PRELIMINARY ASSESSMENT OF MIXED HAZARDOUS AND RADIOACTIVE INACTIVE WASTE SITES AT HANFORD

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ABSTRACT

In July 1986, the U.S. Department of Energy - Richland Operations Office (DOE-RL) and Pacific Northwest Laboratory completed a preliminary assessment of 337 inactive waste sites that were used between 1943 and 1980 to dispose of liquid and solid wastes to the soil column of the Hanford Site. The study, as reported here and in a draft report, was performed as the first phase of DOE-RL's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program and will be used to determine which sites should be further investigated and possibly remediated. It should be noted that, because the report is not yet final, some of the results could change. This work was supported by the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

INTRODUCTION

The CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (1) provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste sites, including those sites on federal agency installations. The U.S. Department of Energy's (DOE) CERCLA program, as implemented by DOE Order 5480.14 (2) defines actions to identify and evaluate inactive hazardous waste disposal sites on DOE installations and to effect remedial actions where necessary to improve control of migration of hazardous substances (i.e., radionuclides or hazardous chemicals) from such sites. The Order requires that potential CERCLA sites be assessed, characterized, monitored, and, if necessary, remedial action provided in a five-phase program as shown in Table I. These phases correlate to the process required by the Environmental Protection Agency (EPA) through 40 CFR 300 (3) and CERCLA remedial investigation guidance documents (4, 5, 6) as shown in Table II.

TABLE I

Outline Schedule of the Five-Phase DOE CERCLA Program

Phase/Title	Activities
I. Installation Assessment	Literature Review Employee Interviews Site Identification/Location Hazard Ranking Report
II. Confirmation	Monitoring/Characterization Plan Sampling/Analysis/Characterization Hazard Ranking Report
III. Engineering Assessment	National Environmental Protection Act (NEPA) Documentation Engineering Studies Alternative Studies Remedial Action Planning Implementation
IV. Remedial Action	Engineering Design Construction
V. Compliance and Verification	Repeat of Phase II

SITE HISTORY

Established in 1943, the Hanford Site was originally designed, built, and operated to produce plutonium for nuclear weapons using fuel fabrication facilities, production reactors, and chemical reprocessing plants. Over the intervening years, waste management, energy research and development, isotope production, and other activities have been added to the mission of the Hanford Site (7). Fig. 1 shows Hanford's major areas and their relationship to the State of Washington.

The Site is divided into four principal areas: 1) nine 2.2- to 3.9-square-kilometer "100 Areas" adjacent to the Columbia River, built to house eight once-through-cooled, and one dual purpose (including steam-generated power) production reactors and support facilities; 2) two 8-square-kilometer "200 Areas" located on a plateau near the center of the Site, dedicated to chemical separations and waste operations; 3) a 1.5-square-kilometer "300 Area" adjacent to the Columbia River and near the southern boundary of the Site, used to support the fabrication of reactor fuel, including laboratories; and most recently, 4) a 0.5-square-kilometer

TABLE II

Comparison of EPA and DOE CERCLA Programs

EPA Process	DOE Process
National Oil and Hazardous Substances	DOE Order 5480.14 CERCLA Program
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Site Discovery/Notification	Phase I - Installation
Preliminary Assessment and Site Inspection (PA/SI)	
Scoring priorities for remedial action using Hazard Ranking System (HRS)	
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Remedial Investigation (RI)	Phase II - Confirmation/ Quantification
Feasibility Study (FS)	Phase III - Engineering Assessment
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Remedial Action Design and Construction	Phase IV - Remedial Action
	Phase V - Compliance and Verification

