



Ground Pattern Performance of the CDF S-2T Turbo Tracker Airtanker

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The Technology and Development Aerial Delivery Program tests a variety of fixed- and rotary-wing tankers to determine the parameters for optimal coverage over a wide range of fuel and fire conditions. The California Department of Forestry (CDF) S-2T Turbo Tracker airtanker (figure 1) is one of a family of Type II airtankers that are used for initial attack during wildland fire suppression.



Figure 1—The California Department of Forestry (CDF) S-2T Turbo Tracker airtanker.

The CDF constant flow system (designed by Marsh Aviation, Inc.) contains a single compartment that is certified by the Interagency Airtanker Board to carry 1,200 gallons. The tank has bulkhead dividers to minimize fluid movement from front to back and to provide structural integrity. Two opposing doors, which run the length of the tank, control the fluid flow. The system controller interprets fluid height information from sensors in the forward

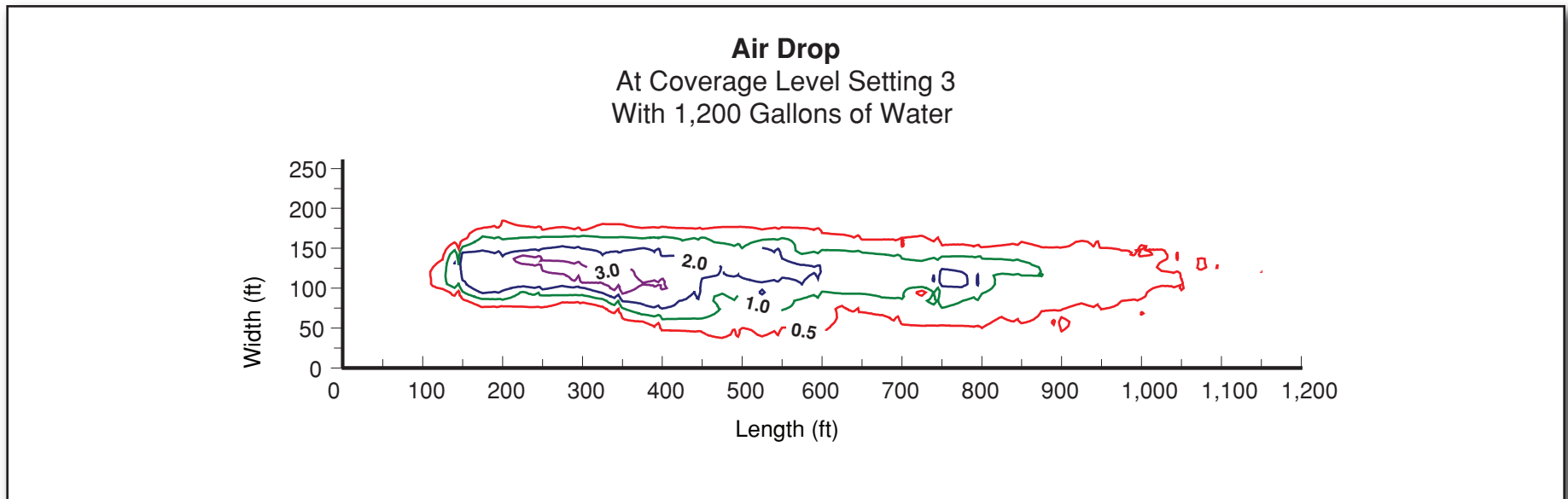


Figure 2—Drop pattern characteristics for the CDF S-2T Turbo Tracker airtanker using 1,200 gallons of water, a coverage level setting of 3, an airspeed of 118 knots, and a drop height of 195 feet.

and aft compartments and adjusts the door opening to produce a constant rate of flow from the tank.

The flow rate and volume for any individual drop can be selected using rotary switches on the drop control panel in the cockpit. Any fraction of the load also can be released by holding down the drop button. When the operator lets go of the button, the doors will close.

Drop tests included airspeeds from 108 to 135 knots and drop heights from 142 to 291 feet (measured from the

bottom of the tank to ground). Drops were made with water, gum-thickened retardant, and a water-enhancing gel.

The materials were dropped over an array of plastic bowls that were 6 inches in diameter and 3 inches deep. The quantity of material in each bowl was measured and the data were used to determine the drop pattern.

