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EFFECTS OF VEHICULAR OPERATION ON CONTAMINATED SLUSHY ROADS

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OCD Work Unit No. 3213B

US ARMY
NUCLEAR DEFENSE LABORATORY
Edgewood Arsenal, Maryland

SUMMARY

The objective of this project (WU3213B) was to develop and test radiological countermeasures that are applicable to post-nuclear-attack recovery operations.

The specific objective of this phase of the project was to determine the effects of vehicular traffic on displacing fallout on bare roads and on packed-snow-covered roads, the build-up of activity on vehicle surfaces, and the variation of subsequent roadway decontamination effectiveness along the path of decontamination effort.

Due to weather conditions that developed at the time of both tests, the roads were covered with slush. For vehicular traffic over a radioactively contaminated slushy road and subsequent roadway decontamination, the following conclusions were established:

1. Exposure rates to operating personnel of vehicles were significantly increased due to vehicular contamination.

2. Vehicles required decontamination following operation.

3. The decontamination efforts conducted on slushy roads were much less effective than those conducted during warm or cold dry weather.

FOREWORD

This work was authorized under Work Order No. OCD-PS-65-19, Office of Civil Defense. Related subtasks include 04-02 Decontamination, 3212A Cold Weather Decontamination, and 3214C Equipment Decontamination. The field effort was conducted during March 1965.

The author wishes to acknowledge the assistance of General Dynamics/Fort Worth in the field phase of the operation, and the assistance of staff personnel at Camp McCoy, Wisconsin, for support at the experimental site.

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EFFECTS OF VEHICULAR OPERATION ON
CONTAMINATED SLUSHY ROADS

1. INTRODUCTION

1.1 Objective.

The objective of this project was to develop and test radiological countermeasures that are applicable to post-nuclear-attack recovery operations.

The specific objective of this phase of the project was to determine the effects of vehicular traffic on displacing fallout on bare roads and on packed-snow-covered roads, the buildup of activity on vehicle surfaces, and the variation of subsequent roadway decontamination effectiveness along the path of decontamination effort.

1.2 Background.

During previous decontamination experiments at Camp McCoy, Wisconsin, it was observed that vehicular traffic could alter the fallout pattern on a road (Reference 1), and in some cases the decontamination effectiveness decreased along the path of decontamination (Reference 2). These previous observations were made over limited areas.

1.3 Operational Plan.

Two tests were planned at Camp McCoy, Wisconsin; one on a bare macadam road and the other on a packed-snow-covered road. After contamination of a one-half mile lane, a jeep was to be driven at 30 miles per hour for a total of 50 miles back and forth over the lane. Then, the dry road was to be swept with a street sweeper and the snow-covered road was to be plowed with a motor grader.

2. TEST OPERATIONS

2.1 Fallout Simulant.

The fallout simulant was identical to that used in previous decontamination tests (References 2, 3, 4, and 5). It consisted of silica sand of 150 to 300 microns in diameter, tagged with lanthanum-140, and deposited at the mass level of 50 g ft^{-2}. A modified 10-foot wide farm seed spreader, towed by a jeep, was used to disseminate this simulant.

Details of simulant production and measurement, including instrumentation description, are contained in the above references.

2.2 Operational Narrative.

A half mile dry stretch of macadam road at Camp McCoy was contaminated according to plan for the dry surface road test, hereafter designated as Test No. 1. To establish the initial road contamination levels, cross-lane radiation intensity scans were made at 100-foot intervals at a height of 1 foot with the collimated anthracene scintillation detector (ASD). At this time, a light freezing rain started.

This turned to wet snow as the 50-mile jeep run started. At first, after each half-mile traverse over the contaminated road, the jeep was monitored in a low-background area for contamination picked up in the operation. Later, monitoring was carried out only after every second or fourth traverse.

After vehicular operations were completed, the slush-covered road was rescanned with the ASD at 100-foot intervals to determine the road contamination level at this time. Then, decontamination was begun with a rotary broom street sweeper and, because of equipment failure, completed with a hopper-type sweeper. Based on limited data from Reference 4, the effectiveness of these two units is estimated to be equal under the test conditions encountered. The final residual radiation levels on the road were again measured by ASD scans at 100-foot intervals.

