AIR DROP TESTS WITH HELITANKERS

by

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ABSTRACT

A series of air drop tests was carried out with the following helicopter/bucket combinations: (1) Sikorsky S58T/Chadwick (325 gal.); (2) Bell 204B/Alberta Forest Service (AFS) Monsoon (235 gal.) and Griffith Big Dipper (250 gal.); and (3) Bell 206B/Sims Rainmaker (90 gal.). Drop tests were made into both open areas and forest stands using water, Phos-Check 259 and XA and Fire-Trol 100 and 931. Drop speed, bucket height and retardant viscosity affected the ground distribution patterns obtained, however, the degree to which each drop variable affected the patterns was primarily controlled by the drop mechanism on the bucket; i.e., size of drop gate(s) and rate of gate opening and discharge. Each bucket had different drop characteristics and patterns. The most consistent ground distribution patterns in both the open and forested areas were obtained with gum-thickened Phos-Chek retardant in the 800-1000 centipoises viscosity range. The length of retardant line established by the S58T and Bell 204B helicopters at the .04-inch application rate equalled or surpassed similar patterns established by fixed wing airtankers dropping between 285 and 450 gallons of thickened retardant.

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* Research was conducted by the Canadian Forestry Service and this report prepared by Canwest Fire Management Ltd. under contract to the Canadian Forestry Service.

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INTRODUCTION

The use of helicopters to apply water on wildfires is a well-established practice in western Canada. Water from rivers, lakes and sloughs is usually abundant, and the subsequent short between-load interval makes the helitanker an effective fire suppression tool.

Using long-term retardants increases the effectiveness of the helitanker. Portable mixing systems permit the establishment of retardant stations many miles from permanent bases (Davis, 1963; Anon. 1967). These mixing stations can be established at or near wildfire sites (Grigel, 1971).

This use of the helicopter has promoted the development of numerous application devices. These include tanks secured inside or onto the bottom of the helicopter and "buckets" suspended by cables from the cargo hook of the helicopter. The latter, which permit easy "dip-loading", are the most widely-used applicators in western Canada. The original 45-gallon barrel 'monsoon buckets' have been replaced by specially designed buckets constructed of fiberglass, aluminum, polyurethane or fabrics. Portability is essential, and several designs are collapsible to permit easy transport within the helicopter. These containers range in size from 45 to more than 350 gallons and may employ one of several types of drop mechanisms. Drop gates are activated electrically and are operated either mechanically, hydraulically or pneumatically.

Published information on the ground distribution patterns of the various buckets tested is not available. Drop patterns and concentrations of material vary not only with the bucket size and design but with different drop height and speed combinations. Also, use of fire retardants is likely to affect the patterns.

A study to gather quantitative information on several helicopter-bucket combinations used in western Canada was conducted by the Northern Forest Research Centre in 1972. The objectives were: (1) to calibrate the ground distribution patterns of helicopter/bucket combinations using both water and long-term retardants, and (2) to compare the drop characteristics of water and retardants with varied drop height and speed. The number of drops made limited the results. However, sufficient data were obtained to allow a discussion of the various buckets and retardants and their application.

EQUIPMENT AND MATERIALS

Helicopters and Buckets

The helicopters used were a Sikorsky S58T, a Bell 204B, and a Bell 206B (see table I for helicopter characteristics). A 370-gallon Chadwick fibreglass bucket was used with the Sikorsky helicopter, a 300-gallon Alberta Forest Service (aluminum) Monsoon Bucket and a 330-gallon Griffith Big Dipper polyurethane bucket with the Bell 204B, and a 120-gallon Sims fibreglass bucket with the Bell 206B. Detailed descriptions of the buckets follow. These buckets are the sling-type, which attach to the helicopter's cargo hook.

Chadwick[1]

The 370-gallon capacity Chadwick bucket is made of fiberglass. It is 49 inches in diameter and 51 inches in height. The bucket is tapered from top to bottom to permit easy dip-loading. It weighs 300 pounds empty (Figure 1).

Three 20-inch diameter doors (942 sq. in.) located 120^{o} apart in the bottom are opened and closed by three electric actuators sealed in their own housing and connected to the doors by push-pull rods. The doors, which have a 5-inch stroke, may be opened or closed all together, or one door may be opened or closed independent of the other two. Opening and closing can be regulated; a full-open position is obtained in 3 seconds. The doors can be closed during the release procedure to permit more than one drop from a bucket load.

AFS Monsoon[2]

The 300-gallon capacity Alberta Forest Service (AFS) Monsoon Bucket is made of aluminum. The unit is 42 inches in diameter and 80 inches in height; it can be transported externally or in the passenger section of a medium size helicopter like the Bell 204B. It is sloped at the bottom to permit easy dip-loading. The bucket weighs 330 pounds empty (Figure 2).

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[1]Source: Fact sheet supplied by Okanagan Helicopters Ltd., Vancouver,B.C.

[2]Source: Fact sheet supplied by Equipment Development Centre, Alberta Forest Service, Edmonton, Alberta. T6H 3S5

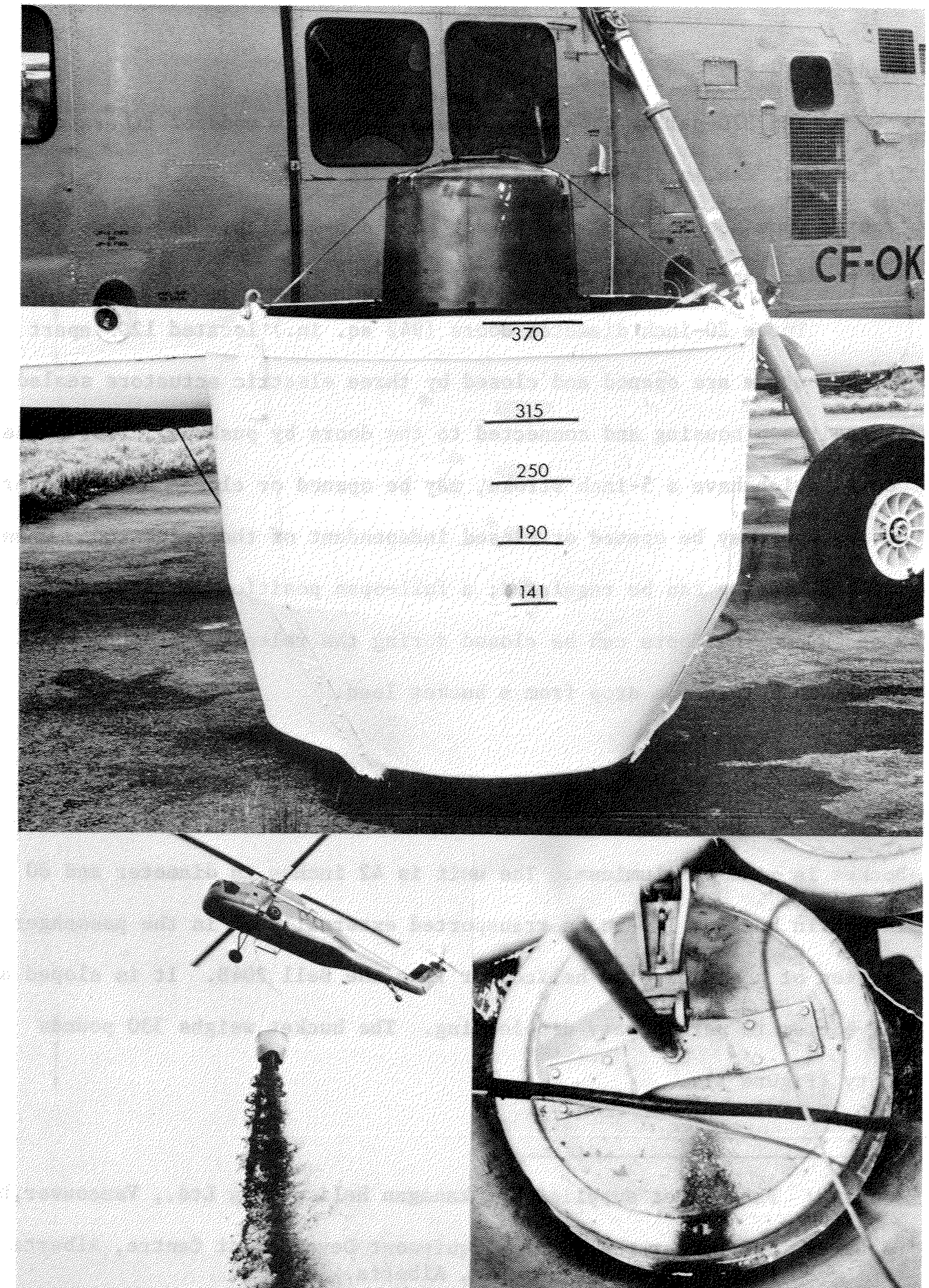

Figure 1. The 370-gallon capacity Chadwick fiberglass bucket with the Sikorsky S58T helicopter in background.

Inserts show the S58T dropping retardant and one of the three 20-inch diameter drop doors.

Figure 2. The 300-gallon capacity AFS Monsoon Bucket attached to a Bell 204B helicopter. Insert shows the two semi-circular doors.

The gate area of the AFS bucket is a 32-inch circle with a 5-inch bar across the center for hinging and mounting the mechanism. Two semi-circular gates, hinged back-to-back on their straight sides, provide an orifice totaling 644 sq. in. An electrically-operated hydraulic system opens and closes the two doors simultaneously. The doors open in three seconds.

Removable caps in four 6-inch diameter drain holes at four load levels permit control of the material carried.

Griffith Big Dipper[3]

The 330-gallon capacity Griffith Big Dipper Model 400 bucket is made of "double bond" polyurethane. The unit is 51 inches in diameter at the top and 43 inches at the bottom; it is 55 inches in height and 'collapses' to less than one-half its extended height. The bucket weighs 225 pounds empty (Figure 3).

The drop gate is 25 inches in diameter (491 sq. in.) and has a 4-inch stroke, or vertical lift. It is operated by motorized linear actuators. To enable it to hold varying loads, the bucket is equipped with threaded self-locking plugs. An aluminum collar is available which attaches to the top of the bucket to make it rigid for dip-loading.

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[3] Source: Technical Data Sheet supplied by Griffith Polymers, Inc., Portland, Oregon. The "Big Dipper" is a registered trademark.

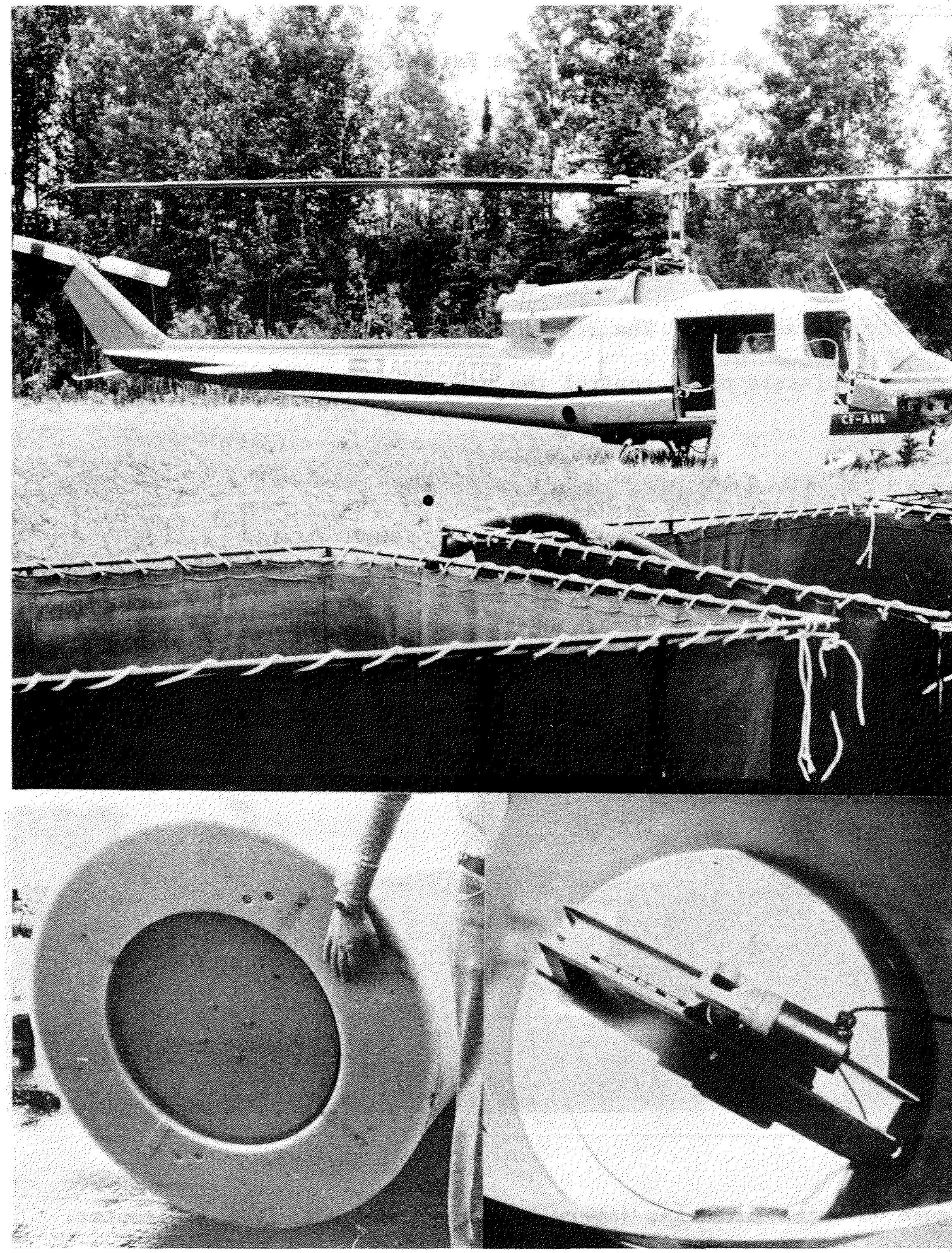

Figure 3. The Griffith Big Dipper polyurethane bucket with inserts showing the circular drop gate. Bell 204B helicopter in background.

Sims Rainmaker[4]

The 120-gallon capacity Sims Rainmaker Model SF150 bucket is made of fiberglass. The unit is conical in shape, with a top diameter of 47½ inches and a bottom diameter of 24½ inches; height is 30 3/4 inches. The bucket weighs 68 pounds empty (Figure 4).

The drop gate is 18½ inches in diameter (269 sq. in.) and is electrically actuated. The degree of door opening can be controlled. Removable plastic plugs control the capacity.

Figure 4. Sims Rainmaker fiberglass bucket and Bell 206B helicopter.

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[4] Source: Technical Data Sheet supplied by Sims Fiberglass Co., Jefferson, Oregon.

Description of Helicopters

The helicopters used in the drop tests represent the medium and small turbine rotary-winged aircraft (Sikorsky S58T/Bell 204B, and Bell 206B, respectively) now commonly used as helitankers in western Canada. A brief description of the helicopters is presented in Table 1.

PROCEDURES

Drop Sites

A series of drop tests was carried out at each of three separate locations. One series involved a single drop site; the others each used two sites. Several cooperators worked with the research team at each site (see Acknowledgements).

Series 1: Sikorsky S58T/Chadwick bucket, Vancouver, B.C.

The drop site was an open field at the Vancouver International Airport. A grid system 600 ft. long and 100 ft. wide was established; containers to collect the retardant were arranged in 10-ft. longitudinal and 5-ft. lateral spacings.

Series 2: Bell 204B/AFS Monsoon and Griffith
Big Dipper Buckets - Edson, Alberta

Two drop sites were used: (1) an open field, and (2) a mature well-stocked stand of lodgepole pine. The stand had an average tree height of 63 ft., an average dbh of 5.9 inches and a crown closure of about 45 percent. There were 1250 stems per acre. On each site, a grid system 250 ft. long and 120 ft. wide was established; containers were arranged in 10-ft. longitudinal and 5-ft. lateral spacings.

Series 3: Bell 206B/Sims Rainmaker SF150 bucket, Whitehorse, Yukon.

Table 1. Operational data for helicopters used for air drop tests[5].

						Load (lbs.)		
Type	Cruise speed (mph)	Maximum Slinging speed (mph)	Fuel Capacity (Imperial gallons)	Fuel Consumption gph	Maximum endurance full fuel hrs.	Maximum external hook load (short haul	1 hr. 20 min. fuel (plus reserve	No. passengers
Sikorsky S58T	115	90	235 JP4	80-90	2 3/4	5000	4220	16-17
Bell 204B	110-130	110	137 JP4	65-70	2-3	4000	3500	9-10
Bell 206B	130	95-105	63 JP4	23-25	2½-3	1200	900	4

[5] Source: Fact sheets. Okanagan Helicopters Ltd., Vancouver, B.C.