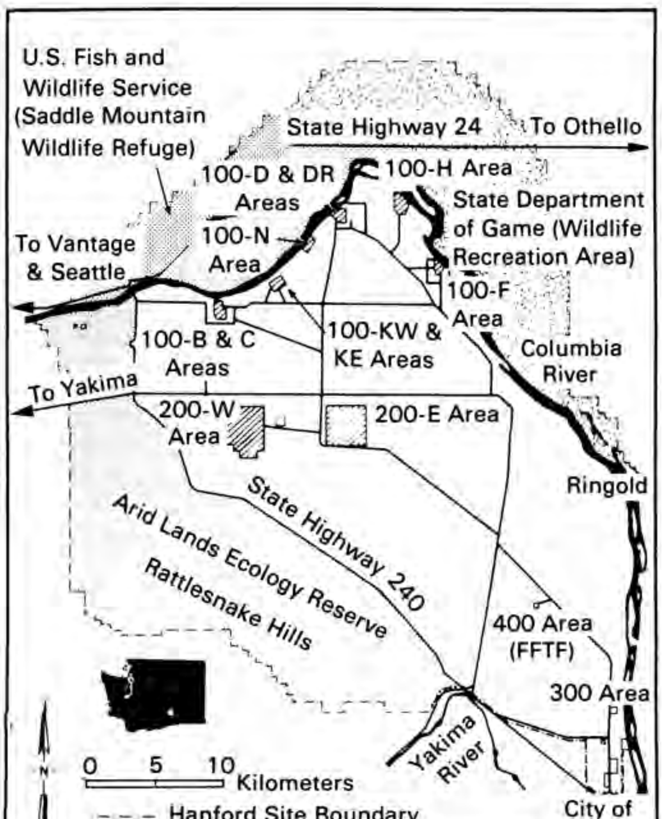

Fig. 1. Features of the Hanford Site

"400 Area" south of the center of the Site, used to support a liquid-sodium-cooled breeder reactor for research and development.

Because of the long history of the Hanford Site, certain changes in mission were determined to be of particular interest to this study since they involved changes in the use of the Hanford soil column for disposal of solids and liquid wastes. These changes are:

- phase-out and shutdown of all eight once-through cooled production reactors and support facilities in the 100 Areas between 1965 and 1971
- substitution of the bismuth phosphate precipitation process with solvent extraction chemical reprocessing in 1956 in the 200 Areas
- segregation (in retrievably stored containers) of transuranic waste from low-level waste, beginning in 1970
- termination of routine liquid discharges containing transuranics to the 200 Area soil column beginning in 1973
- consolidation of radioactive solid-waste disposals in all Hanford Areas into the 200 Areas and of all non-radioactive trash/chemicals into a site near the 200 Areas beginning in 1973.

These process and administrative changes resulted in better waste management practices. For example, the consolidation of all radioactive solid waste burials into the 200 Areas resulted in farther distances between the wastes and water (both surface and ground waters).

METHODOLOGY

According to DOE Order 5480.14 (2), the inactive waste disposal sites on the Hanford Site were preliminarily evaluated to determine if the sites were potential threats to public health and/or the environment. The basic methodology used to evaluate these inactive sites is shown in Fig. 2. The process involved the following steps: 1) data collection through an exhaustive literature review and confirmation via employee and former employee interviews; 2) site inspections and photographs; 3) generation of inventory data by updating existing radionuclide data taken from other sources and estimation of chemical inventories based primarily on knowledge of processes that generated the wastes; 4) distribution of data to DOE and operating contractors and comment resolution; 5) application of both the EPA's and the DOE's ranking processes, entitled the Hazard Ranking System (HRS) and modified Hazard Ranking System (mHRS), respectively; 6) confirmation of the scores in the previous step through a supplemental technical analysis to determine if the sites were potential threats to public health and/or the environment; 7) further prioritization of sites; and 8) reporting of results.

FINDINGS

Following the first four steps in the process described above, many facts were discovered. Hanford operations resulted in the use of 337 engineered liquid- and solid-waste disposal sites beginning as early as 1943 and terminating prior to November 1980. The surface area of these sites ranges from less than 1 square meter to more than 15 hectares; they occupy approximately 1%