Several days later the weather and snow conditions were ideal for the packed-snow road test, Test No. 2. The same stretch of road had been covered by a snowfall, and was packed by vehicular traffic. Residual activity from Test No. 1 at this time was negligible. Operations proceeded according to plan until the first vehicle runs started, at which time rising temperatures melted the hard snow surface into slush. The test continued in the slush in the same manner as Test No. 1. The decontamination operation, however, had to be changed from the snow plowing originally planned to sweeping with the hopper-type street sweeper.

Due to the unpredictable gross changes in the weather, the tests deviated from the plan to the effect that they became similar. The position of the contaminant - below or above the slush layer - was the only difference between the tests.

3. RESULTS AND DISCUSSION

3.1 Results.

The road contamination levels, initial, after traffic, and after decontamination, are presented in Tables A.3 and A.4. Reference 2 provides details of this data treatment and subsequent computations. The results are summarized in Table 3.1. It should be noted that detector current is a linear function of radiation intensity, and that the shielding of deposited radioactive material by slush is estimated to be negligible. Figures 3.1 and 3.2 illustrate the road surface conditions after Test No. 1 and Test No. 2 traffic, respectively.

A statistical linear regression analysis of the data scans produced no significant evidence of anything other than random decontamination effectiveness variations.

TABLE 3.1 DECONTAMINATION EFFECTIVENESS OF TRAFFIC AND STREET SWEEPING UNDER SLUSHY ROAD CONDITIONS

Test	Fraction Remaining After Traffic	Fraction Remaining After Traffic and Decontamination
No. 1-Fallout Under Slush	0.90 ±0.40	0.60 ±0.26
No. 2-Fallout On Slush	0.62 ±0.20	0.46 ±0.14

Figure 3.1 Road surface after Test No. 1 traffic.

Figure 3.2 Road surface after Test No. 2 traffic.

Table A.1 in the Appendix contains exposure rates due to contamination of the vehicle at several vehicle locations for Test No. 1. Table A.2 contains the exposure rates for Test No. 2. These exposure rates have been normalized from experimental conditions to a road contamination level of 1 mCi ft^{-2} for direct comparison and are graphically presented in Figures 3.3 and 3.4. (Normalization of experimental data was based on data contained in Tables A.5 and A.6.) The following vehicle-location exposure rate data and other radiation exposure data of interest are presented in these figures:

A- Operator position, due to vehicle contamination.
B- Maintenance position (over front of hood), due to vehicle contamination.
C- Contamination levels at fenders and frame due to vehicle contamination.