Two drop sites were used: (1) an immature lodgepole pine stand with trees averaging 6 feet in height and having 4120 stems per acre (referred to in the text as an open area), and (2) a mature lodgepole pine stand of 2660 stems per acre with tree crown height averaging 42 feet and dbh 3.5 inches, and with a crown closure of 40%. A grid system 200 ft. long and 50 ft. wide was established in each site, with containers arranged in 5-foot by 5-foot spacings.

At each site a paper cup was placed in each container, which consisted of an open-topped can attached to a metal stake, to collect the water or retardant. Each container and paper cup was marked to identify its exact position within the grid system. After each air drop, the cups containing retardant were capped to prevent evaporation, collected and weighed. The weight of the cup and cap was subtracted for each retardant net weight calculation. Figure 5 shows an open field drop site; Figure 6 shows a stand drop site. The drop sites were delineated by colored markers to permit easy identification from the air.

Preparation of Retardant Solutions

The retardant solutions were prepared and supplied by either the manufacturers or the cooperating Forest Service. Phos-Chek 259 and XA and Fire-Trol 100 and 931 were mixed according to manufacturers' specifications. Combinations of Phos-Chek 259 and XA were prepared to obtain predetermined viscosity levels. With the exception of Fire-Trol 100, all retardants were mixed at the drop sites. Water drops were colored to permit easy visibility of the drop dimensions. The viscosity of each load was measured with a Brookfield Viscometer Model LVF, No. 4

Figure 5. A drop with the Sikorsky S58T and Chadwick bucket onto an open field.

Figure 6. A drop with the Bell 204B and AFS Monsoon bucket onto a lodgepole pine stand.

spindle, 60 rpm.

A brief description of the retardants is presented in Appendix Table A-1[6].

Drop Specifications

Fifty-four airdrops were made; specifications and operational data for the drops are presented in Tables B-1, B-2, B-3 of Appendix B.

The amount of water and retardant dropped varied with the lift capabilities of each helicopter. Since the retardants all weighed approximately 10% more than water, the volume delivered with each bucket was that which would be used on actual wildfire operations. Drops made with the Sikorsky S58T were 325 gal. of retardant or 360-gal. of water; the Bell 204B, 235 gallons with the Monsoon bucket and 250 gal. with the Big Dipper; and the Bell 206B, 90 gal.

The speed and height of each drop were predetermined. Drop speed (*indicated* air speed) was controlled by the pilot. Exact bucket height was established from the ground for both the open and stand drops using two Haga altimeters.

[6] Source: Unpublished data, Northern Forest Research Centre, Edmonton, Alberta.

ANALYSIS OF DATA

For Drop Series 1 and 2, the retardant weights measured for each drop were plotted on a scaled grid and isolines representing > 0", .005", .01", .02", .04", .07", .10", .15" and .20" retardant depth were drawn.[7] A planimeter was used to measure the area of each of the retardant contour levels. Three readings of each level were taken, averaged, then multiplied by a conversion factor to obtain the area in square feet for each interval.

The amount of retardant reaching the ground was calculated for each drop, with the assumption that the amount in each cup in the grid system represented coverage of an area extending one-half the distance to adjacent containers; i.e., 5 x 5-foot spacing = 25 square feet. From this, the total weight of the retardant collected in grams was converted to gallons and the amount recovered on the ground calculated. Since portions of several drops fell outside of the established grid systems, the areas and lengths of these contours were extrapolated. This directly affected the calculation of percent ground recovery.

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[7] A retardant weight of 2.2 grams represented the .02" contour level for water, 2.4 grams for Phos-Chek 259 and XA, 2.5 grams for Fire-Trol 100 and 2.4 grams for Fire-Trol 931, indicating the difference in the specific gravity of the materials. The retardant depths correspond to the following gal./100 sq. ft. values:

Retardant Depth (inches)	Gal./100 sq. ft. Imperial	Gal./100 sq. ft. U.S.
.005	0.2	0.3
.01	0.5	0.6
.02	1.0	1.2
.04	2.1	2.5
.07	3.6	4.4
.10	5.2	6.2
.15	7.8	9.3
.20	10.4	12.5

For Drop Series 3, a line plotter and computer program were used to analyse the data. The ground distribution patterns were prepared by the line plotter, while the area and percentage ground recovery for each contour interval were calculated by computer.

For all series, the length of individual contour levels was measured along the direction of flight to a minimum width of ten ft. This was considered the minimum required for an effective fire-line. A mean width was measured for each contour.

The .04 inch level (2.1 Imp. gal./100 sq. ft.) was used as the main basis for analysis of area covered effectively. The application rate commonly considered effective in most fuel types is 2 - 4 US gal. (1.6 - 3.2 Imp. gal.) per 100 sq. ft. (Anon. 1967).

Minimal replication seriously hampered analysis and caused much of the evaluation to be subjective. However, it was possible to make the following statistical tests for significance:

1. Analysis of variance of Chadwick bucket at 20 and 40 knots only for effects of retardant viscosity, air speed, and drop height on area covered by $\geq$ .04 inch depth of retardant, and length and mean width of that area.

2. Analysis of variance for Chadwick and A F S Monsoon buckets using Phos-Chek 259/XA (400 cps.) for effects of bucket, air speed, and drop height on area covered by $\geq$ .04 inch of retardant.

3. "t" tests of AFS Monsoon bucket against Griffith Big Dipper as to line length and mean width.

RESULTS

In all, 54 experimental drops were made, but only 43 yielded results suitable for analysis. So much retardant from the other 11 drops fell outside the collection grid that complete data on the effective portion was not available. Tables 2, 3, and 4 summarize the results.

TABLE 2

COVERAGE BY DROPS IN THE OPEN IN RELATION TO TYPE OF BUCKET, RETARDANT USED, AIR SPEED AND DROP HEIGHT: AREA COVERED IN SQUARE FEET AT ≥ .04-INCH DEPTH

BUCKET	AIR SPEED (kt.)	WATER 1 cps. Low[1]	High[1]	PHOS-CHEK 259 XA 400 cps. Low[1]	High[1]	OTHER AS NOTED Low[1]	High[1]
Chadwick	20	2,438	1,521	1,564	2,086	2,670[2]	2,760[2]
	40	3,387	2,167	2,952	3,202	2,582[2]	2,987[2]
	60			2,578[3]			
AFS Monsoon	20	1,771		2,133	2,541	1,836[4]	
	20					2,182[5]	
	40			1,881	1,908		
Big Dipper	20	1,222		2,007	1,244[6]	2,001[7]	
	20					1,346[5]	
Sims	20	436				814[8]	1,105[8]
	20					970[9]	
	20					1,105[9]	
	20					1,175[10]	

1 Except as noted "Low" $\simeq$ 50 ft. for Sims bucket, ~ 100 ft. for all others, "High" $\simeq$ 100 ft. for Sims, ~ 200 ft. for all others.

2 Phos-Chek 259, 100 cps.

3 Drop height 50 ft.

4 Phos-Chek XA, 1560 cps.

5 Fire-Trol 100, 2400 cps.

6 Drop height 130 ft.

7 Phos-Chek XA, 1,450 cps.

8 Phos-Chek 259, 1400 cps.

9 Fire-Trol 931, 50 cps.

10 Phos-Chek 259, 220 cps.

TABLE 3

COVERAGE BY DROPS IN THE OPEN IN RELATION TO TYPE OF BUCKET, RETARDANT USED, AIR SPEED AND DROP HEIGHT: LENGTH AND MEAN WIDTH IN FEET OF AREA COVERED AT ≥ .04-INCH DEPTH

BUCKET	AIR SPEED (kt.)	WATER 1 cps Low[1]	High[1]	PHOS-CHEK 259/XA 400 cps. Low[1]	High[1]	OTHER AS NOTED Low[1]	High[1]
		Length of ≥10-ft.wide line:					
Chadwick	20	178	99	150	147	182[2]	180[2]
	40	280	165	240	190	215[2]	222[2]
	60			370[3]			
AFS Monsoon	20	130		200	180	178[4]	
	20					162[5]	
	40			180	170		
Big Dipper	20	200		230	180[6]	210[7]	
	20					190[5]	
Sims	20	25				34[8]	38[8]
	20					33[9]	
	20					100[9]	
	20					37-22[10,11]	
		Mean Width:					
Chadwick	20	35	38	22	35	28[2]	27[2]
	40	26	28	25	35	28[2]	35[2]
	60			17[3]			
AFS Monsoon	20	25		22	32	22[4]	
	20					30[5]	
	40			22	30		
Big Dipper	20	10		24	12	17[7]	
	20					15[5]	
Sims	20	10				12[8]	
	20					11[9]	
	20					10[9]	
	20					13-12[10,11]	

[1] Except as noted "Low" ≃ 50 ft. for Sims bucket, ~ 100 ft. for all others; "High" ≃ 100 ft. for Sims, ~ 200 ft. for all others.
[2] Phos-Chek 259, 100 cps.
[3] Drop height 50 ft.
[4] Phos-Chek XA, 1,560 cps.
[5] Fire-Trol 100, 2,400 cps.
[6] Drop height 130 ft.
[7] Phos-Chek XA, 1,950 cps.
[8] Phos-Chek 259, 1,400 cps.
[9] Fire-Trol 931, 50 cps.
[10] Phos-Chek 259, 220 cps.
[11] Line consisted of two segments

TABLE 4

RESULTS OF DROPS IN LODGEPOLE PINE STANDS

RETARDANT	DROP height[1]	AREA (ft^2) with ≥ .04 in. 20 kt.	40 kt.	LENGTH [2](ft.) 20 kt.	40 kt.	WIDTH [2](ft.) 20 kt.	40 kt.
AFS Monsoon bucket:							
Water	60[1] AT	364	-	52	-	10	-
Phos-Chek 259/XA, 400 cps.	"	346	315	82	40	15	12
Big Dipper:							
Water	"	193	-	25	-	10	-
Sims bucket							
Water	TT	814	0	20-20	0[3]	10-11	0[3]
Fire-Trol 931, 50 cps.	"	782	-	20	-	10	-
Fire-Trol 931, 50 cps.	"	605	-	15	-	10	-
Phos-Chek 259 220 cps.	"	459	-	15	-	10	-
Phos-Chek 259, 220 cps.	60 AT	392	-	30	-	10	-
Phos-Chek/XA, 1,400 cps.	TT	541	-	20	-	10	-
Phos-Chek/XA, 1,400 cps.	50 AT	5	-	0	-	0	-
Phos-Chek 259/XA, 1,000 cps.	20 AT	717	-	10	-	10	-

[1] AT = above trees; TT = tree top level (5 - 15 ft. above trees).

[2] Line with ≥ .04-in. coverage ≥ 10 ft. wide. Hyphenated figure denotes segmented line.

[3] A few spots.

SERIES 1: SIKORSKY S58T HELICOPTER/CHADWICK BUCKET

Drop speed, bucket height and retardant viscosity all influenced ground distribution patterns. A typical pattern is shown in Figure 7 (drop 11). Further results are presented in Appendix C.

Drop Speed

Drop speed had the greatest single effect. A faster drop speed increased the length of the overall pattern, but decreased the concentration of the retardant within the pattern (Drops 1, 3, 6 and 8). However, a corresponding increase in the drop speed from 20 to 40 kts. did not double the length of the resultant patterns. The 20-knot drops were released in 6.5 seconds, the 40-knot drops in 7.5 seconds.

At the .04-inch contour level, drops made at 20 kts. covered a mean area of 2,173 $ft.^2$, those at 40 kts. 2,879 $ft.^2$, a difference of 25% of the larger figure. The difference was not statistically significant ($F=5.07 < 5.59$), but an increase of nearly 25% between application techniques would be of operational importance. Line length at 20 kts. was only 156 ft., significantly less (.01 level, $F = 15.90 > 12.25$) than the 210 ft. produced by flying at 40 kts. Drop No. 7 (Phos-Chek 259 from 100 ft. at 40 kts.) produced a smaller pattern than would be expected, possibly because of the higher-than average wind (10 kts.). Use of more drops under closely comparable conditions should demonstrate a significant affect for drop speed.

Sizable contour areas and increased lengths at higher concentrations ($\geq$.07") were noticeably absent for the high drop speeds (40 kts.). For example, a comparison of Drop 2 (made against a strong headwind and therefore at a ground speed of about 10 kts.) and Drop 4 (made at a ground speed of 40 kts.) shows the slow drop distribution pattern to be circular and much shorter than the fast drop. With a headwind, contours were closer and more concentrated at the front of the pattern.

Bucket Height

Bucket height had a marked influence on the overall pattern. Both water and retardant dispersed more in the 200 ft. drops (4, 6, 8 and 12) than in the 100 ft. drops (3, 5, 7 and 11). The dispersion produced larger areas in the lower contours and smaller areas in the higher contours for the high drops. The lengths of the contours for the low and high drops followed a similar trend.

At the .04-inch contour level, drops made at 100 ft. averaged 2,599 $ft.^2$ as against 2,455 $ft.^2$ from 2,000 ft. This 6% difference was not significant either statistically or operationally. Line length for drops from 100 ft. was 199 ft., 16% greater than the 167 ft. for drops from 200 ft. The difference closely approached statistical significance (.05 level, $F = 5.52 < 5.59$) and would be considered borderline as to operational importance. Mean line width ranged from 22 to 35 ft., with a general mean of 30 ft. Height of drop had the strongest apparent affect (33 ft. for high drops vs. 27 ft. for low drops), but the difference was not significant ($F = 3.90 < 5.59$).

Retardant Viscosity

Retardant viscosity at the levels tested (100 and 400 centipoises (cps.) did not influence the patterns obtained for the drops at 20 kt. and 100 ft. (Tables C-2 and C-3 of Appendix C). However, the effect of viscosity on the distribution patterns of the high drops was noticeable (drops 4, 8 and 12). Larger contour areas and greater lengths were produced by the viscous retardants at the higher concentrations for the drops made at speeds of 40 kts. and heights of 200 ft. In contrast, water drops appeared to erode and disperse more than the two slightly viscous retardant materials.

At the .04-inch contour levels, mean area covered was 2378 $ft.^2$ for water, 2451 $ft.^2$ for Phos-Chek 259/XA and 2750 $ft.^2$ for Phos-Chek 259. The least coverage was 90% of the greatest; the difference was not significant statistically ($F < 1.0$) and would not be considered important operationally. Results for line length at .04-inch depth also showed no difference among materials. Means for the three retardants were: Water - 168 ft.; Phos-Chek 259/XA - 182 ft.; Phos-Chek 259 - 200 ft. Combined effect of drop speed and height had a significant effect on the distribution patterns (drops 4, 8 and 12). For example, a fast drop speed and low drop height combination produced a long, narrow pattern.

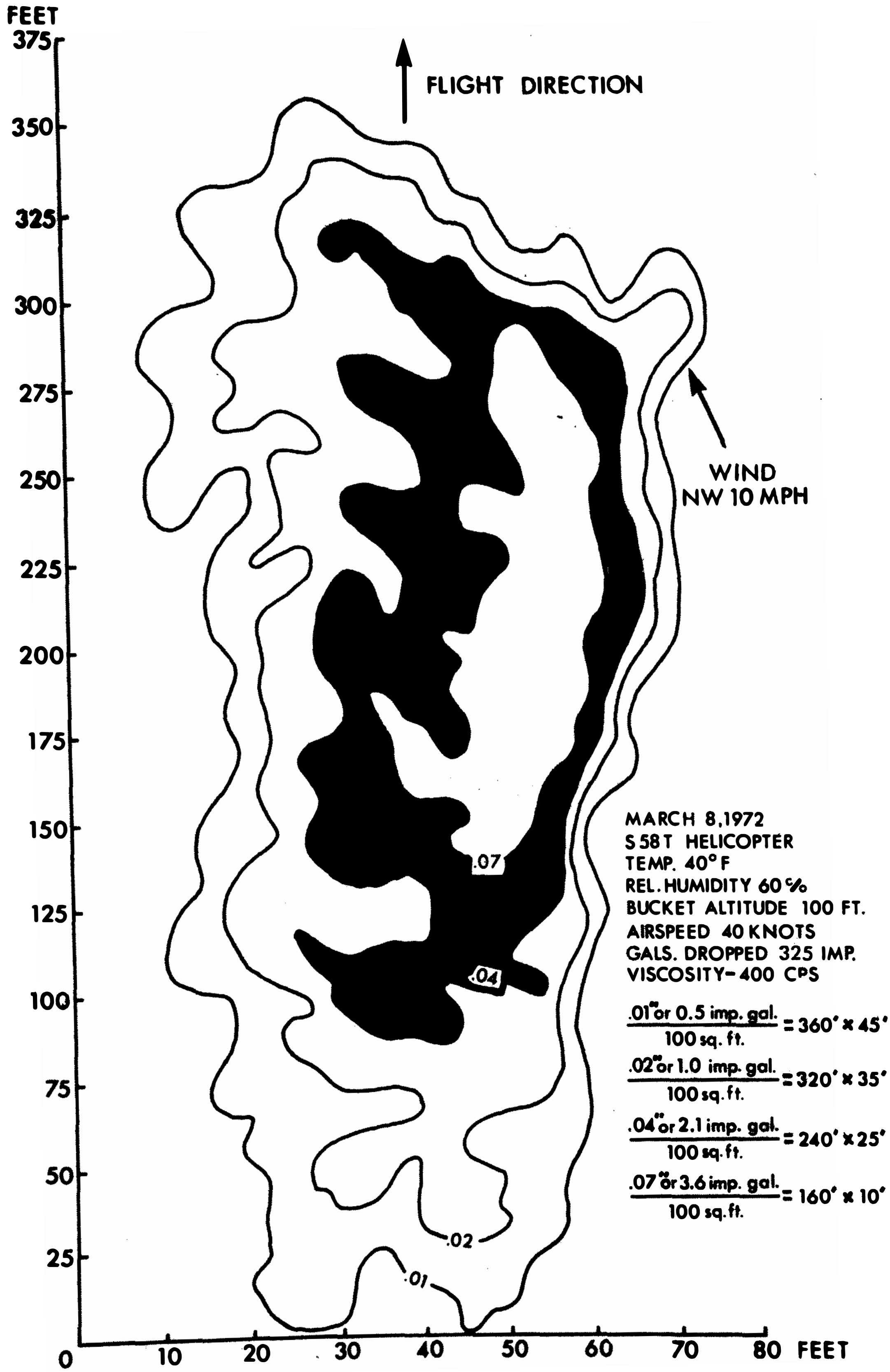


Figure 7. Ground distribution pattern for the open area with the Chadwick bucket using Phos-Chek 259/XA.