Flow rate, drop height, volume, and airspeed affect the drop pattern. Increasing drop height gradually widens the drop while decreasing the coverage levels. This

effect is modified by the ambient wind. Increasing windspeed widens the drop, decreasing coverage levels. Increasing airspeed increases the line length while reducing the coverage level.

Because this airtanker has variable volume and flow rates, it can produce coverage levels needed for various fire suppression missions. Figures 2 to 4 show the effect of three fire-retarding materials (water, a gum-thickened retardant, and a water-enhancing gel) dropped at a coverage level setting of 3.

The proper amount of fire-retarding material to drop, expressed as coverage level in gallons per 100 square feet, differs depending on the fuel type. Table 1 shows the coverage needed for specific fuel types using both the National Fire Danger Rating System (NFDRS) and the Fire Behavior Fuel Models.

The results of drop tests allow managers to estimate the line length of the most effective coverage level required for a given fire intensity based on airspeed, drop height, and flow rate.

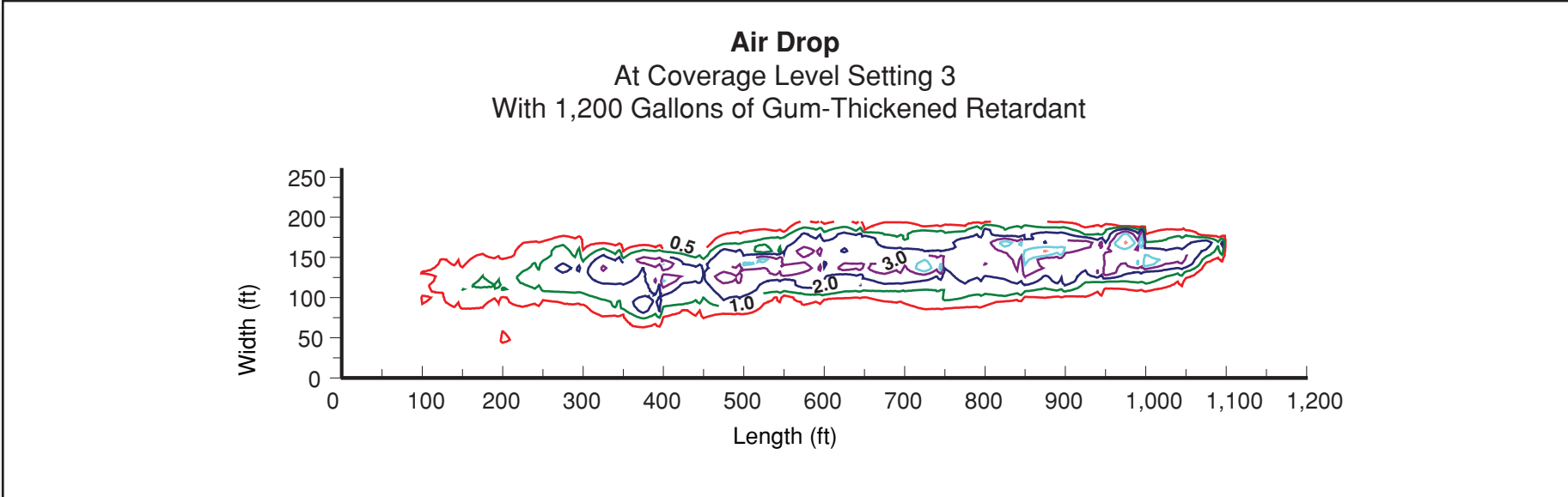


Figure 3—Drop pattern characteristics for the CDF S-2T Turbo Tracker airtanker using 1,200 gallons of gum-thickened retardant, a coverage level setting of 3, an airspeed of 129 knots, and a drop height of 184 feet.

