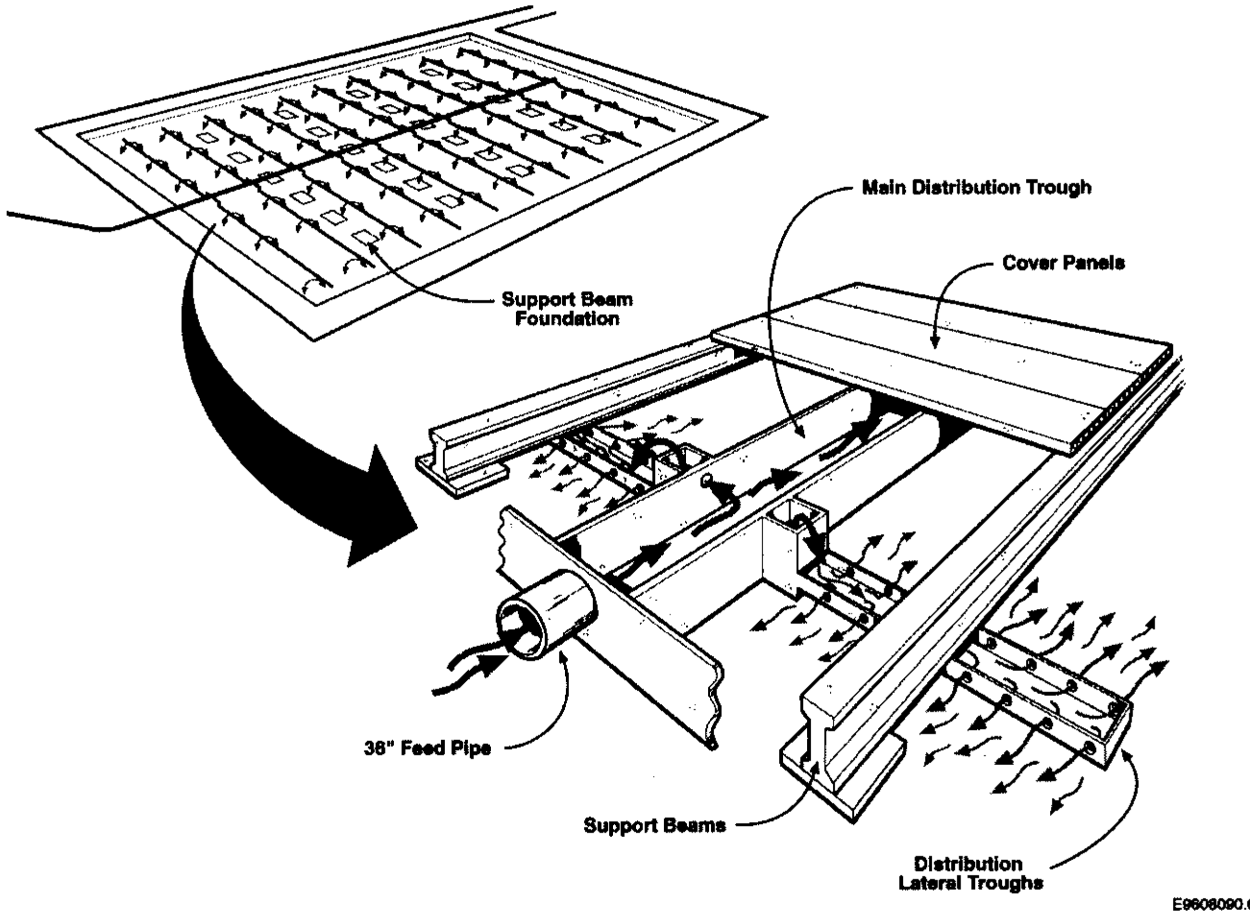

Main Distribution Trough
Cover Panels
Support Beam
Foundation
36" Feed Pipe
Support Beams
Distribution
Lateral Troughs
E9606090.6

FIGURE FIVE

Table 3
Major Radionuclide Constituents, 116-N-3 Crib

Radionuclide	Concentration (pico-Ci/g soil)
Cobalt-60	2.3 E+06
Strontium-90	5.5 E+04
Cesium-137	3.0 E+05
Plutonium-239/240	5.2 E+04
Americium-241	4.1 E+04
Plutonium-238	9.6 E+03

Note that each constituent radionuclide is expressed as a concentration of crib dirt and therefore the radioactive inventory depends on the crib volume assumed. The site's hazard categorization, which of course is derived from that inventory, also therefore depends on the volume of dirt assumed. Since the perimeter dimensions of the site were fixed, the volume of dirt depended directly on the depth considered.

Originally, only the top one centimeter of soil was counted in the dirt volume. Interpretation of data in reference six provides some defense for this practice. While possibly appropriate for very low-level sites, DOE found this unacceptable for sites with any appreciable levels of radiation. Considering only the top centimeter would exclude energy input from excavation and transport activity that could involve the radioactive inventory. In addition, since exclusion of nearly all the site dirt generally resulted in a categorization of radiological (or lower), the practice did not allow for appropriate DOE review of the ER work or its controls. DOE directed that the entire volume of dirt that could reasonably be considered to be contaminated be included in calculating the radiologic inventory. The PHC for the 116-N-3 Crib and Trench was nuclear, Category Three based on sum of the ratios of radioisotopes.

