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SUPPORTING DOCUMENT		Number	Rev. No.	Page A of 15 Total Pages																																																
PROGRAM: Waste Management		SD--WM-TP-30	0																																																	
Document Title: Subsurface Marker Emplacement Test Plan		Baseline Document ☐ Yes ☒ No																																																		
Key Words: Markers, Subsurface Markers Testing, Protective Barriers		WBS No. or Work Package No. HLJAP																																																		
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Abstract <p>Current plans propose placing subsurface markers within protective barriers to deter potential human intrusion into disposed radioactive wastes. The subsurface markers would provide warning to the digging intruder should surface markers be removed, destroyed, or ignored. This plan sets forth procedures for testing the survivability of the subsurface markers during construction of the barrier. After the tests described herein are concluded, a decision can be made as to whether subsurface markers will require protection during barrier construction. If protection is required, additional tests will be needed to test the effectiveness of various protective approaches.</p>		<table border="1"><thead><tr><th>* Distribution</th><th>Name</th><th>Mail Address</th></tr></thead><tbody><tr><td colspan="3">U.S. Department of Energy Richland Operations Office</td></tr><tr><td>*</td><td>E. A. Bracken</td><td>FED/626-A/700</td></tr><tr><td>*</td><td>C. E. Collantes</td><td>FED/588 /700</td></tr><tr><td>*</td><td>M. W. Shupe</td><td>FED/626-D/700</td></tr><tr><td colspan="3">Pacific Northwest Laboratory</td></tr><tr><td>*</td><td>J. N. Hartley</td><td>RTR/1/7/3000</td></tr><tr><td>*</td><td>G. W. Gee</td><td>Sigma-5/3000</td></tr><tr><td colspan="3">Rockwell Hanford Operations</td></tr><tr><td>*</td><td>M. R. Adams</td><td>2750E/D200/200E</td></tr><tr><td>*</td><td>B. W. Anderson</td><td>2750E/C130/200E</td></tr><tr><td>*</td><td>J. W. Cammann</td><td>222U/7B/200W</td></tr><tr><td>*</td><td>R. A. Carlson</td><td>222U/14/200W</td></tr><tr><td>*</td><td>H. E. McGuire</td><td>2750E/A237/200E</td></tr><tr><td>*</td><td>K. W. Owens</td><td>2750E/C128/200E</td></tr><tr><td>*</td><td>N. R. Wing</td><td>222U/5A/200W</td></tr></tbody></table>			* Distribution	Name	Mail Address	U.S. Department of Energy Richland Operations Office			*	E. A. Bracken	FED/626-A/700	*	C. E. Collantes	FED/588 /700	*	M. W. Shupe	FED/626-D/700	Pacific Northwest Laboratory			*	J. N. Hartley	RTR/1/7/3000	*	G. W. Gee	Sigma-5/3000	Rockwell Hanford Operations			*	M. R. Adams	2750E/D200/200E	*	B. W. Anderson	2750E/C130/200E	*	J. W. Cammann	222U/7B/200W	*	R. A. Carlson	222U/14/200W	*	H. E. McGuire	2750E/A237/200E	*	K. W. Owens	2750E/C128/200E	*	N. R. Wing	222U/5A/200W
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Release Stamp <p>APPROVED FOR PUBLIC RELEASE <i>V. Bickland 7/28/94</i></p>		<p>(Continued on reverse side)</p> <p>*COMPLETE DOCUMENT (No asterisk, title page/summary of revision page only)</p>																																																		

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DESCRIPTION OF CHANGE				

EXECUTIVE SUMMARY

This document presents a plan to test the survivability of subsurface markers during the construction of the protective barriers within which the subsurface markers are to be placed. Implementation of the plan will enable the markers to be placed and later exhumed and examined for breakage. The tests will involve use of materials, equipment, and procedures typical of those to be used during actual barrier construction. Three plots will be used to test the effect of the operation of heavy equipment on markers placed under lifts of sand (with geotextile), native Hanford soil, and basalt riprap. The tests are estimated to cost \$30.0 K and require a period of 6 weeks to complete. After the tests described herein are concluded, a decision can be made as to whether subsurface markers will require protection during the barrier construction. If protection is required, additional tests will be needed to determine the effectiveness of various alternate protective approaches and techniques.