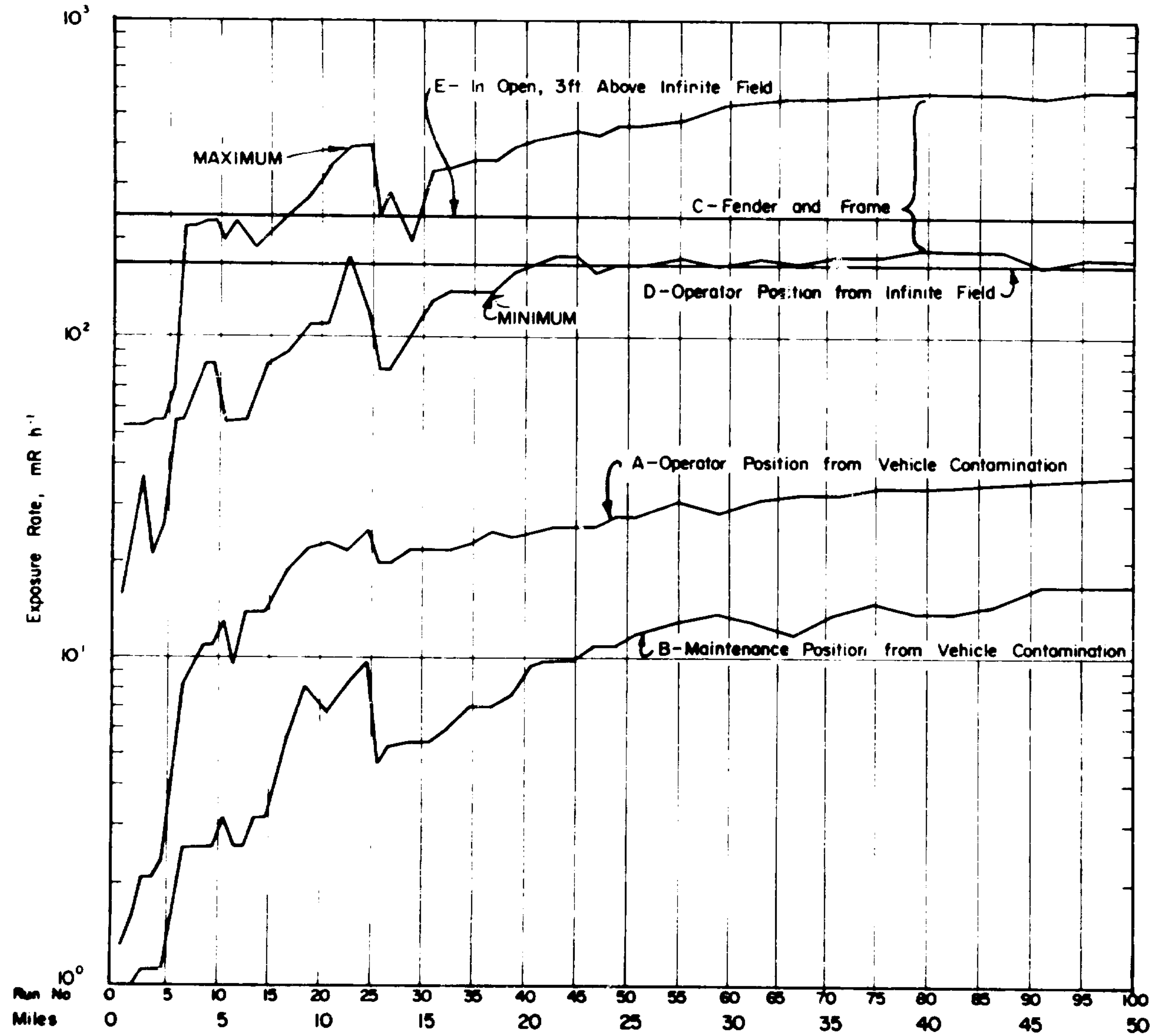

Figure 3.3 Exposure rates for Test No. 1 normalized to 1 mCi ft^{-2} contamination level.