SERIES 2: BELL 204B HELICOPTER/AFS MONSOON AND GRIFFITH BIG DIPPER BUCKETS

AFS Monsoon

Bucket height, retardant viscosity and to a lesser degree drop speed all affected the ground distribution patterns. Results are presented in Tables D-1 and D-2 of Appendix D.

Drop Speed. Drop speed had little effect. The circular drop gate permitted release of the retardant within 4 seconds. This fast exit rate reduced the erosion effect that an increased drop speed had on the falling retardant, although a faster drop speed did cause greater load erosion. This resulted in smaller contour areas and lengths in the higher concentrations for the 40-knot drops than for the 20-knot drops (drops 3 and 5, 4 and 6).

Bucket Height. Bucket height had a limited effect. There was little difference between the low (100 ft.) and high (200 ft.) drops, although the higher drops dispersed more. At the fast drop speed (40 kt.), the high drops tended to have larger contour areas and greater lengths in the lower concentrations (drops 5 and 6).

Retardant Viscosity. The effect of retardant viscosity was evident. The two viscous airtanker retardants, Phos-Chek XA and Fire-Trol 100, produced patterns with larger contour areas and greater lengths in the higher concentrations (drops 9 and 10, Figure 8). These retardants dispersed much less than did water and low viscosity material (drops 1 and 3). The amounts of material recovered on the ground for the various drops in the open field did not differ greatly and approached the 90 percent or greater recovery rate for all drops.

Too few data were available for making solid comparisons or statistical tests, but inspection strongly suggests the same results as for the Chadwick bucket. The analysis of variance of area at the .04-inch contour level for the two buckets with Phos-Chek 259/XA gave a non-significant effect ($F < 1.0$) for air speed, with the lower speed giving 25% greater coverage. The Chadwick bucket gave only 16% greater coverage than the AFS Monsoon (2451 $ft.^2$ vs. 2110 $ft.^2$), not significant statistically ($F < 1.0$) and operationally. The greater average coverage with the Chadwick bucket was less than half of its 38% superiority in capacity as used in this study. Line length and widths for the .04 inch contour differed so little between the AFS Monsoon and the Chadwick that no comparisons were made.

In the lodgepole pine stand drops, the 400 cps. Phos-Chek solution dropped at 20 kts. from 60 ft. above the trees produced larger contour areas and greater lengths in the higher concentrations than did similar drops with water (drops 2 and 7, Figure 9). The thickened material retained its mass during the fall to the canopy and was able to penetrate the tree crown better than water. However, the high speed (40-knot) drop with 400 cps. Phos-Chek did not penetrate the crown canopy and produced a pattern similar to that for water at 20 kts. (drop 8). The interception by the tree canopy reduced the length of the water drops at the .02, .04 and .07-inch concentrations by 37%, 60% and 100% (drops 1 and 2), while the length of the Phos-Chek 259/XA drop was reduced by 20%, 50% and 50% respectively (drops 3 and 7).

The ground recovery rates for the stand drops were considerably lower than those for the open field, indicating that much of the material dropped was retained by the tree crowns. For drops made 60 ft. above the tree canopy, the ground recovery rate was 42% for water and 51% for Phos-Chek at 20 kts. and 29% for Phos-Chek at 40 kts.

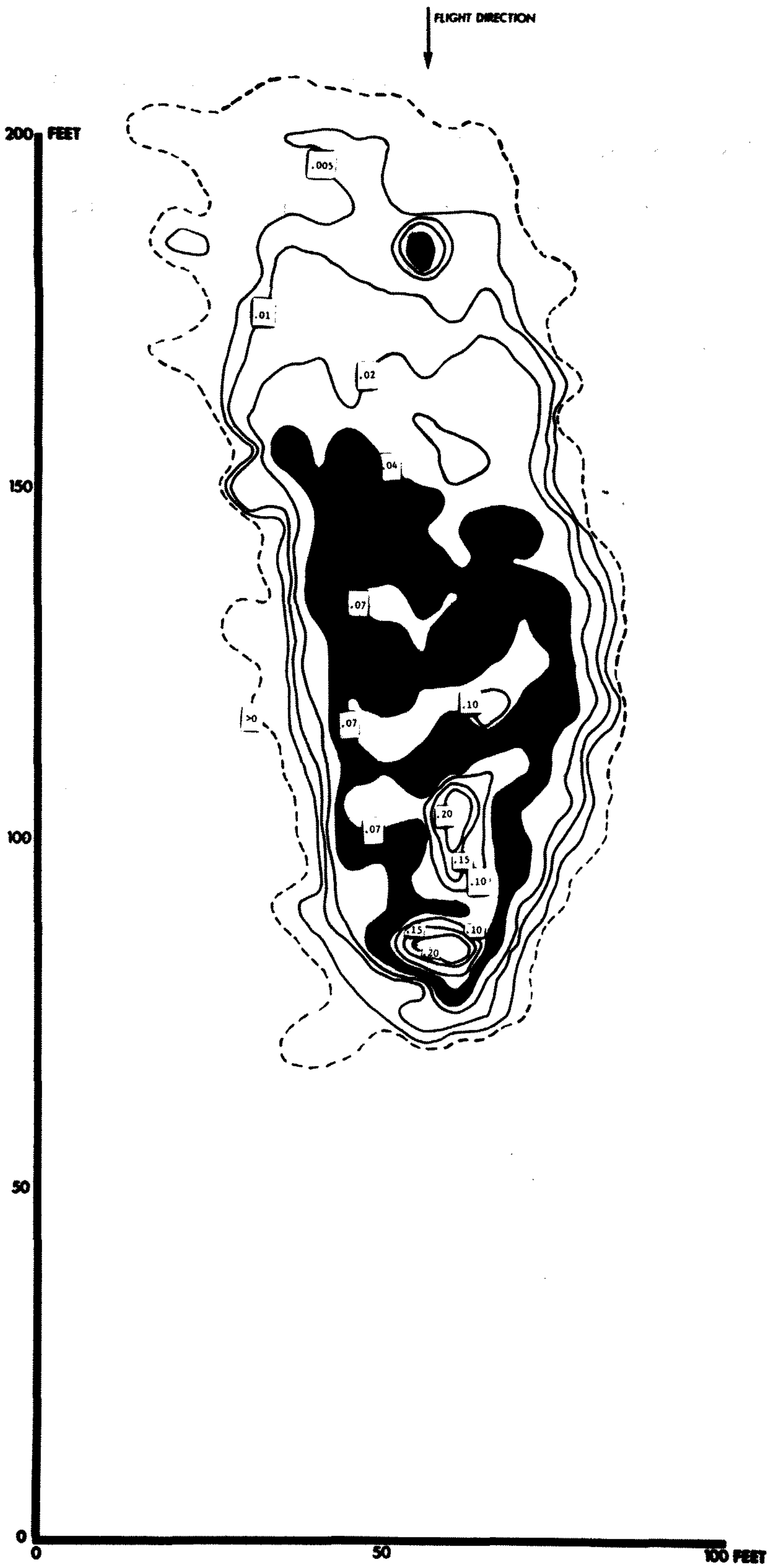
Big Dipper

Difficulties with the electrical activating system on the Griffith Big Dipper bucket limited the results obtained from this drop series. However, drop speed, bucket height and retardant viscosity all affected the ground distribution patterns obtained. Results are presented in Tables D-1 and D-2 of Appendix D.

The restricted drop gate opening (4-inch stroke) and the time required to open the gate produced rather lengthy, light and discontinuous distribution patterns. Time interval for release of the 250-gal. load was 8 seconds. All patterns were characterized by large contour areas and greater lengths in the lower concentrations in contrast to small, discontinuous contour areas and reduced lengths in the higher concentrations (Figure 10). However, viscous materials produced a more concentrated pattern than did water (drops 15 and 16, Fig. 11).

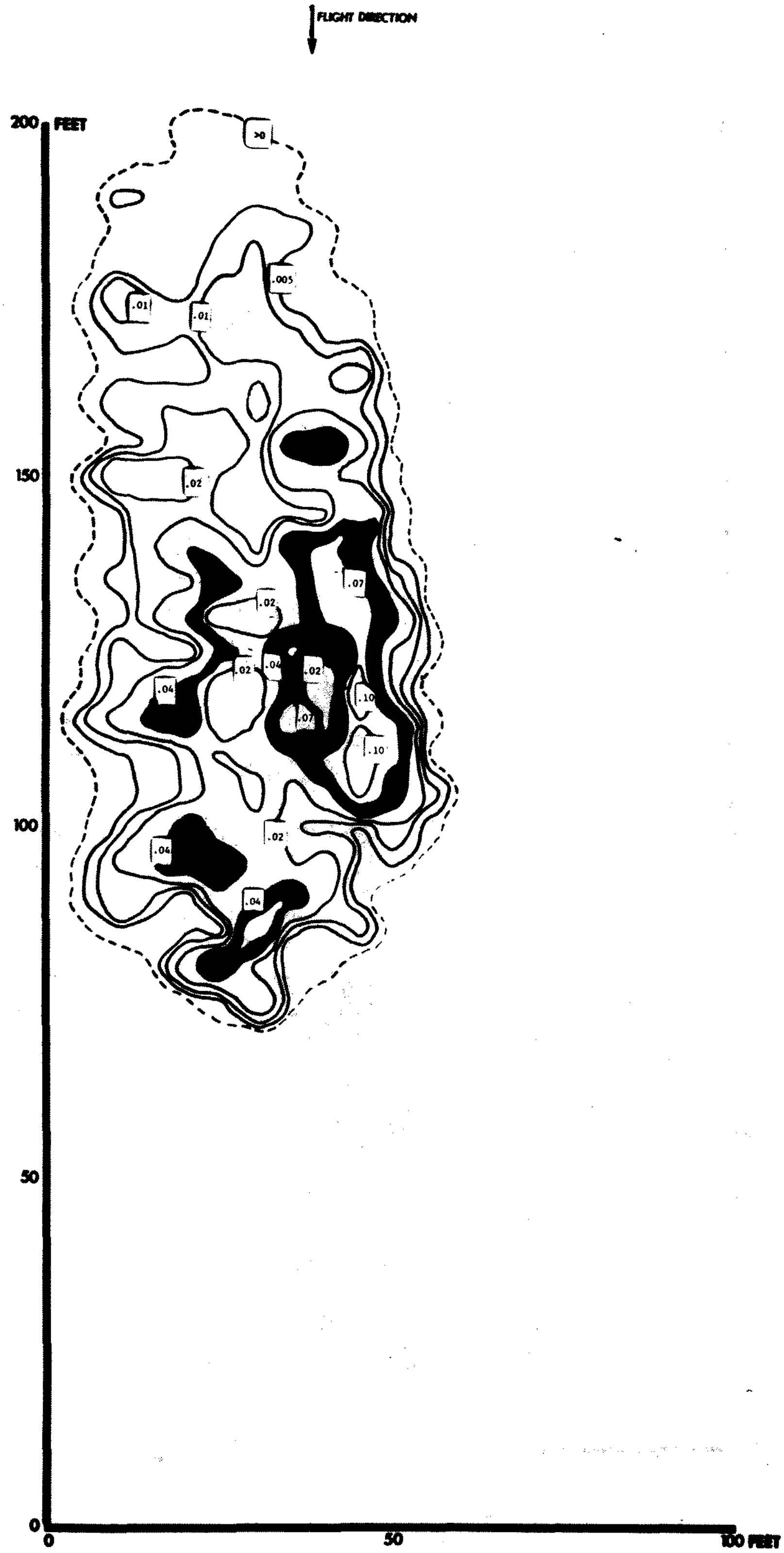
Drops made at speeds of 40 kts. extended well beyond the 200 ft. grid system and could not be calibrated. Furthermore the concentration of these patterns was much less than for the drops at slower speeds. Patterns produced for all drops in the lodgepole pine stand were characterized by small contour areas and reduced lengths in the high concentration levels (Fig. 12).

The obvious features of the Big Dipper performance were the apparent lesser area coverage and greater line length than for the preceeding two buckets. Coverage was significantly less (.05 level, t = 2.31 < 2.26) than for the AFS Monsoon (therefore, also less than for the Chadwick), but line length was not significantly greater (t = 2.21 < 2.90).



DROP NUMBER	10
MONTH	JUNE
DAY	22
NAME OF RETARDANT FIRE-TROL	100
DROP HEIGHT (FT)	100
AIRCRAFT SPEED (MPH)	23
CROSSWIND VEL (MPH)	0
FLIGHT ORIENTATION	(180 DEG)
VISCOSITY (CPS)	2400
SALT CONTENT (SPEC GRAV)	1.100
TEMPERATURE (DEG F.)	60
RELATIVE HUMIDITY	63
GALLONS/DROP (IMP)	235

FIGURE 8. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE AFS MONSOON BUCKET.



DROP NUMBER	7
MONTH	JUNE
DAY	21
NAME OF RETARDANT PHOS-CHEK	259/XA
DROP HEIGHT (FT)	65
AIRCRAFT SPEED (MPH)	23
CROSSWIND VEL (MPH)	0
FLIGHT ORIENTATION	(180 DEG)
VISCOSITY (CPS)	400
SALT CONTENT (SPEC GRAV)	1.090
TEMPERATURE (DEG F.)	67
RELATIVE HUMIDITY	40
GALLONS/DROP (IMP)	235

FIGURE 9. THE GROUND DISTRIBUTION PATTERN FOR THE LODGEPOLE PINE STAND WITH THE AFS MONSOON BUCKET.