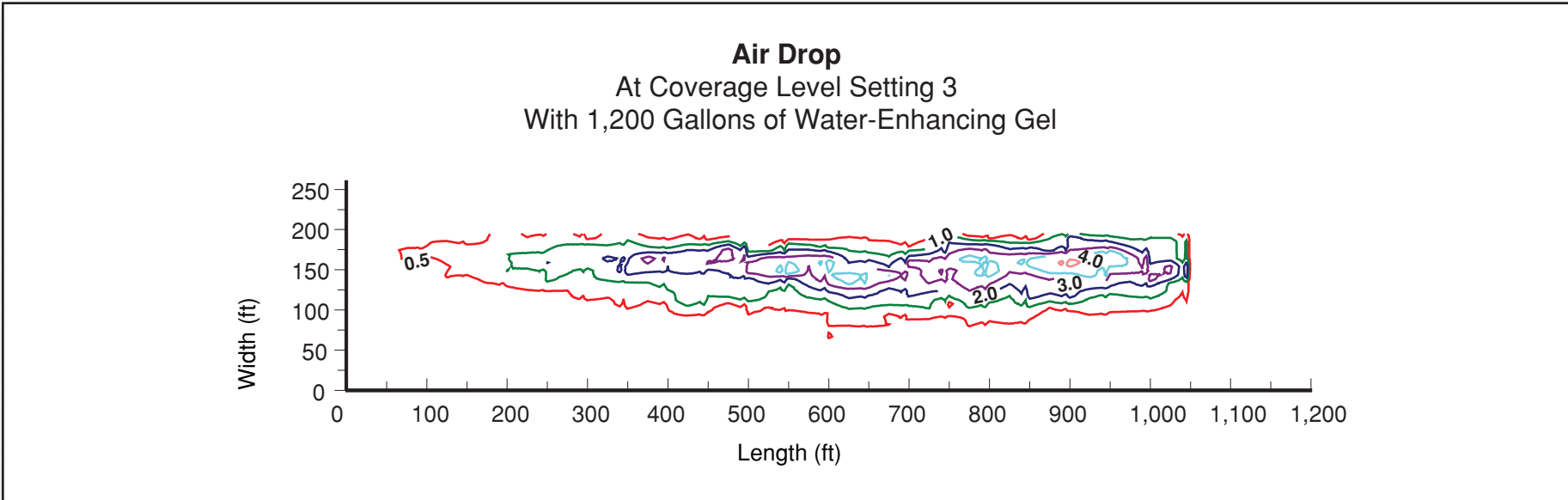


Figure 4—Drop pattern characteristics for the CDF S-2T Turbo Tracker airtanker using 1,200 gallons of water-enhancing gel, a coverage level setting of 3, an airspeed of 111 knots, and a drop height of 179 feet.

Table 1—The retardant coverage needed for specific fuel types.

Fuel Model		Coverage Level (gal/100 ft ²)	Description
National Fire Danger Rating System (NFDRS)	Fire Behavior		
A, L, S	1	1.0	Annual and perennial western grasses, tundra
C	2	2.0	Conifer with grass
H, R	8	2.0	Shortneedle closed conifer, summer hardwood
E, P, U	9	2.0	Longneedle conifer, fall hardwood
T	2	3.0	Sagebrush with grass
N	3	3.0	Sawgrass
F	5	3.0	Intermediate brush (green)
K	11	3.0	Light slash
G	10	4.0	Shortneedle conifer (heavy dead litter)
O	4	6.0	Southern rough
F, Q	6	6.0	Intermediate brush (cured), Alaska black spruce
B, O	4	Greater than 6.0	California mixed chaparral, high pocosin
J	12	Greater than 6.0	Medium slash
I	13	Greater than 6.0	Heavy slash

Tables 2, 3, and 4 were constructed from actual drop test data and indicate the longest measured line length (on the

ground) of each coverage level using water, gum-thickened retardant, and water-enhancing gel. The graphs in

figures 5, 6, and 7 were derived from the total drop test data set and indicate trends of line length production for a wide range

of coverage levels over the tested range of flow rates using water, gum-thickened retardant, and water-enhancing gel.

Table 2—CDF S-2T Turbo Tracker airtanker water drops producing the longest line length at each coverage level (“ed” is the “emergency dump” setting on the gate controller).

Coverage Level (gal/100 ft ²)	Flow Rate (gal/s)	Coverage Level (setting)	Line Length (ft)
0.5	65	0.5	2,892*
1.0	300	2	930
2.0	640	6	550
3.0	640	6	360
4.0	640	6	220
6.0	955	ed	65
8.0	955	ed	20
10.0	-	-	-

*Normalized to 1,200-gallon load.

Table 3—CDF S-2T Turbo Tracker airtanker gum-thickened retardant drops producing the longest line length at each coverage level.

Coverage Level (gal/100 ft ²)	Flow Rate (gal/s)	Coverage Level (setting)	Line Length (ft)
0.5	59	0.5	5,040*
1.0	180	1	1,644*
2.0	180	1	960
3.0	430	3	595
4.0	650	6	420
6.0	650	6	285
8.0	650	6	70
10.0	650	6	15

*Normalized to 1,200-gallon load.