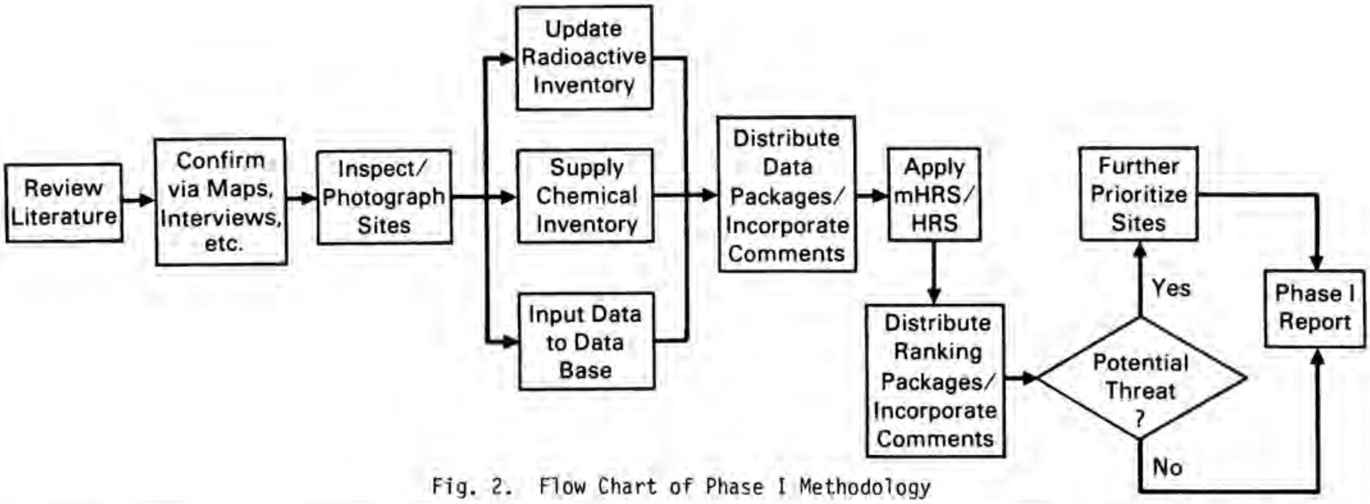

Fig. 2. Flow Chart of Phase I Methodology

(1416 hectares) of the area of the Hanford Site. Their active disposal period ranged from a few days to 32 years. Average depth-to-ground water from the surface of these sites ranged from 13 meters in the 300 Area to 73 meters in the 200 Areas.

Wastes were disposed of in a variety of engineered structures; the most prevalent, by area serviced, included burial grounds (100 Areas), cribs (200 Areas), and liquid-waste trenches (300 Area). The 400 Area contained no inactive waste sites. Fig. 3 through 5 depict typical design features of these waste disposal systems.

Of the 337 sites, three-quarters were used to dispose of liquid. Two-thirds of the sites were within or adjacent to the 200 Areas. Most sites received both radioactive and chemical constituents (i.e., mixed wastes). Approximately 6 and 10% of the sites disposed only nonradioactive or only radioactive wastes, respectively.

In all, inactive sites were used to dispose of over 1×10^8 cubic meters of liquids and 1.4×10^5 cubic meters of solids. Inventories of chemicals and radionuclides disposed of in these systems are shown in Table III.

TABLE III

Inventories of Chemicals and Radionuclides in Inactive Waste Disposal Sites

Contaminant/ Radionuclide	Quantity (metric tons)	Quantity (tons)	Quantity (curies)
Nitrate	63,000	69,445	
Phosphate	4,400	4,850	
Sulfate	3,000	3,307	
Nitrite	2,200	2,425	
Fluoride	970	1,069	
Organic carbon	760	837	
Chromium (VI)	260	287	
^{239}Pu			29,900
^{137}Cs			28,000
^{90}Sr			23,700
^{240}Pu			8,000
^{238}U			200

The final step in this preliminary assessment was the screening of inactive waste sites based on the collected and available data. In the process of using the EPA's HRS and the DOE's modification to that system (mHRS), which more accurately accounts for the radionuclide waste characteristic parameters, like some other authors (8), we noted that migration scores were sometimes inadequate for assessing the potential hazard of many Hanford waste-disposal sites.

These systems require that a site with evidence of release of contaminants to ground or surface water be classified as an "observed release." (This classification, we found, inevitably led to a high score.) Guidance manuals state that contaminants found in these media near a waste site constitute analytical evidence of a release if such contaminants were known to be disposed of in these sites (9, 10). However, the manuals also state that evidence of a release should be confirmed via data that show a direct correlation between the constituents of a waste site and the environmental media.

This ambiguity resulted in a dilemma because the underlying aquifer beneath the Hanford Site is known to have received radionuclides and chemicals (primarily tritium and nitrates) from both inactive and active waste sites (11); moreover, most inactive sites are situated above an aquifer known to contain these contaminants and thus could be construed as having observed releases. In dealing with this ambiguity we had two options available, both of which seemed unreasonable because they would have resulted in uniformly high or low scores. These options were: 1) all waste sites situated over a contaminated aquifer would be classified as having an observed release or 2) only waste sites with direct evidence of releases via near-field monitoring wells would be classified as having observed releases. Because neither of these options would be useful in discriminating between sites *that truly* might or might not pose a risk to public health and/or the environment, an intermediate option was chosen: sites with either direct (e.g., monitoring wells or well-logging techniques) or "strong circumstantial" evidence were classified as observed release sites. Strong circumstantial evidence, in this case, was determined if the volume disposed of in liquid sites exceeded the conservative retention capacity of the soil. In this manner, it could be determined if a wetting front in the vadose zone reached the unconfined aquifer.