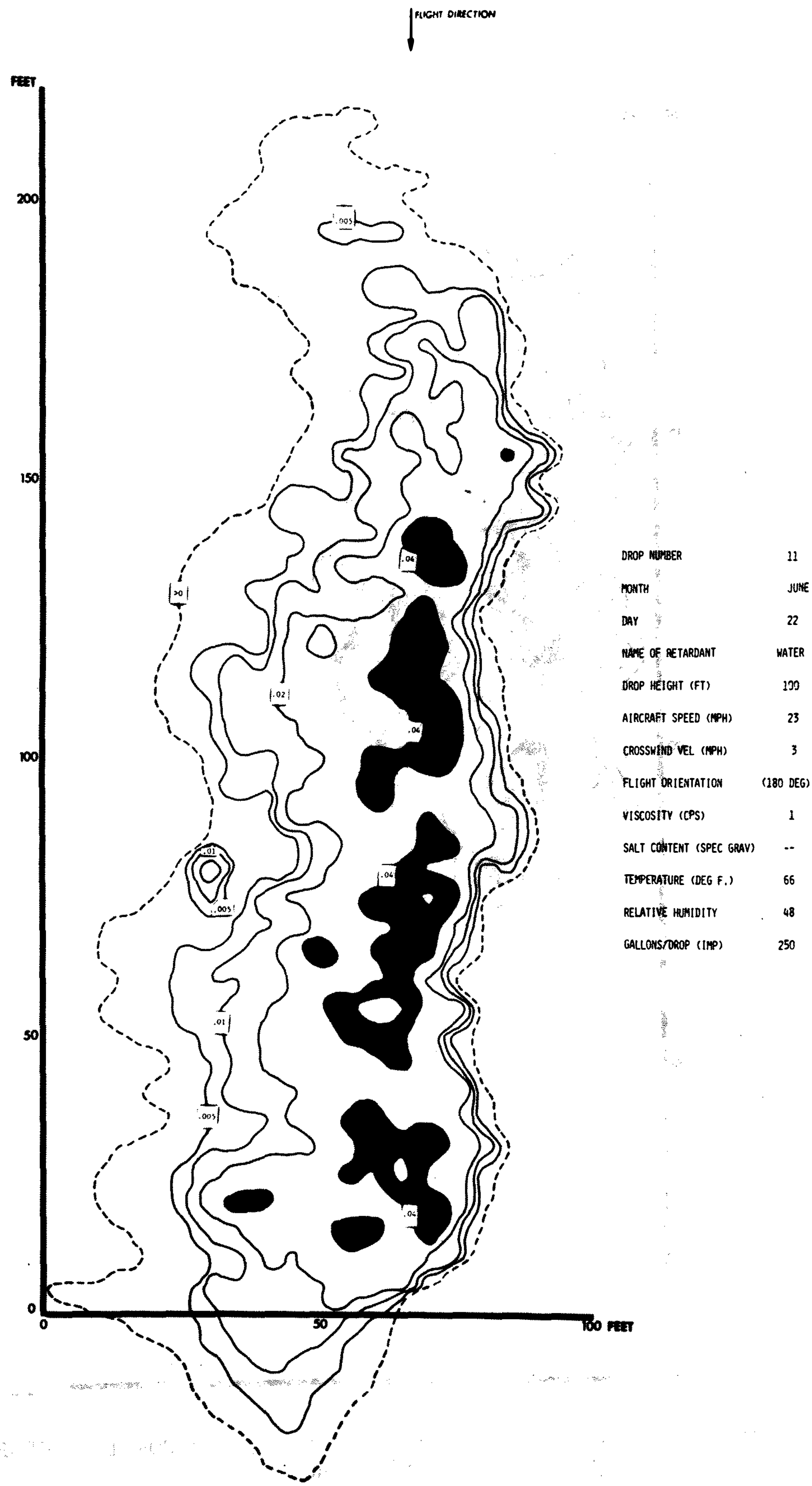


FIGURE 10. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE GRIFFITH BIG DIPPER BUCKET.

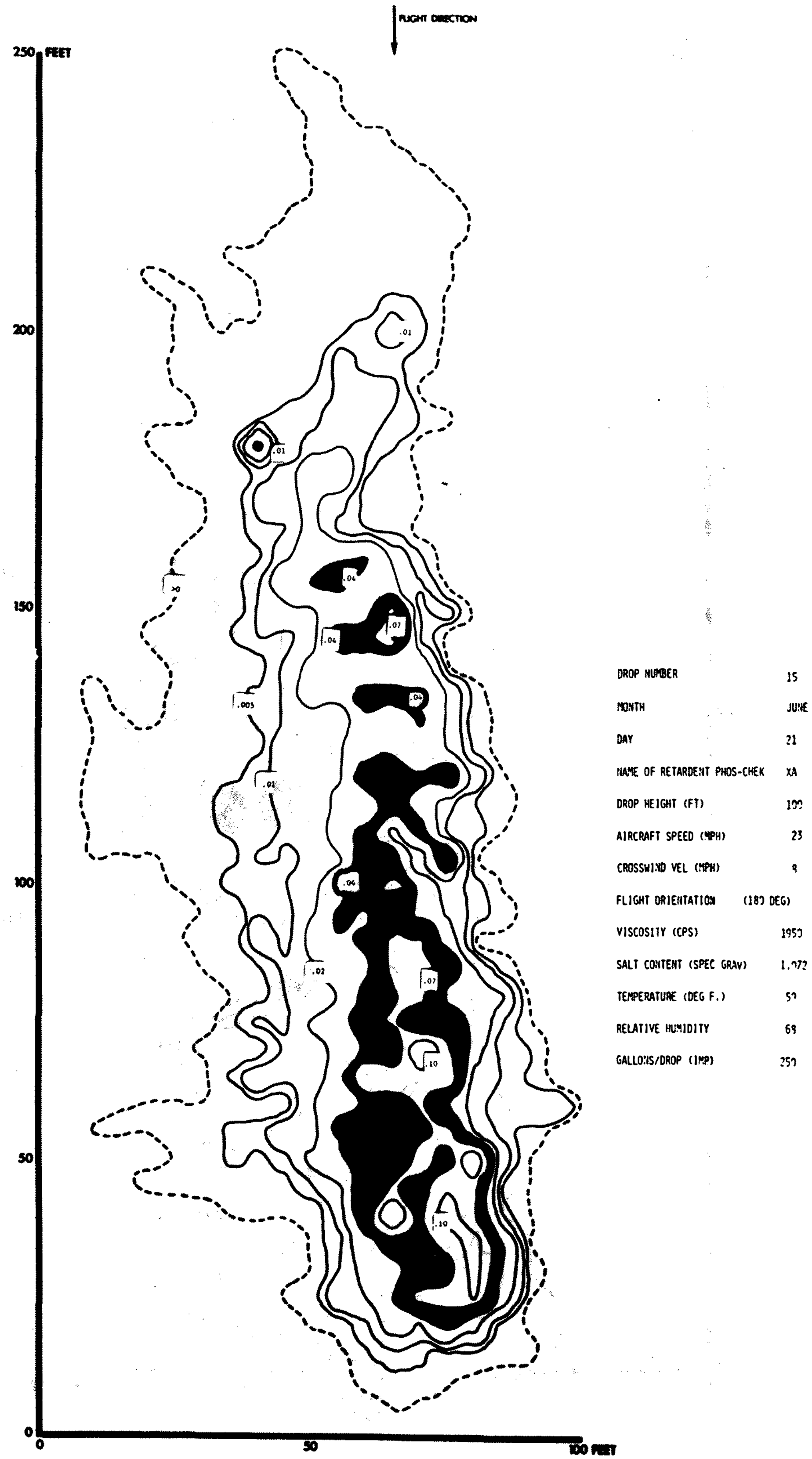


FIGURE 11. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE GRIFFITH BIG DIPPER BUCKET.

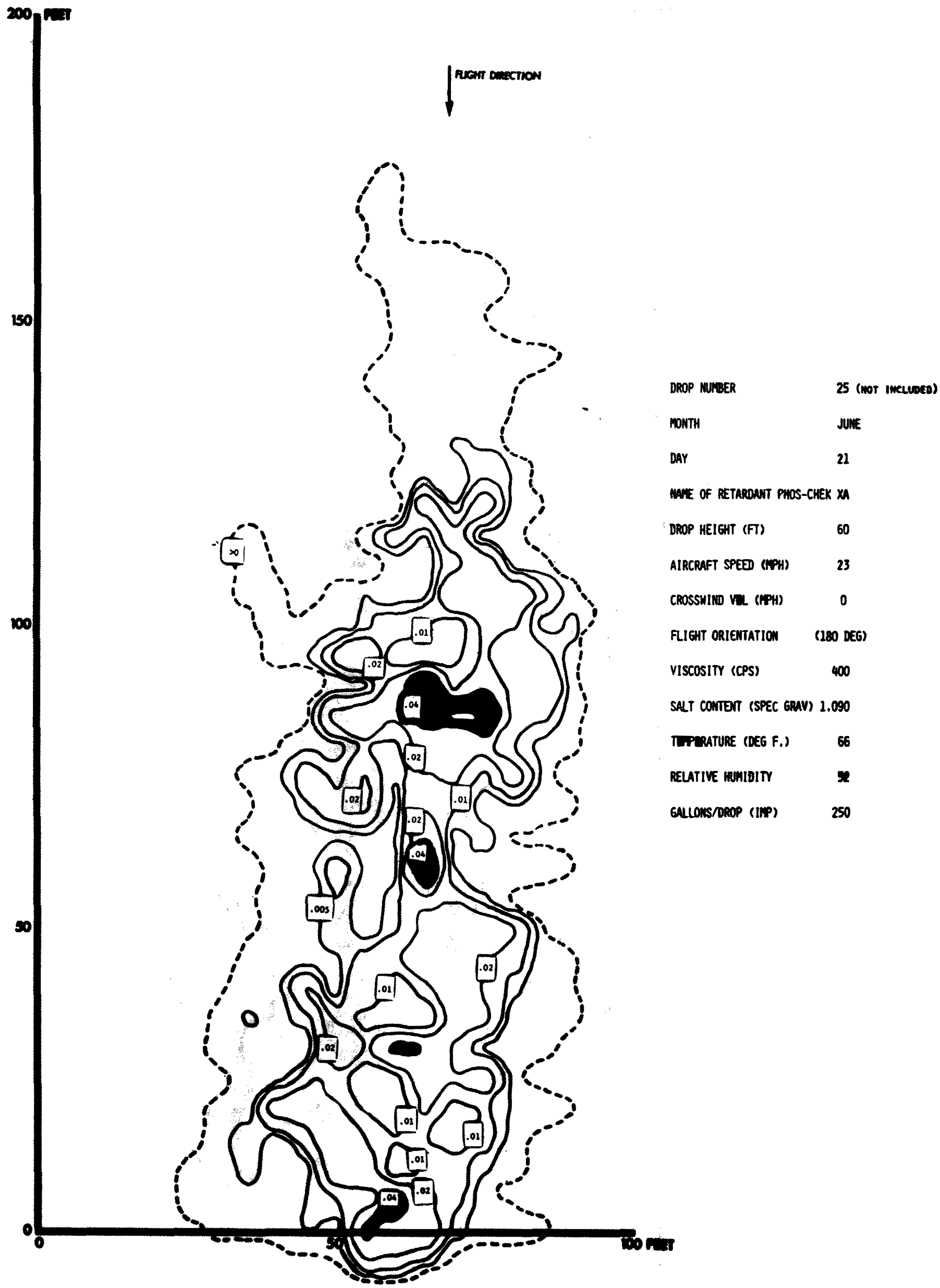


FIGURE 12. THE GROUND DISTRIBUTION PATTERN FOR THE LODGEPOLE PINE STAND WITH THE BIG DIPPER BUCKET.

SERIES 3: BELL 206B HELICOPTER/SIMS BUCKET

The effect of drop speed, bucket height, and retardant viscosity were evident in the drop tests with the Bell 206B helicopter and Sims bucket, Tables E-1 and E-2 of Appendix E. However, the criteria, i.e., a minimum width of 10 ft., used to establish the length of each contour prevented a more complete presentation of these effects. Many areas, especially those in the high concentration levels were less than 10 feet in width for most of their length and consequently were not measured.

Drop Speed

The effect of drop speed was evident for the water drops. Most 40-knot drops extended well beyond the established 200-foot grid systems. In the open area, concentrations at the .04-inch and greater contour levels were measurable at 20 kts. but not 40 (drop 1). With 90-gallon water loads the effect of speed was also evident in a comparison of drops made into the lodgepole pine stand (3 and 5). At the .02-inch contour level, for the fast (40-knot) drop, only spots occurred but larger areas and greater lengths were present at the .04-inch contour level in the slow (20-knot) drop. The length of the .02-inch contour level was 118 feet for the 20-knot drop compared to "spots" for the 40-knot drop. Recovery of material from the slow drop was 46% on the ground, compared to 30 percent for the fast drop (Table E-1). The discharge from the Sims bucket was restricted sufficiently to permit erosion of the falling water at the fast speed.

Bucket Height

Most high (100-ft.) drops fell partially outside the established grid systems and prevented a quantitative comparison with the low drops. Still, the effect of height was noticeable. The high drops with water, and with Fire-Trol 931 dispersed more than the low (50-ft.) drops. As a result smaller concentrations occurred at the .04-inch contour level for the high drops. Similarly Phos-Chek 259 dispersed more in the higher drops, but to a much lesser degree than either water or Fire-Trol 931.

Drops 6 and 8 show the effect of drop height on the resulting patterns over open areas (Figures 13 and 14). For the low drop, dispersal was less and larger contour areas with greater lengths in the higher levels of concentration occurred. The high drop produced larger contour areas and greater lengths in the lower levels of concentration. Specifically, at the .04-inch contour level the 25-ft. drop was 100 ft. long while the 50-ft. drop was 33 ft. long. Seventy-eight percent of the low drop was recovered compared to 70% of the high drop. A considerable portion of the retardant not recovered was retained by the 6-foot high lodgepole pine trees in the open area.

The influence of drop height on a thickened material (Phos-Chek XA) was different than on an unthickened one (drops 16 and 17). Although the total area and length of the .04-inch contour level was greater for the high (100-ft.) drop than the low (60-ft.) drop, the retardant line was irregular or broken at several points (Figure 15). The width of the .04-inch line was less than 10 ft., therefore, the total length of 115 ft. for the low drop and 140 ft. for the high drop was not measured.

Retardant Viscosity

On the Sims bucket, the drop gate opening was not large enough to permit highly-thickened material, e.g. 1400 cps., to discharge freely and resulted in a pulsating flow from the bucket. However, the thickened products did resist the effect of height and wind to a much greater degree than did the unthickened products. The 90-gallon loads of water, Fire-Trol 931 and Phos-Chek 259 were discharged from the bucket in five seconds while Phos-Chek XA was discharged in six seconds.

A comparison of the open area drops at 20-kts. speed and 50-ft. height (drops 1, 6, 12 and 16, respectively) indicated that for this speed and height, the best ground distribution patterns were obtained with Phos-Chek 259 followed by Fire Trol 931, Phos-Chek XA and water. As drop speed and height increased, the unthickened products produced less concentrated patterns than did the thickened ones.

In the mature lodgepole pine stand, the best tree canopy penetration and ground distribution patterns for the slow (20-kts.) drop speed and treetop height were obtained with Fire-Trol 931 followed by water, Phos-Chek 259 and Phos-Chek XA (Figures 16 and 17, drops 9, 11, 3, 14 and 19 respectively). Material recovered on the ground was 56%[8], 53%, 52% and 52% respectively. However, as the drop speed or bucket height, or both, increased, the best tree canopy penetration and ground distribution pattern was obtained with Phos-Chek blended to a viscosity of 800-1,000 cps. At this viscosity level, the retardant load discharged quite evenly, resisted erosion following exit from the bucket and retained enough mass to penetrate the tree crowns (drop 22 and drops 18 and 21 - not included). For the 1,000 centipoises Phos-Chek

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[8] Average ground recovery rate for Fire-Trol 931 drops 9 and 11.

drop at 40 kts. and at 20 feet above the treetops, 62% of the material was recovered on the ground (Figure 18).

The effect of the tree canopy on the ground distribution patterns varied with the material dropped. A comparison of the water drops onto the open area and lodgepole pine stand showed that the lengths of the .02 and .04-inch contour levels were similar. However, the interception of the retardants by the tree crowns was apparent in a comparison of the retardant drops at 20 kts. and 50 feet (also treetop level). The tree canopy reduced the length of the .02 and .04-inch levels by 28% and 40% for Fire-Trol 931; by 12% and 60% for Phos-Chek 259 (220 cps.) and by 37% and 40% for Phos-Chek XA (1,400 cps.)