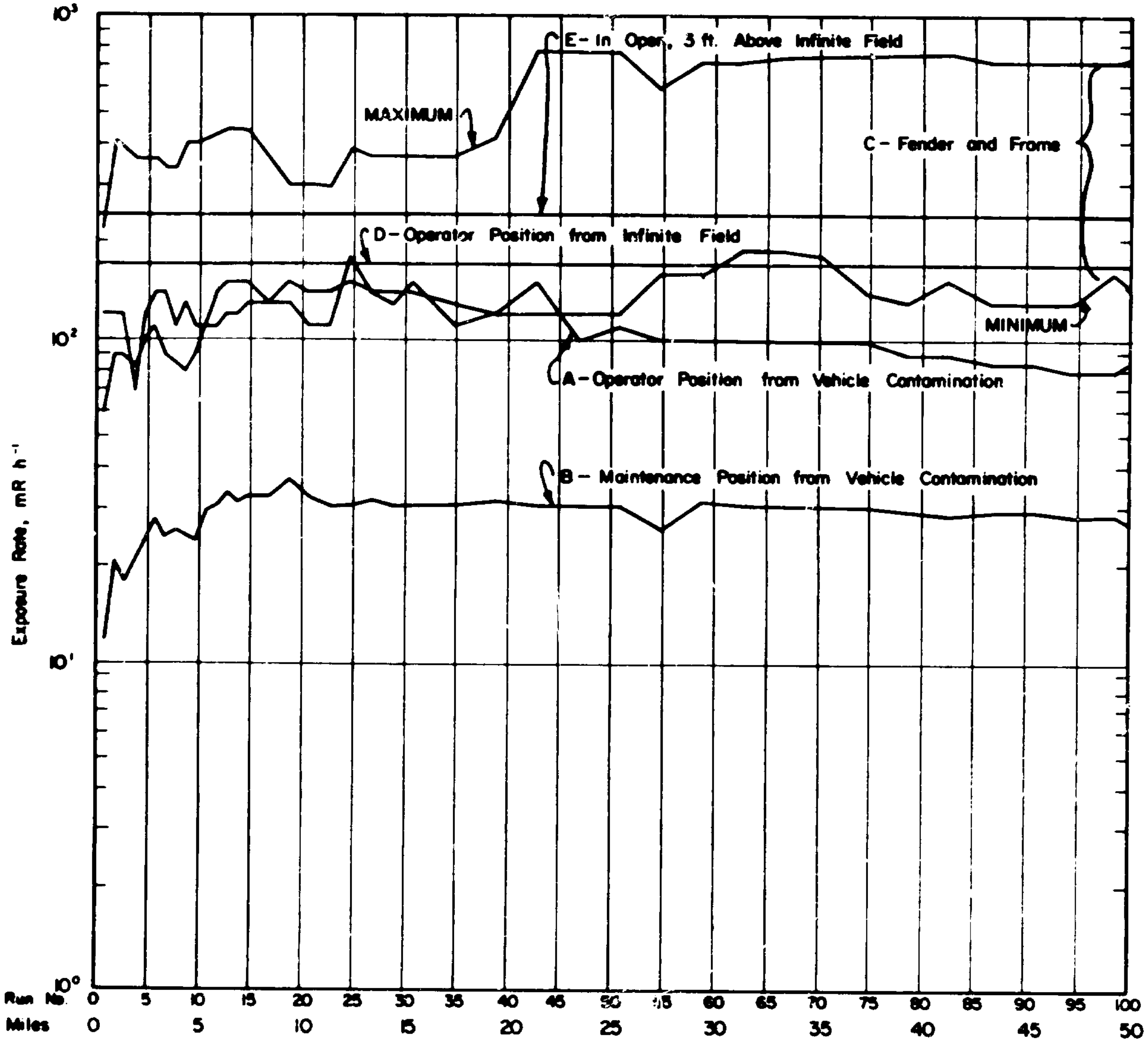

Figure 3.4 Exposure rates for Test No. 2 normalized to 1 mCi ft $^{-2}$ contamination level.

D- Operator position from infinite radiation field (Reference 1).

E- Open field at three-foot height (Reference 1).

3.2 Discussion.

From Table 3.1 it is apparent that traffic had little effect in decontaminating slush-covered roads, and decontamination by sweeping was only marginally effective. This is verified by an analysis of variance which gives no significant differences between initial and final contamination levels. The combination of traffic and sweeping effected a factor of only two in reduction of the initial contamination level. This is contrasted to the sweeping of bare roads or packed snow-covered roads under dry conditions where contamination removal by sweeping was well over 90 percent (References 4 and 6). The contamination removal was slightly better for Test No. 2 than for Test No. 1, probably because the simulant was on top of the slush layer where it was more accessible to displacement by vehicle tires.

Figures 3.3 and 3.4 show that after about 25 miles, the exposure rates from contamination on the jeep seemed to stabilize or only change slightly with time. Test No. 2 exposure rates were higher than those for Test No. 1, probably because the contaminant was more accessible to displacement by the vehicle tires. The operator exposure rate due to simulant being retained on the vehicle was significant, particularly for Test No. 2 where it was always a significant fraction of the exposure rate expected from the surrounding infinite field. The exposure rates at the engine maintenance position were lower than those at the operator position but approached 10 percent of the unprotected open infinite field exposure. In any case, decontamination of the vehicle is indicated to be a requirement following operation on slush-covered roads.