The HRS point system used by the EPA to potentially nominate inactive sites to the National

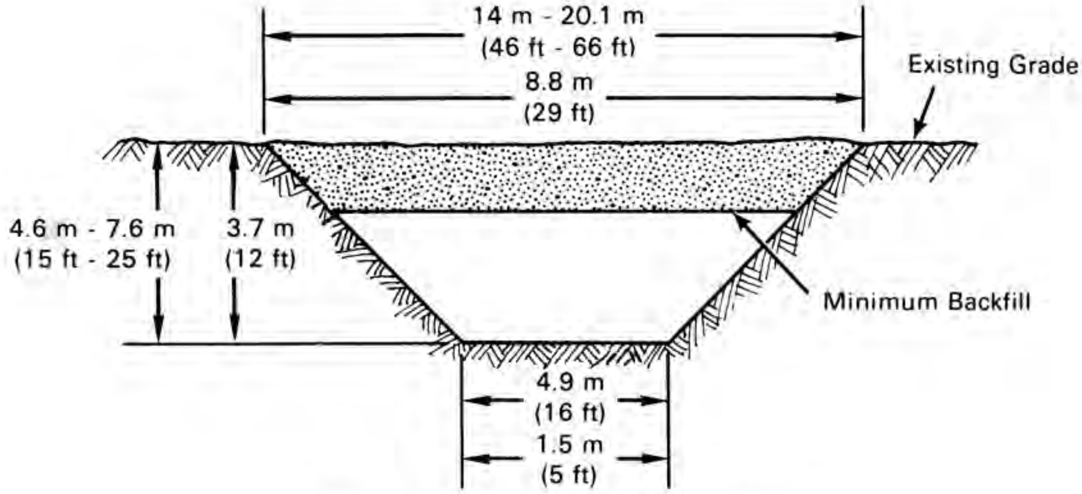

Fig. 3. Typical Hanford Burial Ground.

