FOREST AND RURAL FIRE RESEARCH
NZFRI LTD

Fire Technology Transfer Note

Number - 12 June 1997

Guidelines for determining aerial drop patterns in open areas

By Kimberly Robertson (FRI), Liam Fogarty (FRI) and Steve Webb (CHH Forests Ltd., Central Region)

Introduction

Fire Technology Transfer Note (FTTN) 11 outlined a range of technical factors that influence aerial drop effectiveness. The main conclusion was that to improve standards of firebombing, we need to know how firebreak characteristics (width, depth, additives, time since drop, etc) affect the ability of a fire to cross a firebreak (the firebreak breaching threshold), in different fuel, topographical, and fire danger conditions. As a part of this work, we need to learn more about aerial drop patterns or "footprints" (Figure 1) in open areas.

Figure 1. Footprint from an aerial foam drop conducted at Kaingaroa.

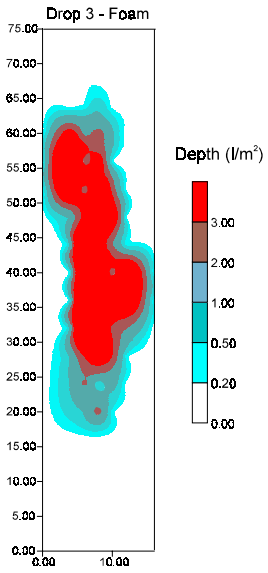


Figure 2 shows that while the bare ground pattern is only one of many elements (e.g., additives, fuel types, canopy, slope, and weather) that interact to determine firebreak breaching thresholds, a knowledge of the basics of footprints allows us to understand how:

- available equipment, aircraft, additives, and wind and flight conditions interact to produce a footprint;
- to achieve nominated footprints (depth thresholds) for open grasslands (see Table 1, FTTN 11);
- to produce guidelines on the production of wet, fluid, and dry foams under different flight and wind conditions; and
- to improve the design and selection of equipment, additives, and aircraft used for firebombing.