4. CONCLUSIONS

Under the conditions of these tests, it is concluded that:

1. Exposure rates to operating personnel of vehicles were significantly increased due to vehicular contamination.

2. Vehicles required decontamination following operation.

3. The decontamination efforts conducted on slushy roads were much less effective than those conducted during warm or cold dry weather.

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APPENDIX

FIELD DATA

TABLE A.1 VEHICLE EXPOSURE RATES FROM CONTAMINATION DURING TEST NO. 1
Note: All measurements are in mR h^{-1}.

Run (½ mile)	Exposure Rate At: Driver Seat	Front of Hood	Fenders	Notes
No.				
1	1.3	0.8	16- 53	Snowing-Surfaces Damp
2	1.6	0.8	24- 53	Temp 36° F
3	2.1	1.1	37- 53	
4	2.1	1.1	21- 55	Surfaces Wet
5	2.4	1.1	26- 55	Snow Thawing
6	4.5	1.6	55- 68	
7	8.2	2.6	55-220	
8	9.5	2.6	68-220	
9	11	2.6	82-230	
10	11	2.6	82-230	
11	13	3.2	55-200	
12	9.5	2.6	55-230	
13	14	2.6	55-220	
14	14	3.2	68-190	
15	14	3.2	82-210	Temp 32° F
16				
17	19	5.5	90-240	
18				
19	22	8.2	110-270	
20				Icing
21	23	6.8	110-340	Snow sticking on jeep
22				
23	22	8.2	180-390	
24				
25	25	9.7	120-400	
26	20	4.7	80-240	
27	20	5.3	80-280	Temp 27° F
28				
29	22	5.5	100-200	
30				
31	22	5.5	130-330	
32				
33	22	6.1	140-340	
34				
35	23	7.1	140-360	Temp 27° F
36				
37	25	7.1	140-360	
38				

TABLE A.1 (Continued)

Run (½ mile)	Exposure Rate At Driver Seat	Front of Hood	Fenders	Notes
No.				
39	24	7.6	160-400	
40				
41	25	9.5	170-420	
42				
43	26	9.7	180-430	
44				
45	26	10	180-450	
46				
47	26	11	160-440	
48				
49	28	11	170-470	
50				
51	28	12	170-470	Temp 27° F
52				
53				
54				
55	31	13	180-490	
56				
57				
58				
59	29	14	170-550	
60				
61				
62				
63	32	13	180-570	
64				
65				Temp 26° F
66				
67	33	12	170-590	Temp 25° F
68				
69				
70				
71	33	14	180-590	
72				
73				
74				
75	35	15	180-600	
76				
77				

TABLE A.1 (Continued)

Run (½ mile)	Exposure Rate At Driver Seat	Front of Hood	Fenders	Notes
No.				
78				
79	35	14	190-620	
80				
81				
82				
83	36	14	190-620	Temp 25° F
84				
85				
86				
87	36	15	190-620	
88				
89				
90				
91	37	17	170-610	
92				
93				Temp 24° F
94				
95	37	17	180-630	
96				
97				
98				
99	38	17	180-640	
100	38		180-640	

All exposure rates corrected for decay and normalized to contamination level of 1 mCi ft^{-2}

TABLE A.2 VEHICLE EXPOSURE RATES FROM CONTAMINATION DURING TEST NO. 2
Note: All measurements are in mR h^{-1}.