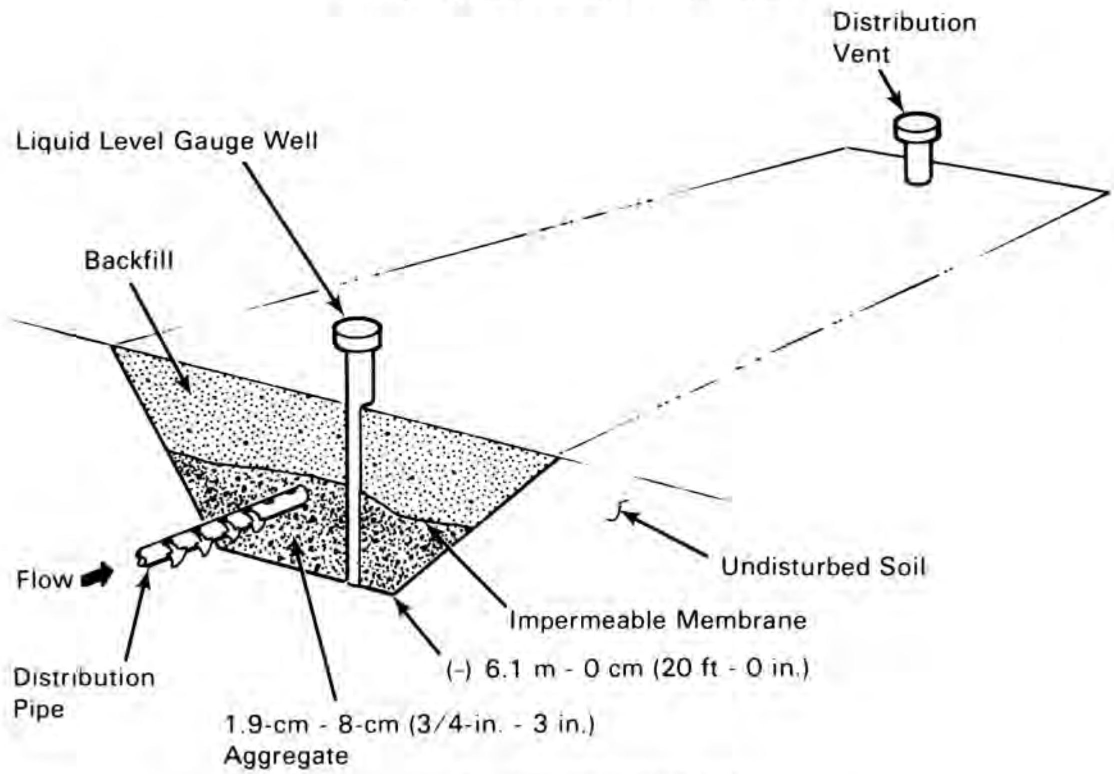

Fig. 4. Typical Hanford Crib.

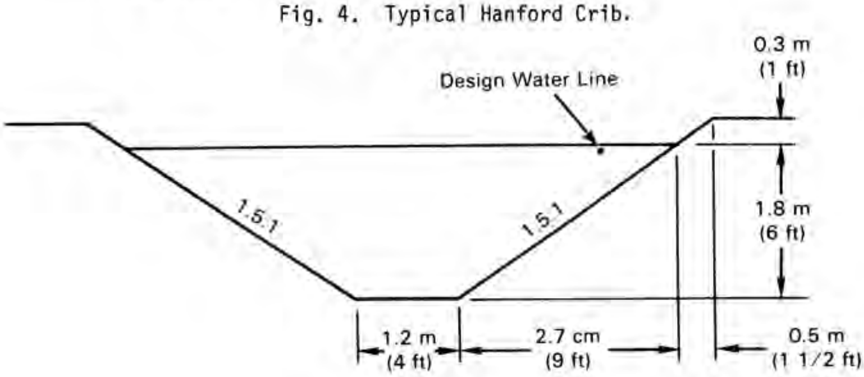

FIGURE B.22. Typical Liquid-Waste Trench

Fig. 5. Typical Hanford Liquid Waste Trench.

Priority List (3) is 28.5 out of 100; this score delineates between sites that should be further investigated and those that may not be or are lower priorities from a characterization standpoint. Of the 337 inactive wastes sites evaluated, 81 (24%) scored higher than 28.5 using HRS/mHRS. All of these sites contained disposed liquids and were classified as having observed releases by the method discussed above. In most cases, however, the observed releases have not yet been positively confirmed by analytical data. About 65% of the sites that ranked greater than 28.5 are located in the 200 Areas, with most of the remainder in the 100 Areas. As shown in Fig. 6, a greater proportion of these sites were designed and first used in the 1940's and 1950's.

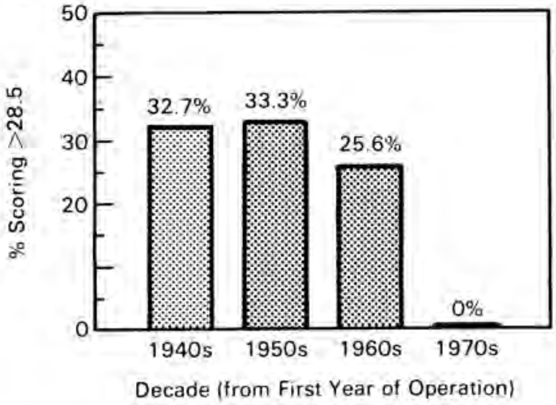

Fig. 6. Proportion of Sites Scoring Over 28.5, by Decade.

A Hanford-specific technical assessment was used to supplement the HRS/mHRS analysis. This assessment grouped sites by their origin, waste type, and ranking by HRS/mHRS scores. The system made additional judgments based on the waste type. For example, 100 Area liquid sites were classified in one of four waste types from least to most potentially hazardous--reactor coolants, ruptured fuel-storage liquid effluents, decontamination wastes, and miscellaneous wastes. Similarly, 200 and 300 Area liquid and solid waste sites were also classified. Results of this supplemental assessment are shown in Fig. 7. Of the 81 sites ranked greater than 28.5 by HRS/mHRS, 19 were determined to be falsely ranked too high. Conversely, of the 256 ranked less than 28.5, 139 were determined to be potentially ranked too low, especially if future conditions are considered. These false highs and lows were grouped together into an intermediate "further action pending" category. The supplemental technical assessment confirmed that HRS/mHRS had correctly ranked 117 sites not requiring further action and 62 sites that should be characterized as part of the next characterization step in the DOE CERCLA process. Of the 62 sites, it was determined that, based on the proximity and similarity of wastes disposed, 13 sites could be combined with others, thereby reducing the actual number of areas to be characterized to 49.