FRI
NEW ZEALAND FOREST RESEARCH INSTITUTE LIMITED
NATIONAL RURAL FIRE AUTHORITY

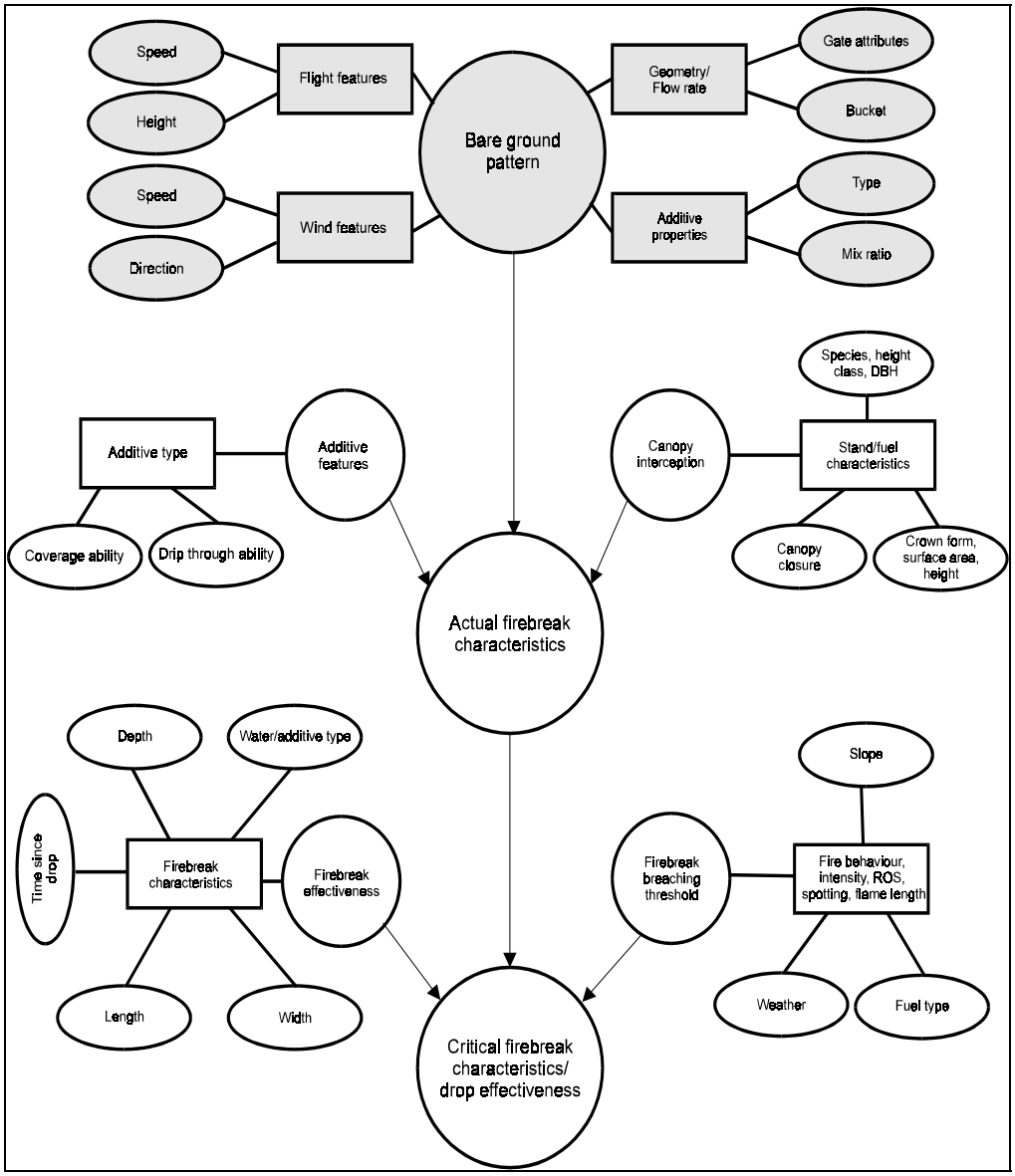


Figure 2. Factors contributing to aerial drop effectiveness (adapted from Hardy 1976).

Firebombing effectiveness information is needed to produce comprehensive guidelines for aerial attack operations. This information can then be applied by fire managers to trial situations and real wildfires, enabling them to better estimate the speed and cost of building firelines. Unfortunately there is no funding available to support our full involvement in such research, so fire managers will need to do much of the work involved in gathering the necessary information themselves. Fire Research staff at FRI will then process and store the trial results for future reference.

Even though this is the simplest step in gathering firebombing effectiveness information, aerial drop trials are time consuming. However, significant gains can be made if the people and aircraft involved at training days and public displays are harnessed. As a starting point, this FTTN outlines standard procedures for the determination of bare ground drop patterns, or "footprints", in open areas. We have a kit at FRI containing most of the necessary equipment; if you are interested in conducting aerial drop trials, or offering comment on the guidelines, please contact Kimberly Robertson, Phone 07 347 5653.

Acknowledgments

The very helpful comments provided by Ken Klitscher are acknowledge and appreciated.

References

Hardy, C.E. 1976. Operational assessment of the effectiveness of aerially applied fire retardants under wildfire conditions. Report summarising work under contract 0SS5-0028.

Robertson, K; Fogarty, L; and Webb, S. 1997. Firebombing effectiveness - where to from here. *Fire Technology Transfer Note* 11 (April 1997).

Guidelines for aerial drop trials in open areas.

These guidelines contain:

- A list of equipment provided by FRI.
- A list of equipment required at the local level.
- Directions as to how to lay the grid out.
- The trial procedure.
- Duty statements for key personnel.

Also attached is:

- A diagram of the grid pattern set up.
- A weather recording form.
- A table to calculate the amount of foam concentrate required for different foam solutions.
- A drop specification form.
- A drop distribution and foam expansion form.

Equipment provided by FRI:

- 290 funnels.
- 290 measuring cups.
- 290 wire frames to anchor funnels and cups.
- 4 measuring cylinders.
- 2 x clipboard and pens.
- 8 injector guns.
- Anti foaming agent.
- Compass (to set out grid).
- Clinometer.
- 100m tape measure (to measure drop length, width and set out grid).
- 2m tape measure (to measure outlet height and diameter, plug diameter, and distance between the skirt bottom and bucket base).
- 12 grease pencils.
- Spray paint.
- Flagging.
- Guidelines.
- Diagram of grid set up.
- Foam concentration table.