Similar to the process for the production reactors, a detailed hazards analysis was conducted and accident releases calculated. Similar to the F Reactor, the FHC was found to be Radiological based on the "< 10 REM @ 30 meters" interpretation of Standard 1027. DOE did not accept this method for determining the FHC.

However, DOE did concur in the Crib and Trench's FHC as Radiological by finding that:

- criticality was incredible;
- emergency evacuation of nearby facilities would not be required as a result of ER;
- no irradiated fuel pieces would be encountered during remediation;
- the hazards analysis did not credit either safety-class or safety-significant SSC's to prevent or mitigate the release of hazardous material; and
- no ER work was performed inside a permanent structure.

Thus, the FHC was consistent with interpretative guidance previously issued on Standard 1027, reference five. In addition, DOE's own calculation showed that the worst case release from the Crib in a wind storm would be .48 REM to a co-located worker, 100 meters from the facility, which DOE considered to be an insignificant local release.[8] (Actual location of such a worker is at least 300 meters.) Applying the definition of a Category Three hazard facility from paragraph 8.c.(1).(c) of Order 5480.23, since the hazards and accident analysis showed the potential for less than significant localized (i.e., on-site) consequences, the Crib and Trench were below category Three. Based on the above conditions and calculations, DOE concurred that the FHC for the Crib and Trench was non-nuclear, Radiological.

Determination of the hazard category of the 116-N-3 Crib and Trench FHC was not strictly consistent with Standard 1027. However, DOE's determination of hazard category was consistent with DOE Order 5480.23, which was (at the time) the binding requirement on both the contractor and DOE.

Application of 10 CFR 830 Subpart B to the Above Cases:

With the exception of the "327" Building, none of the above cases of hazard categorization was determined in strict compliance with Standard 1027. However, DOE-RL believes that all three cases involved legitimate interpretations of the Standard's intent. Because interpretations were involved, all three cases would have violated 10 CFR 830.202.(b).(3), "categorize the facility consistent with DOE-STD-1027-92." The hazard categorization for all four cases was completed in either 1999 or 2000, prior to implementation of 10 CFR 830 Subpart B.

To the author's knowledge, the waiver or exemption process to the regulations in 10 CFR 830 has yet to be tested. No basis exists for believing an exemption/waiver would either have been granted or denied for these cases. DOE-HQ-EH has stated that the several previously issued interpretative memorandums on Standard 1027 could be used as the basis for an exemption/waiver. That assertion notwithstanding, EH-HQ has also stated that the various interpretations do <u>not</u> now apply to 10 CFR 830 Subpart B and specifically to the categorization process described in the Standard.

Conclusions:

Environmental restoration, D&D, or surveillance and maintenance activity is proceeding smoothly at all the case study sites examined. Each facility's safety analysis, whether a BIO or ASA, is believed by DOE-RL to be comprehensive and thorough for the actual facility hazards, with adequate controls to protect the workers, the public, and the environment. Proper

---

8 – DOE assumed a continuous 6 hour release in a 20 MPH wind under moderately stable atmospheric conditions. Plume meander was not credited, nor was the presence of any confinement or wake structures considered. An airborne release rate and respirable fraction of 4E-05/hr x 1.00 was taken from Section 4.4.4.1, DOE Handbook 3010.

categorization of a facility's hazards is essential to determining the analytic rigor and depth of the safety analysis. Because the hazard category is determined early in the process, it then shadows the remaining analysis. Improper determination of a category higher or lower than it should be for the actual hazards can impact that analysis, either making it excessively detailed or superficial.

It was found that the correct early determination of hazard category substantially simplified the subsequent safety basis by avoiding unnecessarily complex analysis without reducing safety provisions for the workers, the public, or the environment. Interpretations to the provisions in DOE Standard 1027 were used, consistent with DOE policy at the time. DOE-RL believes these interpretations are justified.

The recent implementation of 10 CFR 830, Subpart B presents new challenges in determining hazard category by strict reliance on DOE Standard 1027 with little apparent room (at this time) for interpretation. What is now needed as the Rule is implemented across the DOE complex are interpretative policies that allow the important determination of hazard category to remain straight forward and reasonable. Such interpretations will avoid unproductive additional analysis that adds no incremental safety benefit to the workers, the public, or the environment.

References:

1. UNI-3714. "Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford", UNI-3714, Revision 1, April 1, 1987. Edited by R. L. Miller and J. M. Steffes.

2. Memorandum, R. L. Black, DOE-EH, to C. M. Steele, LANO, "Request for Interpretative Guidance on Final Hazard Categorization of the Sigma Complex", dated February 25, 1999.

3. Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants", Revision 1, November, 1982, reissued February, 1983. Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission.

4. NUREG/CR-6331 (PNNL-10521), "Atmospheric Relative Concentrations in Building Wakes", Revision 1, May, 1997. Prepared by J. V. Ramsdell, Jr. and C. A. Simonen, PNNL, Richland, Wa. Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission.

5. Memorandum, R. L. Black, DOE-EH, to John Psaras, DOE-EM, "Hazard Categorization for Environmental Management Activities Related to Stabilization, Deactivation, Decontamination, and Decommissioning, and Environmental Restoration", dated June 9, 1997.

6. Sehmel. "Particle Resuspension: A Review", G. A. Sehmel, 1980, Environment International, Volume 4, pp. 107-127.