Effects of Flow Rate on Line Length at Various Coverage Levels

CDF S-2T Turbo Tracker airtanker dropping water

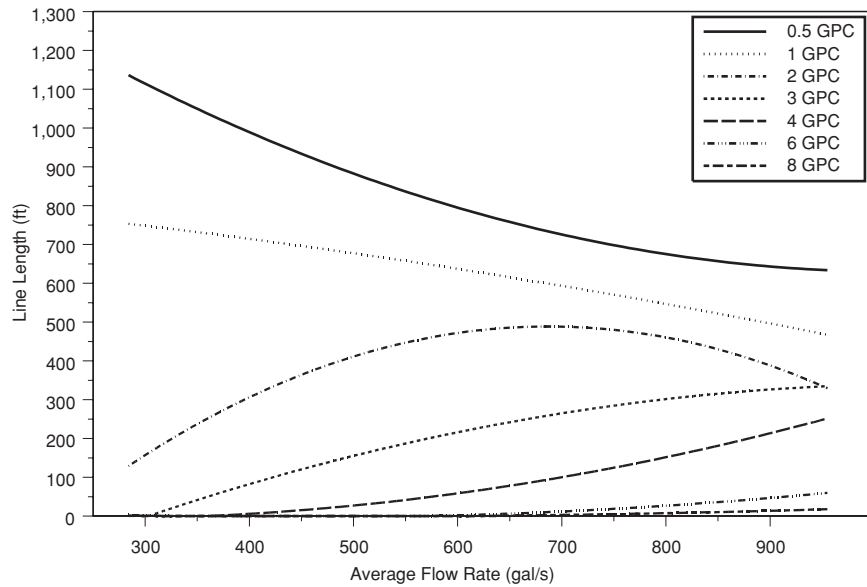


Figure 5—Use this graph to estimate the flow rate needed to produce the longest line of water at various coverage levels. GPC stands for gallons per 100 square feet.

Effects of Flow Rate on Line Length at Various Coverage Levels

CDF S-2T Turbo Tracker airtanker dropping gum-thickened retardant

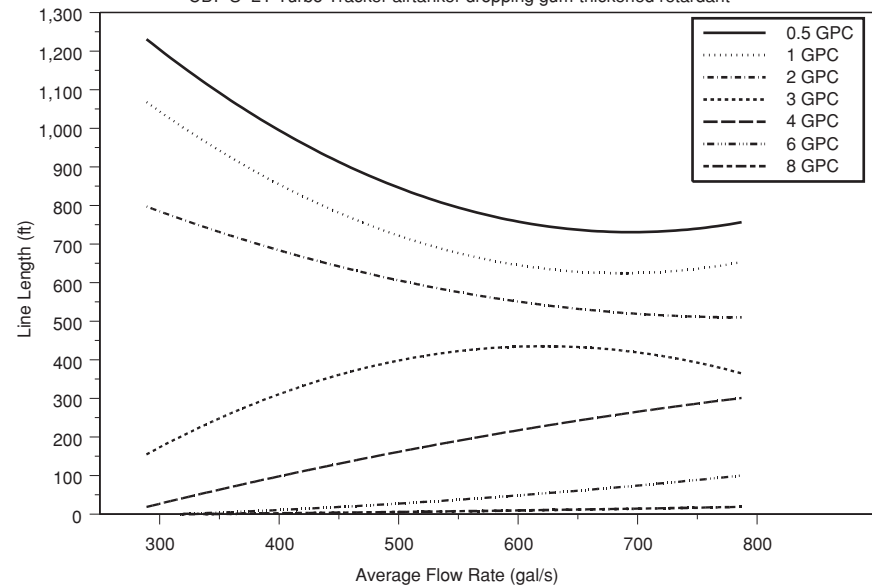


Figure 6—Use this graph to estimate the flow rate needed to produce the longest line of gum-thickened retardant at various coverage levels. GPC stands for gallons per 100 square feet.

Table 4—CDF S-2T Turbo Tracker airtanker water-enhancing gel drops producing the longest line length at each coverage level.

Coverage Level (gal/100 ft ²)	Flow Rate (gal/s)	Coverage Level (setting)	Line Length (ft)
0.5	170	0.5	2,112*
1.0	170	1	1,656*
2.0	290	2	885
3.0	430	3	600
4.0	640	6	360
6.0	640	6	120
8.0	640	6	45
10.0	650	6	15

*Normalized to 1,200-gallon load.