<u>Weather equipment:</u>

- Automatic weather station.
- Palmtop digital diary or laptop computer (if using an automatic weather station).

If no automatic weather station is available, you will require:

- Hand held anemometer (for measuring wind speed) and tripod stand.
- Hand held psychrometer (for temperature and relative humidity).
- Tripod.

Equipment/resources you need to provide:

- Suitable location (i.e., approx 300m × 300m paddock or field).
- Aircraft.
- Monsoon bucket.
- Water supply and filling crew.
- Foam concentrate or retardant.
- Radio (to communicate with pilot).
- 2 to 4 buckets (to rinse out cups and funnels after each drop).
- Rags (to dry cups).
- 1 stop watch.
- Clinometer (if available).
- 6 - 9 people.

Grid layout

To establish the bare ground pattern, the grid should be laid out on an open, mowed or grazed paddock (see Photo 1). Orientate the long grid axis in the prevailing wind direction to minimise side-wind effects.

Photo 1. Grid layout

Appendix 1 shows two grid patterns: a 24m × 96m grid for light helicopters (e.g., Jet Ranger, Hughes) and a 24m × 180m grid for medium helicopters (e.g.

Iroquois, Squirrel). The larger grid may also be required on windy days (say greater than 15 km/h) or when aircraft speed (say 100 km/h for a light helicopter) is high. To establish the grid, mark out the boundaries; thread the wire through the funnels, push the wire ends into the ground, and place in the grid pattern shown in Appendix 1. Place the cups securely beneath them (see Photo 2). The wires are used to stop wind, foam impact and rotor wash from upturning or blowing the funnels and cups away. It takes about 4 person hours to set up the smaller 24m × 96m grid.

Photo 2. Funnel and cup set up.

The laminated letters and numbers provided are to aid grid coordinate identification. Anchor the letters on the short axis and numbers on the long axis. Grid coordinate A0 is the right hand corner of the first row (see Appendix 1).

Trial procedure

1. Weather recording: if an automatic weather station is unavailable, set up the anemometer (on the tripod) to measure wind speed and direction at 2m, and the psychrometer to measure wet and dry bulb temperatures for determination of relative humidity. Record wind speed, and wet and dry bulb temperature immediately before and after each drop. Enter in the weather recording form (Appendix 2).

2. Foam concentration: calculate the foam concentrate volume required to provide the desired foam percentage (using the table in Appendix 3).
3. Flight characteristics: decide on flight characteristics (i.e., airspeed and height) of the drop (try to account for the effect of wind on ground speed). Ensure the pilot agrees with these. Record airspeed and height on the drop specification form (Appendix 4). At least two drops should be performed at the same height and speed for replication.

4. Drop height determination: one person should stand at the end of the grid (but out of the drop zone) to estimate which grid line the helicopter is flying along. Place two people with clinometers to one side of the grid. Mark where they are standing. When the helicopter flies past, they must line the clinometer up with the bottom of the bucket and record the angle in the height estimate table on the drop specification form. Fill in their height to eye level. Measure the distance between where they were standing and the grid line the helicopter flew along.

5. Drainage rate: record the time it takes the bucket or hopper to empty.

6. Carry out drop: fill the bucket in the normal manner (ensuring the foam is well mixed) and proceed with the drop at the specified speed and height.

7. Foam expansion: select rows for expansion measurement and mark these by tying flagging to the beginning of each row. Twelve rows, spaced evenly through out the drop, are generally required for foam expansion measurement, although fewer rows may be required for shorter drops. Straight after the drop, send everybody along the foam expansion rows to mark the liquid and total foam amounts on the cups with grease pencils (see Photo 3) for later recording. Ensure the cups are not emptied.

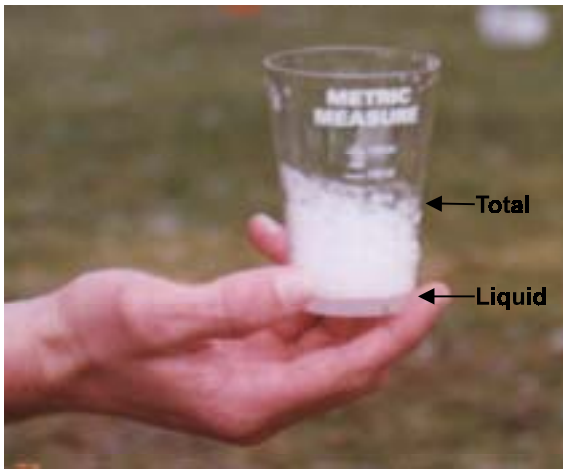


Photo 3. Measuring liquid and total foam depths.