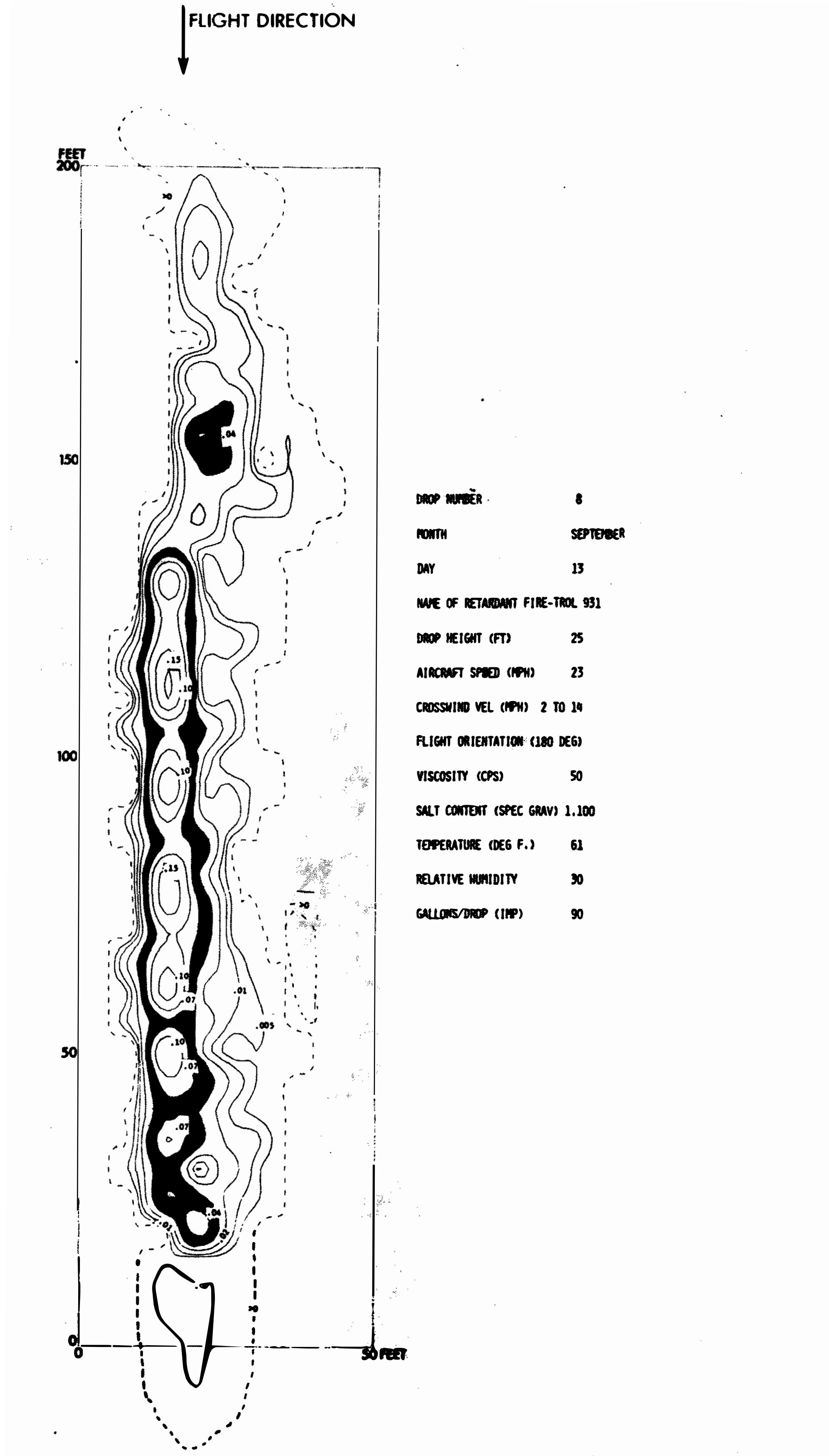


FIGURE 13. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE SIMS BUCKET.

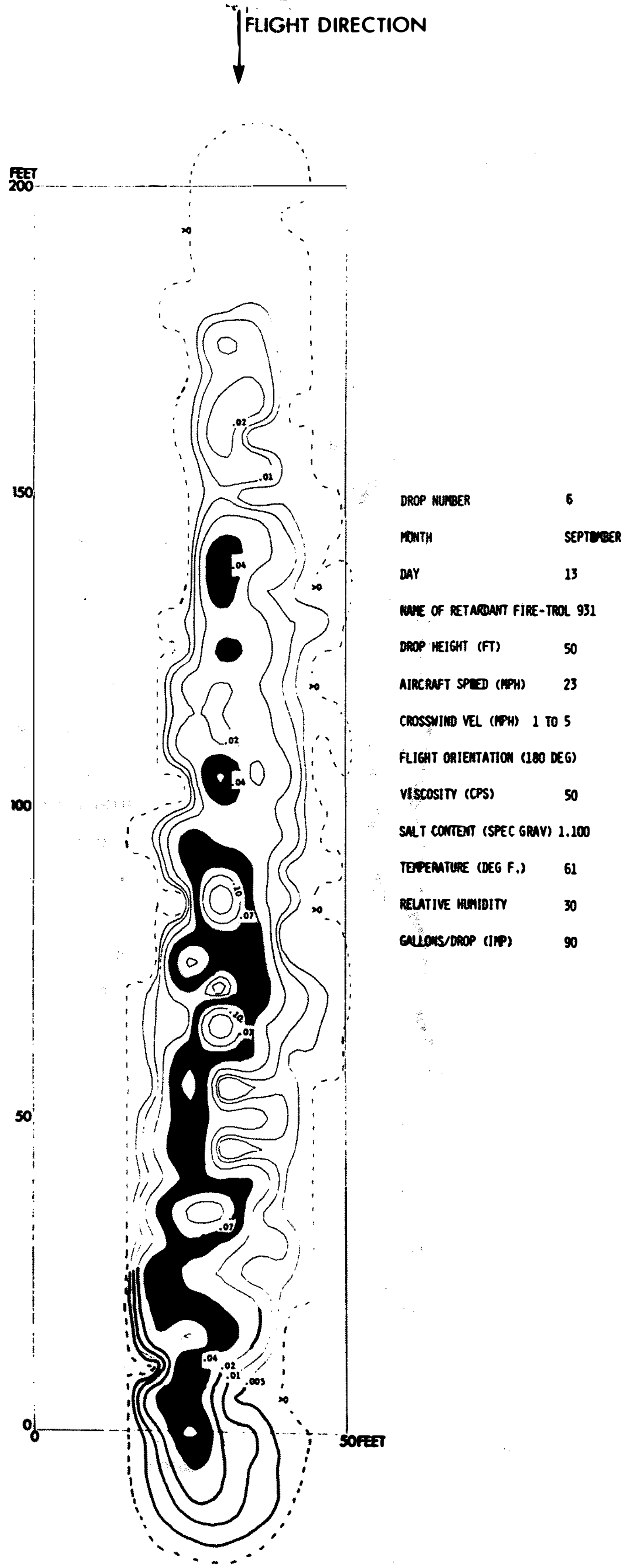


FIGURE 14. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE SIMS BUCKET.

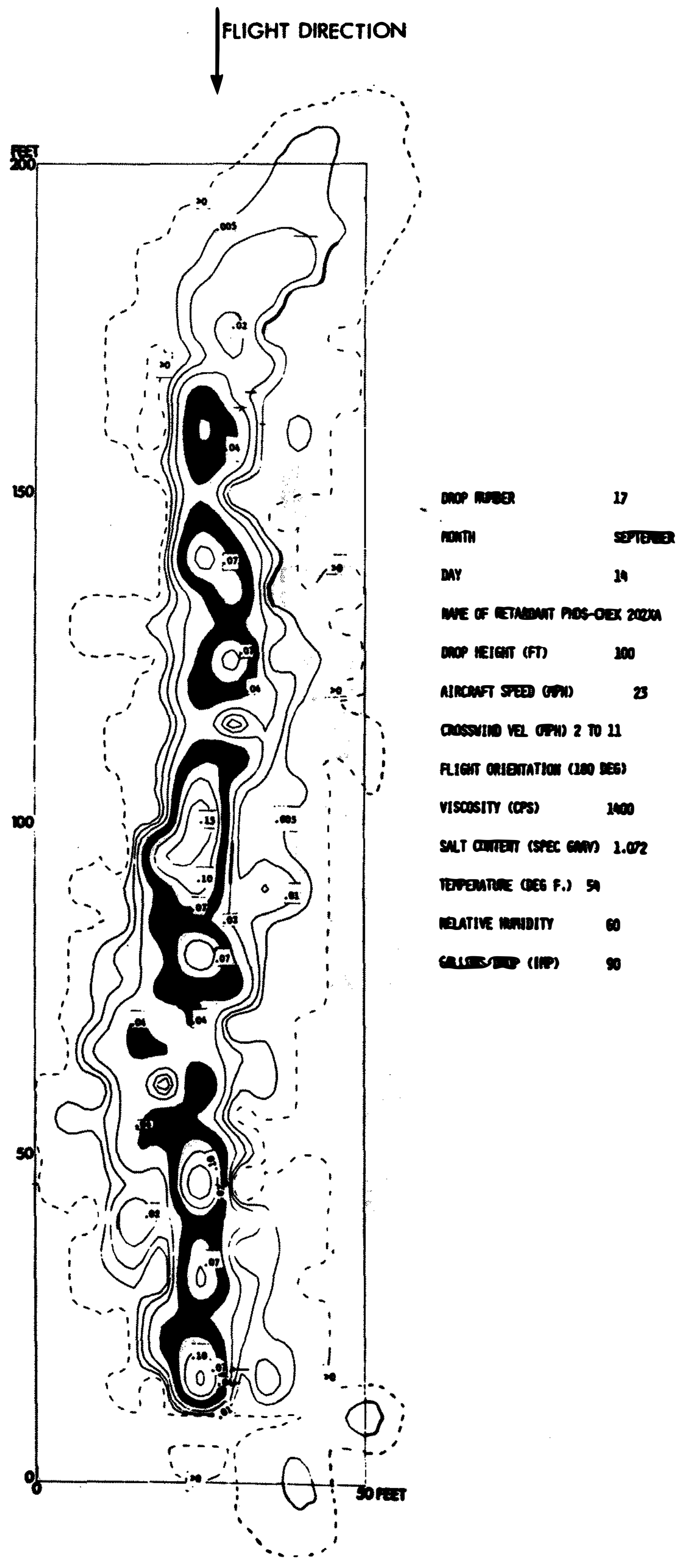


FIGURE 15. THE GROUND DISTRIBUTION PATTERN FOR THE OPEN AREA WITH THE SIMS BUCKET.

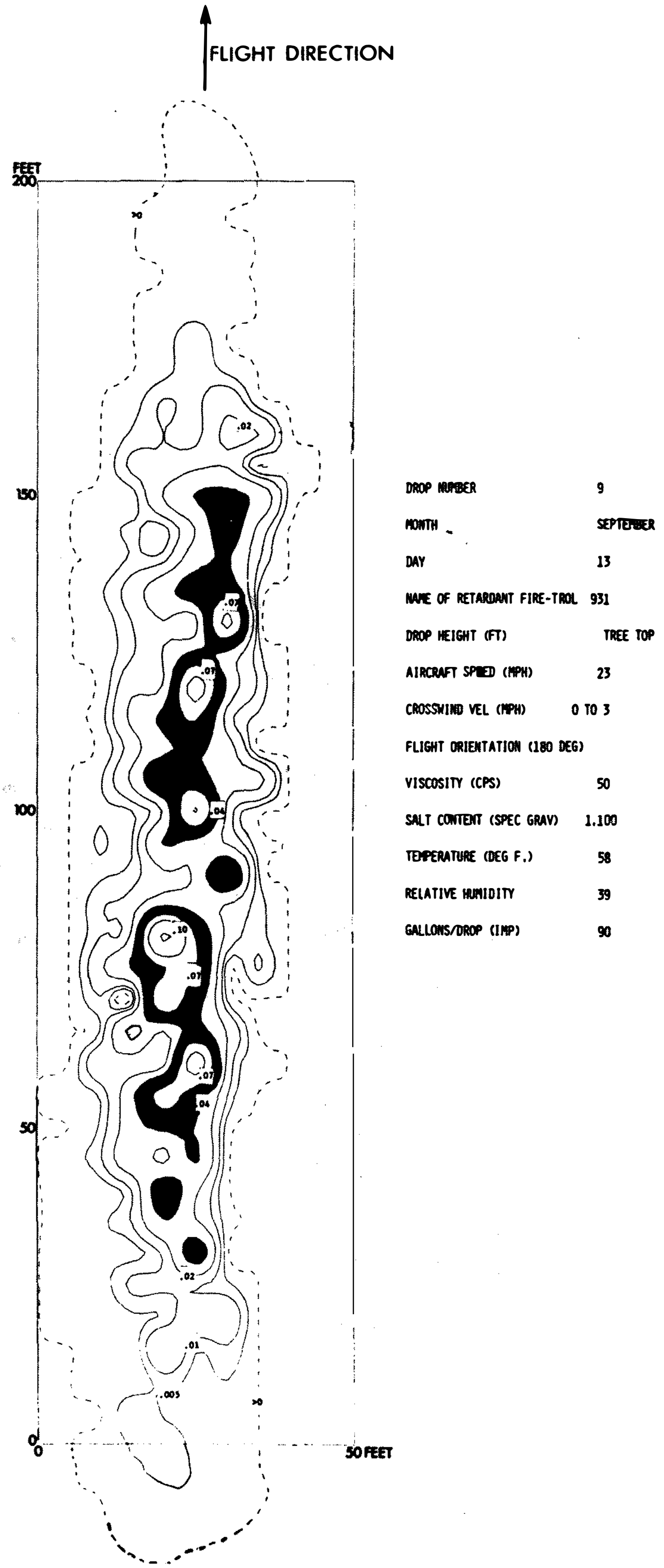


FIGURE 16. THE GROUND DISTRIBUTION PATTERN FOR THE LODGEPOLE PINE STAND WITH THE SIMS BUCKET.

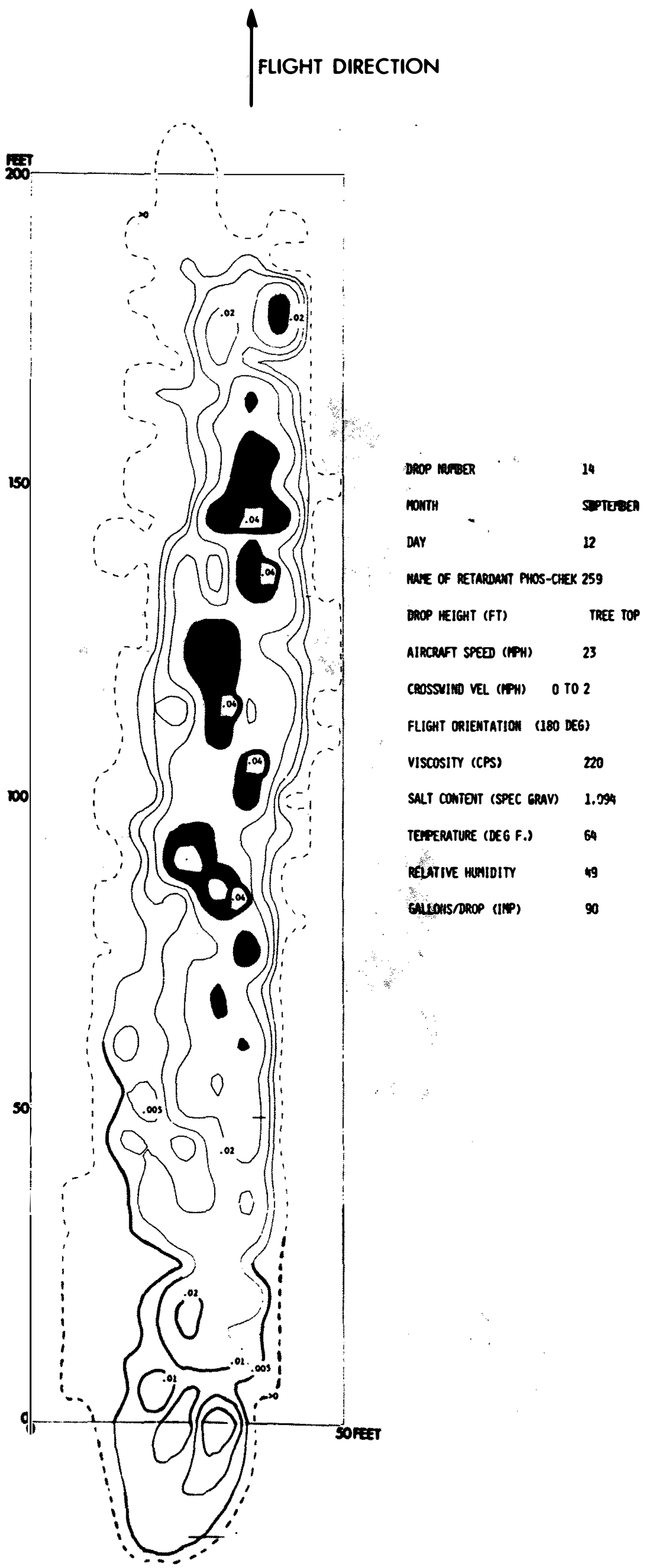


FIGURE 17. THE GROUND DISTRIBUTION PATTERN FOR THE LODGEPOLE PINE STAND WITH THE SIMS BUCKET.