DISCLAIMER

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1.0 INTRODUCTION

A protective barrier and marker system is being developed for potential use in the disposal of radioactive wastes at the Hanford Site. Such a system will be needed to implement any of the final disposal alternatives being considered. Before any waste disposal alternative or plan can be implemented, a number of technical issues must be closed. These technical issues, including those relating to barriers and markers, are described in the Interim Hanford Waste Management Technology Plan (HWMTP).¹ Plans to close barrier and marker development issues are described in greater detail in the Protective Barrier and Warning Marker System Development Plan.² One technical issue associated with marker development is the ability of subsurface markers to survive the construction of the protective barrier within which they will be placed. Current plans call for placing subsurface markers in three different layers within the protective barrier. Subsurface marker prototypes have been procured and subjected to laboratory testing for various chemical, physical, and thermal stresses.³

2.0 OBJECTIVES

The purpose of the document is to set forth a plan for testing in the field the construction survivability of subsurface markers. Specific objectives of the tests are to:

- o Determine if the subsurface markers can survive barrier construction to an acceptable degree given the earth materials, equipment, and construction procedures to be used in actual barrier construction.
- o Verify the laboratory mechanical strength test results in an actual field construction setting.
- o Determine if subsurface markers will need to be shielded or shrouded during barrier construction to provide an adequate degree of survivability. If shielding or shrouding is needed, an additional series of field tests will be required to test alternate shielding/shrouding techniques. These tests will be described in general, but not in detail in this plan.

For purposes of the tests, acceptable survivability will be considered to mean that the markers break into three or less intact pieces during construction. This criterion is justified on findings from archaeological digs in which artifacts found in just a few large pieces can be easily and quickly reconstructed with little loss of information. Laboratory mechanical tests of prototype subsurface markers determined that when the markers failed, they tended to break into three pieces.⁴ This is considered to be acceptable based upon archaeological considerations.

3.0 SCOPE

The scope of these tests extends to prototype markers subjected to live loads of that construction equipment expected to be used in actual barrier construction. The markers will be subjected to live loads after emplacement under lifts of native Hanford soil, sand, and basalt riprap rock typical of those minimum lifts expected to be used during actual barrier construction. Tests will be conducted using incremental subtraction of lift thickness so that the relationship between lift thickness and marker survivability can be determined.

Impact-load tests will also be conducted with basalt riprap to determine the maximum height of dump a subsurface marker can withstand when riprap is placed from a dump truck. The scope extends only to type B prototypes because adequate prototype B markers have been procured and stockpiled to conduct the tests, and because the type B prototype has been selected for testing based on the best overall performance among the five marker prototypes tested considering chemical, thermal, and mechanical resistance factors.

The tests described herein will not include shielding or shrouding tests, however, the data collected can be used to determine whether such tests are required. General descriptions of shielding or shrouding tests will be provided to assist in planning such tests, should they become necessary.

4.0 CONDITIONS OF THE TESTS

4.1 LOCATION

The tests will be located at the Protective Barrier Test Facility (PBTF) (Figure 4.1). An area large enough to accommodate the tests, stockpiles of necessary materials and equipment, parking and turnaround sections will be measured by surveyor chain and staked. The area chosen will be accessible from the road entering the PBTF. The specific location at PBTF will be chosen so as not to interfere with past or future test stations or plots at the PBTF. The area to be used for testing will be cleared and graded before use.

4.2 TEST DESIGN

4.2.1 Lift Tests

Three separate emplacement test plots will be constructed including:

- o Hanford native soil test plot
- o Sand over geotextile test plot
- o Basalt riprap test plot.

Figure 4.1. Location of Protective Barrier Test Facility.

The tests will be conducted in three 60 ft x 46 ft area test plots, each plot then divided into three sections (Figure 4.2). Within each of these sections, a total of 10 subsurface markers will be emplaced, formed in two rows (five markers in each row), as shown in Figure 4.3. The rows will be two ft apart in each section. In the soil test plot, for example, the upper section will be covered with a 2 ft lift of Hanford Site topsoil. The middle section will contain the same array of markers covered by a 1.5 lift of soil. Finally, the marker array in the lower section will be covered with a .5 ft lift of soil. The lifts will be placed by equipment moving from the upper section backward to the lower section such that the equipment will not drive over the markers in any emplaced section. (The machinery will be used to push or dump soil over the markers placed in the section without driving over them.) The sand over geotextile test plot will be arranged the same as the soil test plot except that geotextile will be placed over the markers in the section before the sand lift is placed. Again, the equipment will push or dump soil over the markers in a section without driving over the markers. The basalt riprap test plot will be arranged the same as the soil test plot except that the lifts will be 3 ft, 2 ft, and 1 ft thick, respectively, from the upper to lower sections.