8. Drop length and width: measure the maximum drop length and width, and sketch the rough shape of the drop in relation to the grid. Record these on the drop specification form.

9. Drop depth measurements: inject anti-foaming agent into each cup before measuring. Record the number of squirts of anti-foaming agent added to each cup. Use a swizzle-stick to stir and break down the foam. Systematically measure all cups, recording volumes of liquid, total foam and broken down total for the designated foam expansion rows. For all other rows, record the broken down total (total after anti-foaming agent added). Enter all measurements in the drop distribution and foam expansion form (Appendix 5) (see Drop Supervisor duty statement).

10. Carrying out more than 1 drop: if another drop is required, the funnels and cups must be emptied, rinsed in a bucket and dried. The grease pencil mark on the cups should also be cleaned off.

11. Bucket attributes: Measure and record the bucket attributes of plug diameter, outlet diameter and height, skirt diameter, distance of skirt bottom from the base of the bucket and strop length (see photo 4 and 5).

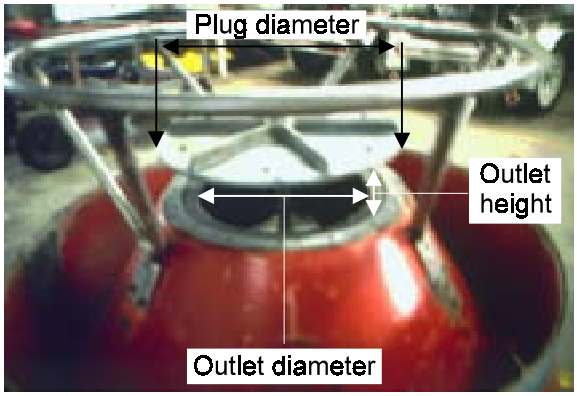


Photo 4. Bucket measurements of plug diameter, outlet diameter and height.

12. Pack up gear: ensure everything is cleaned and returned. This can be checked against the list of gear provided by FRI.

Drop supervisor duty statement

Appoint:

- 1 person to record weather if an automatic weather station is unavailable.
- 1 person to stand at the end of the grid and estimate which grid line the helicopter flies along.
- 1 person to record rainage time.
- 1 - 2 people to measure bucket height using clinometers. Ideally two people should be available, so that if the first person doesn't get it correct the second reading will be available.
- 2 people to measure drop width and length, and
- 1 person to fill in the drop distribution and foam expansion form.

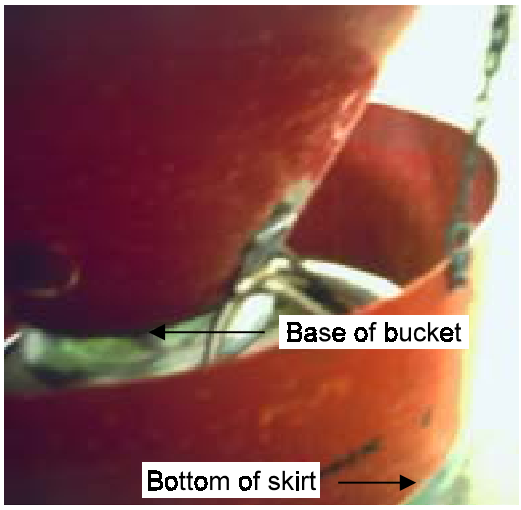
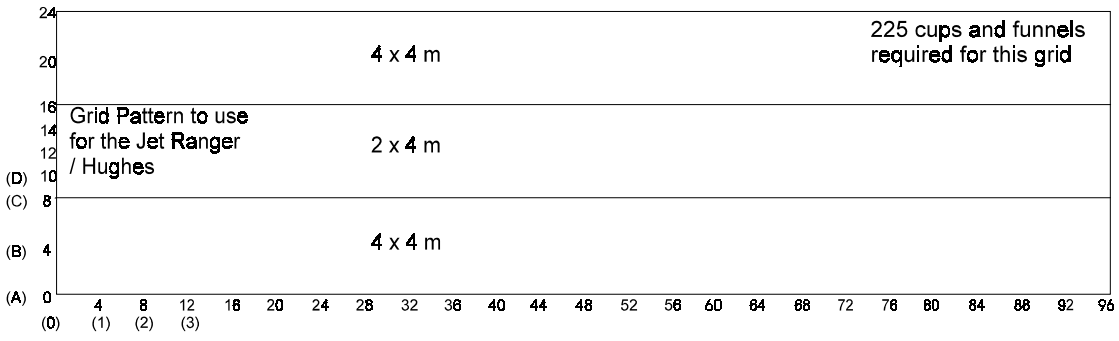