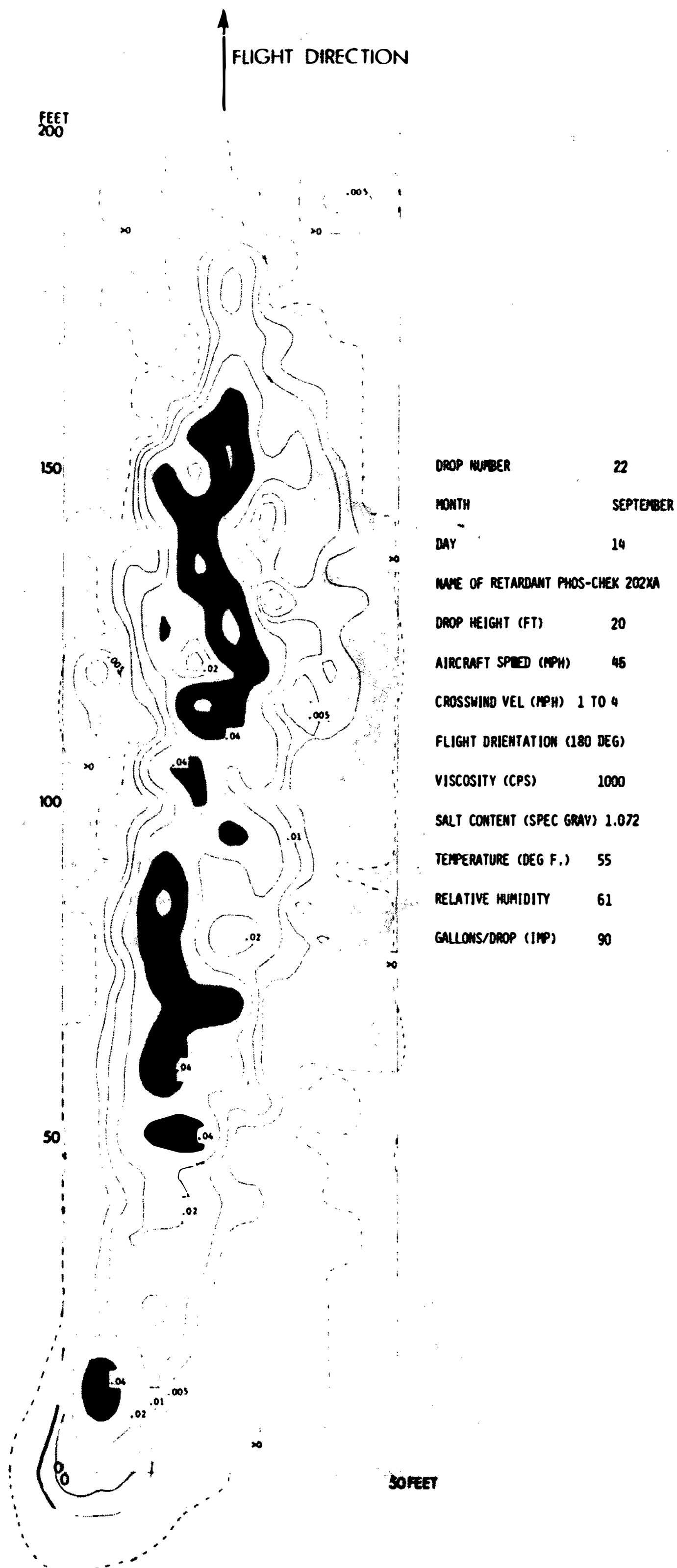


FIGURE 18. A GROUND DISTRIBUTION PATTERN FOR THE LODGEPOLE PINE STAND WITH THE SIMS BUCKET.

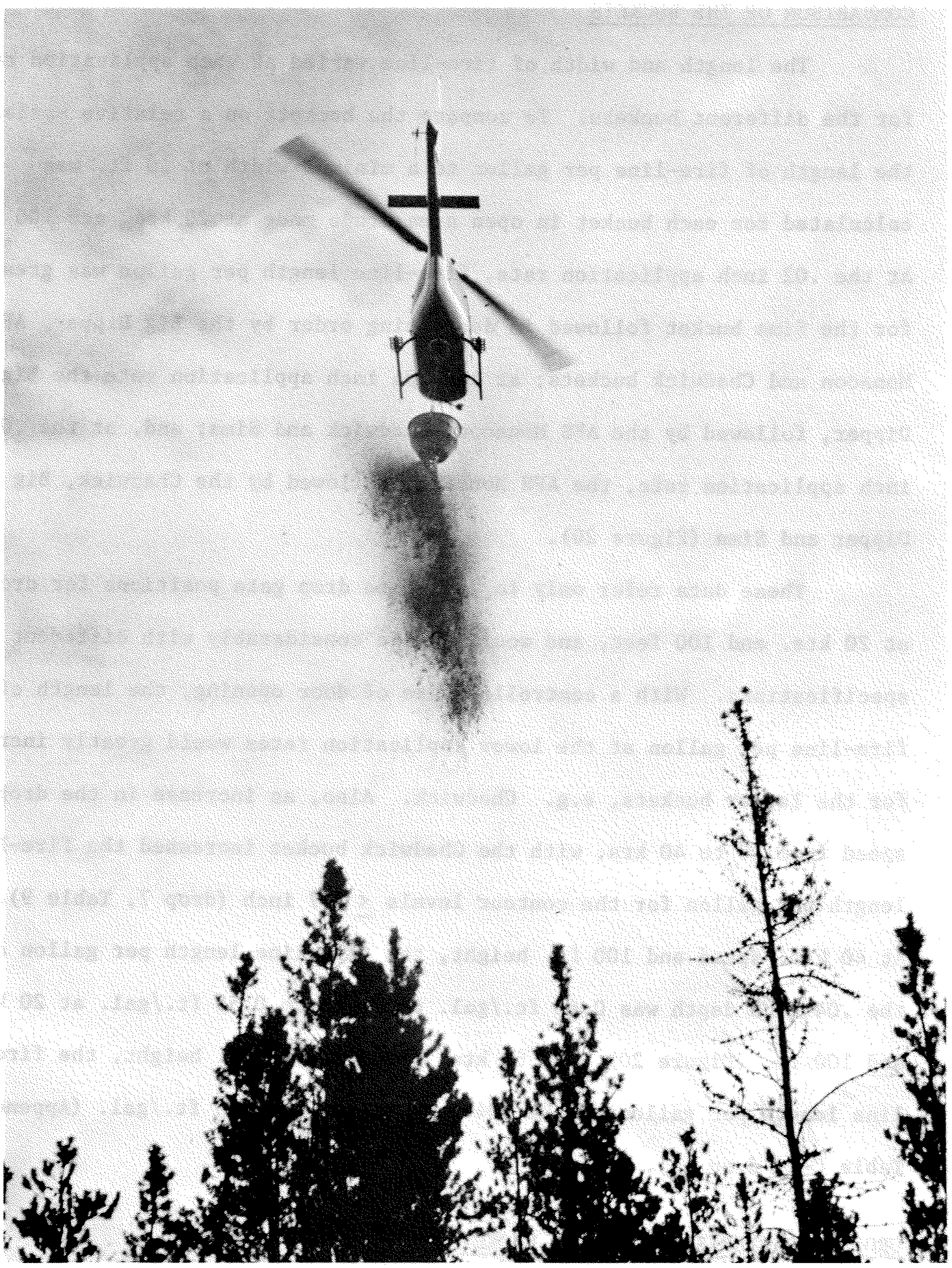


Figure 19. An air drop with the Bell 206B and Sims bucket. Note the off-centre bucket caused by correction for wind and flight path. Also note the pulsating flow of the retardant.

DISCUSSION OF RESULTS

COMPARISON OF THE BUCKETS

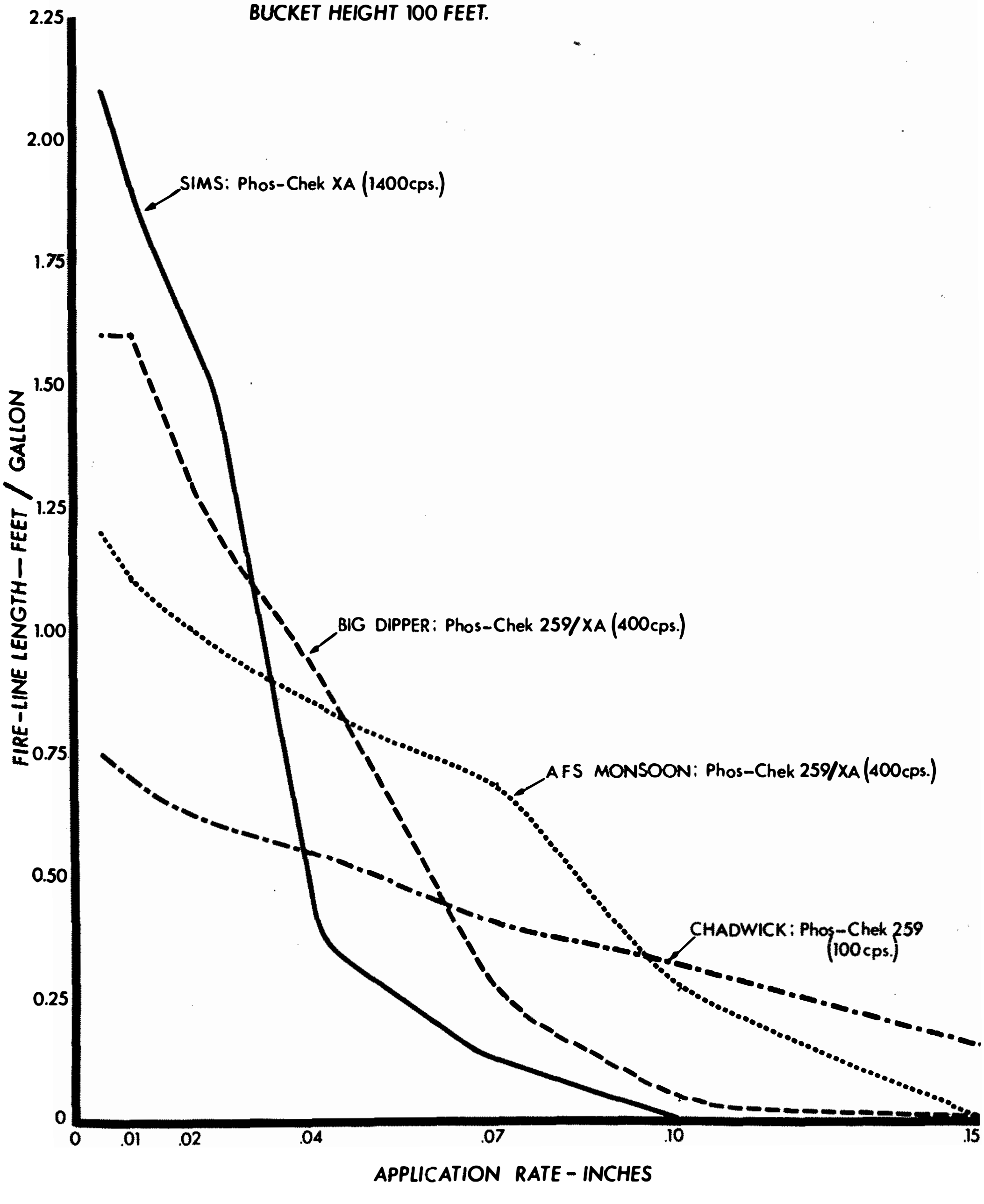
The length and width of fire-line varied at each application rate for the different buckets. To compare the buckets on a relative basis, the length of fire-line per gallon to a minimum width of 10 ft. was calculated for each bucket in open area drops made at 20 kts. and 100 ft. At the .02 inch application rate, fire-line length per gallon was greatest for the Sims bucket followed in decreasing order by the Big Dipper, AFS Monsoon and Chadwick buckets; at the .04 inch application rate the Big Dipper, followed by the AFS Monsoon, Chadwick and Sims; and, at the .07 inch application rate, the AFS Monsoon, followed by the Chadwick, Big Dipper and Sims (Figure 20).

These data refer only to full-open drop gate positions for drops at 20 kts. and 100 feet, and would change considerably with different drop specifications. With a controlled rate of door opening, the length of fire-line per gallon at the lower application rates would greatly increase for the larger buckets, e.g. Chadwick. Also, an increase in the drop speed from 20 to 40 kts. with the Chadwick bucket increased the fire-line length per gallon for the contour levels $\leq$ .07 inch (drop 7, Table 9). At 40 kts. speed and 100 ft. height, the fire-line length per gallon at the .04-inch depth was 0.66 ft./gal. compared to 0.55 ft./gal. at 20 kts. and 100 ft. (Figure 20). At 60 kts. speed and 50 ft. height, the fire-line length per gallon at the .04-inch depth was 1.15 ft./gal. (Appendix Table C-2, drop 13).

DROP CHARACTERISTICS OF THE BUCKET

The design of the bucket controls to a great degree the extent to

FIGURE 20 FIRE-LINE LENGTH PER GALLON TO A MINIMUM WIDTH OF 10 FEET FOR FOUR HELICOPTER BUCKETS. DROP SPEED 20 KNOTS; BUCKET HEIGHT 100 FEET.



which each of the recorded drop variables affects the ground distribution pattern. Each bucket had different drop characteristics. These were partially predetermined by the dimensions of the bucket (height, shape and volume), and the drop gate design (size and type and rate of door opening).

Additional work is needed to improve the drop characteristics of the buckets. Significant amounts of the retardant loads are wasted as light spray and "puddles". A drop mechanism which provides a constant rate of release at a particular setting is required; in combination with varying drop speeds and bucket heights, this will allow the length of fire-line established per gallon dropped to be greatly increased for all levels of application.

Chadwick Bucket

The three 20-inch circular doors on the Chadwick bucket took three seconds to reach their full-open position. The 325-gallon load was released in 7 seconds, or at an average rate of 46 gallons per second. However, most of the material was not released until the doors were fully opened. As the doors started to open, the material squirted out and reached a maximum exit rate just after they were fully opened. The exit rate decreased as the pressure from the head of the material decreased. Thus, the higher concentration levels were found toward the front of the ground distribution pattern: the .04-inch contour was found in the front two-thirds of the pattern while the .07-inch contour was found in the front half of the pattern (Figure 7).

The rate of discharge appears to be satisfactory. With the doors fully opened, a higher drop speed distributes the material over a longer swath on the ground, and tends to break the material into smaller droplets, resulting in a wider pattern with lower concentration levels. Also, a higher drop height provides both a longer and wider, but less concentrated, distribution pattern. A viscous material, on the other hand, resists erosion and decreases the effect of drop speed and height. The direction of the wind in relation to the helicopter's flight path influences the dispersion of the retardant, particularly in the lower contour levels (Figure 7).

Since the pilot can control both the opening and closing of the gates, ground distribution patterns can be varied. By controlling extent of opening, drop speed and bucket height, the length, width and concentration of the pattern can be regulated. The sizeable volume permits more than one drop per load.

AFS Monsoon Bucket

The two semicircular doors on the AFS Monsoon bucket required three seconds to reach their full-open position. The 235-gallon load was released in four seconds, or at an average rate of 60 gallons per second. Only a spray of material was released in the initial second; the bulk exiting during the 2-4 second interval. The higher concentration levels were found toward the front of the pattern (Figure 8).

The rate of discharge appeared to be too great -- at least for fire-line construction with retardant. The broad, short patterns obtained with the bucket are highly concentrated and provide an excessive overkill of chemical retardant. Modification of the drop gate to permit variable door opening would greatly improve the drop characteristics. Perhaps a rectangular rather than a circular door would provide a more regulated exit rate. In addition, a screen-like device to delay the load's exit until the door is opened would likely improve the drop characteristics. However, the present drop mechanism should not be modified to the extent that water application becomes ineffective.

<u>Griffith Big Dipper Bucket</u>

The 25-inch circular door on the Big Dipper bucket required approximately 4 seconds to reach its full-open position. The 250-gallon load was released in 8 seconds, or at an average rate of 30 gallons per second. Once the door was opened, the exit rate appeared to be limited by the four-inch stroke. The slow opening of the door and the limited stroke produced a patchy ground distribution pattern, with the higher concentration levels towards the front of the pattern (Figure 10). The slow rate of opening provided only a light discharge during the first 4 seconds and the limited stroke appeared to create a pulsating exit for the remainder of the load.

The rate of discharge provided by the present 25-inch circular door drop mechanism in the Big Dipper is unsatisfactory. A larger linear actuator may improve the discharge rate; however, the location of the mechanism (at the bottom of the bucket) makes it susceptible to breakdowns. A larger door opening might improve the discharge rate, provided the area between the door and the edge of the bucket is large enough to provide an even flow of material.

Sims Bucket

The 18.5-inch circular gate on the Sims bucket required approximately 3 seconds to reach its full-open position. The 90-gallon load was released in 5 to 6 seconds, or at an average rate of about 16 gallons per second. The vertical lift gate initially restricted the flow of material. The ground distribution patterns had isolated patches of material at the front and rear.

The rate of discharge of the Sims bucket could be increased, perhaps by using a butterfly-type drop gate. However, the small capacity of the bucket limits its fire-line building effectiveness.

ACCURACY

The accuracy of the drops with the small helicopter was partly affected by the drop altitude; a high bucket height greatly decreased the accuracy of the Bell 206B drops. The majority of drops from 100 feet in the open area and from 60 feet above the treetops in the stand area partially or fully missed the established grid system. In addition, the stability of the Bell 206B appeared to be affected by the retardant load to a greater degree than that of the larger helicopters. An increase in the drop height did not greatly affect the accuracy of drops made with the Sikorsky S58T and Bell 204B helicopters.

APPLICATION OF RESULTS

The length and width of fire-line established at each application rate for the different drop conditions encountered in this study can be determined for each helicopter/bucket combination in the Appendices. The Bell 206B helicopter/Sims bucket combination has limited line-building capability when compared to the other two helicopter/bucket combinations used. However, the Bell 206B can be effective on fires in lighter fuels and on small slow-moving spot fires. A cost/effectiveness comparison of the various size categories of helitankers will not be presented in this report.