CONCLUSIONS

Of the 337 engineered structures used for the disposal of liquid and solid wastes on the Hanford Site between 1943 and 1980, there is very little direct evidence to indicate that any pose a risk to

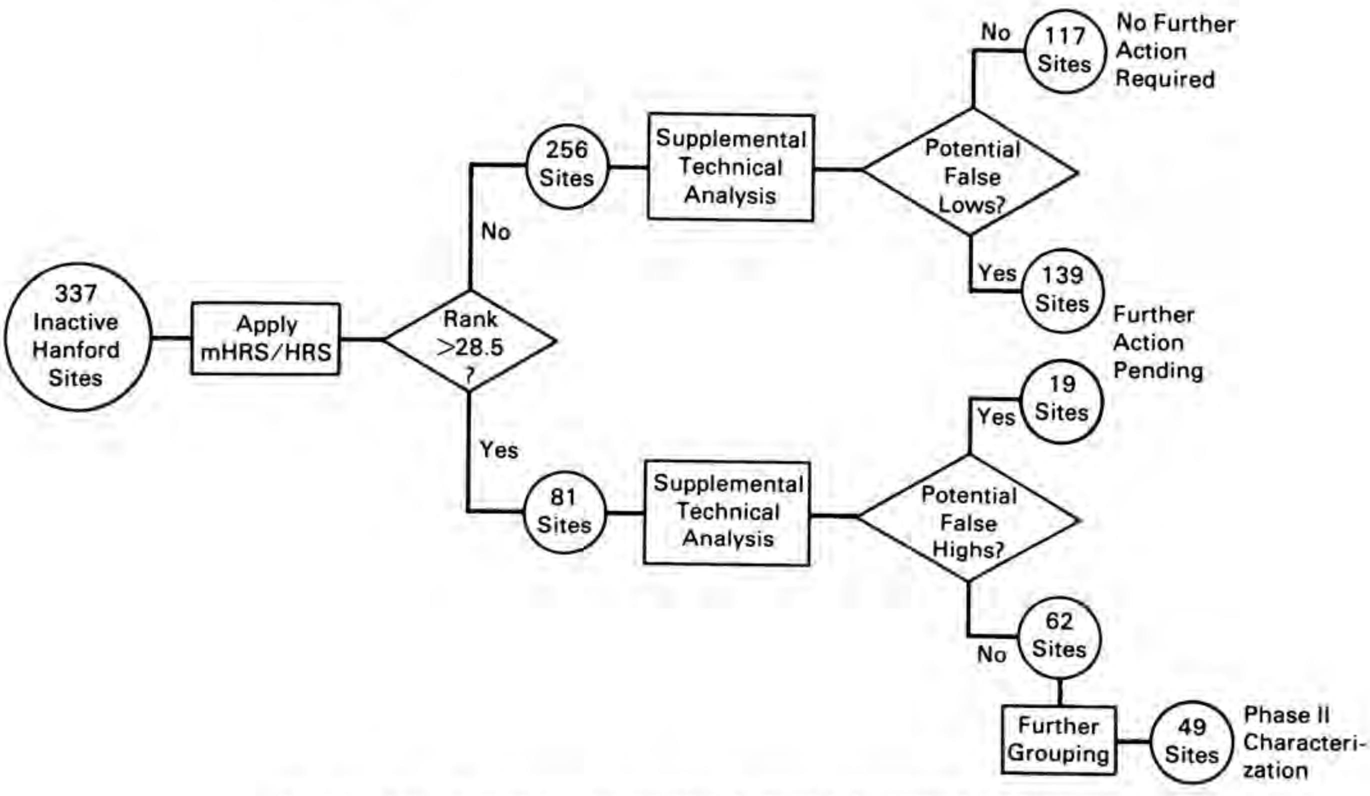

Fig. 7. Flow of Hanford Supplemental Technical Assessment Process.

public health. However, a preliminary assessment showed that 62 sites should be characterized. Moreover, an additional 158 inactive waste sites should also be further investigated to determine if they should be characterized.

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