Photo 5. Measuring the distance between the bucket base and the skirt bottom.

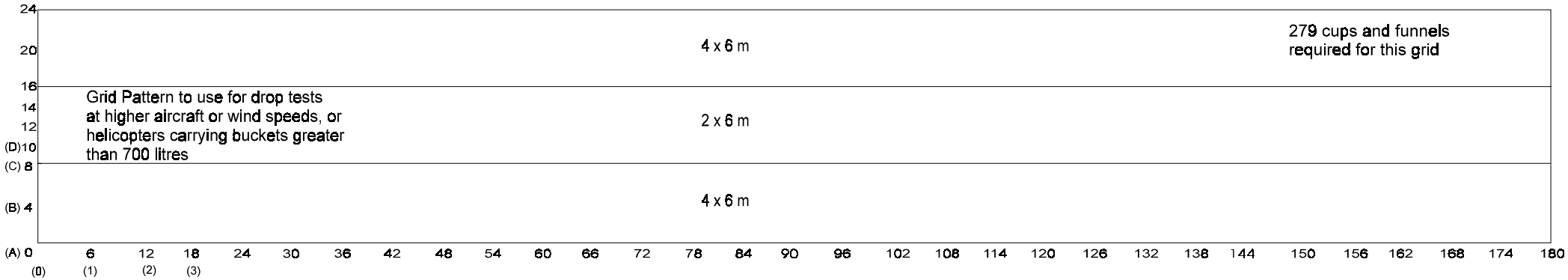
On completion of the drop, the drop supervisor should send everybody along the foam expansion rows to mark liquid and total foam depths, with a grease pencil. Once this has been done, measuring of the drop distribution can begin. Ideally there should be 9 people, measuring one column each. It is easiest to measure from row 0 and measure one row at a time. People doing the measuring need to keep in line with each other, while measurements are recorded. The injector gun contains anti-foaming agent and the volume will normally be set at 2 ml. Don't change this during the day. Add the reagent to the cups, recording how many times the injector gun was used for each cup (the injector guns will be calibrated when returned to FRI). We recommend using 2 mls of the anti foaming agent for every 20 - 30 mls in the cup. All measurements should be entered in the drop distribution and foam expansion form (Appendix 4). Measurements should be made to at least the nearest 5 mls. Volumes of less than 5 mls can be measured using the measuring cylinders.

Apendix 1. Grid pattern setup.

Grid 1



Grid 2



Appendix 2. Weather recording form.

Date: Location:

Trial number 1	Before	After
Wind speed, 2m (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 2	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 3	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 4	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 5	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 6	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 7	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Trial number 8	Before	After
Wind speed (km/h):		
Wind direction (degrees):		
Wet bulb temperature (^{o}C):		
Dry bulb temperature (^{o}C):		

Appendix 3. Volume of foam concentrate (litres) required for different foam solutions (%).

Foam Solution (%)	Bucket Capacity (litres) for 200 - 520 litre buckets																
	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520
0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0
0.3	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.6
0.4	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.8	1.9	2.0	2.1
0.5	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
0.6	1.2	1.3	1.4	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.4	2.5	2.6	2.8	2.9	3.0	3.1
0.7	1.4	1.5	1.7	1.8	2.0	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.4	3.5	3.6
0.8	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.7	2.9	3.0	3.2	3.4	3.5	3.7	3.8	4.0	4.2
0.9	1.8	2.0	2.2	2.3	2.5	2.7	2.9	3.1	3.2	3.4	3.6	3.8	4.0	4.1	4.3	4.5	4.7
1.0	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2