The length and width of retardant line established at the .04-inch application rate with the Sikorsky S58T/Chadwick bucket and Bell 204B/AFS Monsoon bucket compare quite favorably with the length and width of fire-line established with either the TBM (285 gal.), Thrush (310 gal.), PBY5A Canso (400 gal.) or B-26 (450 gal.) fixed-wing airtankers (see Appendix F for detailed comparisons). For example, at the .04-inch application rate, the S58T/Chadwick combination constructs 182 feet of retardant fire-line (20 kts; 100 ft), the Bell 204B/AFS Monsoon combination 200 ft. (20 kts; 95 ft.), the TBM 180 ft., the Thrush 101 ft., the PBY5A 165 ft. and the B-26 180 ft. These helicopters establish a greater length of continuous fire-line at the .07-inch application rate than do any of the airtankers. However, the fixed-wing airtankers, with the exception of the Thrush, are dropping only one-half of their retardant load. The effect that the additional drop speed of the airtankers has on the amount of fire-line established at .04 inch is shown in a comparison of the smaller (225 gal.) and larger (450 gal.) B-26 drops, and in a comparison of the thickened (Fire-Trol 100) and unthickened (Fire-Trol 931) B-26 drops.

The results indicate that medium helicopters like the Sikorsky S58T and Bell 204B may equal or surpass the line-building capabilities of fixed-wing airtankers releasing between 285 and 450 gallons per drop. Of course, the fast speed and sizeable load of most airtankers must be taken into consideration. The airtanker is an effective initial attack tool. Still, helicopters such as the Sikorsky S58T and Bell 204B can be utilized effectively for retardant delivery. The slow speed and logistics associated with the helicopter limit the use of the helitanker to primarily the support role. This implies utilization on larger fires, where time is not as critical as it is with initial action and where retardant stations can be established at or near the fire site. Initial attack with helicopters is dependent on the distance from an established retardant base to the fire, as well as the availability of airtankers and ground crews, the number of fires reported and their accessibility.

SUMMARY AND CONCLUSIONS

1. Drop speed, bucket height and retardant viscosity affected resultant ground distribution patterns; however, the degree to which each drop variable affected the patterns was primarily controlled by the drop mechanism on the bucket; i.e., size of drop gate(s) and rate of gate(s) opening and discharge.
2. Wind speed and direction had an effect on the resultant ground distribution patterns. Drops made from 50 feet and higher above the ground with the smaller Sims bucket (90 gal.) were affected by winds above 5 mph; drops made from 100 feet and higher above the ground with the larger Chadwick, AFS Monsoon and Big Dipper buckets were also affected, but to a lesser degree.
3. For slower drop speeds (20 kts.), lower bucket heights (50 feet for the Sims bucket and 100 ft. for the Chadwick, AFS Monsoon and Big Dipper buckets) and calm conditions, the ground distribution patterns of the unthickened retardant (Fire-Trol 931) and slightly thickened retardant (Phos-Chek 259) did not differ greatly. However, the patterns for the highly thickened retardants (Fire-Trol 100 and Phos-Chek XA) were more concentrated. As the drop speed, bucket height and wind speed increased, the most effective ground distribution patterns were produced by the viscous retardants. At speeds above 20 kts. and heights greater than treetop level, the viscous materials penetrated the tree canopy to a greater extent than did the non- or slightly-viscous materials. Water dispersed to a greater degree than any of the

unthickened or thickened retardants under all drop conditions, and, in the case of forest stand drops, lacked the penetrating qualities of the retardants created by the additional weight and viscosity of the latter.

4. A gum-thickened retardant (Phos-Chek 259/XA) in the 800-1000 cps. range produced a continuous retardant line in both the open area and forest stands. At this viscosity level, the material withstood the shearing effect of drop speed, resisted erosion and drift by the wind, dispersed enough to prevent excessive "puddling" and, in the case of the forest stand drops, retained enough bulk to penetrate the tree canopy.

5. Additional work is needed to improve the drop mechanisms on several of the buckets tested. A consistent rate of material discharge is required to minimize excessive spray and "puddling". The slow reaction of the drop gate(s) and the subsequent time to obtain full door(s)-open position (3 or more seconds) creates an initial light spray usually followed by an excessive amount of material discharge. With a consistent and regulated discharge rate ground distribution patterns with the desired concentration of material can be easily obtained. The concentration rates can be further controlled through the wide range of drop speeds and bucket heights available with the helicopter.

6. The Bell 206B/Sims bucket combination is limited to a drop speed of 20 kts. or less and to a bucket height of about 50 ft. for effective material application. The effects of downwash and rotor wake on fire behavior should be recognized for slower drop speeds and/or lower bucket heights.

7. The medium-sized helicopters dropping between 235 and 325 gallons of retardant equalled or surpassed the line-building capabilities of fixed-wing airtankers dropping between 285 and 450 gallons per drop at the .04-inch application rate (Appendix F). These helicopters established between 150 and 370 ft. of retardant fire-line at the .04-inch application rate for drop speeds between 20 and 60 kts. and bucket heights between 75 and 200 ft. (Appendices C, D and E).

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Series 2: Alberta Forest Service; Associated Helicopters Ltd., Edmonton, Alberta; Monsanto Canada Limited, Abbotsford, B.C.; and Griffith Polymers, Inc., Portland, Oregon.

Series 3: Yukon Lands and Forest Service; Trans North Turbo Air Ltd., Whitehorse, Yukon; Monsanto Canada Limited, Abbotsford, B.C.; and Chemonics Industries Ltd., Kamloops, B. C.

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APPENDIX A - DESCRIPTION OF RETARDANTS

Phos-Chek XA and 259 are manufactured by Monsanto Canada Limited, Abbotsford, B.C. Fire Trol 100 and 931 are manufactured by Chemonics Industries Ltd., Kamloops, B.C. A brief description of each retardant is presented in Table 1

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TABLE 1

FLAME INHIBITING (long-term) RETARDANT CHEMICALS IN USE IN CANADA

★ Information noted a,b,c etc. applies to all products so marked

As adapted from various sources by the NORTHERN FOREST RESEARCH CENTRE – CANADIAN FORESTRY SERVICE, EDMONTON, ALBERTA.

BRAND NAME	COMPOSITION	PERCENT	MIXING RATIO lb/gal water	MIXING RATIO lb/gal soln.	MIXED DENSITY lb/gal.	VISCOSITY IN CENTIPOISES	SALT CONTENT % by weight in soln.	SWELLAGE % BY VOLUME	GAL. SOLN PRODUCED per ton of dry chem/ton	PACKAGING METHOD	MIXING PROCEDURE	APPLICATION METHOD	STORAGE PROCEDURE	1974 COST 22 TON MINIMUM	REMARKS
PHOS-CHEK XA	$(NH_4)_2HPO_4$ DIAMMONIUM PHOSPHATE (ORTHO 21-53-0) GUAR GUM THICKENER IRON OXIDE COLOURING CORROSION AND SPOILAGE INHIBITORS	89 8 1 2	1·37	1·28	10·6	1500-2000	10·6 DAP 5·7 P_2O_5 equivalent	7	1560 (1180 @ 7·5% P_2O_5 equivalent) (1)	– 57 lb. bags – 1 ton pallets – bulk	continuous flow eductor – batch	aerial	– wet – dry	$420.00/ton	(a) Inhibits glowing and flaming comb. Incorporates most superior (b) fire retardant chemical Readily mixed Quality control readily maintained Corrosion inhibited for aluminum, copper, and ferrous alloys, and magnesium Good cohesive properties Viscous solution One-bag product 90-Day wet storage guarantee
PHOS-CHEK 259	AS IN XA ABOVE	94 2 1 3	1·92	1·75	10·9	50-100	15·0 DAP 8·1 P_2O_5 equivalent	10	1140	50 lb. bags	– continuous flow eductor – batch – agitation	ground	– primarily dry	$420.00/ton	(c) Low viscosity for ease of pumping for ground application Higher active salt content than XA a.b.
FIRE-TROL 100	$(NH_4)_2SO_4$ AMMONIUM SULPHATE (21-0-0) ATTAPULGITE CLAY THICKENER IRON OXIDE COLOURING CORROSION INHIBITOR	63·5 35 1 ·5	3·34	2·78	11·3	1800-2300	15·6 $(NH_4)_2SO_4$	20	720	50 lb. bags	– batch	aerial	– primarily wet	$159.00/ton	Viscous slurry Ammonium sulphate only 2/3 as effective as ammonium phosphate Primarily effective in retarding flaming combustion Economical, but logistically inconvenient One-bag or 3-bag product Mixing procedure slow Mixer horsepower and mixing time critical Abrasive when in motion Sodium dichromate inhibits aluminum 2024 T3 corrosion
FIRE-TROL 931	$(NH_4)_2HPO_4$ DIAMMONIUM PHOSPHATE (POLY N 10-34-0 liquid fertilizer) ATTAPULGITE CLAY COLOUR CARRIER AND THICKENER IRON OXIDE COLOURING CORROSION INHIBITOR	93 4 2 1	3·70 @ 4:1 RATIO	2·96 @ 4:1 RATIO	11·0 @ 4:1 RATIO	50-150	15·4 DAP 8·3 P_2O_5 equivalent	0	675 (14·8 lb/gal)	– 670 lb/45 gal – bulk	– proportioner (blender) – agitation	aerial	– concentrate only	$177.00/ton	Non-viscous solution Minimal, and ease of handling "VARIBLENDER" provides improved control of L.C. and water intake New improved corrosion inhibitor Solution mixed upon discharge from loading pump Polyphosphate reverts to orthophosphate during long term storage of L.C. (1) 8·3% P_2O_5 in 10-34-0 is equivalent to 7·5% P_2O_5 in reagent grade DAP In-line thickening agent may be available a.b.
FIRE-TROL 934	DIAMMONIUM PHOSPHATE (POLY N 10-34-0) CORROSION INHIBITOR	98·7 1·3	3·70 @ 4:1 RATIO	2·96 @ 4:1 RATIO	11·0 @ 4:1 RATIO	50-60	15·8 DAP 8·5 P_2O_5 equivalent	0	675 (14·8 lb/gal)	– 670 lb/45 gal – bulk	– proportioner – agitation	ground	– concentrate only	$177.00/ton	Similar to F.T-931 but: -no clay content -non-abrasive -colourless a.b.c.

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APPENDIX B - OPERATIONAL DATA FOR AIR DROP TESTS

TABLE B-1

OPERATIONAL DATA FOR AIR DROP TESTS WITH THE SIKORSKY S-58T HELICOPTER AND CHADWICK BUCKET. VANCOUVER, B.C., MARCH 7 - 8, 1972

NO.	RETARDANT[1]	VISCOSITY (cps.)	DROP SPEED (knots)	BUCKET HEIGHT (feet)	AIR TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (mph)	WIND DIRECTION
1	WATER	1	20	100	39	80	8+	E
2	WATER	1	20	200	39	80	20 gust	E
3	WATER	1	40	100	43	70	7	E
4	WATER	1	40	200	42	65	7	E
5	PHOS-CHEK 259	100	20	100	46	60	5	E
6	PHOS-CHEK 259	100	20	200	43	69	5	E
7	PHOS-CHEK 259	100	40	100	44	70	10	NW
8	PHOS-CHEK 259	100	40	200	46	60	6	NE
9	PHOS-CHEK 259/XA	400	20	75	45	60	3	NW
10	PHOS-CHEK 259/XA	400	20	200	45	55	1	NW
11	PHOS-CHEK 259/XA	400	40	100	46	60	10	NW
12	PHOS-CHEK 259/XA	400	40	200	46	60	6	NE
13	PHOS-CHEK 259/XA	350	60	50	43	64	7	NE

[1] Water drops = 360 gallons, retardant drops = 325 gallons

TABLE B-2

OPERATIONAL DATA FOR AIR DROP TESTS WITH THE BELL 204B HELICOPTER AND AFS MONSOON AND GRIFFITHS BIG DIPPER BUCKETS. EDSON, ALBERTA. JUNE 20-22, 1972

NO.	BUCKET	RETARDANT	VISCOSITY (cps.)	SITE[1]	DROP SPEED (Knots)	BUCKET HEIGHT (feet)	AIR TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (mph)	WIND DIRECTION
1	AFS MONSOON (235 gal.)	WATER	1	0	20	100	57	66	7	NW
2	"	WATER	1	P	20	60 above trees	57	66	0	--
3	"	PHOS-CHEK 259/XA	400	0	20	95	70	40	0	--
4	"	PHOS-CHEK 259/XA	400	0	20	180	73	30	0	--
5	"	PHOS-CHEK 259/XA	400	0	40	100	72	35	0	--
6	"	PHOS-CHEK 259/XA	400	0	40	200	75	30	5	SE
7	"	PHOS-CHEK 259/XA	400	P	20	65 above trees	67	40	0	--
8	"	PHOS-CHEK 259/XA	400	P	40	60 above trees	-	-	-	--
9	"	PHOS-CHEK XA	1560	0	20	100	59	68	0	--
10	"	FIRE-TROL 100	2400	0	20	100	60	63	0	--
11	BIG DIPPER (250 gal.)	WATER	1	0	20	100	66	48	3	NW
12	"	WATER	1	P	20	60 above trees	57	65	0	--
13	"	PHOS-CHEK 259/XA	400	0	20	130	75	30	7	SE
14	"	PHOS-CHEK 259/XA	400	0	20	110	61	72	0	--
15	"	PHOS-CHEK XA	1950	0	20	100	59	68	8	NW
16	"	FIRE-TROL 100	2400	0	20	110	60	63	0	--

[1] 0 - Open area; P - lodgepole pine

TABLE B-3

OPERATIONAL DATA FOR AIR DROP TESTS WITH THE BELL 206B HELICOPTER AND SIMS BUCKET. WHITEHORSE, YUKON. SEPTEMBER 12-14, 1972
- 90 GALLONS -

NO.	RETARDANT	VISCOSITY (cps.)	DROP SPEED (Knots)	BUCKET HEIGHT[1] (feet)	AIR TEMPERATURE (°F)	RELATIVE HUMIDITY (%)	WIND SPEED (mph)	WIND DIRECTION	SITE[2]
1	WATER	1	20	50	59	59	1		0
2	WATER	1	20	100	64	41	0		0
3	WATER	1	20	TT	55	71	0		P
4	WATER	1	20	60 **	63	52	0		P
5	WATER	1	40	TT	64	49	1		P
6	FIRE-TROL 931	50	20	50	61	30	1-5		0
7	FIRE-TROL 931	50	20	100	64	29	1-5		0
8	FIRE-TROL 931	50	20	25	61	30	2+Gusts		0
9	FIRE-TROL 931	50	20	TT	58	39	1-3		P
10	FIRE-TROL 931	50	20	60 **	61	22	1-3		P
11	FIRE-TROL 931	50	20	TT	61	26	1-6		P
12	PHOS-CHEK 259	220	20	50	63	48	1-3		0
13	PHOS-CHEK 259	220	20	95	59	54	2-5		0
14	PHOS-CHEK 259	220	20	TT	64	49	2		P
15	PHOS-CHEK 259	220	20	60 **	61	47	1-3		P
16	PHOS-CHEK XA	1400	20	60	57	34	2-7		0
17	PHOS-CHEK XA	1400	20	100	54	60	2+Gusts		0
18	PHOS-CHEK 259/XA	1000	20	80	56	47	1-5		0
19	PHOS-CHEK XA	1400	20	TT	58	30	1-4		P
20	PHOS-CHEK XA	1400	20	50 **	62	29	1-4		P
21	PHOS-CHEK 259/XA	800	20	50 **	54	55	2		P
22	PHOS-CHEK 259/XA	1000	40	20 **	55	61	1-4		P

[1] TT = Tree top approximately 50 feet above ground; ** indicates height above trees

[2] 0 = immature lodgepole pine; P = mature lodgepole pine.