The lift tests are designed to simulate actual barrier construction conditions. The barrier design calls for markers to be placed under the basalt riprap layer, under a topsoil layer, and within or under the filter layer which consists of sand over geotextile. The emplacement tests therefore duplicate these conditions to the extent practicable. Variable lifts are tested to represent the likely range of lifts to be utilized in actual barrier construction. For example, it is unlikely that lifts thinner than 6 inches (.5 ft) or thicker than 2 ft will be used routinely during construction.

The markers in each row are placed 10 ft apart since the barrier design requires marker placement on 3 m (10 ft) centers. Two rows are placed in each section to provide duplicate test data within each section. The use of duplicate rows and multiple markers within rows will allow the variability in test data to be estimated.

In the soil lift tests, the soil under the marker should be silty without gravel. If the soil at the chosen site is not silty, a depression 6 inches in diameter and 1.5 inches deep should be formed and filled with silty soil. Likewise, for the sand over geotextile tests, markers should be placed on a similarly formed fine, gravel base. In the basalt riprap test, markers should be placed on whatever soil is at the site.

4.2.2 Impact-Load Tests

Because of the potential for breakage of markers when basalt riprap is dumped from dump trucks during the construction of the riprap portion of the barrier, a series of three impact-load tests will be conducted. The first test will involve dumping riprap directly on an array of 10 markers from the minimum dump height obtainable by the equipment. The second and third tests will be done from increased height increments up to the maximum obtainable. Enough rock should be dumped to cover the markers with 2-3 ft of rock. The array of markers will consist of two rows with five markers in each row. The edges of the markers will be separated by a distance of about 3 inches.

Figure 4.2. Layout of Marker Survivability Test Area

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Figure 4.3. Design of Plot for Marker Survivability Test (Soil Lift Test).

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4.3 TEST PROCEDURE

4.3.1 Lift Tests

Following placement of all markers in all marker test plot sections and the placement of lifts, a fully loaded 14,000 gal. capacity water truck will be driven over the native Hanford soil and sand test plots; such that the entirety of each plot is driven over at least once. A D8L-95,000 lb. wt. crawler tractor will be driven over the basalt riprap test plot since a tractor wheel cannot survive construction activity on basalt. After this is done, each marker will be exhumed and inspected for breakage or cracking. The ends of each marker row should be staked prior to the test so that marker locations can be quickly determined with the aid of a surveyor chain. Overburden covering the marker may be removed mechanically provided that this can be done without driving over or touching the markers. In any event, the last increment of soil or rock covering the marker should be removed by hand tools or by hand so that the undisturbed state of the marker can be observed. Information regarding each exhumed marker should be recorded as specified in section 4.7.

4.3.2 Impact-Load Tests

The impact-load tests will be performed as described in section 4.2.2. The tests will be completed prior to the construction of the plots described in section 4.2.1 so that the basalt riprap material can be reused for plot construction. After the impact-load tests, the subsurface markers will be exhumed and inspected for breakage and cracking. Information regarding each exhumed marker must be recorded as specified in section 4.7.

4.4 MATERIALS REQUIRED

Materials required to perform the tests are summarized in Table 4.1. Equipment and instruments required are listed in Table 4.2

Table 4.1. Material Required for Marker Emplacement Tests.

Material	Units Required	Material Specification
Subsurface Markers	120	Type B prototypes, stored in Bldg. U-12, 200 West Area
Hanford Topsoil	135 cu. yd.	Native, silty soil
Sand	135 cu. yd.	ASTM spec. sand characteristics U.S. Standard Sieve Mesh # %

Table 4.2. Equipment Required for Marker Emplacement Tests.

Equipment Required	Number	Function
Crawler tractor (D8L-95,000 lb. wt.)	1 ea.	Lift placement, provide live loads
Surveyor's transit and chain	1 ea.	Plot staking and marker location
Hand tools (shovels, hammers)	several	Exhume markers, placing stakes
Dump truck	1 ea.	Placement of soil/sand/riprap, Provide impact loads
Water truck (14,000 gal. capacity)	1 ea.	Provide live loads

4.5 SCHEDULES AND COST

The testing described in this plan is scheduled for completion in six weeks after commencement of the tests. Plan preparation, test execution, and final report preparation are estimated to cost about \$30.0 K.

