

## **Appendix D**

### **Fire Behavior Predictions**

Fire Behavior predictions were completed by Ann Marx, the City's Wildland Fire Specialist. The purpose of these predictions is to determine the potential fire behavior likely to occur during a wildland fire. Evaluating fire behavior allows fire personnel to predict the rate of spread of a fire, its intensity, and the ability for fire suppression resources to control the fire.

Fire behavior predictions were made using BEHAVE, Fire Behavior Prediction and Fuel Modeling System. BEHAVE is considered the industry standard for wildland fire behavior. It is a mathematical modeling system.

The predictions made for the Wildland Fire Plan are not absolute predictions. Inputs into the model include fuel moisture, wind speed, terrain, and fuel type for a given area, the model then outputs the rate of spread, the potential intensity, and the estimated size of a wildland fire for a given time period.

These predictions allow fire personnel to make tactical decisions in fighting a fire and helped in developing fire protection service policies and actions.

Following are a number of BEHAVE runs using various fuel types under varying weather conditions.

<b>BEHAVE Fire Behavior Calculations for NFFL Fuel Model 2 - Grass/Sage for Upslope Wind Conditions</b>									
<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>10 mph (4)</b>			<b>20 mph (8)</b>			<b>30 mph (12)</b>		
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	35	38	42	115	118	122	238	240	244
Fireline Intensity (btu/ft/sec)	359	383	424	1,172	1,196	1,237	2,417	2,441	2,482
Flame Length (ft)	7	7	7	12	12	12	16	16	16
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Elapsed Time</b>									
6 minutes (acres)	1	1	1	4	4	4	11	12	12
12 minutes (acres)	2	3	3	14	15	16	46	46	48
24 minutes (acres)	9	10	12	59	61	64	183	186	191

<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>40 mph (16)</b>			<b>60 mph (24)</b>					
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	400	402	406	835	837	841			
Fireline Intensity (btu/ft/sec)	4,064	4,089	4,129	8,492	8,517	8,557			
Flame Length (ft)	21	21	21	29	29	29			
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Elapsed Time</b>									
6 minutes (acres)	26	26	26	79	79	80			
12 minutes (acres)	102	103	105	316	317	320			
24 minutes (acres)	409	413	419	1,263	1,269	1,278			

Inputs used for all fire behavior calculations were; Dead Fuel Moisture - 1 hour fuel of 3, 10 hour fuel of 5, 100 fuel of 8; Green Fuel Moisture of 60; Maximum direction of spread; Wind adjustment factor for mid flame wind speed of 0.4.

<b>BEHAVE Fire Behavior Calculations for NFFL Fuel Model 4 - Heavy Chaparral for Upslope Wind Conditions</b>									
<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>10 mph (6)</b>			<b>20 mph (12)</b>			<b>30 mph (18)</b>		
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	163	169	178	421	427	436	742	748	757
Fireline Intensity (btu/ft/sec)	9,462	9,797	10,355	24,459	24,794	25,353	43,099	43,434	43,993
Flame Length (ft)	30	31	32	47	47	48	61	61	62
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Elapsed Time</b>									
6 minutes (acres)	9	10	10	36	37	38	80	81	82
12 minutes (acres)	36	38	41	143	146	151	319	323	329
24 minutes (acres)	144	152	165	574	585	604	1,277	1,291	1,314

<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>40 mph (24)</b>			<b>60 mph (36)</b>					
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	1,112	1,118	1,127	1,971	1,976	1,986			
Fireline Intensity (btu/ft/sec)	64,584	64,919	65,478	114,455	114,790	115,349			
Flame Length (ft)	73	74	74	96	96	96			
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Elapsed Time</b>									
6 minutes (acres)	140	141	143	306	308	310			
12 minutes (acres)	560	564	571	1,225	1,230	1,238			
24 minutes (acres)	2,240	2,256	2,283	4,901	4,921	4,953			

Inputs used for all fire behavior calculations were; Dead Fuel Moisture - 1 hour fuel of 3, 10 hour fuel of 5, 100 fuel of 8; Green Fuel Moisture of 60; Maximum direction of spread; Wind adjustment factor for mid flame wind speed of 0.6.