Run ($\frac{1}{2}$ mile)	Exposure Rate At Driver Seat	Front of Hood	Fenders	Notes
No.				
1	60	12	120-220	Temp 42° F
2	91	21	120-410	
3	89	18	120-390	
4	82	21	71-360	
5	100	24	120-360	
6	110	28	140-360	
7	89	25	140-340	Temp 41° F
8	84	26	110-340	
9	80	25	130-410	
10	90	24	110-410	
11	110	30	110-420	Temp 41° F
12	140	31	110-440	
13	150	34	120-430	
14	150	32	120-430	
15	150	33	130-420	
16				
17	130	33	130-360	Temp 39° F
18				
19	150	37	130-300	Temp 40° F
20				
21	140	33	110-300	
22				
23	140	31	110-310	Temp 39° F
24				
25	150	31	180-390	
26				
27	140	32	140-370	
28				
29	140	31	130-370	
30				
31	140	31	150-370	
32				
33				
34				
35	130	31	110-370	Temp 36° F
36				

TABLE A.2 (Continued)

Run (½ Mile)	Exposure Rate At Driver Seat	Front of Hood	Fenders	Notes
No.				
37				
38				
39	120	32	120-430	
40				
41				
42				
43	150	31	120-800	Temp 37° F
44				
45				
46				
47	100	31	120-800	
48				
49				
50				
51	110	31	120-800	
52				
53				
54				
55	100	26	160-620	Temp 35° F
56				
57				
58				
59	100	32	160-750	
60				
61				
62				
63	100	31	190-750	Temp 36° F
64				
65				
66				
67	100	31	190-780	
68				
69				
70				
71	100	31	180-790	Temp 35° F
72				
73				
74				
75	100	31	140-790	

TABLE A.2 (Continued)

Run (½ mile)	Exposure Rate At Driver Seat	Front of Hood	Fenders	Notes
No.				
76				
77				
78				
79	91	30	130-790	
80				
81				
82				
83	90	29	150-800	Temp 32° F
84				
85				
86				
87	85	30	130-760	
88				
89				
90				
91	85	30	130-770	
92				
93				
94				
95	80	29	130-770	
96				
97				
98				
99	80	29	160-770	
100	82	28	150-780	Temp 25° F

All exposure rates corrected for decay and normalized to contamination level of 1 mCi. ft^{-2}.

TABLE A-3 ASD CROSS-LANE SCANS FOR TEST NO. 1 IN UNITS OF CURRENT

SAMPLE NO.	CONTAMINATED	AFTER TRAFFIC	AFTER DECON
1	36.70	65.90	53.02
2	35.80	25.60	20.20
3	27.10	19.93	18.11
4	30.18	23.76	32.09
5	30.87	16.44	14.48
6	33.80	16.46	10.39
7	35.26	70.10	36.78
8	40.94	43.97	25.89
9	44.66	44.46	32.41
10	49.64	49.27	28.80
11	53.12	76.70	35.45
12	52.80	53.17	28.73
13	54.65	47.92	34.35
14	56.73	53.44	36.28
15	57.11	55.54	34.83
16	59.16	43.90	30.31
17	58.45	43.41	27.94
18	66.01	67.50	27.26
19	62.10	63.35	45.94
20	65.50	46.99	29.23
21	64.66	11.80	10.46
22	63.28	50.70	34.88
23	62.71	49.24	34.06
24	61.69	59.57	23.58
25	66.41	53.20	52.47
26	68.08	54.25	41.09
27	71.15	63.85	44.79
28	69.59	55.60	41.39
TOTALS	1478.15	1326.02	885.11
AVERAGES	52.79	47.36	31.61
VARIANCE	188.30	300.58	119.04
STD. DEV.	13.72	17.34	10.91