Foam Solution (%)	Bucket Capacity (litres) for 540 - 860 litre buckets																
	540	560	580	600	620	640	660	680	700	720	740	760	780	800	820	840	860
0.1	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9
0.2	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7
0.3	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	2.3	2.4	2.5	2.5	2.6
0.4	2.2	2.2	2.3	2.4	2.5	2.6	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.4
0.5	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3
0.6	3.2	3.4	3.5	3.6	3.7	3.8	4.0	4.1	4.2	4.3	4.4	4.6	4.7	4.8	4.9	5.0	5.2
0.7	3.8	3.9	4.1	4.2	4.3	4.5	4.6	4.8	4.9	5.0	5.2	5.3	5.5	5.6	5.7	5.9	6.0
0.8	4.3	4.5	4.6	4.8	5.0	5.1	5.3	5.4	5.6	5.8	5.9	6.1	6.2	6.4	6.6	6.7	6.9
0.9	4.9	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.3	6.5	6.7	6.8	7.0	7.2	7.4	7.6	7.7
1.0	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6

Foam Solution (%)	Bucket Capacity (litres) for 880 - 1200 litre buckets																
	880	900	920	940	960	980	1000	1020	1040	1060	1080	1100	1120	1140	1160	1180	1200
0.1	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2
0.2	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.4	2.4
0.3	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.2	3.3	3.4	3.4	3.5	3.5	3.6
0.4	3.5	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.6	4.7	4.8
0.5	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
0.6	5.3	5.4	5.5	5.6	5.8	5.9	6.0	6.1	6.2	6.4	6.5	6.6	6.7	6.8	7.0	7.1	7.2
0.7	6.2	6.3	6.4	6.6	6.7	6.9	7.0	7.1	7.3	7.4	7.6	7.7	7.8	8.0	8.1	8.3	8.4
0.8	7.0	7.2	7.4	7.5	7.7	7.8	8.0	8.2	8.3	8.5	8.6	8.8	9.0	9.1	9.3	9.4	9.6
0.9	7.9	8.1	8.3	8.5	8.6	8.8	9.0	9.2	9.4	9.5	9.7	9.9	10.1	10.3	10.4	10.6	10.8
1.0	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0

Foam Solution (%)	Bucket Capacity (litres) for 1220 -1540 litre buckets																
	1220	1240	1260	1280	1300	1320	1340	1360	1380	1400	1420	1440	1460	1480	1500	1520	1540
0.1	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5
0.2	2.4	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1
0.3	3.7	3.7	3.8	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.4	4.5	4.6	4.6
0.4	4.9	5.0	5.0	5.1	5.2	5.3	5.4	5.4	5.5	5.6	5.7	5.8	5.8	5.9	6.0	6.1	6.2
0.5	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7
0.6	7.3	7.4	7.6	7.7	7.8	7.9	8.0	8.2	8.3	8.4	8.5	8.6	8.8	8.9	9.0	9.1	9.2
0.7	8.5	8.7	8.8	9.0	9.1	9.2	9.4	9.5	9.7	9.8	9.9	10.1	10.2	10.4	10.5	10.6	10.8
0.8	9.8	9.9	10.1	10.2	10.4	10.6	10.7	10.9	11.0	11.2	11.4	11.5	11.7	11.8	12.0	12.2	12.3
0.9	11.0	11.2	11.3	11.5	11.7	11.9	12.1	12.2	12.4	12.6	12.8	13.0	13.1	13.3	13.5	13.7	13.9
1.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	14.4	14.6	14.8	15.0	15.2	15.4

Foam Solution (%)	Bucket Capacity (litres) for 1560 - 1880 litre buckets																
	1560	1580	1600	1620	1640	1660	1680	1700	1720	1740	1760	1780	1800	1820	1840	1860	1880
0.1	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.9	1.9
0.2	3.1	3.2	3.2	3.2	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.8
0.3	4.7	4.7	4.8	4.9	4.9	5.0	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.6
0.4	6.2	6.3	6.4	6.5	6.6	6.6	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.3	7.4	7.4	7.5
0.5	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4
0.6	9.4	9.5	9.6	9.7	9.8	10.0	10.1	10.2	10.3	10.4	10.6	10.7	10.8	10.9	11.0	11.2	11.3
0.7	10.9	11.1	11.2	11.3	11.5	11.6	11.8	11.9	12.0	12.2	12.3	12.5	12.6	12.7	12.9	13.0	13.2
0.8	12.5	12.6	12.8	13.0	13.1	13.3	13.4	13.6	13.8	13.9	14.1	14.2	14.4	14.6	14.7	14.9	15.0
0.9	14.0	14.2	14.4	14.6	14.8	14.9	15.1	15.3	15.5	15.7	15.8	16.0	16.2	16.4	16.6	16.7	16.9
1.0	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8