Effects of Flow Rate on Line Length at Various Coverage Levels

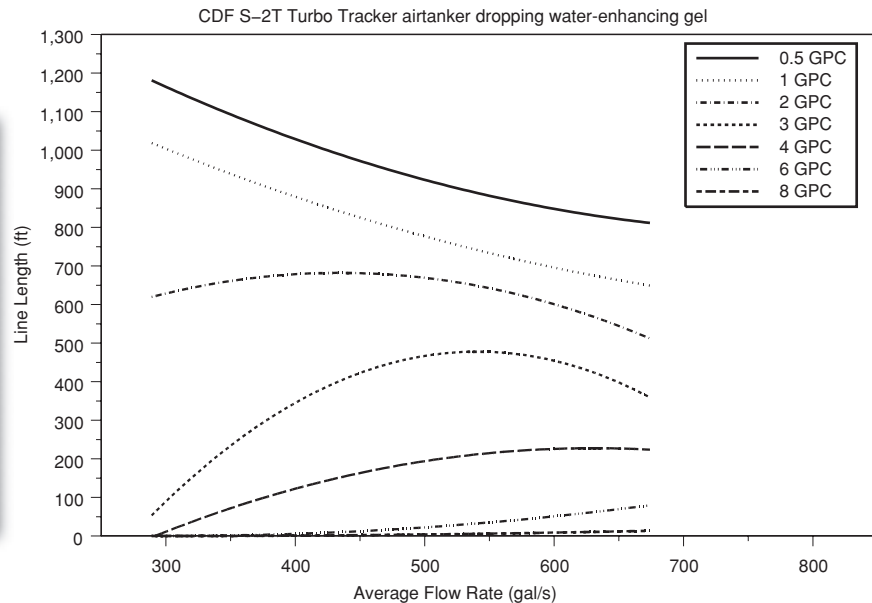


Figure 7—Use this graph to estimate the flow rate needed to produce the longest line of water-enhancing gel at various coverage levels. GPC stands for gallons per 100 square feet.

To select the proper flow rate, first use table 1 to determine the coverage level required by the NFDRS or Fire Behavior Fuel Model. The coverage levels in table 1 represent the coverage level required for average fire intensity for each fuel model. The required coverage level can be adjusted up or down depending on the actual fire intensity. Use the table for the material

dropped (water, gum-thickened retardant, or water-enhancing gel) to find the corresponding flow rate, coverage level setting (on the aircraft drop controller), and longest line produced for the desired coverage level. Similar information can be found in the appropriate graphs.

For example, a coverage level of 3.0 (gal/100 ft²) is required if a fire is burning in light slash (NFDRS Fuel

Model K/Fire Behavior Fuel Model 11—see table 1). Table 3 for gum-thickened retardant shows that a coverage level setting of 3 produces the longest line (595 feet), when dropping a full 1,200-gallon load.

The ground drop characteristics for the CDF S-2T Turbo Tracker airtanker were derived through controlled drop test procedures on flat ground (figure 8).

This information is to serve only as a guide to help field personnel determine the proper airspeed, drop height, and flow rate for delivering water, gum-thickened retardant, or water-enhancing gel. Actual coverage may vary depending on terrain, wind, weather, and pilot proficiency.



Figure 8—A drop test of the CDF S-2T Turbo Tracker airtanker.



About the Authors

Greg Lovellette is a physical scientist for the Forest Service's Technology and Development Aerial Delivery Project. He has worked with the technical tank and gating aspects of aerial retardant delivery systems since joining the Forest Service in 1989.

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Library Card

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Describes the results of tests to determine the optimal ground pattern coverage of three fire-retarding materials (water, gum-thickened retardant, or water-enhancing gel) dropped from the California Department of Forestry S-2T Turbo Tracker airtanker. The results of drop tests allow managers to estimate the line length of the most effective coverage level required for a given fire intensity based on airspeed, drop height, and flow rate. Graphs with contour lines at 0.5, 1, 2, 3, 4, 6, 8, and 10 gallons per 100 square feet show the drop pattern characteristics for the CDF S-2T Turbo Tracker airtanker flying at drop heights of 179 to 195 feet and airspeeds of 111 to 129 knots. A table shows the coverage of fire-retarding material needed for specific fuel types and fire behavior.

Keywords: chemicals, drop guides, retardants, water, water-enhanced gels, WFCS, wildfires, wildland fires

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