RATIOS

TBAR1 = AFTER TRAF / CONTAMINATED = 0.90 ± 0.403

TBAR2 = AFTER DECON / AFTER TRAF = 0.67 ± 0.301

TBAR3 = AFTER DECON / CONTAMINATED = 0.60 ± 0.259

TABLE A-4 ASD CROSS-LANE SCANS FOR TEST NO. 2 IN UNITS OF CURRENT

SAMPLE NO.	CONTAMINATED	AFTER TRAFFIC	AFTER DECON
1	197.30	131.20	81.90
2	193.40	134.65	116.60
3	192.20	107.20	70.76
4	186.20	79.87	64.26
5	180.20	128.90	107.20
6	176.40	106.60	84.74
7	168.10	116.00	98.40
8	174.60	99.48	92.70
9	170.70	107.52	123.30
10	179.80	113.90	93.19
11	178.60	[illegible].31	37.58
12	192.20	107.20	70.76
13	193.60	91.24	88.[illegible]7
14	225.80	124.20	104.46
15	215.80	108.20	85.25
16	220.50	116.50	100.20
17	211.70	162.50	103.90
18	224.50	139.80	124.40
19	209.70	107.90	94.36
20	212.30	152.60	121.60
21	202.20	117.50	95.37
22	223.20	171.60	144.10
23	234.50	160.00	118.90
24	281.70	185.10	69.30
25	278.50	186.70	142.40
26	228.10	137.40	104.30
27	324.70	238.10	112.80
28	211.00	157.60	61.82
TOTALS	5905.50	3672.77	2712.92
AVERAGES	210.91	131.17	96.89
VARIANCE	1465.53	1260.85	604.86
STD. DEV.	38.28	35.51	24.59

RATIOS

TBAR1 = AFTER TRAF / CONTAMINATED = 0.62 ± 0.203

TBAR2 = AFTER DECON / AFTER TRAF = 0.74 ± 0.286

TBAR3 = AFTER DECON / CONTAMINATED = 0.46 ± 0.143

TABLE A-5 PAN SAMPLE DATA FOR SIMULANT DEPOSITION - TEST NO. 1

SAMPLE NO.	GMS/FT SQ.	UC/GM	MC/FT SQ.
1	36.00	8.64	0.31
2	33.60	8.24	0.28
3	24.80	8.24	0.20
4	25.30		
5	30.50	8.24	0.25
6	35.90	8.24	0.30
7	31.10	8.64	0.27
8	46.90	8.51	0.40
9	48.20	8.64	0.42
10	54.90	8.91	0.49
11	49.60		
12	55.50	8.78	0.49
13	58.10		
14	57.70		
15	57.10	8.64	0.49
16	42.60		
17	48.80		
18	50.40		
19	58.20	8.64	0.50
TOTALS	845.20	102.36	4.40
AVERAGES	44.48	8.53	0.38
VARIANCE	135.25	0.05	0.01
DEVIATION	44.48 ± 11.63	8.53 ± 0.23	0.38 ± 0.10

TABLE A-6 PAN SAMPLE DATA FOR SIMULANT DEPOSITION - TEST NO. 2

SAMPLE NO.	GMS/FT SQ.	UC/GM	MC/FT SQ.
1	33.00	22.74	0.75
2	33.90		
3	32.30		
4	30.80		
5	34.30		
6	30.60	21.32	0.65
7	27.80		
8	36.80		
9	26.00		
10	35.80		
11		21.32	
12	40.10		
13	40.60		
14	45.60		
15	46.70	22.74	1.06
16	50.60		
17	66.30		
18	46.10		
19	47.10		
20	43.60	22.74	0.99
TOTALS	748.00	110.86	3.46
AVERAGES	39.37	22.17	0.87
VARIANCE	94.30	0.60	0.05
DEVIATION	39.37 ± 9.71	22.17 ± 0.78	0.87 ± 0.22

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13. ABSTRACT

The objective of this project (WU3213b) was to develop and test radiological countermeasures that are applicable to post-nuclear-attack recovery operations. The specific objective of this phase of the project was to determine the effects of vehicular traffic on displacing fallout on bare roads and on packed-snow-covered roads, the build-up of activity on vehicle surfaces, and the variation of subsequent roadway decontamination effectiveness along the path of decontamination effort. Due to weather conditions that developed at the time of both tests, the roads were covered with slush. For vehicular traffic over a radioactively contaminated slushy road and subsequent roadway decontamination, the following conclusions were established:

1. Exposure rates to operating personnel of vehicles were significantly increased due to vehicular contamination.
2. Vehicles required decontamination following operation.
3. The decontamination efforts conducted on slushy roads were much less effective than those conducted during warm or cold dry weather.

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Slushy surfaces, decontamination of						
Fallout displacement						
Vehicular contamination						