Foam Solution (%)	Bucket Capacity (litres) for 1900 - 2220 litre buckets																
	1900	1920	1940	1960	1980	2000	2020	2040	2060	2080	2100	2120	2140	2160	2180	2200	2220
0.1	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
0.2	3.8	3.8	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	4.3	4.4	4.4	4.4
0.3	5.7	5.8	5.8	5.9	5.9	6.0	6.1	6.1	6.2	6.2	6.3	6.4	6.4	6.5	6.5	6.6	6.7
0.4	7.6	7.7	7.8	7.8	7.9	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.9
0.5	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1
0.6	11.4	11.5	11.6	11.8	11.9	12.0	12.1	12.2	12.4	12.5	12.6	12.7	12.8	13.0	13.1	13.2	13.3
0.7	13.3	13.4	13.6	13.7	13.9	14.0	14.1	14.3	14.4	14.6	14.7	14.8	15.0	15.1	15.3	15.4	15.5
0.8	15.2	15.4	15.5	15.7	15.8	16.0	16.2	16.3	16.5	16.6	16.8	17.0	17.1	17.3	17.4	17.6	17.8
0.9	17.1	17.3	17.5	17.6	17.8	18.0	18.2	18.4	18.5	18.7	18.9	19.1	19.3	19.4	19.6	19.8	20.0
1.0	19.0	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.8	22.0	22.2

Appendix 4. Drop specification form.

Location:	Date:	Trial number:
Time of drop:	Aircraft:	Grid direction(°):

Bucket attributes	**Flight and drop features**	**Foam/retardant attributes**
Drainage time (secs):	Drop height (ft):	Brand:
Bucket volume (*l*):	Airspeed (kts):	Concentration(%):
Outlet diameter (cm):	Max. drop length (m):	Foam consistency:
Plug diameter (cm):	Max. drop width (m):	
Outlet height (cm):		
Skirt diameter (cm):		
Strop length (m):		
Distance of skirt bottom above or below (please specify) the base of the bucket (cm):		

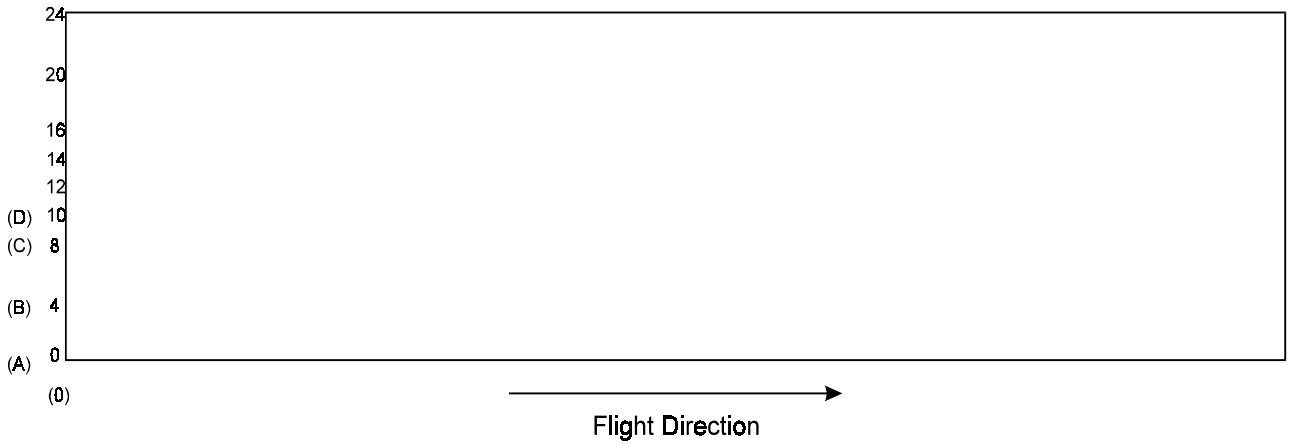
Foam consistency.