<b>BEHAVE Fire Behavior Calculations for NFFL Fuel Model 4 - Heavy Chaparral for Down Slope Wind Conditions</b>									
<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>10 mph (6)</b>			<b>20 mph (12)</b>			<b>30 mph (18)</b>		
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	159	153	144	417	411	402	738	732	723
Fireline Intensity (btu/ft/sec)	9,238	8,903	8,345	24,236	23,901	23,342	42,876	42,541	41,982
Flame Length (ft)	30	30	29	47	47	46	61	61	60
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Elapsed Time</b>									
6 minutes (acres)	8	8	8	35	35	34	79	78	77
12 minutes (acres)	35	33	30	142	139	134	317	314	308
24 minutes (acres)	139	132	120	566	555	537	1268	1254	1231

<b>Inputs 20 foot wind speed (mid flame wind speed)</b>									
	<b>40 mph (24)</b>			<b>60 mph (36)</b>					
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	1,108	1,102	1,093	1,967	1,961	1,951			
Fireline Intensity (btu/ft/sec)	64,361	64,026	63,467	114,232	113,897	113,338			
Flame Length (ft)	73	73	73	96	95	95			
<b>EXPECTED FIRE SIZE (Acres)</b>									
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Elapsed Time</b>									
6 minutes (acres)	139	138	137	306	304	302			
12 minutes (acres)	557	553	547	1,222	1,217	1,509			
24 minutes (acres)	2,229	2,213	2,187	4,888	4,869	4,835			

Inputs used for all fire behavior calculations were; Dead Fuel Moisture - 1 hour fuel of 3, 10 hour fuel of 5, 100 fuel of 8; Green Fuel Moisture of 60; Maximum direction of spread; Wind adjustment factor for mid flame wind speed of 0.6.

BEHAVE Fire Behavior Calculations for NFFL Fuel Model 9 - Hardwood Canopy for Upslope Wind Conditions **(Tree canopies not torching)									
Inputs 20 foot wind speed (mid flame wind speed)									
	10 mph (4)			20 mph (8)			30 mph (12)		
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	9	9	10	25	25	27	50	50	51
Fireline Intensity (btu/ft/sec)	71	75	83	209	213	220	408	413	420
Flame Length (ft)	3	3	3	5	5	5	7	7	7
	EXPECTED FIRE SIZE (Acres)								
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope
<b>Elapsed Time</b>									
6 minutes (acres)	<1	<1	<1	<1	<1	<1**	<1**	<1**	<1**
12 minutes (acres)	<1	<1	<1	<1	1	1	2**	2**	2**
24 minutes (acres)	<1	1	1	3	3	3	8**	8**	8**

Inputs 20 foot wind speed (mid flame wind speed)									
	40 mph (16)			60 mph (24)					
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Outputs</b>									
Rate of Fire Spread (chains per hour)	81	81	82	161	161	162			
Fireline Intensity (btu/ft/sec)	663	667	675	1,321	1,325	1,333			
Flame Length (ft)	9	9	9	12	12	12			
	EXPECTED FIRE SIZE (Acres)								
	10% Slope	20% Slope	30% Slope	10% Slope	20% Slope	30% Slope			
<b>Elapsed Time</b>									
6 minutes (acres)	1**	1**	1**	3**	3**	3**			
12 minutes (acres)	4**	4**	4**	12**	12**	12**			
24 minutes (acres)	17**	17**	17**	47**	47**	47**			

Inputs used for all fire behavior calculations were; Dead Fuel Moisture - 1 hour fuel of 3, 10 hour fuel of 5, 100 fuel of 8; Green Fuel Moisture of 60; Maximum direction of spread; Wind adjustment factor for mid flame wind speed of 0.4.

\*\* BEHAVE fire behavior modeling does not have the ability to predict extreme fire behavior, such as crowning and torching of fuel that would occur under extreme wind conditions. Therefore the fire behavior modeled in this scenario does not account for torching of tree canopies, it models a surface fire under tree canopies only.