APPENDIX C - GROUND DISTRIBUTION PATTERNS WITH SIKORSKY S58T/CHADWICK BUCKET

TABLE C-1

CONTOUR AREAS AND PERCENTAGE GROUND RECOVERY FOR GROUND DISTRIBUTION PATTERNS WITH SIKORSKY S58T/CHADWICK BUCKET. VANCOUVER, B.C., MARCH 7 - 8, 1972

NO.	RETARDANT[1] AND VISCOSITY	DROP SPEED (Knots)	BUCKET HEIGHT (feet)	Contour (depth in inches)[2] >0	≥.005	≥.01	≥.02	≥.04	≥.07	≥.10	≥.15	≥.20	GROUND RECOVERY (%)
				Area in square feet									
1	Water, 1 cps.	20	100	5524+	4655+	4183+	3578+	2438	1702	1204	536	285	85*
2	Water, 1 cps.	20	200	3047	2422	2165	1847	1521	953	728	592	425	70
3	Water, 1 cps.	40	100	10125+	8636+	7512	5606	3387	1079	214	5	-	86*
4	Water, 1 cps.	40	200	13507+	11083+	9178	6238	2167	416	-	-	-	84*
5	PC-259, 100 cps.	20	100	6536	4829	4273	3588	2670	1371	606	250	48	82
6	"	20	200	6101	4562	4010	3436	2760	1509	526	133	88	77
7	"	40	100	9364	6846	5497	4036	2582	1030	350	80	24	81
8	"	40	200	10930+	9008+	7602+	5850	2987	374	35	-	-	93*
9	PC-259/XA,400 cps.	20	75	3932	2823	2375	1977	1564	1073	813	604	418	76
10	"	20	200	5148	3849	3333	2772	2086	1524	1024	675	417	96
11	"	40	100	12070+	8138+	6891	5067	2952	966	-	-	-	91*
12	"	40	200	9303+	7766+	6689+	6023	3202	490	34	-	-	85*
13	" 350 cps.	60	50	12819	9091	7221	4977	2578	345	37	-	-	95

[1] PC = Phos-Chek, quantities were 360 gal for water, 325 for retardant.

[2] * + indicates coverage estimated for part of pattern that fell outside grid.

TABLE C-2

CONTOUR LENGTHS AND AVERAGE WIDTHS FOR GROUND DISTRIBUTION PATTERNS WITH SIKORSKY S58T HELICOPTER/CHADWICK BUCKET. VANCOUVER, B.C., MARCH 7 - 8, 1972

NO.	RETARDANT[1] AND VISCOSITY	DROP SPEED (Knots)	BUCKET HEIGHT (feet)		Contour (depth in inches)[2] >0	≥.005	≥.01	≥.02	≥.04	≥.07	≥.10	≥.15	≥.20
					Length and width in feet								
1	Water, 1 cps.	20	100	length	255	245	225	215	178	140	130	90*	52*
				width	50	45	40	38	35	30	22	15	10
2	Water, 1 cps.	20	200	length	145	125	115	105	99	85	68	60	50
				width	55	50	42	40	38	35	30	28	25
3	Water, 1 cps.	40	100	length	470	440	410	360	230*	210	20	*	-
				width	47	45	40	35	26	10	10	-	-
4	Water, 1 cps.	40	200	length	540	505	470	335	165*	15	-	-	-
				width	53	48	40	35	28	15	-	-	-
5	PC-259, 100 cps.	20	100	length	355	245	230	205	182	130	100	50	*
				width	42	38	35	32	28	22	15	10	-
6	"	20	200	length	335	260	210*	200	180	140	60*	10	10
				width	50	40	35	32	27	25	15	10	10
7	"	40	100	length	405	310	280	265	215*	155	80	20*	*
				width	50	45	40	32	28	15	12	10	-
8	"	40	200	length	418	360	337	270*	222	75	*	-	-
				width	60	53	48	60	35	12	-	-	-
9	PC-259/XA, 400 cps.	20	75	length	250	200	170	160	150	130	120	110	80*
				width	40	30	27	25	22	17	15	14	12
10	"	20	200	length	235	200	178	170	147	135	110	104	100
				width	55	50	47	42	35	25	23	15	10
11	"	40	100	length	430	400	360*	320*	240*	160	-	-	-
				width	60	47	45	35	25	10	-	-	-
12	"	40	200	length	350	330	308	260	190	50*	*	-	-
				width	55	50	40	37	35	20	-	-	-
13	" 350 cps.	60	50	length	600	580	520	450	370*	22	10*	-	-
				width	45	35	28	23	17	15+[3]	10	-	-

[1] PC = Phos-Chek, quantities were 360 gal. for water, 325 for retardant.

[2] * indicates additional spots not joined to main body of contour interval.

[3] + indicates many similar spots along flight line.

APPENDIX D - GROUND DISTRIBUTION PATTERNS WITH BELL 204B HELICOPTER/ AFS MONSOON AND GRIFFITH BIG DIPPER BUCKETS.

TABLE D-1

CONTOUR AREAS AND PERCENTAGE GROUND RECOVERY FOR GROUND DISTRIBUTION PATTERNS WITH BELL 204B HELICOPTER/AFS MONSOON AND GRIFFITH BIG DIPPER BUCKETS. EDSON, ALBERTA. JUNE 20-22, 1972.

NO.	RETARDANT[1] AND VISCOSITY	SITE	DROP SPEED (Knots)	BUCKET[2] HEIGHT (feet)	Contour (depth in inches)[3] >0	≥.005	≥.01	≥.02	≥.04	≥.07	≥.10	≥.15	≥.20	GROUND RECOVERY %
					Area in square feet									
AFS Monsoon 235 gal.														
1	Water, 1 cps.	Open	20	100	7759	4926	4052	3126	1771	933	470	184	-	95
2	Water, 1 cps.	Pine	20	60**	8276+	4691+	3715+	1685+	364+	31	-	-		42
3	PC-259, 400 cps.	Open	20	95	9257	6069	5251	4150	2113	725	265	30	-	98
4	"	Open	20	180	6686+	5758+	5132+	4078	2541	950	185	30	-	95
5	"	Open	40	100	7525+	5750	4831	3589	1881	618	97	-	-	88
6	"	Open	40	200	8804+	5982	4950	3777	1908	822	217	12	-	94
7	"	Pine	20	65**	5380+	4060+	3132+	2192	346	261	42	-	-	51
8	"	Pine	40	60**	5145+	3060+	2240	1172	315	40	11	-	-	29
9	PC-XA, 1560 cps.	Open	20	100	7345	4738	3932	3271	1836	878	144	11	-	92
10	FT-100,2400 cps.	Open	20	100	6491	4883	4089	3242	2182	675	227	107	48	86
Big Dipper 250 gal.														
11	Water, 1 cps.	Open	20	100	12633+	8592+	6921+	4772	1222	61	-	-	-	85
12	Water, 1 cps.	Pine	20	60**	10693+	5809+	3882+	1461	193	-	-	-	-	39
13	PC-259, 400 cps.	Open	20	130	11449+	9023+	7035+	3528	1244	209	16	-	-	87
14	"	Open	20	110	10450	7835	6485	4498	2007	562	116	16	-	98
15	PC-XA, 1950 cps.	Open	20	100	12153	7228	5631	3795	2001	662	106	-	-	93
16	FT-100,2400 cps.	Open	20	110	11143+	7821+	6406+	4149	1346	169	-	-	-	78

[1] PC = Phos-Chek, FT = Fire-Trol

[2] ** indicates height above trees

[3] + indicates coverage estimated for part of pattern that fell outside grid.

TABLE D-2

CONTOUR LENGTHS AND AVERAGE WIDTHS FOR GROUND DISTRIBUTION PATTERNS WITH BELL 204B HELICOPTER/AFS MONSOON AND GRIFFITH BIG DIPPER BUCKETS EDSON, ALBERTA. JUNE 20-22, 1972.

DROP NO.	RETARDANT[1] AND VISCOSITY	SITE	DROP SPEEDS (Knots)	BUCKET[2] HEIGHT (feet)		Contour (depth in inches)[3] >0	≥.005	≥.01	≥.02	≥.04	≥.07	≥.10	≥.15	≥.20
AFS Monsoon 235 gal.														
1	Water, 1 cps.	Open	20	100	length	250	215	200	190	130	80	56	35	25
					width	60	45	40	37	25	20	15	10	5
2	Water, 1 cps.	Pine	20	60**	length	280	230	220	120	52	-	-	-	-
					width	55	35	30	20	10	-	-	-	-
3	PC-259/XA,400 cps.	Open	20	95	length	370	272	250	230	200	160	65*	-	-
					width	50	45	40	35	22	12	7	-	-
4	"	Open	20	180	length	272	244	238	212	180	100	25	10	-
					width	50	45	40	37	32	20	10	7	-
5	"	Open	40	100	length	255	240	225	220	180	120	10	-	-
					width	55	50	47	40	22	10	5	-	-
6	"	Open	40	200	length	330	302	280	238	170	128	21	-	-
					width	50	45	40	35	30	15	10	-	-
7	"	Pine	20	65**	length	260	240	218	180	82*	80	30	-	-
					width	40	35	28	24	15	8	5	-	-
8	"	Pine	40	60**	length	262	200	180	120	40*	10	-	-	-
					width	40	30	22	20	12	10	-	-	-
9	PC-XA, 1560 cps.	Open	20	100	length	263	220	216	200	178	122	110	30*	-
					width	55	50	45	35	22	12	10	7	-
10	FT-100, 2400 cps.	Open	20	100	length	284	260	224	190	162	100	40*	25*	10*
					width	50	40	35	32	30	20	10	10	7
Big Dipper 250 gal.														
11	Water, 1 cps.	Open	20	100	length	495	420	390	340	200*	-	-	-	-
					width	50	40	32	25	10	-	-	-	-
12	Water, 1 cps.	Pine	20	60**	length	410	340	280	160*	25	-	-	-	-
					width	50	38	30	17	10	-	-	-	-
13	PC-259/XA,400 cps.	Open	20	130	length	465	430	405	302	180	-	-	-	-
					width	45	42	38	22	12	-	-	-	-
14	"	Open	20	110	length	440	400	390	330	230	62*	10	-	-
					width	45	40	35	31	24	10	10	-	-
15	PC-XA, 1950 cps.	Open	20	100	length	490	392	370	326	210*	134	-	-	-
					width	50	40	37	30	17	10	-	-	-
16	FT-100, 2400 cps.	Open	20	110	length	510	440	410	316*	190	40*	-	-	-
					width	35	31	28	24	15	7	-	-	-

[1] PC = Phos-Chek, FT = Fire-Trol

[2] ** indicates height above trees

[3] * indicates additional spots not joined to main body of contour interval

APPENDIX E - GROUND DISTRIBUTION PATTERNS WITH BELL 206B HELICOPTER/ SIMS BUCKET.

TABLE E-1

CONTOUR AREAS AND PERCENTAGE GROUND RECOVERY FOR GROUND DISTRIBUTION PATTERNS WITH BELL 206B HELICOPTER/SIMS BUCKET. WHITEHORSE, YUKON. SEPTEMBER 12 - 14, 1973

NO.	RETARDANT[1] AND VISCOSITY	SITE[2]	DROP SPEED (Knots)	BUCKET[3] HEIGHT (feet)	Contour (depth in inches)[4] ≥.005	≥.01	≥.02	≥.04	≥.07	GROUND RECOVERY %
						Area in square feet				
1	Water, 1 cps.	Open	20	50	4712+	3634+	1415+	436+	-	53
3	Water, 1 cps.	Pine	20	TT	3702+	3105+	2091	814	110	46
5	Water, 1 cps.	Pine	40	TT	3885+	1965+	288	-	-	30
6	FT-931, 50 cps.	Open	20	50	4015+	3153+	2152+	970	165	70
8	"	Open	20	25	3150+	2406	1700	1105	642	78
9	"	Pine	20	TT	3695	2663	1710	782	220	61
11	"	Pine	20	TT	3525+	2580	1472	605	80	50
12	PC-259, 220 cps.	Open	20	50	4005+	3112+	2170+	1175+	435	73
14	"	Pine	20	TT	4410+	3020+	1725	459	20	52
15	"	Pine	20	60**	5010+	4290+	2002+	392	90	54
									estimated	
16	PC-XA, 1400 cps.	Open	20	60	4280+	3865+	2392+	880	110	69
17	"	Open	20	100	3850+	2835	1982	1105	434	78
19	"	Pine	20	TT	3751+	2540+	1540	541	105	52
20	"	Pine	20	50**	3960	2024	268	5	-	32
22	PC-259/XA,100 cps.	Pine	40	20**	4475	3400	2040	717	25	62

[1] PC = Phos-Chek, FT = Fire-Trol
[2] Open = immature lodgepole pine, pine = mature lodgepole pine
[3] TT = tree top height (i.e. 42' + 5 - 15 ft), ** indicates height above trees
[4] + indicates coverage estimated for part of pattern that fell outside grid

TABLE E-2

CONTOUR LENGTHS AND AVERAGE WIDTHS FOR GROUND DISTRIBUTION PATTERNS WITH BELL 206B HELICOPTER AND SIMS BUCKET WHITEHORSE, YUKON. SEPTEMBER 12-14, 1972

DROP NO.	RETARDANT[1] AND VISCOSITY	SITE[2]	DROP SPEED (Knots)	BUCKET[3] HEIGHT (feet)		Contour (depth in inches) ≥.005	≥.01	≥.02	≥.04	≥.07
1	Water, 1 cps.	Open	20	50	length	230	187	115	25	-
					width	23	20	16	10	-
3	Water, 1 cps.	Pine	20	TT	length	173	158	118	20;20	-
					width	22	19	16	10;11	-
5	Water, 1 cps.	Pine	40	TT	length	175	85	spots	-	-
					width	19	14	-		-
6	FT-931, 50 cps.	Open	20	50	length	197	190	155	33	spots
					width	16	14	14	11	-
8	"	Open	20	25	length	175	150	142	100	spots
					width	17	14	11	10	-
9	"	Pine	20	TT	length	158	146	112	20	spots
					width	21	18	12	10	-
11	"	Pine	20	TT	length	170	162	90	15	-
					width	19	15	13	10	-
12	PC-259, 220 cps.	Open	20	50	length	200	185	128	37;22	spots
					width	20	16	14	13;12	-
14	"	Pine	20	TT	length	202	172	113	15	-
					width	21	17	14	10	-
15	"	Pine	20	60**	length	191	145	97	30	spots
					width	28	27	17	10	-
16	PC-XA, 1400 cps.	Open	20	60	length	218	207	132	36	-
					width	21	18	15	12	-
17	"	Open	20	100	length	190	173	145	38	10
					width	20	15	13	12	10
19	"	Pine	20	TT	length	178	155	83	20	-
					width	20	16	12	10	-
20	"	Pine	20	50**	length	175	143	10	-	-
					width	20	12	10	-	-
22	PC-259/XA, 1000 cps.	Pine	40	20**	length	187	165	117	10 spots	-
					width	22	19	14	10	-

1 PC = Phos-Chek, FT = Fire-Trol
2 Open = immature lodgepole pine; pine = mature lodgepole pine
3 TT = tree top height (i.e. 42' + 5-15'); ** indicates height above trees

APPENDIX F - ESTABLISHED RETARDANT FIRE LINES

TABLE F-1

RETARDANT FIRE-LINE ESTABLISHED WITH A DIFFERENT HELICOPTER/BUCKET COMBINATIONS AND FIXED-WING AIRTANKERS

AIRCRAFT	RETARDANT	DROP VOLUME (gal.)	DROP SPEED (Knots)	DROP HEIGHT (feet)		Contour (depth in inches) .01	.02	.04	.07
Helicopters									
Sikorsky S58T/					length	410	360	230	210
Chadwick	Water	350	40	100	width	40	35	26	10
"	Phos-Chek 259				length	230	205	182	130
	(100 cps.)	325	20	100	width	35	32	28	22
"	Phos-Chek 259/XA				length	178	170	147	135
	(400 cps.)	325	20	200	width	47	42	35	25
"	Phos-Chek 259/XA				length	520	450	370	22
	(350 cps.)	325	60	50	width	28	23	17	15
Bell 204B/	Phos-Chek 259/XA				length	250	230	200	160
AFS Monsoon	(400 cps.)	235	20	95	width	40	35	22	12
"	Phos-Chek 259/XA				length	280	238	170	128
	(400 cps.)	235	40	200	width	40	35	30	15
"	Phos-Chek XA				length	216	200	178	122
	(1560 cps.)	235	20	100	width	45	35	22	12
Bell 206B/	Fire-Trol 931				length	190	155	33	spots
Sims bucket	(50 cps.)	90	20	50	width	14	14	11	-
"	Phos-Chek XA				length	173	145	38	10
	(1400 cps.)	90	20	100	width	15	13	12	10
Fixed-wing Airtankers[1]									
Thrush	Fire-Trol 100				length	203	141	101	70
Commander	(2083 cps.)	310	85	85	width	50	45	35	25
					length	225	250	165	95
PBY5A Canso	Gelgard	400	85	90	width	50	40	30	15
					length	150	122	10	-
B-26 (4-door)	Fire-Trol 931	225	120	90	width	67	35	10	-
					length	320	290	170	10
B-26 (4-door)	Fire-Trol 931	450	120	90	width	64	42	20	10
	Fire-Trol 100				length	224	142	90	12
B-26 (4-door)	(2600 cps.)	225	120	90	width	44	31	20	10
	Fire-Trol 100				length	270	220	180	78
B-26 (4-door)	(2600 cps.)	450	120	90	width	42	33	30	15
	Phos-Chek XA				length	330	260	200	40
TBM	(1250 cps.)	285	120	140	width	38	30	25	15

[1] Source: Northern Forest Research Centre

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