1. Wet - watery, runny, no body, bubble size varies, more water than air, fast draining.
2. Fluid - watery shaving cream, does not hold peaks, medium to small bubbles, flows readily, moderate drain rates.
3. Dry - shaving cream, holds peaks for a long time, mostly air, very “dry” and fluffy, slow draining.

Height of bucket base.

Observer 1	**Observer 2**
Eye height (m):	Eye height (m):
Distance to flight line (m):	Distance to flight line (m):
Angle (degrees) to base of bucket:	Angle (degrees) to base of bucket:

Sketch of drop shape.



Appendix 5. Drop distribution and foam expansion form.

Date: Location: Trial Number:

Grid number.	Initial volume (ml) (as shown by grease pencil mark). Liquid	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A0					
B0					
C0					
D0					
E0					
F0					
G0					
H0					
I0					
A1					
B1					
C1					
D1					
E1					
F1					
G1					
H1					
I1					
A2					
B2					
C2					
D2					
E2					
F2					
G2					
H2					
I2					
A3					
B3					
C3					
D3					
E3					
F3					
G3					
H3					
I3					
A4					
B4					
C4					
D4					
E4					
F4					
G4					
H4					
I4					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A5					
B5					
C5					
D5					
E5					
F5					
G5					
H5					
I5					
A6					
B6					
C6					
D6					
E6					
F6					
G6					
H6					
I6					
A7					
B7					
C7					
D7					
E7					
F7					
G7					
H7					
I7					
A8					
B8					
C8					
D8					
E8					
F8					
G8					
H8					
I8					
A8					
B8					
C8					
D8					
E8					
F8					
G8					
H8					
I8					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A9					
B9					
C9					
D9					
E9					
F9					
G9					
H9					
I9					
A10					
B10					
C10					
D10					
E10					
F10					
G10					
H10					
I10					
A11					
B11					
C11					
D11					
E11					
F11					
G11					
H11					
I11					
A12					
B12					
C12					
D12					
E12					
F12					
G12					
H12					
I12					
A13					
B13					
C13					
D13					
E13					
F13					
G13					
H13					
I13					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A14					
B14					
C14					
D14					
E14					
F14					
G14					
H14					
I14					
A15					
B15					
C15					
D15					
E15					
F15					
G15					
H15					
I15					
A16					
B16					
C16					
D16					
E16					
F16					
G16					
H16					
I16					
A17					
B17					
C17					
D17					
E17					
F17					
G17					
H17					
I17					
A18					
B18					
C18					
D18					
E18					
F18					
G18					
H18					
I18					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A19					
B19					
C19					
D19					
E19					
F19					
G19					
H19					
I19					
A20					
B20					
C20					
D20					
E20					
F20					
G20					
H20					
I20					
A21					
B21					
C21					
D21					
E21					
F21					
G21					
H21					
I21					
A22					
B22					
C22					
D22					
E22					
F22					
G22					
H22					
I22					
A23					
B23					
C23					
D23					
E23					
F23					
G23					
H23					
I23					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A24					
B24					
C24					
D24					
E24					
F24					
G24					
H24					
I24					
A25					
B25					
C25					
D25					
E25					
F25					
G25					
H25					
I25					
A26					
B26					
C26					
D26					
E26					
F26					
G26					
H26					
I26					
A27					
B27					
C27					
D27					
E27					
F27					
G27					
H27					
I27					
A28					
B28					
C28					
D28					
E28					
F28					
G28					
H28					
I28					

Grid number.	Initial volume (ml) Liquid (as shown by grease pencil mark).	Total foam	Measurement on injector gun (ml).	Number of times injected into the cup.	Final volume (ml).
A29					
B29					
C29					
D29					
E29					
F29					
G29					
H29					
I29					
A30					
B30					
C30					
D30					
E30					
F30					
G30					
H30					
I30					
A31					
B31					
C31					
D31					
E31					
F31					
G31					
H31					
I31					
A32					
B32					
C32					
D32					
E32					
F32					
G32					
H32					
I32					
A33					
B33					
C33					
D33					
E33					
F33					
G33					
H33					
I33					