4.6 EXPECTED RESULTS

Mechanical strength tests conducted on type B prototypes in the laboratory indicate that the markers will break into three pieces with an applied load of about 77 psi. Using the Boussinesq formula, wheel loads under sand/soil lifts have been calculated for a fully loaded water truck (14,000 gal. capacity). The calculations indicate that under the shallow lift (.5 ft), the load on the marker from the water truck should be about 73 psi. Because the Boussinesq calculation is conservative, the markers are not expected to break during the soil or sand lift tests. A fully loaded water truck is the heaviest equipment that would be driven over the barrier during construction of the soil or sand lifts. The test with the water truck is, therefore, conservative.

A crawler tractor will be used to construct the riprap portion of the barrier since wheeled vehicles would be damaged by the riprap. No standard formulas apparently exist for stress/depth relationships under basalt riprap lifts. While load spreading and bridging is expected due to interlocking of the angular riprap pieces, point loads may be exerted on the markers. It is expected that the markers may break under the riprap load but not into more than three pieces.

If a high degree of breakage is noted (more than 3 pieces), additional tests of shrouds or shields will be required. Plates or squares of plywood, aluminum metal, or rigid plastic would be considered for placement over each marker.

The degree of breakage of markers when subjected to impact loads from direct dumps of basalt riprap is unknown. However, the markers are expected to be vulnerable to this operation and damage may result.

4.7 DATA COLLECTION REQUIRED

After overburden removal, each marker will be examined for breakage. A detailed data record sheet will be kept. The sheet will include the plot, section, row, and row location of each marker; the date; the condition of the marker including number of pieces (if 10, or less) and degree of pulverization (if more than 10 pieces). If the marker is not broken or pulverized, the degree of cracking will be observed and noted as will the degree of color-change due to the grinding in of soil. Ground-in soil on the marker will be brushed or washed and a note made as to whether the original color of the marker is restored by brushing or washing. Data will be accumulated and presented to show the range, mean, and standard deviation of the number of pieces each marker broke into for each section of the plot.

For the impact-load tests, each marker will also be examined for breakage, cracking, and degree of pulverization. The number of markers breaking at each dump height will be recorded on the data sheet. Data will be accumulated and presented to show ranges, mean, and standard deviation of the number of pieces each markers broke into at each height of dump.

5.0 SAFETY

Normal precautions associated with the operation of heavy construction equipment will be exercised. When near construction operations and heavy equipment, hardhats and safety shoes will be worn at all times when in the test area. Because a number of test beds are located at the PBTF, all such areas near the selected test area will be marked with red warning flags so that heavy equipment does not inadvertently move into controlled areas. At least two people must be at the site during testing.

6.0 QUALITY ASSURANCE

Data will be entered into a hard-bound numbered and controlled field notebook. (The data to be collected are described in section 4.7.) Entries will be dated and signed by the collector. At the end of the project, the field data notebook will be signed, copied, and the copy given a supporting document (SD) number and placed in the SD and barrier development records management systems. All calculations will be checked, dated, and initialed by individuals listed in the notebook, other than the original entry person. Field observations will be spot-checked by a supervisor or engineer other than the collector. The checker will date and initial the notebook to indicate his/her findings regarding the accuracy of the field observations.

7.0 REPORTS

A final test report will be prepared by September 30, 1987. The report will be prepared as a cleared report and placed in the SD and barrier development records management systems.

8.0 REFERENCES

- 1) Hanford Waste Management Plan, Department of Energy - Richland Operations Office, Richland, Washington, 1984.
- 2) Hanford Waste Management Technology Plan, Department of Energy - Richland Operations Office, Richland, Washington, 1984.
- 3) Adams, M. R., and Wing, N. R., "Protective Barrier and Warning Marker System Development Plan," SD-WM-PAP-040, Rockwell Hanford Operations, Richland, Washington, 1985.
- 4) Adams, M. R., and Kaplan, M. F., "Marker Development for Hanford Waste Site Disposal," Symposium on Waste Management, R. G. Post (ed.), University of Arizona, Tucson, Arizona, 1986.
- 5) U.S. Testing Company, Inc. (Los Angeles), Report of Test - Ceramic Subsurface Marker Prototypes, Subcontract SA-5028, May, 2, 1985.

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